MONASH UNIVERSITY
ACCIDENT RESEARCH CENTRE

EVALUATION OF ACCIDENT BLACK SPOT TREATMENTS

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Title and sub-title:
Evaluation of Accident Black Spot Treatments

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Abstract:

In 1979 an Accident Black Spot Program was initiated in Victoria. The program aims to reduce the incidence and severity of casualty accidents at locations with a bad accident record through the use of low cost, highly effective crash countermeasures.

The primary purpose of this study is to evaluate the effectiveness of particular types of treatments at various types of locations, with a range of accident types. Effectiveness is measured in terms of both changes in reported casualty accident frequencies and economic worth of the treatments implemented.

An efficient, computer-based method for evaluation has been developed as part of this study. The results provide practical and objective information for the refinement of the methods for selection of sites and treatments and, ultimately, to intelligently set directions and establish appropriate emphases for the program.

The accident evaluation indicates that the intersections component reduced casualty accident occurrence by 33% overall. Substantial casualty accident savings were derived from new roundabouts (81% reduction), new intersection signals (53%) and remodelled intersection signals (33%), with fully controlled right-turn phases seeming to contribute the bulk of the savings for remodelled signals. The treatment of intersections outside of the Melbourne Metropolitan area produced a 69% reduction, compared to a 30% reduction in the Metropolitan area.

The main findings of the economic evaluation are that the intersections component of the Program resulted in BCR values of 8.8 overall, 7.1 for intersections in Metropolitan Melbourne and 19.1 for intersections outside of the Metropolitan area. BCR values of 7.5 for new roundabouts, 8.2 for new intersection signals, and 22.1 for the remodelling of existing signals were achieved. The evaluation found average NPW values per treatment of $0.72 million overall, $1.25 million for new roundabouts, $1.06 for new intersection signals and $0.85 million for remodelled intersection signals.

The treatment of midblock locations was unsuccessful overall in reducing casualty accident frequency at treated sites. This aspect warrants more detailed study.

Key Words:
Accident prevention, accident black spot, cost benefit analysis, effectiveness evaluation (assessment), intersection, traffic signal, roundabout, traffic engineering

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Contents

1.0 INTRODUCTION

In 1979 an Accident Black Spot Program was initiated in Victoria, after attention had been drawn to the highly successful operation of this type of approach in Europe, England and the U.S.A. (Conn and Vulcan (1978)). In Victoria, the program aims to reduce the incidence and severity of casualty accidents at locations with a bad accident record. Though the major emphasis of the program is on low cost, highly effective crash countermeasures, higher cost treatments have also been used where economically justified.

The early development of the program was directed at establishing technical and organisational procedures, and applying these procedures in the treatment of a range of black spot location types. The program has grown progressively from approximately 4 sites treated in 1979/80 to 256 sites, at a cost of about $9 million in 1986/87. By 1989/90, over $17 million had been allocated for safety improvements at black spot locations.

An evaluation of the road safety effects for a sample of 46 accident black spot treatments, implemented in the period 1980- 1985, has reported a 41% overall reduction in casualty accidents, with accident savings some ten times higher than the amortised costs (Richardson (1987)). The sample studied consisted mainly of traffic signal 'remodels and new signal installations.

1.1 STUDY OBJECTIVE:

The primary purpose of this study of the Accident Black Spot Program is to evaluate the effectiveness of particular types of treatments at various types of locations, with a range of accident types. Effectiveness is measured in terms of both charges in reported casualty accident frequencies and economic worth of the treatments implemented.

1.2 SIGNIFICANCE OF THE RESULTS:

The results provide practical and objective information for the refinement of the methods for selection of sites and treatments under the program. Ultimately, this information is necessary to intelligently set directions and establish appropriate emphases among a range of traffic engineering safety programs and projects competing for available funds.

The study also provides an evaluation of the overall program over a wider range of treatment types, a much larger number of sites and a longer 'after' period than the initial sample study of 46 sites.

2.0 STUDY METHOD

The study method is based on a "before and after" comparison of reported casualty accident frequencies at locations treated under the Accident Black Spot Program since its inception in 1979. The analyses also included the estimation of economic worth of individual treatments and of other treatment groupings. Various aspects of the method are discussed below:

2.1 DATA COLLECTION:

Data were collected from various sources from within Vicroads, but principally from the Corporation's Program Management System (PMS) and the State Traffic Accident Record (STAR).

2.1.1 The Program Management System:

PMS is a computer data base containing information on various traffic management programs for which Vicroads has responsibility. It includes locations identified for investigation and possible treatment under the Black Spot Program. Among the information contained in the data base are the location, the type of treatment, the date of completion of the treatment and its capital cost - all key items in the evaluation. It was initially expected that a large proportion of the Black Spot Program would be evaluated through this study, but the PMS lacked information on critical data items for many treatments.

The PMS data were therefore supplemented by collecting information from other sources, such as location files, Memorandum of Consent records and various historical records from the early years of the program. This was only partly successful and, as a result, many treatments could not be evaluated unless an inordinate amount of time was spent on manual data collection, with limited probability of success. Nevertheless, it is believed that the results of the evaluations, which were able to be undertaken, are indicative of the Program’s performance overall.

2.1.2 The State Traffic Accident Record:

Accident histories for the locations which could be evaluated were obtained from the STAR, a computer data base containing details of accidents reported to the police (a description of the accident data base is given in Corben and Ashton (1984)).

The relevant accident data were obtained by computer match-merging (by the location street names) the treatments file with the accidents file. The accident data for the relevant "before and after" treatment periods were merged with the treatments file for all locations where a successful match of street names was achieved.

Major difficulties were encountered in this process due to the following problems:

- street names in PMS often did not precisely correspond to street names in the STAR, thereby preventing a completely successful match of the data;
- street naming convention in the STAR, particularly the order of naming of the streets, changed during the evaluation period for many locations;

- only limited use could be made of grid references due to changes in referencing convention and in maps during the evaluation period.

Consequently, manual accident data extraction and entry were required, thus affecting efficiency of data base establishment and in some extreme cases, preventing locations with other key information available from being included in the analysis.

2.2 THE FINAL DATA BASE:

Following the completion of the data collection phase, as described above, there was a total of 175 treatment locations for evaluation. These were made up of 116 intersections and 59 road lengths. A full listing of the sites included in the data base is contained in Appendix 1, together with their respective treatment details.

The data base was created using SAS (SAS Institute Inc., 1985:1, manipulated using Microsoft Excel (Microsoft Corporation, 1987) and later converted back into SAS format for statistical analysis. The statistical analysis technique was developed from Tanner's method and is described in Section 2.3.

2.3 METHOD OF STATISTICAL ANALYSIS:

Two basic methods exist for evaluating countermeasure effectiveness - conventional and Bayesian methods. Often Regression-to-the-Mean effects are calculated using Bayesian methods and incorporated in an otherwise conventional analysis. Both methods are necessarily based on a "before and after" approach with the use of control groups (Teale, 1984).

The usual procedure for conventional methods is to use the control ratio (as defined later in Section 2.3.2) and the before period accident record to estimate the expected number of crashes in the after period, calculate the difference between the expected and actual numbers of crashes for the treatment group in the after period, calculate chi-squared values and determine a level of significance from these.

Bayesian methods have gained popularity in European countries where criticism of conventional methods is strong. Hauer (1981), for example, has been outspoken in his criticism of the use of arbitrary significance levels/null hypothesis testing which underpins conventional techniques.

Despite this, only partial use of Bayesian methods (mainly in the determination of Regression-to-the-Mean effects) has been more generally adopted. Reticence for a fuller use of the method probably lies in "the difficulty of incorporating control group information " (into the analysis), as discussed by Abbess et. al. (1981).

The most satisfactory conventional method found was by Tanner (1958).

2.3.1 Tanner's Method:

Tanner (1958) proposed an analysis method for estimating the average effect on accident frequencies before and after changes are made at a number of sites. The method incorporates the use of control ratios but does not account for changes in traffic exposure nor Regression-to-the-Mean effects. As described below, the latter two issues were dealt with separately in this study. For a detailed explanation of Tanner's method, the reader is referred to the original paper (Tanner, 1958).

In general, before and after periods were chosen in this study to each be three years, except in the case of sites treated in 1985/86, for which only two years of accident data were available. For 1985/86 treatments, three year before periods and two year after periods were used. Scaling adjustments were carried out to forecast 'actual' three year casualty accident frequencies after treatment, from the actual two year frequencies after treatment.

In many cases, reliable dates for the completion of treatments were unavailable from PMS or other sources. In order to define before and after periods in a meaningful way and to increase reliability, the second-mentioned calendar year, in the financial year of treatment, was designated as the "treatment year". The "treatment year" was then excluded from the analysis in the knowledge that, in reality, most treatments in any financial year were completed in the latter months (say, February to June) or in the early months of the next financial year (say, July to September). This assumption has the added advantage, in most cases, of allowing for pre- and post-treatment "settling-in" periods.

The before period was, therefore, able to be defined as the three calendar years prior to the "treatment year" and the after period as the three (or, in the case of 1985/86 treatments, two) calendar years following the "treatment year".

2.3.2 Control Groups:

As mentioned above, Tanner's method includes the use of control groups within the analysis. Control groups in this study comprise reported casualty accident totals for the municipality in which the treated location is situated. The individual control ratio for each treatment was formed from before and after periods exactly matching the before and after periods of the treated site.

The expected number of crashes in the after period for each treated site is given by the product of its 'before' casualty crash frequency and its corresponding control ratio (i.e. total casualty crash frequency in the municipality during the after period / total casualty crash frequency in the municipality during the before period).

The control ratios and expected casualty crash frequencies for each treatment are contained in Appendix 1.

2.3.3 Estimating Exposure:

Adequate volume data were not available (or, more likely, did not exist) to enable account to be taken of exposure in the evaluation of treatment effectiveness. Sites known to have experienced substantial changes in traffic volumes were deleted from the analysis, consistent with the approach adopted by Teale (1984). There were relatively few sites in this category.

Furthermore, the view was taken that, if a treatment changes crash frequencies because of a change in exposure resulting from the treatment, then this component of the change in crash frequency ought to be included in the measurement of the overall effect of the treatment. That is, the overall effect of the treatment is made up of a component due to the intrinsically different safety performances of the location before and after treatment, and an equally legitimate component due to any exposure changes resulting from the treatment.

For these reasons, estimates of effectiveness of various treatment types include a component due to exposure changes. A discussion of issues relating to exposure are contained in Appendix 2.

2.3.4 Accident Migration and Risk Compensation:

The preceding section concludes that effects due to exposure changes could rightfully be regarded as an intrinsic part of the overall effect of a treatment. This hypothesis, however, does not accommodate accident changes at surrounding sites, resulting from exposure changes at the treated site.

Where a particular site is treated, it is argued (Boyle and Wright, 1984) that the change will lower drivers' perception of risk and consequently increase the likelihood of crashes downstream, that is, in the area immediately surrounding the treated site. Hence, it has been suggested that rather than there being a reduction in crashes, there is merely a transfer to other locations. Obviously if all or a representative number of sites in the given area are under study and not just one or two, the effect is accounted for (and there would be concluded to be no change, given the theory).

Maher (1987), however, argues that the apparent increase in crashes at surrounding sites is simply another manifestation of the regression to the mean effect (in this case the selected sites are biased compared with those immediately adjacent to untreated ones).

A more substantial evaluation than could be undertaken here would be needed to quantify the accident migration component of treatment effect. This does not seem to be warranted given the relatively large size of the treatment effects.

2.3.5 Regression-to-the-Mean:

If black-spot sites are selected on their immediate prior history then such a selection will include not only those sites with an abnormally large true mean accident rate, but those sites which are randomly high due to statistical fluctuation. It is highly likely that, for a large proportion of similarly selected sites, crashes in the period after selection will drop, irrespective of any treatment or its effectiveness

The effects of "Regression-to-the-Mean" (RTM) have been well documented, particularly amongst proponents of Bayesian Methods (for example Hauer, 1981).

On the basis of work reported by Nicholson (1986), at least three, and desirably five, years is the preferred before/after time period required to smooth out arty random fluctuations as well as providing sufficient evidence of any trend or change in an established pattern of accidents. If only lesser periods are available, the RTM effects should be estimated, in terms of expected accident reduction, and subtracted from actual accident reduction to arrive at any underlying "real" effects.

Estimation of the R TM effect is itself subject to error and thus adjustment of crash effects should be made with this in mind.

The majority of locations being evaluated in this study were identified on the basis of their five year casualty accident histories and, therefore, the effects of RTM are likely to be small. Furthermore, there has tended to be at least 18 months lag between the time of identification and the introduction of the treatment and an additional six months lag in the availability of up-to-date crash records from the STAR. When this is taken into account, together with the manner in which "treatment year" is defined, the analysis would have used mainly different years in the before period to those used to identify the location as a black spot. Hence, any over-estimation of the effect of a treatment due to RTM is assessed as minimal.

Richardson (1987) estimated the size of the RTM bias for a sample of 46 black spots, the majority of which were treated with new signals or improvements to existing signals. He found that, had RTM bias not been taken into account, treatment effectiveness would have been over-estimated by 5%.

Procedures for the estimation of RTM effects are described in Appendix 3. These procedures were applied to a subset of the sample of 116 intersection treatments, with the results shown in Appendix 4. The subset comprised 62 intersections which were signalised prior to treatment, situated in the Melbourne Metropolitan area and had four approach legs. A reasonably homogeneous subset was chosen to reduce the variability in the estimate of the RTM effects (Nguyen, 1986). The results indicate that the estimates of effectiveness are conservative, i.e. tending to under-estimate treatment effectiveness by approximately 9%. Part of the reason for this may lie in the fact that the RTM analysis was carried out on accident data which were essentially from different periods to the data used to identify the site as a Black Spot in the first instance.

In summary, the results are presented without adjustments for RTM, though estimates of the effect are available for information in Appendix 4. The RTM effects were not estimated for other than this subset, as the number of locations in any other "homogeneous" subset were too low for reliable results.

2.3.6 Categorisation of treatment types:

A basic aim of the study is to estimate the effectiveness of particular treatment types. Because most black spots analysed had been subject to a combination of individual treatments, the number of possible treatment "sets" was high and consequently reduced accident numbers in each set to an infeasibly low level for analysis.

A compromise was adopted. It involved the development of coarser groupings based on the treatment assessed as being the "dominant" treatment in the collection of measures implemented. Sites with one or more treatment types could then be incorporated into the group on this basis. Obviously the coarser the categories, the greater the loss of accuracy in what could be concluded about individual treatment types. Conversely, the increase in sample size improves the accuracy of the analysis itself.

2.4 METHOD OF ECONOMIC ANALYSIS:

In addition to the above analyses, which evaluated the effect of accident black spot treatments on reported casualty accident frequencies, the study also estimated the economic worth of the program and, where possible, of individual program components, in terms of Benefit-Cost Ratios and Net Present Worth values.

These two measures of economic worth are based on the same set of assumptions but simply express the results using different indicators. Given the scope of the project and the range of treatment types being evaluated, a number of simplifying assumptions were made in the economic evaluations. These assumptions are summarised below:

1. Monetary values of benefits and costs are expressed in present day (1989) values.

2. Because the study evaluated the effectiveness of treatments on casualty accident totals, average casualty accident costs, rather than costs by accident type, were used in the economic evaluation. The monetary value of an average casually crash is:

   - $53,500 for urban areas,
   - $84,000 for rural areas.

   These estimates were derived by increasing, by a nominal 7% for inflation, the average costs recommended for use in such analyses by the Road Traffic Authority (1988).

3. The estimated annual reported casualty accident savings ($'s;) = A * (B-C)

   where, A = average cost of a casualty accident;
   B = expected number of reported casualty accidents per annum after treatment, and
   C = actual number of reported casualty accidents per annum after treatment.

4. The monetary value of any significant travel time, vehicle operating cost, air or noise pollution impacts have not been included in the economic evaluation (while these values are not known, they are unlikely to be large for most of the treatments analysed).

5. The maintenance costs of various treatment types are as follows:

   - - new intersection signals $8,000 per year;
   - - remodelled intersection signals, $2,000 per year (for additional detectors, globes and power);
   - - other treatment types, 10% per year of the capital cost of treatment.

6. Future year's benefits and costs have been discounted at the rate of 4% per annum to express project impacts in present day values. This is the currently recommended rate of the Victorian Department of Management and Budget.

7. The average project life of each treatment is ten years, with the exception of delineation treatments which were assumed to have an effective project life of three years only. (Some project types, notably roadworks improvements, typically have physical lives considerably in excess of ten years, however, traffic growth/land use changes and other factors often necessitate that further improvements be made before the full project life is realised).

3.0 RESULTS OF ACCIDENT ANALYSIS

This section summarises the results of the analyses of accident frequency change described in Section 2.0. The sample of treated sites, for which sufficient data could be obtained, were evaluated by location type (i.e. intersections and midblocks), by treatment type and by geographic area (i.e. metropolitan Melbourne and non-metropolitan Melbourne). The full results of the analyses are detailed in Appendix 5 and Appendix, 6, with the main findings summarised below.

3.1 ANALYSIS OF INTERSECTIONS BY TREATMENT TYPE:

Treated locations were evaluated separately, according to whether the treatments were implemented at an intersection or within a midblock location.

The sample of 116 locations included in the intersections analysis showed a 33% (highly significant $p<0.0001$) reduction in casualty accident frequencies overall. The expected number of reported casualty accidents after treatment is 1513 compared with an actual number of 1007. This result corresponds to an estimated 506 casualty accidents saved over a three year period, or an average casualty accident saving per intersection treatment per year of 1.5.

Reported casualty accident data for treated intersections were analysed by individual treatment type (refer to Section 2.3.6 for categorisation method). The results of these analyses are contained in Appendix 5.

The major findings of the intersections analysis are:

- an 81% (highly significant, $p<0.001$) reduction in casualty accidents from new roundabouts. The estimated number of casualty accidents prevented is 2.4 per roundabout per year;
- a 53% (significant, $p<0.05$) decrease in casualty accidents from new intersection signals. The estimated number of casualty accidents prevented is 2.2 per new intersection signals treatment per year;
- a 33% (highly significant, $p<0.0001$) reduction in casualty crashes from signal remodelling works. The estimated number of casualty accidents prevented is 1.8 per signal remodelling treatment per year;
- a 32% (marginally significant, $p<0.10$) decrease in casualty crashes from pedestrian treatments. The estimated number of casualty accidents prevented is 1.6 per pedestrian treatment per year;

The collection of intersections treated with **signal remodelling works** is made up of a range of individual treatment types, involving new signal hardware, installation of turn phases, delineation improvements, etc. This treatment type has been examined in greater detail to determine whether some forms of remodelling works, particularly the addition of right-turn phases, are more effective than others.

The 47 intersections forming this group were disaggregated into two sub-groups, according to whether or not treatments involved the installation of right-turn phases. The results of this more detailed analysis (refer Appendix 5) indicate that the 30 intersection treatments involving right-turn phase installation showed a 44% highly significant ($p<0.0001$)

reduction in casualty accidents, while the remaining 17 treatments showed a non-significant increase of 4%.

It should be remembered that the reduction levels reported here are for all casualty accident types and, therefore, since this countermeasure is quite specifically targeted at right-turn-against accidents, higher percentage reductions could reasonably be expected for the target accident type. It is also noteworthy that the majority of intersections in this treatment category had fully controlled right-turn phases, suggesting that the major portion of the benefits may have been derived from this countermeasure type.

The Accident Research Centre has commenced a study of the safety and operational performance of alternative forms of right-turn control. This study should improve our ability to quantify these effects.

3.2 ANALYSIS OF MIDBLOCK LOCATIONS BY TREATMENT TYPE:

A total of 59 road lengths, comprising mainly midblock locations, were evaluated. Overall, they showed a non-significant 2% reduction in casualty crashes. The results of this analysis are contained in Appendix 7.

Although the midblocks showed no statistically significant reduction in crashes either overall or for specific treatment types, a substantial proportion of these locations gave indications of reductions. Of the sample of 59 locations, 37 locations fell into this category, namely, the 'after' treatment frequencies were lower than the expected frequencies, while a proportion of the remaining 22 midblocks experienced large increases, indicating that perhaps there are some midblock characteristics which are amenable to casualty accident frequency reduction and others not.

A general inspection of the list of locations belonging to these two categories of midblock type reveals no apparent differences in characteristics of locations receiving successful treatment and those where treatments were unsuccessful. This aspect warrants more detailed study.

3.3 ANALYSIS BY GEOGRAPHIC AREA:

Both the intersection treatment group and the midblock treatment group were analysed in terms of tile area in which the treated locations were situated. locations were classified as belonging to either the Melbourne Metropolitan area or to the "Rural" area (rest of State).

The results are contained in Appendix 5 and Appendix 7.

For **intersections**, it was found that:

- Metropolitan area treatments exhibited a 30% (highly significant $p<0.0001$) reduction in casualty crashes, corresponding to an average casualty accident saving of 1.3 per intersection treatment, and
- "Rural" area treatments showed a 69% (highly significant $p<0.001$) reduction in casualty crashes, producing an average saving in casualty accidents of 2.6 per intersection treatment.

The analysis of **midblocks** showed that neither the Metropolitan nor "Rural" areas experienced significant reductions in casualty crashes.

3.4 ANALYSIS BY YEAR OF TREATMENT:

Appendix 5 also includes an analysis of **intersection treatments** by year of treatment. The results indicate that, despite low numbers of treatments in the early years, statistically significant reductions in casualty accidents occurred for each year examined, except in 1984/85, which showed a non-significant ($p<0.11$) apparent reduction of 12%. There is a generally declining trend in the level of reduction from 1979/80 through to 1984/85, with 1985/86 rising markedly to 39%.

For **midblock treatments**, only 1982/83 showed statistically significant reductions in casualty crashes after treatment (52%, $p<0.05$ for four treatments). There was only one other midblock treated in the sample prior to 1982/83 and therefore the opportunity to draw inferences about effectiveness of midblock treatments in the early years of the Program is negligible. The full results of the analysis by year are shown in Appendix 7.

4.0 RESULTS OF ECONOMIC ANALYSIS

Section 2.4 explains the method and assumptions made in analysing the economic worth of black spot treatments. This section reports the results of the analysis, providing separate findings for intersections and midblock locations, both overall and by treatment type and by geographic area.

4.1 ANALYSIS OF INTERSECTIONS BY TREATMENT TYPE:

Of the 116 intersections analysed to determine the effects of treatments on casualty accident occurrence, only 82 intersections had adequate cost data to enable their inclusion in the economic evaluation. For completeness, the results of the economic evaluation for each of the 82 intersections are listed in Appendix 1. The measures of economic worth of each individual treatment reflect the result of countermeasure application at that particular location. The actual outcome for a given treatment type will vary from site to site, depending on site-specific circumstances. For this reason, generalisations from results at individual sites to other sites receiving like-treatment should be avoided.

Set out below are the major findings of the economic evaluation of intersection treatments (refer Appendix 8). Only those results which are supported by statistically significant reductions in casualty accident frequency for both the full sample of 116 intersections and the sub-set of 82 intersections (for which adequate cost data were available, refer Appendix 6) are regarded as providing reliable indications of economic worth.

- the **overall program** of 82 intersections analysed had an estimated Benefit to Cost Ratio (BCR) of 8.8, and an estimated Net Present Worth (NPW) value of over $58.7 million, corresponding to an average NPW value of $0'.72 million per treatment;
- **new roundabouts** showed a BCR of 7.5 and a NPW value of over $10 million. This corresponds to an average NPW value of $1.25 million per roundabout treatment;
- the estimated BCR for **new intersection signals** is 8.2, with an overall NPW value of $7.4 million and an estimated average NPW value per treatment of $1.06 million;
- **signal remodelling works** resulted in an estimated BCR of 22.1 and a total NPW for the 33 intersections in the sample of nearly $28 million, or an average $0.85 million per location treated;

The results of the economic analysis for other treatment categories are considered indicative only, given their small sample sizes and/or the lack of statistically significant findings in the analysis of accident frequencies.

4.2 ANALYSIS OF MIDBLOCKS BY TREATMENT TYPE:

Of the 59 midblock locations analysed to determine the effects of treatments on casualty accident occurrence, only 38 treatments had adequate cost data to enable their inclusion in the economic evaluation. For completeness, the list for each of the 59 midblock locations are presented in Appendix 1, with the results of the analysis by treatment type in Appendix 9.

The results of the economic analysis for individual midblock treatment categories need to be interpreted with caution, given their small sample sizes and/or the lack of statistically significant findings in the corresponding analysis of accident frequencies. The measures of economic worth of each individual treatment reflect the result of countermeasure application at that particular location. The actual outcome for a given treatment type will vary from site to site, depending on site-specific circumstances. For this reason, generalisations from results at individual sites to other sites receiving like-treatment should be avoided.

Having regard to the number of observations in each treatment category and to the statistical significance of accident effects reported in Section 3.2, no meaningful conclusions can be drawn regarding the economic evaluation of midblock treatments.

4.3 ANALYSIS BY GEOGRAPHIC AREA:

The 82 intersection treatments and 38 midblock treatments which were subject to economic evaluation were also analysed separately for the Melbourne Metropolitan and "Rural" areas.

4.3.1 Intersection Treatments:

There were 72 intersections treated in the Metropolitan area and 10 in the rest of the State.

The following results were obtained:

- The BCR for Metropolitan intersections is estimated to be 7.1 and the NPW value $39.5 million, at an average of $0.55 million per treatment.
- For "Rural" treatments, the estimated BCR is 19.1 and the NPW value $19.2 million. The average NPW value per intersection treatment in "Rural" areas is estimated to be $1.92 million.

4.3.2 Midblock Treatments:

All of the midblock locations for which adequate cost data were available were located in Metropolitan Melbourne and therefore no indication of the relative economic performance of black spot treatments by area type can be given in this study.

4.4 ANALYSIS BY YEAR OF TREATMENT:

Included in Appendix 8 are the results of analysing the economic worth of intersection treatments by year of treatment. Apart from the 1979/80 year which showed very high economic worth for just 3 locations, other years for which adequate cost data were available to enable analysis show BCR's ranging between 6 and 15, and NPW values per treatment ranging from $ 0.37 million to $ 2.32 million.

While the analysis by the year of treatment may be indicating a downward trend in BCR, the existence of such a trend is by no means clear, given the small sample sizes for early years and the absence of a statistically significant reduction in accidents in 1984/85. The performance of the program over time is worthy of more detailed examination, as numerous program management changes have occurred and many of the worst locations have been treated during this period.

The general absence of statistically significant reductions in casualty accident occurrence for treated midblocks means that little can be concluded from the economic analysis of midblocks by year of treatment.

5.0 SUMMARY AND CONCLUSIONS:

This study has successfully developed a computer-based method for evaluating the effectiveness of accident black spot treatments, in terms of the effects on accident occurrence and the economic worth of investing in such a program. The method has proven to be highly efficient in conducting analyses of this type, using conventional statistical analysis and economic evaluation techniques.

The results of both the accident analysis and the economic evaluation are potentially of major significance to the future direction of Vicroads' traffic engineering safety programs for Victoria.

5.1 ACCIDENT EVALUATION:

In summary, the accident evaluation of a sample of treated locations indicates that:

- the intersections component of the Accident Black Spot Program has been highly effective in reducing casualty accident occurrence, achieving highly significant reductions of 33% overall;
- for the midblocks component of the Black Spot Program, no statistically significant overall reduction in casualty accident frequencies has been found;
- the evaluation of intersections by treatment type indicates that substantial casualty accident savings can be derived from new roundabouts (81% reduction), new intersection signals (53% reduction) and remodelled intersection signals (33% reduction), with fully controlled right-turn phases seeming to contribute the bulk of the savings for remodelled signals;
- the treatment of intersections outside of the Melbourne Metropolitan area produced a highly significant 69% reduction in casualty crash frequencies, compared to a highly significant 30% reduction in the Metropolitan area.

5.2 ECONOMIC EVALUATION:

The main findings of the economic evaluation of the sample of treatments for which adequate cost data were available are:

- the intersections component of the Black Spot Program has been highly successful in economic terms, resulting in BCR values of 8.8 overall, 7.1 for intersections in Metropolitan Melbourne and 19.1 for intersections outside of the Metropolitan area.
- This corresponds to NPW values of $58.7 million overall, $39.5 million for treatments in the Metropolitan area and $19.2 million j[or treatments outside the Metropolitan area;
- various categories of intersection treatments have achieved impressive results in economic terms, resulting in BCR values of 7.5 for new roundabouts, 8.2 for new intersection signals, and 22.1 for the remodelling of existing signals. In terms of NPW assessment, the evaluation found average values per treatment of $0.72 million overall, $1.25 million for new roundabouts, $1.06 for new intersection signals and $0.85 million for remodelled intersection signals;
- the treatment of midblock locations was largely unsuccessful in reducing casualty accident frequency at treated sites.

5.3 CONSIDERATIONS FOR THE FUTURE:

The results obtained strongly suggest that the evaluation process developed as part of this project should resume in one to two years time. The purpose of this on-going project would be to evaluate sites treated since the 1985/86 year, this being the latest year for which treated sites could be included in the current analysis.

The results of the evaluation of midblock treatments indicate that some location and/or accident types are not yielding results comparable with the intersection types treated. The analysis included all locations for which adequate treatment data were contained in the records provided. It is recommended that other information sources be searched to obtain previously unavailable midblock treatment details. This would enable further treatments to be added to the sample for evaluation to better quantify the Program' s performance and to determine whether there are some midblock location or accident types that are worthy of continued attention. Better performing treatments might then become the focus of a more accurately targeted midblock program.

Given the major data collection difficulties experienced in the current study (and in the studies previously undertaken by the RTA), it is further recommended that a comprehensive and systematic method of data collection be introduced and maintained to facilitate future program evaluation.

If the techniques developed in this study are to be applied in the future to evaluate the program and its individual components, it is strongly recommended that major improvements be carried out in the following areas:

- accurate and timely recording of details of treatments, including location, treatment type(s), accident type(s) being treated, costs, start and completion dates and any other details relevant to future evaluation, and
- consistency of street naming convention (or other appropriate location reference method) to obtain location-specific accident data collected from the State Traffic Accident Record;

Finally, and importantly, despite the overall success of the Accident Black Spot Program, this study has identified a number of intersections and midblock locations which, for reasons that are not apparent at this level of evaluation, did not respond as intended to the treatments implemented. As such, they may still be experiencing bad accident records and should therefore be the subject of more detailed investigation by Vicroads to determine the need for and nature of further treatment to alleviate continuing safety problems.

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APPENDICES

Appendix 1: List of intersection and midblock locations investigated in the accident and economic analysis.

Appendix 2: Discussion of issues concerning the estimation of exposure effects.

Appendix 3: Determination of the Regression-to-the-Mean effect.

Appendix 4: Results of the Regression-to-the-Mean effect.

Appendix 5: Summary table of the accident analysis results for intersections.

Appendix 6: Summary table of the accident analysis results for intersections for which treatment costs are available.

Appendix 7: Summary table of the accident analysis results for midblock locations.

Appendix 8: Summary table of the economic analysis results for intersections.

Appendix 9: Summary table of the economic analysis results for midblock locations.

APPENDIX 1 : List of intersection and midblock locations investigated in the accident and economic analysis.

	INTERSECTION LOCATIONS		YR_C	TRT	TREAT	TOTAL	TOTAL	BCR	NPW	BEF	AFT	EXPT	C_RAT	LGA
	STREET1	STREET2		NO	COST	COST	BENEFIT							
1	BLACK ST	MC MAHON RD	8586	1	$7,300	$16,606	$624,633	37.62	$608,027	4	0.00	4.32	1.08	PRESTON
2	BORRIE ST	ST VIGEONS RD	8586	1	$9,200	$20,928	$251,508	12.02	$230,580	3	1.50	3.24	1.08	PRESTON
3	BREED ST	KAY ST	8586	1	$147,100	$334,621	$2,199,909	6.57	$1,865,288	13	3.00	12.69	0.98	TRARALGON (CITY)
4	CRANBOURNE-FRANKSTO	DANDENONG-HASTINGS	8586	1	$381,900	$868,741	$2,547,362	2.93	$1,678,621	13	3.00	20.61	1.59	CRANBOURNE
5	DAVID ST	JAMES ST	7980	1	$10,000	$37,273	$2,365,545	63.47	$2,328,273	18	4.00	20.35	1.13	DANDENONG
6	FOOT ST	TOWERHILL RD	8182	1	NA	NA	NA	NA	NA	2	1.00	2.42	1.21	FRANKSTON
7	HENNA ST	KOROIT ST	8586	1	$35,900	$81,665	$856,357	10.49	$774,692	3	0.00	3.77	1.26	WARRNAMBOOL CITY
8	MC KILLOP ST	YARRA ST	7980	1	$12,000	$44,727	$2,202,919	49.25	$2,158,192	13	2.00	11.70	0.90	GEELONG CITY
9	MONASH RD	OLD SALE RD	8586	1	$57,900	$131,710	$520,775	3.95	$389,065	4	1.50	3.79	0.95	MOE (CITY)
10	COOLART RD	FRANKSTON-FLINDERS	8586	2	$1,600	$2,567	$11,675	4.55	$9,108	1	1.50	1.58	1.58	HASTINGS
11	DANDENONG-HASTINGS	ERAMOSA RD	8586	2	$5,000	$8,023	$23,351	2.91	$15,328	2	3.00	3.16	1.58	HASTINGS
12	FLINDERS ST	SWANSTON ST	8283	2	$2,000	$3,915	($1,141,460)	-291.55	($1,145,375)	21	30.00	22.11	1.05	MELBOURNE
13	NORTH RD	PEARCEDALE RD	8586	2	$1,400	$2,246	$687,991	306.26	$685,745	3	0.00	4.76	1.59	CRANBOURNE
14	SOUTH GIPPSLAND HWY	THOMPSON RD	8586	2	$2,700	$4,332	$557,572	128.70	$553,240	10	12.00	15.85	1.59	CRANBOURNE
15	BRIGHTON RD	GLENHUNTLY RD	8586	3	$4,600	$10,464	$613,379	58.62	$602,915	6	3.00	7.24	1.21	BRIGHTON
16	BRIGHTON RD	CHAPEL ST	8283	4	NA	NA	NA	NA	NA	9	5.00	9.80	1.09	ST. KILDA
17	CARLISLE ST	CHAPEL ST	8586	4	$17,700	$40,264	$1,251,065	31.07	$1,210,802	10	1.50	10.15	1.01	ST. KILDA
18	DANDENONG RD	DARLING RD	8586	4	$54,600	$124,203	$112,493	0.91	($11,711)	10	10.50	11.28	1.13	CAULFIELD
19	FITZROY ST	QUEENS RD/ST K JUNC	8283	4	$25,000	$69,381	$692,024	9.97	$622,643	24	24.00	28.78	1.20	PRAHRAN
20	BOUNDARY RD	OLD DANDENONG RD	8283	5	NA	NA	NA	NA	NA	1	12.00	1.09	1.09	MOORABBIN
21	BOURKE RD	CLAYTON RD	8586	5	$130,700	$229,051	$3,151,411	13.76	$2,922,360	22	6.00	27.79	1.26	OAKLEIGH
22	BRADY RD	STUD RD	8384	5	$31,200	$109,320	($326,060)	-2.98	($435,379)	9	13.00	10.75	1.19	DANDENONG
23	DANDENONG RD	DENBIGH RD	8283	5	$88,900	$201,113	$1,387,829	6.90	$1,186,716	8	0.00	9.59	1.20	PRAHRAN
24	ELIZABETH ST	MURRAY RD	8283	5	NA	NA	NA	NA	NA	22	14.00	25.10	1.14	COBURG
25	GARDEN ST	MC KILLOP ST	8586	5	$53,800	$132,462	$2,626,409	19.83	$2,493,948	15	3.00	14.56	0.97	GEELONG CITY
26	HAMPSTEAD RD	WILLIAMSON RD	8586	5	NA	NA	NA	NA	NA	7	0.00	8.91	1.27	SUNSHINE
27	HEATHERTON RD	JAMES ST	8384	5	NA	NA	NA	NA	NA	12	9.00	14.33	1.19	DANDENONG
28	HUME HWY	JUKES RD	8586	5	$57,300	$136,858	$186,616	1.36	$49,758	8	7.50	8.79	1.10	BROADMEADOWS
29	HUME HWY	LYNCH RD	8586	5	$31,000	$103,824	$635,724	6.12	$531,900	4	0.00	4.40	1.10	BROADMEADOWS
30	KING ST	WILLIAMSONS RD	8283	5	NA	NA	NA	NA	NA	15	3.00	14.86	0.99	DONCASTER+TMPLST
31	MILLER ST	ST GEORGES RD	8283	5	$30,000	$110,858	$757,418	6.83	$646,560	7	2.00	7.24	1.03	NORTHCOTE
32	ANDERSON RD	HUME HWY	8586	6	$8,600	$27,024	$504,478	18.67	$477,454	10	7.50	10.99	1.10	BROADMEADOWS
33	BARKLY ST	GORDON ST	8384	6	NA	NA	NA	NA	NA	6	9.00	6.41	1.07	FOOTSCRAY
34	BAYSWATER RD	CANTERBURY RD	8283	6	$5,000	$23,884	$294,044	12.31	$270,160	14	14.00	16.03	1.15	CROYDON
35	BAYSWATER RD	MOUNTAIN HWY	8384	6	NA	NA	NA	NA	NA	21	14.00	26.22	1.25	KNOX
36	BENT ST	PLENTY RD	8283	6	$3,000	$20,819	$1,036,119	49.77	$1,015,300	11	5.00	12.16	1.11	DIAMOND VALLEY
37	BLACKBURN RD	BURWOOD HWY	8283	6	$3,400	$21,432	$2,599,782	121.30	$2,578,350	28	11.00	28.97	1.03	NUNAWADING
38	BORONIA RD	MOUNTAIN HWY	8283	6	$27,000	$57,595	$4,016,116	69.73	$3,958,520	26	4.00	31.77	1.22	KNOX
39	BORONIA RD	SCORESBY RD	8586	6	$10,900	$29,913	$2,164,914	72.37	$2,135,001	16	7.50	22.47	1.40	KNOX

NA - Not Available

APPENDIX 1 : List of intersection and midblock locations investigated in the accident and economic analysis.

	INTERSECTION LOCATIONS STREET1	STREET2	YR_C	TRT NO.	TREAT COST	TOTAL COST	TOTAL BENEFIT	BCR	NPW	BEF	AFT	EXPT	O_RAT	LGA
40	BOUNDARY RD	RACECOURSE RD	8485	6	$20,000	$43,478	$448,474	10.32	$404,997	14	13.00	16.10	1.15	MELBOURNE
41	BRIDGE RD	HODDLE ST	8283	6	$30,000	$62,192	$236,267	3.80	$174,074	12	11.00	12.63	1.05	MELBOURNE
42	BURWOOD HWY	DORSET RD	8384	6	$9,500	$29,751	$974,370	32.75	$944,619	11	7.00	13.74	1.25	KNOX
43	BURWOOD HWY	SCORESBY RD	8586	6	NA	NA	NA	NA	NA	14	13.50	19.66	1.40	KNOX
44	BURWOOD HWY	SPRINGVALE RD	8182	6	NA	NA	NA	NA	NA	43	8.00	43.41	1.01	NUNAWADING
45	BURWOOD HWY	STATION ST	8586	6	$5,100	$22,628	$18,238	0.81	($4,390)	8	10.50	10.63	1.33	BOX HILL
46	CANTERBURY RD	DORSET RD	8384	6	$15,000	$37,584	($252,250)	-6.71	($289,834)	9	13.00	11.26	1.25	CROYDON
47	CEMETERY RD	PRINCES ST	8485	6	NA	NA	NA	NA	NA	12	15.00	13.80	1.15	MELBOURNE
48	CEMETERY RD	ROYAL PDE	8485	6	$10,000	$29,850	$614,821	20.60	$584,971	15	13.00	17.25	1.15	MELBOURNE
49	CENTRE RD	EAST BOUNDARY RD	8283	6	$6,000	$25,416	$1,800,973	70.86	$1,775,557	17	6.00	18.45	1.09	MOORABBIN
50	COMMERCIAL RD	ST KILDA RD	8485	6	NA	NA	NA	NA	NA	12	18.00	13.80	1.15	MELBOURNE
51	DANDENONG RD	HOTHAM ST	8384	6	NA	NA	NA	NA	NA	16	21.00	18.65	1.17	PRAHRAN
52	DORSET RD	MT DANDENONG RD	8485	6	$2,000	$18,947	($895,135)	-47.24	($914,082)	9	19.00	12.81	1.42	CROYDON
53	DUDLEY ST	SPENCER ST	8586	6	$62,800	$95,101	($543,430)	-5.71	($638,531)	2	6.00	2.24	1.12	MELBOURNE
54	EAST BOUNDARY RD	NORTH RD	8384	6	NA	NA	NA	NA	NA	17	12.00	17.91	1.05	CAULFIELD
55	EDITHVALE RD	NEPEAN HWY	8586	6	$3,500	$20,618	$40,466	1.96	$19,848	5	6.00	6.28	1.26	CHELSEA
56	ELIZABETH ST	THERRY ST	8586	6	$11,600	$30,792	($56,776)	-1.84	($87,568)	5	6.00	5.61	1.12	MELBOURNE
57	EXHIBITION ST	VICTORIA ST	8485	6	$20,000	$43,478	($159,076)	-3.66	($202,553)	6	8.00	6.90	1.15	MELBOURNE
58	FLEMINGTON RD	GATEHOUSE ST	8283	6	$12,000	$34,610	$358,429	10.36	$323,819	28	27.00	29.48	1.05	MELBOURNE
59	FLINDERS ST	SPENCER ST	8485	6	$28,000	$54,380	$1,157,265	21.28	$1,102,885	20	15.00	23.00	1.15	MELBOURNE
60	GLEN EIRA RD	HOTHAM ST	8586	6	$33,500	$58,299	$670,329	11.50	$612,030	9	4.50	9.13	1.01	ST. KILDA
61	HEATHERTON RD	SPRINGVALE RD	8384	6	NA	NA	NA	NA	NA	11	23.00	14.00	1.27	SPRINGVALE
62	HEATHERTON RD	STUD RD	8384	6	NA	NA	NA	NA	NA	18	14.00	21.4[illegible]	1.19	DANDENONG
63	HIGH STREET RD	SPRINGVALE RD	8384	6	NA	NA	NA	NA	NA	13	8.00	14.37	1.11	WAVERLEY
64	HODDLE ST	JOHNSTON ST	8586	6	$5,600	$23,256	$2,319,509	99.74	$2,296,253	23	12.00	28.04	1.22	COLLINGWOOD
65	JACKSONS RD	POLICE RD	8384	6	NA	NA	NA	NA	NA	14	9.00	16.72	1.19	DANDENONG
66	KINGS WAY	ST KILDA RD	8485	6	NA	NA	NA	NA	NA	9	25.00	10.35	1.15	MELBOURNE
67	KINGSTON RD	WARRIGAL RD	8586	6	$95,800	$136,550	$670,795	4.91	$534,245	13	10.50	15.14	1.16	MOORABBIN
68	KOROROIT CREEK RD	MILLERS RD	8586	6	$13,900	$33,681	$1,588,708	47.17	$1,555,028	10	1.50	12.48	1.25	ALTONA
69	LAKESIDE DR	QUEENS RD	8485	6	$4,000	$21,673	$200,577	9.25	$178,904	5	4.00	5.39	1.08	ST. KILDA
70	LOWER DANDENONG RD	NEPEAN HWY	8586	6	$1,300	$17,855	($184,562)	-10.34	($202,417)	10	13.50	12.22	1.22	MORDIALLOC
71	MALVERN RD	WILLIAMS RD	8586	6	$4,800	$22,251	($805,569)	-36.20	($827,819)	7	13.50	7.93	1.13	PRAHRAN
72	MAROONDAH HWY	MIDDLEBOROUGH RD	8182	6	NA	NA	NA	NA	NA	17	10.00	16.25	0.96	BOX HILL
73	MAROONDAH HWY	SPRINGVALE RD	8586	6	$79,200	$115,700	$3,881,602	33.55	$3,765,902	33	13.50	40.34	1.22	NUNAWADING
74	MITCHAM RD	SPRINGVALE RD	8384	6	$2,000	$19,070	$1,080,011	56.63	$1,060,941	16	10.00	17.47	1.09	DONCASTER+TMPLST
75	PEEL ST	VICTORIA ST	8485	6	$25,000	$50,292	$1,439,282	28.62	$1,388,991	13	5.00	14.95	1.15	MELBOURNE
76	PUNT RD	TOORAK RD	8283	6	$25,000	$54,531	$2,086,526	38.26	$2,031,995	27	14.00	28.43	1.05	MELBOURNE
77	SPRINGVALE RD	WELLINGTON RD	8586	6	$5,000	$22,502	$1,627,248	72.32	$1,604,747	14	9.00	20.25	1.45	WAVERLEY
78	SWANSTON ST	VICTORIA ST	8485	6	$2,506	$19,637	$282,128	14.37	$262,491	13	13.00	14.95	1.15	MELBOURNE

NA - Not Available

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	INTERSECTION LOCATIONS STREET1	STREET2	YR_C	TRT NO	TREAT COST	TOTAL COST	TOTAL BENEFIT	BCR	NPW	BEF	AFT	EXPT	C_RAT	LGA
79	BAILLIE ST	URQUHART ST	8586	7	NA	NA	NA	NA	NA	3	4.50	3.89	1.30	HORSHAM (CITY)
80	HUNTINGDALE RD	WAVERLEY RD	8586	7	$10,300	$23,430	($137,088)	-5.85	($160,519)	4	6.00	5.05	1.26	OAKLEIGH
81	ARMSTRONG ST	DANA ST	8586	8	$20,000	$45,496	$4,022,543	88.42	$3,977,048	13	3.00	20.71	1.59	BALLAARAT CITY
82	BALCOMBE RD	RESERVE RD	8485	8	$2,000	$4,936	$126,373	25.60	$121,437	2	1.00	1.87	0.94	SANDRINGHAM
83	BANKSIA ST	LOWER HEIDELBERG RD	8586	8	$22,700	$51,638	$106,447	2.06	$54,810	14	15.00	15.74	1.12	HEIDELBERG
84	BARWON HEADS RD	BREAKWATER RD	8485	8	$23,000	$56,767	$3,694,243	65.08	$3,637,475	14	1.00	17.27	1.23	SOUTH BARWON
85	BAXTER-TOORADIN RD	FRANKSTON-FLINDERS	8283	8	$15,000	$41,628	$663,803	15.95	$622,175	11	6.00	10.59	0.96	HASTINGS
86	BELGRAVE RD	DANDENONG RD	8586	8	$1,400	$3,185	($142,395)	-44.71	($145,580)	11	15.00	14.02	1.27	MALVERN
87	BLACKSHAWS RD	MILLERS RD	8485	8	$1,312	$3,238	$288,763	89.17	$285,524	8	9.00	11.00	1.37	ALTONA
88	BLYTH ST	LYGON ST	8485	8	$10,000	$24,681	($81,231)	-3.29	($105,912)	8	8.00	7.44	0.93	BRUNSWICK
89	BURWOOD HWY	ELGAR RD	8586	8	$14,300	$32,529	($967,230)	-29.73	($999,760)	4	12.00	5.31	1.33	BOX HILL
90	CENTRAL AVE	SHEPPARTON-DOOKIE RD	8586	8	$69,200	$157,415	($1,594,897)	-10.13	($1,752,312)	2	10.50	3.48	1.74	SHEPPARTON
91	CHARLES ST	HIGH ST	8485	8	$4,000	$9,873	$209,341	21.20	$199,469	4	3.00	4.45	1.11	KEW
92	CLARENDON ST	COVENTRY ST	8586	8	NA	NA	NA	NA	NA	4	7.50	5.18	1.30	SOUTH MELBOURNE
93	COOLART RD	ERAMOSA RD	8283	8	$59,800	$165,959	($744,828)	-4.49	($910,787)	4	9.00	3.85	0.96	HASTINGS
94	CORRIGAN RD	HEATHERTON RD	8485	8	$23,875	$58,927	$514,774	8.74	$455,847	8	8.00	11.56	1.44	SPRINGVALE
95	DANDENONG RD	NORTH RD	8586	8	$700,000	$1,592,351	$1,004,684	0.63	($587,667)	15	12.00	18.95	1.26	OAKLEIGH
96	DANDENONG RD	ORRONG RD	8485	8	$6,000	$14,809	($268,625)	-18.14	($283,434)	14	18.00	16.14	1.15	PRAHRAN
97	DECARLE ST	MORELAND RD	8283	8	$10,000	$27,752	($412,092)	-14.85	($439,844)	2	5.00	2.15	1.08	BRUNSWICK
98	DROOP ST	GEELONG RD	8485	8	$130,000	$320,859	$1,486,751	4.63	$1,165,892	17	8.00	18.28	1.08	FOOTSCRAY
99	ELLIOTT AVE	FLEMINGTON RD	8485	8	$10,000	$24,681	($527,902)	-21.39	($552,584)	9	14.00	10.35	1.15	MELBOURNE
100	EXCELSIOR DR	FRANKSTON-DANDENONG	8283	8	$17,600	$48,844	$901,451	18.46	$852,607	9	5.00	11.23	1.25	FRANKSTON
101	GEELONG RD	GEELONG ST	8586	8	$232,900	$529,798	($618,939)	-1.17	($1,148,737)	7	12.00	7.72	1.10	FOOTSCRAY
102	SCHOOL RD	WARBURTON HWY	8485	8	$10,000	$24,681	($144,644)	-5.86	($169,326)	0	1.00	0.00	1.20	LILLYDALE
103	DAWSON ST	SYDNEY RD	8586	9	NA	NA	NA	NA	NA	10	7.50	9.25	0.92	BRUNSWICK
104	GAFFNEY ST	SYDNEY RD	8586	9	NA	NA	NA	NA	NA	10	21.00	11.76	1.18	COBURG
105	CANTERBURY RD	WANTIRNA RD	8384	10	NA	NA	NA	NA	NA	10	10.00	12.92	1.29	RINGWOOD
106	FOSTER ST	LONSDALE ST	8586	10	NA	NA	NA	NA	NA	13	6.00	17.12	1.32	DANDENONG
107	BRUNTON AVE	JOLIMONT ST	8586	10	$2,300	$5,232	$1,026,028	196.11	$1,020,796	9	3.00	10.09	1.12	MELBOURNE
108	CHAPEL ST	COMMERCIAL RD	8586	10	NA	NA	NA	NA	NA	13	9.00	14.73	1.13	PRAHRAN
109	CLEELAND ST	CLOW ST	8586	10	NA	NA	NA	NA	NA	6	15.00	7.90	1.32	DANDENONG
110	CRAMER ST	HIGH ST	8586	10	NA	NA	NA	NA	NA	8	3.00	8.64	1.08	PRESTON
111	FENNELL ST	INGLES ST	8586	10	NA	NA	NA	NA	NA	3	4.50	2.74	0.91	PORT MELBOURNE
112	HIGH ST	MITCHELL ST	8586	10	$22,400	$50,955	$3,286,344	64.49	$3,235,389	15	7.50	21.97	1.46	BENDIGO (CITY)
113	LACEY ST	WINDSOR RD	8586	10	NA	NA	NA	NA	NA	2	0.00	2.89	1.44	CROYDON
114	MIDLAND HWY	PRINCES HWY	8586	10	NA	NA	NA	NA	NA	9	4.50	10.58	1.18	MORWELL
115	ANGLESEA RD	PRINCES HWY	7980	11	$8,000	$29,818	$2,499,524	83.83	$2,469,706	15	3.00	14.01	0.93	BARRABOOL
116	SOUTH GIPPSLAND HWY	THOMPSON RD	8384	11	NA	NA	NA	NA	NA	7	11.00	9.30	1.33	CRANBOURNE

NA - Not Available

APPENDIX 1 : List of intersection and midblock locations investigated in the accident and economic analysis.

	MIDBLOCK LOACTIONS	YR_C	TRT NO	TREAT COST	TOTAL COST	TOTAL BENEFIT	BCR	NPW	BEF	AFT	EXPT	C_RAT	LGA
1	ALEXANDRA AVE B/W WILLIAMS RD & RIVER ST	8586	2	$21,500	$34,499	$496,230	14.38	$461,731	7	4.50	7.93	1.13	PRAHRAN
2	BALLARAT RD B/W HOBSONS RD & MOORE ST	8384	2	$5,000	$9,097	($711,613)	-78.23	($720,710)	16	22.00	17.08	1.07	FOOTSCRAY
3	BRUNTON AV B/W PUNT RD & JOLLIMONT ST	8283	2	$25,000	$48,940	$243,902	4.98	$194,962	13	12.00	13.69	1.05	MELBOURNE
4	BURWOOD HWY B/W ACACIA RD & FOREST RD	8384	2	NA	NA	NA	NA	NA	5	2.00	6.24	1.25	KNOX
5	BURWOOD HWY B/W ACACIA RD & FOREST RD	8586	2	$20,900	$33,536	($3,273,105)	-97.60	($3,306,641)	17	46.50	23.87	1.40	KNOX
6	DANDENONG RD B/W DRUMMOND ST & ATKINSON ST	8384	2	NA	NA	NA	NA	NA	6	6.00	6.90	1.15	OAKLEIGH
7	DORSET RD B/W BORONIA RD & BURWOOD HWY	8586	2	$4,300	$6,900	$73,642	10.67	$66,742	26	36.00	36.51	1.40	KNOX
8	FLEMINGTON RD B/W DRYBURGH ST & MELROSE ST	8586	2	NA	NA	NA	NA	NA	6	3.00	6.73	1.12	MELBOURNE
9	HAWTHORN RD B/W MAHONEYS RD & SPRINGVALE RD	8586	2	$3,800	$6,097	$353,594	57.99	$347,496	2	0.00	2.44	1.22	NUNAWADING
10	HUME HWY B/W CAMP RD & BARRY RD	8586	2	$100	$160	($1,349,991)	-8,413.29	($1,350,151)	27	39.00	29.67	1.10	BROADMEADOWS
11	MCNAUGHTON RD B/W CENTRE RD & DANDENONG RD	8384	2	$5,000	$9,097	$606,824	66.71	$597,727	8	5.00	9.20	1.15	OAKLEIGH
12	PLENTY RD B/W TAUNTON DR & BETULA AV	8283	2	$800	$1,566	$1,310,112	836.56	$1,308,546	10	2.00	11.06	1.11	DIAMOND VALLEY
13	STUD RD B/W ESSEX ST & ROWVILLE RES	8384	2	NA	NA	NA	NA	NA	1	1.00	1.25	1.25	KNOX
14	ALEXANDRA AV B/W CHAPEL ST & RIVER ST	8586	3	NA	NA	NA	NA	NA	4	3.00	4.53	1.13	PRAHRAN
15	BEACH RD B/W BAY RD & SIMS ST	8586	3	$1,500	$3,412	$0	0.00	($3,412)	0	0.00	0.00	1.10	SANDRINGHAM
16	BLUFF RD B/W HIGHETT RD & LINACRE RD	8586	3	$1,500	$3,412	$288,317	84.50	$284,905	3	1.50	3.49	1.16	MOORABBIN
17	BLUFF RD B/W HIGHETT RD & LINACRE RD	8485	3	$1,000	$2,468	$337,960	136.93	$335,492	2	0.00	2.34	1.17	NUNAWADING
18	MAHONEYS RD B/W ONSLOW AVE & PHILLIP ST	8586	3	$1,500	$3,412	($623,215)	-182.64	($626,627)	7	12.00	7.69	1.10	BROADMEADOW
19	PRINCES FWY B/W KOROROIT CK RD& WGATE FWY	8586	3	NA	NA	NA	NA	NA	6	9.00	7.49	1.25	ALTONA
20	SUNBURY RD B/W BULLA-DIGGERS RD & QUARTZ RD	8384	3	NA	NA	NA	NA	NA	6	7.00	9.67	1.61	BULLA
21	CLARENDON ST B/W DORCAS ST & COVENTRY ST	8586	4	NA	NA	NA	NA	NA	3	4.50	3.89	1.30	STH MELB
22	KEILOR RD B/W MATHEWS AVE & HOFFMANS RD	8586	4	NA	NA	NA	NA	NA	6	7.50	7.52	1.25	KEILOR
23	MAROONDAH HWY B/W ELGAR RD & STATION ST	8586	4	NA	NA	NA	NA	NA	21	28.50	27.89	1.33	BOX HILL
24	PRINCES HWY B/W CHURCH ST & HOYLE ST	8586	4	NA	NA	NA	NA	NA	4	3.00	4.70	1.18	MORWELL
25	WARRIGAL RD B/W BATESFORD RD & THE BLVD	8586	7	$2,300	$5,232	($163,346)	-31.22	($168,578)	5	7.50	6.37	1.27	MALVERN
26	BEACH RD B/W BAY RD & SIMS ST	8485	8	$3,500	$8,639	$0	0.00	($8,639)	0	0.00	0.00	0.94	SANDRINGHAM
27	BLUFF RD B/W HIGHETT RD & LINACRE RD	8485	8	$3,500	$8,639	$357,135	41.34	$348,496	3	1.00	3.47	1.16	MOORABBIN
28	CHURCH ST B/W BROUGHAM ST & GIPPS ST	8485	8	$20,000	$49,363	$179,710	3.64	$130,347	4	3.00	4.24	1.06	RICHMOND
29	CHURCHILL AV B/W VINE ST & HARGRAVE ST	8485	8	$72,900	$179,928	$79,841	0.44	($100,087)	2	2.00	2.55	1.28	SUNSHINE
30	CLARENDON ST BETWEEN NORMANBY RD & WHITEMAN ST	7980	8	$15,000	$55,909	$470,293	8.41	$414,384	8	4.00	7.25	0.91	STH MELB
31	COLLINS ST B/W ELIZABETH ST & SWANSTON ST	8485	8	$10,000	$24,681	($426,662)	-17.29	($451,344)	7	11.00	8.05	1.15	MELBOURNE
32	DYNON RD B/W RADCLIFFE ST & DRYBURGH ST	8485	8	$1,800	$4,443	$332,693	74.89	$328,250	2	0.00	2.30	1.15	MELBOURNE
33	ELIZABETH B/W FLEMINGTON RD & QUEENSBERRY ST	8485	8	$20,000	$49,363	($202,480)	-4.10	($251,843)	4	6.00	4.60	1.15	MELBOURNE
34	FLEMINGTON RD B/W GATEHOUSE ST & ABBOTSFORD ST	8485	8	$8,000	$19,745	($1,598,248)	-80.94	($1,617,993)	13	26.00	14.95	1.15	MELBOURNE
35	FLINDERS ST B/W ELIZABETH ST & SWANSTON ST	8485	8	$10,000	$24,681	$130,213	5.28	$105,531	6	6.00	6.90	1.15	MELBOURNE
36	MALVERN RD B/W HIGH ST & DORRINGTON AV	8485	8	$10,000	$24,681	($9,643)	-0.39	($34,324)	6	7.00	6.93	1.16	MALVERN
37	MONBULK RD B/W GLEN HARROW HT RD & KALLISTA-EMERALD RD	8283	8	$6,000	$16,651	$433,046	26.01	$416,394	6	4.00	6.99	1.17	SHERBROOKE
38	MT DANDENONG T'R B/W BROWNS RD & INVERNESS RD	8485	8	$30,800	$76,019	$958,660	12.61	$882,641	8	3.00	9.63	1.20	LILLYDALE
39	NEPEAN HWY B/W EELRACE RD & SEAFORD RD	8485	8	$20,000	$49,363	($596,455)	-12.08	($645,818)	27	38.00	33.88	1.25	FRANKSTON

NA - Not Available

APPENDIX 1 : List of intersection and midblock locations investigated in the accident and economic analysis.

	MIDBLOCK LOACTIONS	YR_C	TRT NO	TREAT COST	TOTAL COST	TOTAL BENEFIT	BCR	NPW	BEF	AFT	EXPT	C_RAT	LGA
40	PLENTY RD B/W CLUNES ST & CURTAIN ST	8485	8	$7,000	$17,277	$583,137	33.75	$565,860	20	18.00	22.03	1.10	PRESTON
41	PUNT RD B/W BLANCHE ST & ROUT ST	8485	8	$2,000	$4,936	$17,533	3.55	$12,596	2	2.00	2.12	1.06	RICHMOND
42	QUEENS PDE B/W HODDLE ST & RUSHALL CR	8485	8	$10,000	$24,681	$84,157	3.41	$59,475	4	4.00	4.58	1.15	FITZROY
43	STATION ST B/W DUMBFRIES ST & BILLINGHAM RD	8485	8	$9,000	$22,213	($394,013)	-17.74	($416,226)	1	4.00	1.28	1.28	SUNSHINE
44	SYDNEY RD B/W BELL ST & PAGE ST	8485	8	$20,000	$49,363	$153,549	3.11	$104,186	7	7.00	8.06	1.15	COBURG
45	SYDNEY RD B/W BLYTH RD & VICTORIA RD	8485	8	$10,000	$24,681	$383,164	15.52	$358,482	5	2.00	4.65	0.93	BRUNSWICK
46	SYDNEY RD B/W VICTORIA ST & DAWSON ST	8485	8	$10,000	$24,681	$96,366	3.90	$71,684	19	17.00	17.67	0.93	BRUNSWICK
47	WELLS RD B/W BOWEN RD & EDITHVALE RD	8283	8	$9,900	$27,475	$1,396,609	50.83	$1,369,134	11	3.00	12.66	1.15	SPRINGVALE
48	HEATHERTON RD B/W KELVINSIDE RD & IAN ST	8586	10	NA	NA	NA	NA	NA	2	3.00	2.88	1.44	SPRINGVALE
49	NORMANBY AVE B/W LEINSTER GV & ST GEORGES RD	8586	10	$1,000	$2,275	($57,798)	-25.41	($60,073)	7	7.50	7.10	1.01	NORTHCOTE
50	BATMAN AVE B/W SWANSTON ST & SWAN ST	8586	12	NA	NA	NA	NA	NA	4	16.50	4.49	1.12	MELBOURNE
51	FERNTREE GULLY B/W CATHIES LA & ELMSTEAD DR	8586	12	NA	NA	NA	NA	NA	8	21.00	11.23	1.40	KNOX
52	NEPEAN HWY B/W MAIN ST & PARANA ST	8586	12	NA	NA	NA	NA	NA	5	6.00	6.28	1.26	CHELSEA
53	NEPEAN HWY B/W SEAFORD RD & OVERTON RD	8586	12	NA	NA	NA	NA	NA	16	16.50	19.29	1.21	FRANKSTON
54	ST ALBANS RD B/W GILMOUR RD & BALLARAT RD	8586	12	$65,500	$148,999	$355,670	2.39	$206,671	9	9.00	11.46	1.27	SUNSHINE
55	STH EASTERN FWY B/W YARRA BV & TOORAK RD	8586	12	NA	NA	NA	NA	NA	10	7.50	9.75	0.98	RICHMOND
56	TOORAK RD B/W MELTON AV & WARRIGAL RD	8586	12	$3,200	$7,279	$229,343	31.51	$222,064	5	4.50	6.09	1.22	CAMBERWELL
57	TULLAMARINE FWY B/W BELL ST & MORELAND RD	8586	12	NA	NA	NA	NA	NA	12	0.00	14.11	1.18	COBURG
58	TULLAMARINE FWY B/W MORELAND RD & BRUNSWICK RD	8586	12	NA	NA	NA	NA	NA	37	36.00	34.22	0.92	BRUNSWICK
59	WARRIGAL RD B/W BATESFORD RD & THE BLVD	8586	12	NA	NA	NA	NA	NA	5	7.50	6.37	1.27	MALVERN

Abbrevations used in Appendix 1

YR_C..................: Financial Year of Treatment
TRT NO................: Treatment Type
1. New Roundabouts
2. Delineation Treatments
3. Roadside Safety Treatments
4. Pedestrian Treatments
5. New Intersection Signals
6. Signals Remodelling Works
8. Roadworks
9. Fairway Works
10. Interim Project Description
11. Flashing Red Signals
12. All Accidents Treatments

TOTAL COST.........: Total cost of the Treatment in 1989 dollars (includes maintainence cost)
TOTAL BENEFIT.....: Total accident savings in 1989 dollars
BCR......................: Benefit Cost Ratio
NPW.....................: Net Present Worth
BEF......................: Number of Casualty Accidents in 3 years period before the location was treated
AFT......................: Number of Casualty Accidents in 3 years period after the location was treated
EXPT....................: Expected number of Casualty Accidents in 3 years period if location was not treated
C_RAT..................: Ratio of Casualty Accidents after to before in the control area
(In this study Local Government Area has been used as the control area)
LGA......................: Local Government Area

NA - Not Available

Appendix 2: Discussion of Issues Concerning the Estimation of Exposure Effects

A change in the true mean casualty accident frequency may occur as a result of there being an increase in exposure rather than any site modifications. Where such an increase is localized, such as at a number of individual sites, in the proximity of re-routed traffic, it will not be accounted for through the use of control groups. As site modifications are also themselves conducive to changing exposure, measurements of volumes are required over tile period of study to determine the extent of such changes.

Exposure itself is a difficult variable to assess. Whilst being a function of traffic flows, the particular flows and their functional form are dependant on the accident type under study. Overall exposure measures aggregated across accident class are available, but these are subject to the assumption that there is a homogeneous and uniform distribution of accident classes across the group of sites under study. This is not necessarily valid, particularly where the treatment is of a specific type, or to address a particular accident type.

A further problem lies in the manner in which exposure relates to crash occurrence. If the measure of effectiveness is simply adjusted from change in casualty accident frequency to change in casualty accident rate (i.e. frequency per unit of exposure), a linear relationship between crashes and exposure is implied. Such an assumption is not tenable in many instances. An example is that high exposure, when coupled with low speeds (such as in peak hour traffic) is unlikely to produce a correspondingly proportional increase in crashes. Teale (1984) lists further difficulties and implies that greater accuracy in the way exposure relates to crash occurrence needs to be established before it is incorporated in countermeasure effectiveness studies.

Aside from these theoretical difficulties are the physical problems of obtaining traffic volume data for all sites over the period of study. For the greatest exposure measure accuracy, such volume data need to be supplied for each approach and turning movement.

As there were difficulties in obtaining traffic volume data for many of the sites, particularly prior to 1987, it was decided not to attempt to allow for changes in exposure at the specific site. The effects on accidents of overall changes in exposure between the before and after periods are included by using the control ratio for the municipality in which the site is located.

Appendix 3: Determination of the Regression-the-the-Mean Effect:

Regression-to-the-Mean effects should be taken into account for each and every experimental site. The following Bayesian-based method for estimating the RTM effect is taken from Jarrett et. al (1982).

Assume accidents at a site i follow a Poisson distribution, so that over a given time t:

$$p(x\backslash m) = (e^{-m}.m^{x})/x! \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where m= True mean accident rate for site i, and
x= Number of accidents at site i.

Assume also that m varies from site to site, according to a Gamma distribution with probability density function:

$$f(m) = (ck/T[k]).m^{k-1}.e^{-cm}\ldots\ldots\ldots\ldots(2)$$

where c and k are shape parameters. (T="Torr")

Under these assumptions, it can be shown that the variability of x over all sites (in the control group) is given by the negative binomial distribution:

$$q(x) = (T[k+x]/x!T[k]).(1/[1+c])^{x}.(c/[1+c])^{k} \quad (3)$$

Now, for a given control group of sites in the before period of a set of experimental sites to which it "belongs", we can generate a plot of relative frequencies versus numbers of accidents and fit this equation to it, varying c and k to maximize the goodness of fit. The preferred method for doing this is the Method of Maximum Likelihood.

The two parameters c and k are then used to derive parameters S_O and N_O for inclusion in the following formula to estimate the magnitude of the effect, R. (Nguyen,1986 and Abbess et. al, 1981 describe the procedure in greater detail).

$$R\% = \left\{ \frac{(S_O + S) * N}{(N_O + N) * S} - 1 \right\} * 100$$

Appendix 4 : Results of Regression-to-the-Mean effects.

OBS	STREET1	STREET2	BEFORE	S_O	N_O	R %
1	BURWOOD HWY	SPRINGVALE RD	43	4.83513	1.00565	-16.684
2	MAROONDAH HWY	MIDDLEBOROUGH RD	17	4.83513	1.00565	-3.804
3	BAYSWATER RD	CANTERBURY RD	14	4.83641	0.99789	0.963
4	BENT ST	PLENTY RD	11	4.83641	0.99789	8.033
5	BLACKBURN RD	BURWOOD HWY	28	4.83641	0.99789	-11.999
6	BORONIA RD	MOUNTAIN HWY	26	4.83641	0.99789	-11.002
7	BRIDGE RD	HODDLE ST	12	4.83641	0.99789	5.283
8	CENTRE RD	EAST BOUNDARY RD	17	4.83641	0.99789	-3.612
9	ELIZABETH ST	MURRAY RD	22	4.83641	0.99789	-8.464
10	FLEMINGTON RD	GATEHOUSE ST	28	4.83641	0.99789	-11.999
11	FLINDERS ST	SWANSTON ST	21	4.83641	0.99789	-7.678
12	PUNT RD	TOORAK RD	27	4.83641	0.99789	-11.519
13	BARKLY ST	GORDON ST	6	5.32772	1.17865	35.543
14	BAYSWATER RD	MOUNTAIN HWY	21	5.32772	1.17865	-9.992
15	CANTERBURY RD	DORSET RD	9	5.32772	1.17865	14.293
16	CANTERBURY RD	WANTIRNA RD	10	5.32772	1.17865	10.043
17	DANDENONG RD	HOTHAM ST	16	5.32772	1.17865	-4.300
18	EAST BOUNDARY RD	NORTH RD	17	5.32772	1.17865	-5.707
19	HEATHERTON RD	SPRINGVALE RD	11	5.32772	1.17865	6.566
20	HEATHERTON RD	STUD RD	18	5.32772	1.17865	-6.957
21	HIGH STREET RD	SPRINGVALE RD	13	5.32772	1.17865	1.216
22	JACKSONS RD	POLICE RD	14	5.32772	1.17865	-0.885
23	MITCHAM RD	SPRINGVALE RD	16	5.32772	1.17865	-4.300
24	BALCOMBE RD	RESERVE RD	2	6.18842	1.51736	171.898
25	BLACKSHAWS RD	MILLERS RD	8	6.18842	1.51736	17.782
26	BOUNDARY RD	RACECOURSE RD	14	6.18842	1.51736	-4.234
27	CEMETERY RD	PRINCES ST	12	6.18842	1.51736	0.658
28	CEMETERY RD	ROYAL PDE	15	6.18842	1.51736	-6.191
29	COMMERCIAL RD	ST KILDA RD	12	6.18842	1.51736	0.658
30	CORRIGAN RD	HEATHERTON RD	8	6.18842	1.51736	17.782
31	DANDENONG RD	ORRONG RD	14	6.18842	1.51736	-4.234
32	DORSET RD	MT DANDENONG RD	9	6.18842	1.51736	12.074
33	DROOP ST	GEELONG RD	17	6.18842	1.51736	-9.414
34	ELLIOTT AVE	FLEMINGTON RD	9	6.18842	1.51736	12.074
35	EXHIBITION ST	VICTORIA ST	6	6.18842	1.51736	34.906
36	FLINDERS ST	SPENCER ST	20	6.18842	1.51736	-13.041
37	LAKESIDE DR	QUEENS RD	5	6.18842	1.51736	48.606
38	PEEL ST	VICTORIA ST	13	6.18842	1.51736	-1.976
39	SWANSTON ST	VICTORIA ST	13	6.18842	1.51736	-1.976
40	ANDERSON RD	HUME HWY	10	7.66396	1.96946	6.635
41	BANKSIA ST	LOWER HEIDELBERG RD	14	7.66396	1.96946	-6.584
42	BELGRAVE RD	DANDENONG RD	11	7.66396	1.96946	2.429
43	BORONIA RD	SCORESBY RD	16	7.66396	1.96946	-10.715
44	BOURKE RD	CLAYTON RD	22	7.66396	1.96946	-18.601
45	BRIGHTON RD	GLENHUNTLY RD	6	7.66396	1.96946	37.479
46	BURWOOD HWY	ELGAR RD	4	7.66396	1.96946	76.035
47	BURWOOD HWY	SCORESBY RD	14	7.66396	1.96946	-6.584
48	BURWOOD HWY	STATION ST	8	7.66396	1.96946	18.202
49	CHAPEL ST	COMMERCIAL RD	13	7.66396	1.96946	-4.042

50	CLEELAND ST	CLOW ST	6	7.66396	1.96946	37.479
51	DANDENONG RD	DARLING RD	10	7.66396	1.96946	6.635
52	DANDENONG RD	NORTH RD	15	7.66396	1.96946	-8.787
53	DUDLEY ST	SPENCER ST	2	7.66396	1.96946	191.700
54	FOSTER ST	LONSDALE ST	13	7.66396	1.96946	-4.042
55	GEELONG RD	GEELONG ST	7	7.66396	1.96946	26.464
56	GLEN EIRA RD	HOTHAM ST	9	7.66396	1.96946	11.776
57	HODDLE ST	JOHNSTON ST	23	7.66396	1.96946	-19.515
58	KINGSTON RD	WARRIGAL RD	13	7.66396	1.96946	-4.042
59	KORORORIT CREEK RD	MILLERS RD	10	7.66396	1.96946	6.635
60	MALVERN RD	WILLIAMS RD	7	7.66396	1.96946	26.464
61	MAROONDAH HWY	SPRINGVALE RD	33	7.66396	1.96946	-25.611
62	SPRINGVALE RD	WELLINGTON RD	14	7.66396	1.96946	-6.584

Average R for signalised, 4-leg intersections in metro area is 9.2 %

Note :

S_0 and N_0 are the two parameters from the Gamma-prior-distribution function and
BEFORE is the number of casualty accidents in 3 years before the location was treated.
R% is the correction factor due to Regression-to-the-Mean effect.
The signs + or - assigned to **R%** indicate whether the bias is due to an **under (+ sign)** or **over (- sign) estimation** of the apparent effect of the treatment under investigation.

APPENDIX 5 : Summary table of the accident analysis results for intersections.

ACCIDENT BLACKSPOT EVALUATION FOR INTERSECTIONS	No. of Sites	No. of Accidents Before Treatment	No. of Accidents After Treatment	Expected No. of Accidents if Not Treated	Percentage Accident Reduction	Level of Statistical Significance for Accident Reduction	Comments
OVERALL PROGRAM	116	1298	1007	1513	33.48%	< 0.0001	Highly significant
TREATMENT TYPE							
1. New Roundabouts	9	73	16	82	80.56%	0.000177	Highly significant
2. Delineation Treatments	5	37	46	47	0.00%	-	No reduction
3. Roadside Safety Treatments	1	6	3	7	58.57%	0.1981	Not significant
4. Pedestrian Treatments	4	53	41	60	32.40%	0.078212	Marginally significant
5. New Intersection Signals	12	130	69	147	52.78%	0.022842	Significant
6. Signals Remodelling Works	47	682	533	788	32.56%	< 0.0001	Highly significant
a) installation of right-turn phase	30	518	335	597	43.99%	< 0.0001	Highly significant
b) other signals remodelling works	17	164	198	191	0.00%	-	No reduction
7. Signal Linking	2	7	10	8	0.00%	-	No reduction
8. Roadworks	22	180	183	217	15.18%	0.1599	Not significant
9. Fairway Works	2	20	28	21	0.00%	-	No reduction
10.Interim Project Description	10	88	62	109	42.63%	0.00423	Highly significant
11.Flashing Red Signals	2	22	14	23	43.50%	0.17238	Not significant
METRO AREAS	104	1179	964	1375	29.85%	< 0.0001	Highly significant
RURAL AREAS	12	119	43	138	69.40%	0.000722	Highly significant
YEAR OF COMPLETION							
1979-1980	3	46	9	46	80.50%	0.023201	Significant
1980-1981	0						No observation
1981-1982	3	62	19	62	69.37%	0.022916	Significant
1982-1983	20	296	207	324	35.86%	0.012577	Highly significant
1983-1984	15	190	183	225	19.11%	0.03	Significant
1984-1985	21	212	219	247	11.70%	0.105863	Not significant
1985-1986	54	492	370	608	38.86%	< 0.0001	Highly significant

APPENDIX 6 : Summary table of the accident analysis results for intersections with adequate treatment cost data available.

ACCIDENT BLACKSPOT EVALUATION FOR INTERSECTIONS	No. of Sites	No. of Accidents Before Treatment	No. of Accidents After Treatment	Expected No. of Accidents if Not Treated	Percentage Accident Reduction	Level of Statistical Signficance for Accident Reduction	Comments
OVERALL PROGRAM	82	909	660	1067	38.04%	< 0.0001	Highly significant
TREATMENT TYPE							
1. New Roundabouts	8	71	15	80	81.29%	0.000307	Highly Significant
2. Delineation Treatments	5	37	46	47	0.00%	-	No reduction
3. Roadside Safety Treatments	1	6	3	7	58.57%	0.1981	Not significant
4. Pedestrian Treatments	3	44	36	50	29.10%	0.1329	Not significant
5. New Intersection Signals	7	73	31	83	62.18%	0.02848	Significant
6. Signals Remodelling Works	33	459	333	535	37.69%	< 0.0001	Highly significant
7. Signal Linking	1	4	6	5	0.00%	-	No reduction
8. Roadworks	21	176	175	212	16.60%	0.1448	Not significant
9. Fairway Works	0	-	-	-	-	-	No observation
10.Interim Project Description	2	24	10	32	67.50%	0.10148	Not significant
11.Flashing Red Signals	1	15	3	14	78.58%	0.00726	Highly significant
METRO AREAS	72	802	626	943	33.39%	< 0.0001	Highly significant
RURAL AREAS	10	107	34	123	72.95%	< 0.0001	Highly significant
YEAR OF COMPLETION							
1979-1980	3	46	9	46	80.48%	0.023201	Significant
1980-1981	0	-	-	-	-	-	No observation
1981-1982	0	-	-	-	-	-	No observation
1982-1983	16	249	173	273	36.30%	0.01511	Highly significant
1983-1984	4	45	43	53	19.60%	0.19089	Not significant
1984-1985	18	179	161	209	23.48%	0.01243	Highly significant
1985-1986	41	390	274	484	43.25%	< 0.0001	Highly significant

APPENDIX 7 : Summary table of the accident analysis results for midblock locations.

ACCIDENT BLACKSPOT EVALUATION FOR MIDBLOCKS	No. of Sites	No. of Accidents Before Treatment	No. of Accidents After Treatment	Expected No. of Accidents if Not Treated	Percentage Accident Reduction	Level of Statistical Significance for Accident Reduction	Comments
OVERALL PROGRAM	59	496	565	576	2.41%	0.3469	Not significant
TREATMENT TYPE							
1. New Roundabouts	not applicable	-	-	-	-	-	Not applicable
2. Delineation Treatments	13	144	179	172	0.00%	-	No reduction
3. Roadside Safety Treatments	7	28	32	35	6.50%	0.4018	Not significant
4. Pedestrian Treatments	4	34	43	43	1.40%	0.4774	Not significant
5. New Intersection Signals	not applicable	-	-	-	-	-	Not applicable
6. Signals Remodelling Works	not applicable	-	-	-	-	-	Not applicable
7. Signal Linking	1	5	7	6	0.00%	-	No reduction
8. Roadworks	22	165	168	184	9.60%	0.1841	Not significant
9. Fairway Works	0	-	-	-	-	-	No observation
10.Interim Project Description	2	9	10	9	0.00%	-	No reduction
11.Flashing Red Signals	not applicable	-	-	-	-	-	Not applicable
12. All Accidents Treatments	10	111	124	123	0.00%	-	No reduction
METRO AREAS	58	492	562	571	2.13%	0.3645	Not significant
RURAL AREAS	1	4	3	4	36.22%	0.5526	Not significant
YEAR OF COMPLETION							
1979-1980	1	8	4	7	55.16%	0.3242	Not significant
1980-1981	0	-	-	-	-	-	
1981-1982	0	-	-	-	-	-	No observation
1982-1983	4	40	21	44	52.45%	0.0351	Highly significant
1983-1984	6	42	43	50	13.40%	0.2687	Not significant
1984-1985	20	142	157	160	2.40%	0.4181	Not significant
1985-1986	28	264	340	314	0.00%	-	No Reduction

APPENDIX 8 : Summary table of the economic analysis results for intersections.

ECONOMIC ANALYSIS FOR INTERSECTIONS	NO. OF SITES	COST	BENEFIT	BENEFIT COST RATIO	NET PRESENT WORTH
OVERALL PROGRAM	82	$7,499,420	$66,202,316	8.83	$58,702,896
TREATMENT TYPE					
1. New Roundabouts	8	$1,536,271	$11,569,010	7.53	$10,032,739
2. Delineation Treatments	5	$21,084	$139,129	6.60*	$118,045
3. Roadside Safety Treatments	1	$10,464	$613,379	58.62*	$602,915
4. Pedestrian Treatments	3	$233,848	$2,055,582	8.79	$1,821,734
5. New intersection signals	7	$1,023,485	$8,419,347	8.23	$7,395,862
6. Signal Remodelling Works	33	$1,324,783	$29,214,671	22.05	$27,889,888
7. Signal Linking	2	$23,430	($137,088)	-5.85	($160,518)
8. Roadworks	20	$3,240,049	$7,516,390	2.32*	$4,276,341
9. Fairway Works	0				
10. Interim Project Description	2	$56,187	$4,312,372	76.75	$4,256,185
11. Flashing Red Signals	1	$29,818	$2,499,524	83.83*	$2,469,706
METRO AREAS	72	$6,433,783	$45,888,189	7.13	$39,454,406
RURAL AREAS	10	$1,065,637	$20,314,127	19.06	$19,248,490
YEAR OF COMPLETION					
1979-1980	3	$111,818	$7,067,989	63.21	$6,956,171
1980-1981	0				
1981-1982	0				
1982-1983	16	$969,929	$14,532,400	14.98	$13,562,471
1983-1984	4	$195,724	$1,476,071	7.54	$1,476,071
1984-1985	18	$825,187	$8,386,180	10.16*	$7,560,993
1985-1986	41	$5,396,761	$34,739,677	6.44	$29,342,916

* Note : The Benefit Cost Ratio and Net Present Worth for these treatments are indicative and should be treated with caution, because the apparent reductions on which they are based are not statistically significant.

APPENDIX 9 : Summary table of the economic analysis results for midblock locations.

ECONOMIC ANALYSIS FOR MIDBLOCKS	NO. OF SITES	COST	BENEFIT	BENEFIT COST RATIO	NET PRESENT WORTH
OVERALL PROGRAM	38	$1,113,634	$1,895,118	1.70*	$781,484
TREATMENT TYPE					
1. New Roundabouts	Not applicable				
2. Delineation Treatments	8	$149,731	$900,415	6.01*	$1,050,146
3. Roadside Safety Treatments	4	$12,705	$3,062	0.24*	$9,642
4. Pedestrian Treatments	0				
5. New Intersection Signals	Not applicable				
6. Signals Remodelling Works	Not applicable				
7. Signals Linking	1	$5,232	$163,346	31.22*	$168,578
8. Roadworks	22	$787,413	$2,428,603	3.08*	$1,641,190
9. Fairway Works	0				
10. Interim Project Description	1	$2,275	$57,798	25.41*	$60,073
11. Flashing Red Signals	Not applicable				
12. All Accidents Treatments	2	$156,278	$585,013	3.74*	$428,735
METRO AREAS	38	$1,113,634	$1,895,118	1.70*	$781,484
RURAL AREAS	0				
YEAR OF COMPLETION					
1979-1980	1	$55,909	$470,293	8.41*	$414,384
1980-1981	0				
1981-1982	0				
1982-1983	4	$94,632	$3,383,668	35.76	$3,289,036
1983-1984	2	$18,193	$104,790	5.76*	$122,983
1984-1985	20	$689,846	$466,616	0.68*	$223,231
1985-1986	11	$255,053	$2,320,669	9.10*	$2,575,722

* Note : The Benefit Cost Ratio and Net Present Worth for these treatments are indicative and should be treated with caution, because the apparent reductions on which they are based are not statistically significant.

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