

Technical Direction

for Road Safety Practitioners

POLICY - GUIDELINES - ADVICE



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Supersedes: Ref. 'Action'

Accident Reduction Guide

Part 1 – Accident Investigation and Prevention

Background

In May 1995, the following documents were published and distributed across the RTA Branches for use:

- *Accident Investigation and Prevention - Policy and Guidelines* (version 1.0)
- *Accident Investigation and Prevention – Procedures for Road Based Countermeasures* (version 1.0)

The Road Environment and Light Vehicle Standards (RELVS) section of the Road Safety Strategy Branch is in the process of developing the Accident Reduction Guide, which effectively combines the above two documents with the RTA's *Road Safety Auditing Manual* (2nd edition) which was also published and distributed in May 1995. Part 1 of the Accident Reduction Guide entitled *Accident Investigation and Prevention* (AIP) has been completed.

General

The *Accident Reduction Guide: Part 1 – Accident Investigation and Prevention* is now available and copies can be obtained via the details given below. This document incorporates guidelines and procedures for undertaking AIPs and Mass Action studies. It provides more up-to-date material with respects to programming AIP/Mass Action projects, the analysis work involved, and implementation of accident-reduction countermeasures. It also provides more guidance on monitoring and evaluation of the AIP/Mass Action program.

Action

The *Accident Reduction Guide: Part 1 – Accident Investigation and Prevention* supersedes (1) the Policy and Guidelines document and (2) the Procedures for Road Based Countermeasures documents which are listed above.

This policy is to take effect immediately.

Approved for use by:

(signed)

Sue Sinclair

Director, Road Safety, Licensing & Vehicle Management

For:

- Director Road Network Infrastructure
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- Director Operations
- Director Traffic and Transport
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Accident Reduction Guide

Part 1: Accident Investigation and Prevention

Part 2: Road Safety Audits

Title: Accident Reduction Guide

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This document is also available on the RTA Intranet under Policies/Road safety.

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Read this first

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Introduction to the guide

1. Background

The NSW Government through the Roads and Traffic Authority (RTA) is accountable for the funding, condition and standards of around 17,600 km of major arterial roads known as State Roads. Arterial roads support Australian, state and regional economic activity.

Local government is accountable for funding, condition and standards of regional and local roads, with the exception of the road network in the unincorporated area of the state (where there is no local authority). The NSW Government provides significant grants for regional roads infrastructure in recognition of the role of these roads in supporting regional economic activity. The NSW Government also provides financial assistance to local government for safety engineering and traffic works on local roads.

The RTA has a statutory responsibility of providing a road network that is safe for all road users such as vehicle drivers and their occupants, pedestrians, cyclists and motorcyclists. As part of this responsibility and its commitment, the RTA has fully embraced quality assurance principles and practices.

2. Road safety

The RTA seeks to achieve safety gains through the implementation of safety initiatives that seek to develop safer road users, safer roads and safer vehicles.

The development and implementation of appropriately targeted blackspot and mass action treatments, and road safety auditing programs, is expected to play a crucial role as part of this strategy.

3. Accident reduction guide

3.1 Purpose of the guide

The guide includes two parts:

- Part one - accident investigation and prevention.
- Part two - road safety audits.

The guide consolidates the policies, procedures and practices of the Accident Investigation and Prevention (AIP) program (including the management of blackspot and mass action projects), and the Road Safety Audit program.

It aims to provide RTA personnel with direction in each of the program areas by providing processes to be used for program development and delivery.

Part one: accident investigation and prevention (AIP)

Part one of the guide outlines the methodology involved in the treatment of accident locations by analysing accident data and investigation accident locations. If the investigations justify remedial action, the AIP can lead to the following types of treatment:

- Accident blackspot treatments.
- Mass action treatments.

Accident blackspot sites may be considered as locations, roads segments or areas where clusters of accidents have occurred, while mass actions may be considered as the implementation of proven accident countermeasure/s that target specific types of accidents that occur at a site, or randomly along a length of road or within an area.

Both accident blackspot and mass action programs have been demonstrated to be highly effective in reducing road trauma. Evaluation of the Federal Blackspot Program¹ revealed that for the first three years of the 1996 – 2002 period, the program delivered to the community a net present value of \$1.3 Billion, and an overall benefit cost ratio of 14 to 1 (18:1 in urban areas and 11:1 in regional areas).

Part two: road safety audits

Part two of the guide outlines the application of road safety auditing practices and policies to be adopted in the RTA. The road safety audit process is a formal examination of a future road or traffic project or an existing road, in which an independent, qualified team reports on the project's accident potential and safety performance.

Unlike the AIP program, which relies on the analysis of historic accident data, road safety audits aim to proactively improve road safety through the detection of road safety deficiencies and the implementation of corrective actions. Road safety audits have demonstrated to be an effective means of reducing road accidents.

Types of road safety audits

Road safety audit processes may be applied prior to road construction, during construction and on the existing road network.

The types of road safety audits that may be carried out are:

Stage one: feasibility stage audits. Feasibility stage audits consider route options, layout options and/or treatment options. They allow an assessment of the relative safety performance of each option to be made and identify the specific safety needs of various road users.

Stage two: preliminary design stage audits. At the preliminary design stage, issues such as intersection layout and the chosen design standards are addressed.

Stage three: detailed design stage audits. At this stage, the more specific design issues are addressed, for example, geometric design, signing scheme, and linemarking plans are looked at in relation to operation of the traffic and safety of all road users.

Stage four: pre-opening stage audits. Prior to opening, a site inspection is made to ensure previous concerns have been addressed and to identify any hazardous conditions that may not have been apparent from the plans.

Stage five: existing road audits. This stage audit entails the formal examination of the existing road network. This can be done at a location, along a route or road segment, or on an area wide basis.

Thematic audits. Thematic audits are carried out on the existing road network focusing on particular road users (ie. pedestrian, cyclist, motorcyclists, etc), or specific road features (ie. roadside furniture, delineation, etc).

¹ The Blackspot Program. 1996-2002. An Evaluation of the First Three Years. Bureau of Transport and Economics, Report 104. 2001.

3.2 Structure of the guide

Part one: accident investigation and prevention (AIP)

Part one of the guide provides information and direction related to the following:

- Road accidents, their causes and strategies used to address them
- Outline of the AIP program:
 - Accident data.
 - Steps in AIP.
 - Levels of investigation.
 - AIP programming.
 - Resources for developing road based countermeasures.
- Procedures to be used for AIP.
- Development of a program of AIP studies:
 - Annual review.
 - Developing a program of AIP studies.
- Setting up an AIP study:
 - Investigation team, and roles and responsibilities of team members.
 - Data collection.
- Accident data analysis:
 - Preliminary analysis: site and mass action diagnosis.
- Field investigations (includes identification of countermeasure options).
- Economic evaluation of countermeasures:
 - Calculation of benefits.
 - Consideration of other impacts of countermeasures.
 - Multiple countermeasures.
- Report preparation.
- Formulation of a ranked AIP program:
 - Size of program.
 - Programming.
- Implementing countermeasures.
- Monitoring and evaluating countermeasures and programs.
- Case studies.

Part two: road safety audits

Part two of the guide provides information and direction related to the following:

- Detail of the types of road safety audits.
- Legal issues.
- RTA road safety audit management:
 - Administration.
 - Programming.
 - Contract management.
 - Accreditation of road safety auditors.
 - Reporting and review.
- Road safety audits:
 - RTA processes.
 - Minimum intervention levels.
 - Management procedures.
 - Continuous improvement.

- Conducting road safety audits:
 - Steps in the process.
 - Selection of the road safety audit team.
 - Information requirements.
 - Commencement meeting.
 - Site inspection.
 - Writing the road safety audit report.
 - Completion meeting.
 - Follow-up response by the project manager to the road safety audit.
 - Close out procedures.
- Case studies.

Reference documents

This guide is to be used as the primary document for RTA road safety audit practice. The Austroads '*Road Safety Audits*' 2nd edition 2002 publication provides guidance in road safety auditing and should be used as a supplement to this guide. It should be recognised that some differences between the RTA and the Austroads publication exist.

The key differences between this guide and the Austroads publication are:

- RTA policy is that road safety auditors are not to make recommendations on correction of road safety deficiencies identified as part of the road safety audit. This is reflected in this guide.
- This guide defines the road safety auditing of existing roads as 'stage five: road safety audits of existing roads', whereas the Austroads publication terms these types of audits as 'road safety reviews'.

4. Policy

4.1 Accident investigation and prevention (AIP) program

- a. The RTA will undertake and maintain an accident investigation and prevention (AIP) program aimed at:
 - The identification of accident locations.
 - The implementation of timely and cost effective treatments.
- b. The Road Safety, Licensing and Vehicle Management Directorate (RS,L&VM) provides strategic direction, guidance, training and funding for the program. The AIP program facilitates the programming of forward accident reduction works. RS,L&VM is also responsible for monitoring and evaluating the effectiveness of the forward program of works.
- c. The regions' responsibilities include:
 - An annual review of the traffic accident database.
 - Collection and analysis of additional information regarding regional accident locations or problems.
 - Implementation of accident countermeasures and preventative measures, which may include a combination of blackspot and mass action treatments.
- d. The regions and directorates shall participate in the training courses established for the purpose.
- e. The RTA will report annually on the program in terms of the findings, measures taken, costs and benefits.
- f. RS,L&VM will provide guidance on quality assurance for the program in keeping with the RTA's continuous improvement strategy.

4.2 Road safety audits

- a. As part of the RTA's commitment to road safety, the RTA road safety audit program aims to:
 - Audit a cross-section of projects at a number of stages, ie. during planning, design, construction and pre-opening , to identify and address safety problems prior to use by road users.
 - Systematically audit the road network, identify safety problems and corrective actions.

It should also be noted that RTA promotes mandatory road safety audits of all new road developments.
- b. RS,L&VM will provide strategic direction, training, funding and technical support for the program.
- c. The Region's responsibilities include:
 - The delivery of an annual road safety audit program within their region.
 - Ensuring that road safety audits are carried out by appropriately skilled, and independent (of the project) road safety auditors.
 - Advice to the RS,L&VM directorate of concerns and suggested improvements for consideration, and where appropriate changes to the road safety auditing practices.
- d. RS,L&VM may carry out compliance audits of regional road safety audits to ascertain the quality of audits conducted and the manner in which issues raised are addressed.
- e. RS,L&VM and RTA Regions are responsible for ensuring that the necessary road safety audits skills are maintained and enhanced.

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Accident Reduction Guide

Part I: Accident Investigation and Prevention

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About this release

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1. Introduction

1.1 Background

One of the RTA's prime responsibilities is to provide the people of NSW with a road network that is safe and efficient. As part of this commitment, the RTA administers an annual program of Accident Investigation and Prevention (AIP) projects with the specific objective of reducing road accidents.

NSW experienced 51,814 road traffic accidents during 2001. Of these, 23,168 were casualty accidents. These accidents resulted in 524 persons killed and 29,913 people being injured. The estimated cost to the community of these accidents was over \$2.5 billion.

Road authorities have a legal obligation to take due and reasonable care to ensure that the roads under their control are safe for road users. The identification and investigation of accident problems and the subsequent development of a suitable program of treatments is one way for the RTA to meet this obligation.

With limited funds and resources available within the RTA, any funds or resources that are used should be directed to give the best value for money. In the accident reduction area, this can be best achieved by listing countermeasure treatments in an appropriate order of economic benefit, so that the overall benefit is maximised for the funds available.

The RTA has an annual program for accident investigation and prevention studies, and implementation of selected cost-effective countermeasures.

The program will ensure that the best use is made of accident data already available; ensure the best use of RTA resources (including improved staff skills) in undertaking accident investigation and prevention; and improve Regional and Corporate coordination, communication and interaction in accident investigation and prevention.

1.2 Accident Investigation and Prevention (AIP) and Road Safety 2010

To meet its challenge to reduce road trauma in the State, the New South Wales Government has developed *Road Safety 2010*. The strategy aims to make roads in the state the safest in the world and provides a framework to halve the road toll and save 2,000 lives by the year 2010.

Under the "Safer Roads" section of the strategy, one of the objectives is the "expansion of the Blackspot Program".

The AIP program is a structured systematic method that will facilitate the development of the Blackspot program to meet this objective.

1.3 Definition

The RTA's AIP program provides a framework for coordinating corporate and regional activities in the investigation and treatment of accident sites. It is an ongoing program encompassing a wide variety of activities aimed at:

- Identification of crash locations; and
- Implementation of timely and cost effective treatments.

It identifies, through a consistent reporting process, the benefits, costs and priorities for appropriate countermeasure programs.

1.4 Policy

The RTA will undertake and maintain an accident investigation and prevention (AIP) program aimed at:

- The identification of accident locations, and
 - The implementation of timely and cost effective treatments.
2. The Road Safety, Licensing & Vehicle Management (RSL&VM) Directorate provides strategic direction, guidance, training and funding for the program. The AIP program facilitates the programming of forward accident reduction works. RSL&VM is also responsible for monitoring and evaluating the effectiveness of the forward program of works.
 3. The Regions' responsibilities include:
 - An annual review of the traffic accident database.
 - Collection and analysis of additional information regarding Regional accident locations or problems.
 - Implementation of accident countermeasures and preventative measures, which may include a combination of blackspot and mass action treatments.
 4. The Regions and Directorates shall participate in the training courses established for the purpose.
 5. The RTA will report annually on the program in terms of the findings, measures taken, costs and benefits.
 6. The RSL&VM Directorate will provide guidance on Quality Assurance for the program in keeping with the RTA's Continuous Improvement Strategy.

1.5 Purpose of the guidelines

In 2004, AUSTRROADS released Part 4 of the Guide to Traffic Engineering entitled "Treatment of Crash Locations" which replaced the former edition entitled "Road Crashes" (first published in 1988). As an AUSTRROADS publication, it provides guidance for safety practitioners for investigating and treating accident locations at a broad level which is relevant for all road transport and traffic authorities in Australia and New Zealand. It is strongly recommended that this AUSTRROADS document be referenced prior to undertaking AIP and blackspot/mass action projects.

The purpose of Part 1 of the RTA's Accident Reduction Guide entitled "Accident Investigation and Prevention" is to provide a further overview of the AIP program (including blackspot and mass action treatments) and to outline issues that are specifically associated with RTA administered programs. These RTA administered programs also include blackspot programs funded by the state and federal governments as well as projects with joint involvement from RTA and local governments of NSW. It is relevant for all RTA and local government staff (and their contractors) involved in road safety and traffic management programs.

This guide also describes all steps (in sequential order) involved in the AIP program. These include the investigation of accident data, identification of hazardous road locations, development of cost-effective countermeasures, and the subsequent development and proposal of blackspot and mass action treatments.

1.6 Accident Investigation and Prevention - programming

Each year, the Road Safety Strategy Branch provides the *Annual Regional Program Development Process Guidelines* (i.e. "bidding guidelines"), to assist the Client Services Directorate develop the Road Environment Safety Programs. The bidding guidelines for Accident Blackspot and Mass Action Treatments are provided under *Program positions 16301* and *16303* respectively of the Road Environment and Light Vehicle Standards (RELVS) Program. All projects funded under program position 16301 and 16303 are funded by the State Government.

The feature of this program is to objectively and systematically identify "blackspot" locations, and to implement cost-effective measures designed to reduce the incidence and severity of road accidents. In this respect, the bidding guidelines also specify that funding proposals for Accident Blackspot and Mass Action Treatments need to satisfy stringent criteria with regard to project and program benefit cost ratios (BCRs).

Council *Blackspot* submissions for local roads as well as projects where there are multiple sources of funds may be accepted within this program provided they satisfy all of the requirements specified within the guidelines.

Each year a small budget allocation may also be provided to enable the funding of AIP as a means of identifying Blackspot treatments for future years. The bidding guidelines provide guidance in this aspect.

During the site inspection component of the AIP, in addition to assessing the site for specific deficiencies that have contributed to crashes, the principles of Road Safety Auditing may also be applied to identify other potential hazards that may result in increased accident frequency and severity. These hazards should undergo further investigation and possible treatment under *Program position 16302: Road Safety Audits and Investigative Works*.

It should also be noted that within the bidding guidelines and RTA Technical Direction TD2003/RS03 (*Policy for Road Safety Audits of Construction and Reconstruction Projects*), road safety projects with project costs over a set minimum intervention level are required to undergo a road safety audit between Stages 1 and 4 (from the project's feasibility stage to the pre-opening stage).

Blackspot Projects may also be funded by the Federal Government under RTA *Program position 16309: National Blackspot Program*. The National Blackspot Program *Notes on Administration* provides guidance and criteria with respects to the nomination of projects seeking Federal funds.

2. Road accidents

2.1 What causes accidents?

A key requirement of the road transport system is to provide safe and efficient travel for its users. The transport system is made up of three major components which are:

- The road user
- The vehicle
- The road environment

A breakdown in one or more of these components will significantly increase the risk of a serious accident. This is why so many accidents are caused by the interplay of human factors, vehicle factors and road environment factors.

The road environment and the vehicles using it should be designed, built and maintained to inform the road user and to minimise the outcomes of human error. A well designed road should allow road users to accurately perceive the “demands” of the road environment and perform the required road user task. If there is a failure in the road user’s ability to accurately perceive this demand, then the roadway should be forgiving by either allowing the road user to recover and continue (thus changing the outcome of the event) or by minimising the severity of the accident.

Ideally, the roadway should have been designed, built and maintained to achieve these objectives. The Road Safety Audit Program detailed in Part 2 of this Guide is the tool used to ensure that the roadway is constructed and continually managed to the required safety standard. The AIP Program detailed in this part of the Guide, focuses on identifying locations that have “failed” and retrospectively applying treatments to achieve these objectives. The management of roads should include a combination of Road Safety Audits and AIPs.

2.2 Accident reduction strategies

AIP studies provide a systematic means which enable cost-effective remedial treatments to be ultimately identified and implemented. AIPs can either use:

1. An analysis by accident type (DCA) method; or
2. An analysis by accident outcome (severity).

The RTA’s preferred method is the analysis by accident type.

There are two AIP approaches that may in accident reduction programs. These are described briefly in 2.2.1 and 2.2.2, and in more detail in Section 7.

2.2.1 Site analysis and treatment (“Blackspots”)

This involves the analysis and treatment of identified accident problems at a single site. While the site is often an intersection, it can include short road sections of road such as a curved section of road.

2.2.2 Mass action analysis and treatment

This involves the analysis and treatment of a number of locations as a Mass Action, ie. the implementation of known effective countermeasures at a number of locations which have a common accident problem. The locations can be grouped as:

- A length of road, commonly referred to as a “blacklength”.
- An area wide treatment.

3. Outline of the Accident Investigation and Prevention (AIP) Program

The purpose of this section is to provide a broad overview of the Accident Investigation and Prevention (AIP) process. Each of the stages described below are also described in further detail (with worked examples) in subsequent sections of this Guide.

The five key stages of an AIP program are:

1. Accident Data Analysis.
2. Detailed Accident Investigation.
3. Developing And Selecting Countermeasures.
4. Implementing Countermeasures.
5. Monitoring and Evaluating Countermeasures.

The output of the AIP program is a schedule of treatments for accident locations ranked in priority to optimise the safety benefits. This schedule may then be developed into works program.

The intention of these guidelines is to ensure best practice in developing annual programs of treatments for hazardous road locations, such as the Accident Blackspot program.

3.1 Accident data

The ongoing and routine collection of accident data, collected by the Police, is the platform upon which the development of a program commences.

On 1 December 1999, the previous Traffic Act 1909 was repealed and replaced by new traffic regulations, including the adoption of the new Australian Road Rules (ARR). Reference is made in the Road Transport (General) Act 1999 and the Road Transport (Safety and Traffic Management) Act 1999 and the regulations made under those Acts.

Rule 287 (3) of the ARR outlines the responsibilities of persons involved in traffic accidents with respects to reporting the incident to the police. The police will attend the accident if:

- A person was killed or injured; or
- There was over \$500 damage to property other than the vehicles concerned; or
- One of the parties failed to stop and exchange particulars; or
- One or more of the drivers was reported to be under the influence of alcohol or other drug; or
- One or more vehicle was required to be towed away.

Road accidents attended by the police as well as self reported accidents are recorded on a database known as the Computerised Operational Policing System (COPS). For accidents attended by the police, a sketch of the accident site is prepared and sent to central office of the NSW police for microfilming and logging.

All accident events that were attended by police and where a person was killed or injured or at least one motor vehicle was towed away are entered on the RTA's Traffic Accident Database System (TADS). The data is checked and transferred from COPS in a weekly basis. Other police-attended accidents (referred to as "non-towaway accidents") may also be transferred onto TADS, but these are filtered out in any accident data reporting. Self-reported accidents are not recorded on TADS. When analysing accident data as a part of an AIP, it is important to acknowledge that the accident data obtained from TADS does not contain self-reported or non-towaway accident events.

The Road Safety, Licensing & Vehicle Management Directorate (RSL&VM) of the RTA analyse the data in TADS for consistency and ensure that any accident events that do not meet the national criteria as well as duplicate data entries are removed. Accident data is forwarded to each RTA Regional office both in electronic format as well as in a number of summary reports.

More detailed information related to the TADS is provided in the RTA's Traffic Accident Database System Data Manual, Version 1.6, June 2002. The manual provides in detail the four main stages in producing traffic accident statistics from TADS. These are:

- Obtaining data on road traffic accidents.
- Entering data into TADS.
- Managing the data in TADS.
- Producing outputs from TADS.

3.2 Steps in accident investigation and prevention

Step 1: Accident data analysis

(a) Preliminary analysis

The purpose of the preliminary analysis of the traffic accident database is to determine the broad nature of the accident problem for a Region or local government area. This allows identification of accident problems worthy of further investigation. This is effectively a filtering process to identify those accident problems for which there may be treatments with good benefit cost ratios.

Once specific sites have been identified, it is necessary to carry out a more in-depth accident data analysis of the sites.

Accidents are past events and cannot be prevented. However, future recurrence of accidents can be prevented given that an accurate understanding of the accident problems is known. Therefore the analysis of the accident data needs to look for patterns of accidents that are very likely to keep repeating unless some treatments are implemented.

For example, one or two accidents at a particular location over a period of 3 years is not a good indicator of the accidents likely to happen at that location in the future. However, 7 right angle accidents at a location over 3 years, suggests quite a clear accident pattern and one that would most likely continue unchanged unless a treatment was implemented. The pattern is readily identifiable because the accidents have something in common, i.e. their accident type and their location.

Furthermore, if the 7 accidents were distributed over the 3 year period in a markedly declining trend, and during this period the characteristics of the site have changed and are acknowledged to have contributed to the accident reduction, then it may not be worth considering for future countermeasure works.

Section 7, *Accident Data Analysis* provides more detail of the steps required in AIP. Accident patterns that should be identified are:

- Blackspot Analysis: Identification of isolated locations with clusters of accidents of similar type. These sites are typically intersections or short lengths of a road.
- Mass Action Analysis: Identification of a number of similar locations where a known effective countermeasure can be applied to reduce accidents and their severity.

Appropriate treatments may be devised to counter accident problems at these sites, on these routes, or in these areas.

These principles can also be applied when analysing the database for possible road user based and/or vehicle and equipment based countermeasures.

(b) Detailed analysis

At this point, a more detailed analysis of the characteristics of the accidents needs to be undertaken. This will assist in identifying crash causal and severity factors and help determine appropriate countermeasures.

For road based countermeasures, the RTA's accepted methodology is to examine accident data by accident-type or DCA Codes (or RUM Codes) and not by severity (e.g. fatal, injury and tow-away property damage accidents). Most road treatments generally affect particular types of accidents and not the severity of accidents. For example determining that 15 right angle accidents have occurred at an intersection can reasonably lead to the selection of

traffic signals, a roundabout or more conspicuous stop signs as appropriate countermeasures. However, determining that the injuries were 0 killed and 6 injured does not help very much in determining a suitable road treatment. Another advantage of extracting accident data by accident-type is that it is better able to describe the accident process, whereas severity only describes the outcome of the accident. By describing processes it is often easier to determine what sort of countermeasures are appropriate.

Step 2: Detailed accident investigation

Detailed investigation of accident problems involves the use of data additional to that available on the traffic accident database. Using a jigsaw puzzle analogy, not all of the pieces will be available on the accident database. The detailed analysis using the database will help determine what other pieces are required. The detailed accident investigation is the collection of those additional pieces.

The use of this additional data helps in developing a more detailed understanding of the accident problem. This is essential if the most suitable treatments are to be selected for the accident problem. Level 2 investigations (defined in 3.1.3) are essential for a thorough understanding of the accident problem. The selection of countermeasures without the use of some level 2 investigations can easily lead to sub-optimal countermeasures being chosen. Any one of a number of countermeasures may be appropriate for a particular accident problem and indeed many may even prove to be cost-effective, but a site inspection will help determine which one is the most appropriate. For example, at an unsignalised intersection with a number of right angle accidents, a roundabout might be selected instead of a cheaper but equally effective option of more conspicuous stop or give way signs.

For the development of road based countermeasures, the main sources of additional data will be the Police reports of the accidents (PP4 forms) and site inspections.

The level of effort applied to the collection of additional data can vary. These levels of accident investigation are explained below.

Step 3: Developing and selecting countermeasures

Steps 1 and 2 will have, to a certain extent, enabled the accident problem to be identified.

For each accident problem studied, a number of countermeasures may appear both feasible and effective. However, they will have different costs and different levels of effectiveness. The selection of a treatment or a package of treatments from a number of possible alternatives requires some economic assessment of the alternatives. The benefits for each alternative can be determined by estimating the likely number of accidents prevented (or the likely number of fatalities or injuries prevented) by the type of treatment. Costs of accidents by accident type and costs of fatalities and injuries are provided in the RTA's Economic Analysis manual. As stated above, the accepted methodology for accident analysis and economic evaluation uses costs by accident type. The cost of each alternative treatment as well as maintenance costs over the design life of the treatment can be estimated by reference to historic costs, or estimates can be made from first principles.

Care must be taken in estimating the accident "savings". Credit cannot be claimed for preventing accidents that the treatment will not or cannot have an affect on. For example, if a wide variety of accident-types are present at an intersection, only those accidents directly affected by the proposed treatment can be used in determining the accident "savings". It is wrong to estimate the accident savings based on all the accidents at the intersection. In addition to the accident type, the specific location of the accidents also has a bearing on whether it is likely to be addressed by the treatments. A crash 20m from an intersection may not necessarily be affected by the treatment at the intersection.

Treatments should be implemented through a program of countermeasure treatments such as a "blackspot program". Each project should be ranked using appropriate economic criteria. The appropriate method for ranking projects according to the RTA's Economic Analysis manual is by benefit cost ratios (BCR). The BCR is defined the present value of benefits (PVB) divided by the present value of costs (PVC). "Benefits" refer to present value of accident savings over the design life of the treatment. "Costs" refer to present value of initial capital investment (construction costs) and recurring operating and maintenance costs for the life of the project. The "cost" must also include the full project management costs. A BCR greater than 1.0 indicates that the benefits outweigh the costs. Projects falling below the budget cut-off are excluded from the program.

$$\text{BCR} = \text{PVB}/\text{PVC}, \text{ where}$$

PVC = Present Value of Capital Costs + Present Value of recurring operating and maintenance costs.

More detail on road safety benefit cost analysis for AIP projects is contained in Section 10, *Economic Evaluation of Measures Proposed*. Further information related to economic assessments can also be found in the RTA's *Economic Analysis Manual, Version 2, 1999*.

A secondary measure for assessing the economic feasibility of a treatment is Net Present Value (NPV). The NPV is defined as the difference between the present value of benefits (PVB) and the present value of costs (PVC) over the life of the project, i.e.

$$\text{NPV} = \text{PVB} - \text{PVC}$$

A positive NPV indicates that the project will deliver economic value.

It is worth also considering the overall benefits of proposed treatments, especially when there is more than one treatment option for an accident location. If one treatment option only addresses a small portion of the overall accident problem, but can be implemented at a low cost, it will have a favourable BCR. Another treatment option may address a larger portion of the accident problem, but the cost to implement this may be considerably more which then compromises its BCR. It is these cases that require sound judgement and careful consideration. Although the first option is comparatively more cost effective in reducing a small number of accidents, the residual accidents may either be too costly to correct or not correctable at all once the initial treatment has been completed. It may be more worthwhile (for the long term) to address the larger accident population with the more demanding initial investment.

For the program to achieve "maximum" value for money, more projects need to be developed than will be implemented. If a budget of \$15 million is available, then \$30 million or even \$50 million in projects should be developed. In this way, the "best" projects for the \$15 million budget can be identified. If only \$15 million of projects are developed, then there is no way of knowing whether they were the best projects available. This also identifies candidate projects that may be implemented should extra funds become available. In the annual proposals for road safety funding, the RTA Regions are encouraged to "over-program" in this manner.

Step 4: Implementing countermeasures

Community consultation may be required for the successful implementation of some treatments. This is to ensure that the proposed countermeasures are not delayed as a result of community opposition once the project has commenced.

The design and implementation of the countermeasures should also be checked to ensure that they match the concepts originally envisaged by the investigation or study team.

Step 5: Monitoring and evaluating countermeasures

Knowledge about the success or failure of countermeasures is fundamental to the accident investigation and prevention program. Dissemination of this knowledge is vital to avoid using unsuccessful countermeasures in the future and in making more accurate estimates of the benefits of the successful ones.

For road based countermeasures, each project should have a record of the type of treatment as executed, including photographs of the final work, the cost and the start and finish dates of the project.

An Accident Blackspot database has been developed to enable monitoring and evaluation of the performance of Road Safety infrastructure projects. The Road Safety benefit cost ratio (BCR) is the parameter that is used to evaluate the ongoing success or otherwise of countermeasure treatments. Prior to the treatment, assumed levels of accident reduction and preliminary cost estimations are used to derive the BCR. Several years after the treatment, the BCR can be re-calculated using the actual cost and accident reduction achieved. It is important to account for changes in accident frequency that may have resulted from other factors. For urban sites, at least 3 years should elapse before such an "after" evaluation is undertaken. For rural sites, the "after" data period should be at least 5 years. The post construction BCR is only a preliminary indicator of performance. It is assumed that the benefits of the treatment will continue to accrue over the remaining life of the treatment.

Monitoring and evaluating individual projects:

- enables a program as a whole to be evaluated;
- determines whether a project was successful at addressing the accident problem; and
- confirms or provides a basis upon which to re-calibrate accident costs and/or expected percentage accident reductions of various remedial treatments.

3.3 Levels of accident investigation

There are 3 levels of accident investigation:

Level 1: Analysis of mass data

Level 1 investigations involve the analysis of mass accident databases and provides the basis upon which to conduct subsequent levels of investigation.

Level 2: Analysis of accident specific data

Level 2 investigations involve the collection of accident data not available on the mass database. This includes preliminary fatal accident reports and any data that may have been collected on-scene at the time of the accident by other agencies for their own purposes, e.g. Ambulance and emergency services. It also includes data that is collected by or for the RTA some time after (weeks or months) the accident (if still available), e.g. accident site data. Other information such as traffic data, speed surveys, weather data, road design or footage from crash cameras are also included.

Level 3: In-depth analysis of accident data

For the purposes of the RTA's accident investigation and prevention program, level 3 investigations are those where detailed accident data is collected on-scene and very close to the time of the accident, preferably while the vehicles involved are still on-site. Level 3 investigations are carried out by staff that have been appropriately trained in collecting "in-depth" accident data.

The size and purpose of level 3 investigations will vary. They can involve more complex studies such as research into the performance of infant restraints, or the role of vehicle defects in accident events. They can also be used to assist in clarifying the accident problem at an intersection. In such a case, the study would be limited to one site and a small number of accident events.

3.4 Resources for developing road-based countermeasures

An ongoing AIP program requires resources if it is to be successful. These resources include staff and staff skills; techniques and methods; equipment and tools; and funds. The following is suggested as a guide to required resources (it should be noted that the skills component will, in some instances, depend on the subject of the AIP project at any given time).

Staff skills

- Road design and engineering.
- Traffic engineering/ traffic management.
- Problem solving.
- Human perception.
- Road safety fundamentals.
- Accident investigation techniques.
- Psychology.
- Vehicle engineering.
- Occupant safety.

Techniques/methods

- Accident investigation.
- Road safety auditing.
- Interviewing local residents, police highway patrol, community consultation.

Office equipment

- Computers PC.
- Crash database.
- Geographic Information Systems.

Field equipment

- Video/still cameras.
- Tapes, Road-wheels.
- Cue sheets (e.g. Road Safety Audit Manual checklist).

4. Procedures for undertaking an AIP program

4.1 Structure of procedures

Table 4.1 summarises the major steps and activities in the AIP Process. The diagram refers to subsequent sections which describe these activities.

Table 4.1: The Accident Investigation and Prevention (AIP) Process

The Accident Investigation and Prevention Process		
AIP Major Steps	Activities	Procedure Sections
Annual Review	Define the parameters of the Annual Review that will determine the road network to undergo broad level analysis to identify sites, routes and areas to carry out an AIP study.	5.1
	Obtain the relevant data to undertake this broad level analysis	5.2
	Develop a ranked list of Sites and Mass Action studies to be carried out with the available budget	5.3
Commencing the AIP projects	Co-ordinating Roles and Responsibilities of persons involved in the AIP projects	6.1
	Gather data required for the AIP study	6.2
Accident Data Analysis	Undertake a Collision Diagram to map the accident dataset and identify cluster types and locations	7.1, 7.2
	Undertake an accident characteristics analysis (using a Factor Matrix) to identify common accident factors that should be targeted for treatment.	7.1, 7.2
Field Investigations	Undertake a Drive-over inspection traversing all approaches to the Site, Route or Area being investigated.	8.1
	Undertake a Walkover inspection to confirm pre-diagnosed problems, to correlate accident patterns with site conditions and to identify any other hazardous features of the Site, Route or Area.	8.2
	Determine and document countermeasure options that may be successful in treating the identified problems	8.3
Economic Evaluation	Carry out a benefit cost Analysis to determine the feasibility of the countermeasure options.	9.1
	Account for other impacts of the proposed countermeasures in economic terms	9.2
	Consider the effects of multiple countermeasures	9.3
Reporting	Complete a report for each AIP Project undertaken	10.1
	Complete a summary report for the whole AIP program	10.2
Programming works projects	Each Region should submit proposals for Countermeasure treatments via annual Program Proposals ("bids")	11.2
Implementing Countermeasures	Regional Project Managers should assess whether Community Consultation is required for the project as well as the extent of community involvement that is appropriate.	12.1
	Regional Project Managers should assess the level of Environmental Assessment required under legislative and policy requirements.	12.2
	The projects can be designed and installed following the community and environmental consultative work	12.3
Monitoring countermeasures	Each Region is required to submit post-construction data related to each Blackspot and Mass Action project to enable ongoing evaluation at a project and program level.	13

5. The Annual Review for developing a program of AIP studies

Each Region should undertake annual reviews of the road network under its jurisdiction in order to systematically identify sites, routes or areas to include in the annual AIP program. It should be emphasised that an annual review is not an in-depth analysis and investigation of the accident problem at a site, but rather a macroscopic preliminary step (broad level analysis) leading to this process. Similarly, evaluation of completed blackspot and mass action projects via “after” analyses should not be facilitated through the annual review process.

The methodology associated with annual reviews may be adjusted in response to changing accident patterns.

5.1 Define the parameters of the Annual Review

The first task in an annual review is to define the parameters of the Annual Review. This includes the extent of road network included, the time period for which accident data is to be analysed for, and determining the mix of urban/rural locations or classified/unclassified routes in accordance with prevailing demands.

Typically, the whole State Road Network within the Region would be covered in the broad level analysis that forms part of the annual review. The annual review should also include sites, sections and areas that were identified in the previous year’s “shortlist”, but which failed to have an in-depth accident analysis and investigation due to funding or resource constraints¹.

The output of this exercise is a prioritised list of sites, routes or areas that would undergo more in-depth analysis and investigation as described in Sections 6-12. Prioritising the list enables more effective allocation of funds for AIP projects.

Occasionally, there will be a need for ad hoc investigations of one or more sites which come to the attention of the RTA. When this occurs, the investigation methodologies outlined in these procedures are still appropriate and should be used. If no funding is available for these projects they should be included in the following year’s annual review.

5.2 Obtain accident and road network data

The next task is to determine the period from which to draw accident data. The time period is dependant on the nature of the site being investigated and the time that it has been operating in its current form. It is unlikely that a period of less than three years would be suitable for a site operating under stable conditions. However, a shorter time period may be appropriate where major developments or roadworks in the area may have significantly affected traffic patterns at the site. Where a period of less than three years is used, the reasons should be identified and documented. Otherwise the following time periods should be used for sites, routes or areas:

- In urban road environments, three years of accident data should be used.
- In rural road environments or alternatively, where it is known that the traffic/road/network conditions have remained constant², five years of accident data should be used.

In any case, the most recent accident data available should be used.

Section 3.1 gives a brief overview of the process by which accident data is received, checked and stored by the RSL&VM Directorate. Additional information related to the Traffic Accident Database System (TADS) is provided in the RTA’s Traffic Accident Database System Data Manual, Version 1.6 June 2002.

The accident data comprises different accident components, such as:

- Characteristics of the accident, such as time of day, day of week, location etc.

¹ This does not apply in the case where the site, route or area was removed from previous year’s AIP program due to either (i) future programmed development projects or (ii) cases where the accident problem had been proven to be rectified through other completed works.

² A reasonably steady rate of growth/decline in traffic volume is accepted. However, accident data periods extending over points where there had been an abrupt change in traffic volume should not be used.

- Traffic unit (road vehicle or pedestrian) involved in the accident.
- Controller³ of each traffic unit (some traffic units may not have a controller, such as in the case where an unattended parked car rolls into a fence).
- Casualties (i.e. fatalities or injuries) which may have resulted from the accident.

The accident database can be interrogated in many ways to identify specific sites, routes and (to a limited extent) areas.

As Geographic Information System (GIS) technology is applied to the accident database, the capability is now available to display maps showing accidents. These will assist in the reviewing of accident problems.

Other road network data that is available include:

- Road hierarchy data from district schemes.
- Traffic volume data.
- Construction and maintenance records.

These may be useful in determining whether each site, route or area is suitable for a more in-depth analysis and investigation.

5.3 Developing a ranked list of potential AIP projects

Once the network and accident data period components of the annual review have been determined, it is then possible to undertake a preliminary macroscopic analysis to rank the selected sites, routes and areas. The AIP program should involve a combination of site and mass action analyses to ensure that the accident problem as a whole is treated effectively.

5.3.1 Ranking potential sites (“blackspots”) for inclusion in the AIP Program

Each Region should develop a systematic approach for ranking potential sites (“blackspots”) for inclusion in the AIP Program. There is no set methodology for achieving this as the primary purpose of undertaking this exercise is to identify and filter out the more critical sites that should undergo more in-depth analysis and investigation as described in Sections 6-10. One example of a methodology for achieving this is detailed in Table 5.1.

³ A person occupying the controlling position of a road vehicle.

Table 5.1: An example of a methodology for ranking potential sites by accident clusters.

Road environment	Ranking methodology	Example of criteria
Urban intersection	Rank each intersection within the network defined by the annual review, by number of accidents of particular DCA type ⁴ per three-year period	All intersection with more than 5 accidents (of the particular DCA type) for the three-year period should undergo more in-depth analysis and investigation
Rural intersection	Rank each intersection within the network defined by the annual review, by number of accidents of particular DCA type per five-year period	All intersection with more than 3 accidents (of the particular DCA type) for the five-year period should undergo more in-depth analysis and investigation
Urban non-intersection (< 150m)	Rank each site by number of crashes (of a particular DCA group) that occurred within the 150m section for a three-year period	All sites with more than 5 accidents (of the particular DCA type) for the three-year period should undergo more in-depth analysis and investigation
Rural non-intersection (< 150m)	Rank each site by number of crashes (of a particular DCA group) that occurred within the 150m section for a three-year period	All sites with more than 3 accidents (of the particular DCA type) for the five-year period should undergo more in-depth analysis and investigation

The advantage of this methodology is that it can more effectively identify sites where clusters of accidents can be addressed. As such, this facilitates more effective development of countermeasures. However, this methodology does not acknowledge that some accident types are more costly to the community than others. Therefore, the blackspot projects that eventuate may not produce the optimum economic returns.

Another example of a ranking methodology has been described in Table 5.2.

⁴ Appendix A provides a listing of DCA codes used to describe the types of accidents that may occur.

Table 5.2: An example of a methodology for ranking potential sites by accident costs

Road environment	Ranking methodology	Example of criteria
Urban intersection	Rank each site within the network defined by the annual review, by cost of all accidents occurring within 10m of the intersection using three years of accident data.	All intersections having experienced more than \$500,000 of accidents in the three years should undergo more in-depth analysis and investigation
Rural intersection	Rank each intersection within the network defined by the annual review, by number of accidents of particular DCA type per five-year period	All intersections having experienced more than \$300,000 of accidents in the five years should undergo more in-depth analysis and investigation
Urban non-intersection (<150m)	Rank each site within the network defined by the annual review, by cost of all accidents occurring within the 150m section using three years of accident data.	All sites having experienced more than \$300,000 of accidents in the three years should undergo more in-depth analysis and investigation
Rural non-intersection (<150m)	Rank each site within the network defined by the annual review, by cost of all accidents occurring within the 150m section using five years of accident data.	All sites having experienced more than \$400,000 of accidents in the five years should undergo more in-depth analysis and investigation

The advantage of this method is that it will identify sites that have higher potential cost savings due to accident reduction.

Whichever method is ultimately used, the criteria may be increased or decreased depending on how many sites are generated. For example, in a heavily trafficked area experiencing a lot of accidents it may be more appropriate to increase the criteria to identify the urgent sites from the average.

This exercise would result in a *shortlist* of sites for more in-depth analysis and investigation. Where it is practical to do so, the list should be reviewed in consultation with relevant personnel (eg. maintenance planners, infrastructure development, local governments etc) to determine whether there had been any changes to the site that would have affected the road safety performance in the period between the start date of the dataset and the present. Some examples of such changes include major works such as by-passes, reconstructions and realignment works as well as minor works such as pavement reseals, installation of signage and other traffic control devices and lighting improvements. If changes could be attributed to a substantial reduction in accident occurrence, then this may justify removal of this project from the shortlist.

5.3.2 Ranking potential mass action projects for inclusion in the AIP program

Mass action treatments are applications of known effective countermeasures to routes or areas. Unlike blackspot treatments where improvements are more centralised at a site (intersection or short section of a route), the application of treatments as a mass action apply to the whole route of area. Mass action analysis involves (i) the identification of the route or section for which a mass action treatment may be effective in improving road safety performance, and (ii) identification of the type of treatment to be applied. It is emphasised that this methodology only relates to the former. The latter is discussed in more detail in Section 7.2.

An example of a ranking methodology for potential AIP mass action projects has been described in Table 5.3.

Table 5.3: An example of a ranking methodology for prioritising AIP Mass Action Studies.

Road environment	Ranking methodology	Example of criteria
Urban route (>150m)	Rank each route by number of crashes per MVKM using three years of accident data and compare this with the State's average for urban routes.	All routes with crash rates higher than the State's average should undergo more in-depth analysis and investigation
Rural route (>150m)	Rank each route by number of crashes per MVKM using five years of accident data and compare this with the State's average for that road stereotype ⁵ .	All routes with crash rates exceeding the State's average for that stereotype by more than one standard deviation should undergo more in-depth analysis and investigation
Urban area	Rank each site by number of crashes per square kilometre per year using three years of accident data	All areas with more than 10 accidents per square kilometre per year should undergo more in-depth analysis and investigation
Rural area	Rank each site by number of crashes per square kilometre per year using five years of accident data	All areas with more than 6 accidents per square kilometre per year should undergo more in-depth analysis and investigation

Similar with the ranking of sites, the shortlist of routes/areas can also be reviewed to determine whether there had been any recent changes that would have affected road safety performance. If this cannot be practically achieved at this stage, the trend analysis undertaken as a part of the detailed analysis (as detailed in Section 7.1) would prompt this investigation.

⁵ Road Stereotypes are defined by attributes such as lane, median and shoulder width, speed limit, curve radii etc. The RTA has developed a database that enables calculation of crash rates for different stereotypes of roads.

6. Commencing an AIP Project

6.1 Co-ordinating roles and responsibilities in an AIP project

As most jurisdictions are unlikely to have sufficient resources to devote personnel full-time to the delivery of AIP projects, the appropriate resources should be assembled at the commencement of any AIP project. Ideally, the AIP project should be undertaken by a team of suitably qualified and experienced staff. However, where resources are limited, it is possible for a sole person to undertake the AIP project.

If there are sufficient resources to assemble a team, a team leader should be appointed to coordinate the roles of other team members as well as the activities involved in the AIP project. If a sole person is managing the project, then his/her responsibilities are similar in that they would be required to manage the activities in the AIP project as well as liaising with other contacts (eg. local government, police, asset managers).

Table 6.1 shows the stages of an AIP project as well as the tasks which are allocated to each team member/personnel involved.

Team size

The ideal team will have combined expertise in accident investigation, traffic management and road engineering. Other skills as listed in Section 3.5 may be of benefit when seeking team members or in identifying external specialists to consult during the AIP project.

Team Leader

Each team should have a leader who is employed in a traffic or road engineering role. The team leader will have primary responsibility for the undertaking of the project, ideally from the commencement of the investigation through to the monitoring of the impact of the remedial treatment.

AIP Specialist

If the team leader lacks expertise and experience, the project can be contracted to a suitably qualified person. This AIP specialist can either be brought in as additional team member or may be brought in as to manage the AIP project on behalf of the team leader.

Other team members

The team may include a representative of the Local Council where the sites, route or area is located. This is particularly the case when local roads are involved. It will allow local knowledge to be better incorporated, and provide for better community acceptance of remedial treatments, particularly where the measures may require action to be taken by Council. The LGA representative should have either traffic or road engineering expertise to complement the expertise of the other team members.

Other members can be added to the team where necessary to supplement local knowledge. It can be advantageous for other traffic engineers, network managers, maintenance, and/or Police personnel to be involved during the field investigations.

Table 6.1: Personnel and tasks involved in conducting an AIP project with a suggested time scale for completion

Team member/ personnel	Annual review (Sect 5)	Data collection (Sect 6.2)	Detailed analysis (Sect 7)	Field investigations (Sect 8)	Countermeasure development	Economic evaluation of countermeasures (Sect 9)	Reporting (Sect 10)	Implementation of countermeasures (Sect 12)	Evaluation of AIP program (Sect13)
Team approach									
Team Leader	⊗			⊗	⊗				
Team Officer	⊗	⊗	⊗	⊗	⊗	⊗	⊗		⊗
LG Rep (optional)		⊗		⊗	⊗				
Police (optional)		⊗		⊗	⊗				
Network Manager (optional)		⊗		⊗	⊗				
Maintenance personnel (optional)		⊗		⊗	⊗				
AIP Specialist (optional)		⊗		⊗	⊗				
Service provider for works								⊗	
Sole manager approach									
Project Leader	⊗	⊗		⊗	⊗	⊗	⊗		⊗
Specialist input LG Rep		⊗		⊗	⊗				
Specialist input Police		⊗		⊗	⊗				
Specialist input Network Manager		⊗		⊗	⊗				
Specialist input – Maintenance Personnel		⊗		⊗	⊗				
AIP Specialist		⊗	⊗	⊗	⊗	⊗	⊗		
Service provider for works								⊗	

⊗ Indicates involvement of specified person

6.2 Data collection

6.2.1 Study period

The period of the accident dataset used in AIP projects should be as follows:

- For sites or mass action studies in urban locations, three years of accident data should be used.
- For sites or mass action studies in rural locations, **or where it is known that the traffic/road/network conditions have remained constant**, five years of accident data should be used.

With the latter, a reasonably steady rate of growth/decline in traffic volume is accepted. However, accident data periods extending over points where there had been an abrupt change in traffic volume should not be used.

In special situations, a period of less than three years may be used where accidents are occurring in large numbers, or where traffic/road/network conditions have recently changed (including the opening of a new road).

6.2.2 Accident data

The annual review should have provided a broad range of sites, routes or areas to be studied in more detail. The next step is to obtain accident data for these studies in accordance with the guidelines above.

The accident data should include a summary listing of information coded from PP4 forms. At present this can be obtained in three ways:

- A hard copy listing of accidents for each site, route or area being studied from Regional accident database queries.
- A hard copy or computer listing of accidents for an entire area containing the sites, routes or areas being studied. (this type of listing is often used by LGA's), from which the data for the sites, routes and areas can be extracted.
- A listing of accidents for each site, route or area obtained from a GIS system.

For preparation of the Factor Matrix (Section 7.1, Step 1), an electronic version of the data is desirable to enable the analyst to conveniently sort the data. A simple summary of each accident including language descriptions of the main characteristics of the accident, as produced by Regional accident database is also useful for inclusion in the final report which may be viewed later by members of the public.

For each accident, the following accident data fields should be included as a minimum:

- Accident Number.
- Date of accident.
- Location of accident.
- Type of location and alignment.
- Feature of location.
- Day of week.
- Time of accident.
- Light conditions.
- Road surface and weather conditions.
- DCA code.
- Travel directions of traffic units.
- Vehicle types involved.
- Age of controllers.
- Casualty data.

- Traffic unit manoeuvres.
- Traffic unit factors.
- Objects hit by traffic units.
- Alcohol involvement.

For some studies, copies of the PP4 forms may be required for all the accidents and sites under investigation. These can be obtained from the Road Safety, Licensing & Vehicle Management Directorate at the data gathering stage of the investigation.

Examples of the type of studies where PP4 forms would be required are:

- Studies where relatively few accidents are reported at each location, and where maximum information is required (eg. locations with suspected pedestrian safety problems).
- Studies where exact accident location is critical (eg. sites where utility pole accidents are being investigated).

Useful supplementary information can also sometimes be available from:

- Special studies of particular accidents, (Police accident investigation reports, Coroner's reports and press clippings).
- Knowledge of unreported accidents from maintenance and operational staff, tow truck operators and police.
- Footage from crash cameras.
- Previously conducted road safety audits.
- Skid resistance test results.

However, supplementary data should only be used to fill in missing data, and not used to replace or overturn information from the mass action database.

6.2.3 Road data

Road Data required for the analysis and investigation may include:

- Road hierarchy; from district schemes, traffic count data and local knowledge.
- Suitable base maps.
- Traffic flows for arterials and turning volumes at major intersections.
- Construction and maintenance records.
- Aerial photos for site layout, if available.
- Gipsicam images and road attributes obtained through AssetLoc.
- Land use and property plans.
- Any available data on through traffic or vehicle speed.
- Results of surveys of road geometry, (RGDAS output if available is very useful in rural areas).
- Other survey of road condition, including SCRIM and ROADCRACK etc.

7. Accident Data Analysis

7.1 Site analysis

Site analysis is used where the accident problem is centralised at a specific location such as an intersection (Figure 7.1) or short section of road. Better results can be obtained by considering particular accident types when investigating clusters rather than on the basis of total accident numbers only. Particular accident types can be identified by DCA codes (shown in Appendix A), such as clusters of right-angle accidents and run-off-road accidents.

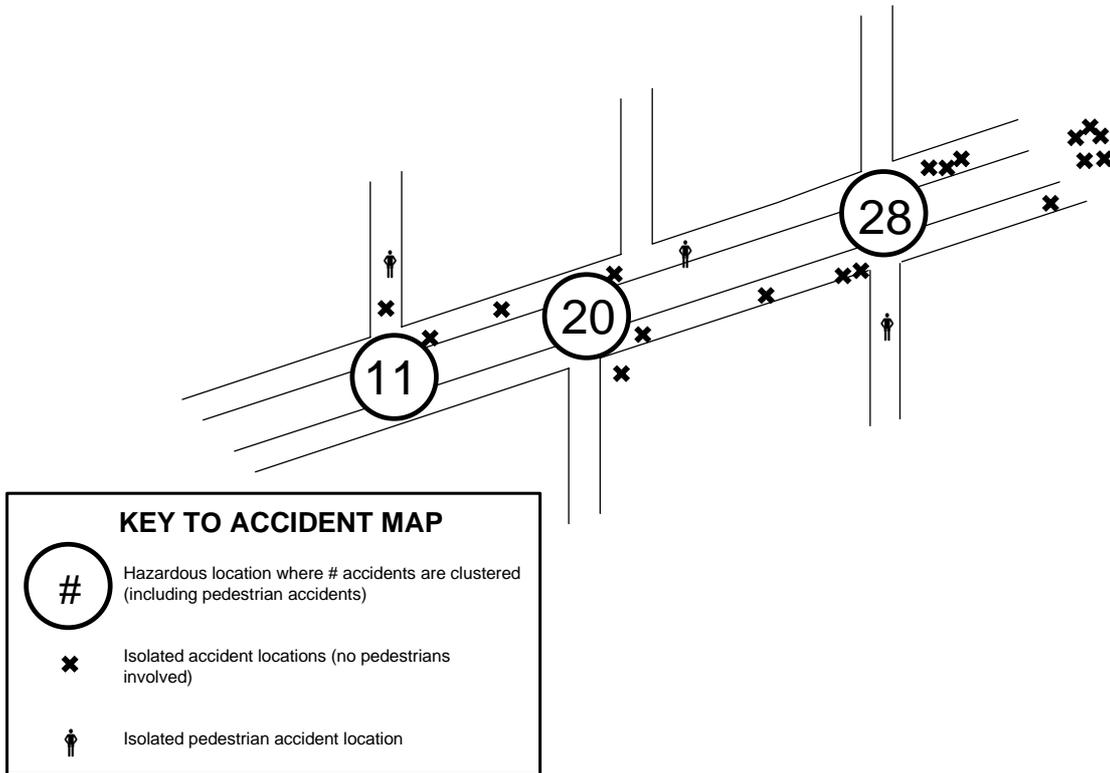


Figure 7.1: These three clusters are examples of candidate sites identified through *Site Analysis*

AIPs involve a number of analytical techniques to enable a holistic assessment of the site being investigated. Tabular crash data such as that in Table 7.1 is often cumbersome and makes it difficult for the analyst to draw conclusions on the safety problems and possible solutions. The data must be arranged and presented in a way that clarifies the problem. This is achieved through the steps listed below.

Table 7.1: Tabular accident data - Intersection of Beach Highway and Harold Drive

Key no.	Accident no.	Image Number	Day	Date	Time	Street	Distance	Direction	Ref Street	DCA Code	Key Direction	Other Direction	Surface	Weather	Light	Accident Location	Accident Align	Accident Feat	Key Type	Other Type	Key MAN	Other MAN	Key Fact	Other Fact	Key OBJ	Killed	Injured	Alcohol	Key Age group	Other Age group
1	922426800	90802	Sun	21/06/01	135	Beach Hwy	0	AT	Harold Dr	104	N	W	Wet	Over	Nit	03	01	29	12	01	20	10	98	98	98	0	0	2	3	4
2	893168018	370020	Sat	16/09/98	1630	Beach Hwy	0	AT	Harold Dr	201	E	W	Dry	Fine	Day	03	01	11	01	01	16	10	98	98	98	0	0	2	3	5
3	924459971	310973	Sat	14/11/01	855	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Day	03	01	11	01	06	20	10	98	98	98	0	0	2	5	5
4	924450982	250984	Tue	13/10/01	2150	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Nit	03	02	11	02	01	20	10	98	98	98	0	0	2	8	8
5	904278801	101303	Tue	16/10/99	745	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Day	04	02	11	02	01	20	10	98	98	98	0	0	2	3	5
6	931481864	460366	Sat	20/02/99	1910	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Dusk	03	01	11	01	01	20	10	98	98	98	0	0	2	5	10
7	914365378	680880	Sun	6/10/00	1505	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Day	03	01	29	01	02	20	10	98	98	98	0	0	2	3	6
8	911310768	320270	Mon	25/02/00	1440	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Day	04	01	11	01	01	20	10	98	98	98	0	0	2	7	6
9	914372419	730421	Sun	10/01/00	1815	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Day	04	01	11	29	01	20	10	98	98	98	0	0	2	10	4
10	922413268	770	Sat	2/05/01	915	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Day	03	01	98	12	01	20	10	98	98	98	0	0	2	9	7
11	931486870	490872	Thu	28/01/99	1320	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Day	03	01	98	10	01	20	10	98	98	98	0	2	2	6	9
12	893173005	400507	Sat	23/09/98	1920	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Nit	03	02	11	01	10	20	10	98	98	98	0	0	1	8	4
13	913349336	571338	Tue	16/07/99	1040	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Day	03	01	24	01	01	20	10	98	98	98	0	2	2	6	3
14	902249733	910735	Fri	18/05/99	1105	Beach Hwy	0	AT	Harold Dr	202	E	W	Wet	Rain	Day	03	01	29	01	02	20	10	98	98	98	0	1	2	4	6
15	891114072	10074	Sat	11/03/98	1045	Beach Hwy	0	AT	Harold Dr	202	E	W	Wet	Rain	Day	03	01	11	01	01	20	10	98	98	98	0	0	2	9	6
16	891116435	20937	Wed	22/03/98	1035	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Day	03	01	11	03	01	20	10	98	98	98	0	0	2	11	6
17	923439350	171352	Mon	3/08/98	1400	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Day	03	01	12	01	01	20	10	98	98	98	0	0	2	9	6
18	894194426	540928	Mon	25/12/98	1745	Beach Hwy	0	AT	Harold Dr	202	E	W	Dry	Fine	Day	03	01	11	01	02	20	10	05	98	98	0	0	2	5	8
19	911295450	211452	Fri	25/01/00	2015	Beach Hwy	0	AT	Harold Dr	202	N	S	Dry	Fine	Day	04	01	29	01	01	20	10	98	98	98	0	2	2	3	3
20	901210537	650539	Fri	23/02/99	1815	Beach Hwy	0	AT	Harold Dr	202	N	S	Wet	Wet	Day	03	01	11	01	01	20	10	98	98	98	0	0	2	8	10
21	901216676	690678	Tue	13/03/99	915	Beach Hwy	0	AT	Harold Dr	202	N	S	Dry	Over	Day	03	01	11	01	01	20	10	98	98	98	0	0	2	8	7
22	902250001	911003	Fri	22/06/99	750	Beach Hwy	0	AT	Harold Dr	202	N	S	Dry	Fine	Day	03	01	11	01	01	20	10	98	98	98	0	0	2	6	4
23	904288840	170842	Wed	19/12/99	910	Beach Hwy	0	AT	Harold Dr	202	S	W	Dry	Fine	Day	03	01	11	01	01	20	10	98	98	98	0	0	2	8	6
24	921397062	891064	Mon	17/02/01	1755	Beach Hwy	0	AT	Harold Dr	202	S	W	Dry	Fine	Day	03	01	11	02	01	20	10	98	98	98	0	0	2	5	8
25	902232305	791307	Tue	22/05/99	1615	Beach Hwy	0	AT	Harold Dr	202	S	W	Wet	Over	Day	03	01	11	10	01	20	10	98	98	98	0	0	2	3	8
26	892122051	60553	Tue	11/04/98	1545	Beach Hwy	0	AT	Harold Dr	202	S	W	Dry	Fine	Day	03	01	11	01	01	20	10	98	98	98	0	0	2	3	4
27	934533873	801375	Wed	13/10/02	1505	Beach Hwy	2	WEST	Harold Dr	301	E	E	Dry	Fine	Day	03	01	11	12	29	10	01	98	98	55	0	0	2	5	7
28	922422983	61485	Wed	20/05/01	610	Beach Hwy	8	EAST	Harold Dr	301	W	W	Dry	Fine	Nit	03	01	11	01	10	13	10	98	98	98	0	3	2	5	6
29	932513998	671000	Thu	6/05/02	550	Beach Hwy	2	WEST	Harold Dr	505	E	E	Dry	Fine	Nit	03	02	11	12	01	15	01	50	98	55	0	0	2	8	6

Step 1: Construct factor matrix

The key to finding a treatment that may reduce an accident problem is to identify a frequent problem that is occurring. This may be in the form of accidents that occur due to an unsafe manoeuvre or during certain conditions such as wet weather or at night. To analyse this, a Factor Matrix should be produced to quickly allow common features of the problem to be identified.

If the accident list for each site is contained in a database file then this can assist in the production of a Factor Matrix. The production of a Factor Matrix can assist with the drawing of collision diagrams.

The Factor Matrix contains summaries of the following relevant factors associated with each movement type:

- Number of reported accidents.
- Year of accident.
- Day of week - that is weekday or weekend.
- Whether the accident occurred during peak or off-peak periods.
- Light conditions.
- Whether the road surface was dry or wet.
- Whether alcohol was involved in the accident.
- Whether there was a TU factor for the key vehicle, or other vehicles.
- Accident severity.
- The type of the crash (DCA Code).

By summarising common factors for each accident type, specific countermeasure treatments can be developed to address each of these factors. The Factor Matrix in Table 7.2 highlights some common factors in the accident dataset amenable to treatment. These commonalities comprise the predominance of DCA 202 right-thru accidents, the predominance of accidents involving cars, and the possibility that many of the accidents involved recreational traffic (i.e. 13 of the 29 accidents occurred during weekends and holidays).

The Factor Matrix also includes an analysis of accident trends by year (see the columns marked “year of accident” in the Factor Matrix in Table 7.2). This allows the analyst to determine whether accident patterns are emerging, steady or declining. For example, the predominance of DCA 202 accidents (16 accidents out of a total of 29) may seem like a warrant for a countermeasure against this accident type. However, there is an observed declining trend in this accident type between 1998 and 2002. The analysis of year-by-year trends enables analysts to discriminate between current road safety problems and historic problems that may have diminished. If the analyst was able to identify a reason for the decline, this could enable the scope of the road safety works to be either reduced or even eliminated altogether, allowing funds to be allocated to sites with more current problems.

The Factor Matrix could also be enlarged to include summaries of other factors according to the specific needs of the study, for example type of vehicle and age of pedestrians.

Step 2: Draw collision diagram

A collision diagram is a sketch or plan of the site under investigation, including as many relevant features which are available, such as intersection priorities, traffic lanes, markers and adjacent land use etc. Aerial photos are useful if available. The diagram should always have streets labelled and an arrow indicating true north. Other relevant details such as the position of road furniture can be added to the sketch during the field investigations.

The purpose of the Collision Diagram is to enable the team to identify clusters of similar accidents. This can enable the development of countermeasure treatments that can be applied at specific locations within the study area to address specific problems. The Collision Diagram in Figure 7.2 was prepared using the data from Table 7.1. One noticeable feature is that the Collision Diagram has highlighted some inaccuracies in the reporting of accident information, particularly with the directions of traffic units involved in the DCA202 accidents. The nature of the site (being a T-intersection) only permitted one type of DCA202 accident involving a key vehicle heading east on Beach Highway and turning right into Harold Drive and the second traffic unit head west on Beach Highway. The tabular data and factor matrix showed that 8 of these DCA202 crashes involved traffic units traveling in alternative directions. The Collision Diagram allows these types of errors to be identified and allows the team to make reasonable assumptions as to the true nature of the accident event.

Using the Collision Diagram as produced in Figure 7.2, the team may conclude that there is a need for addressing the DCA202 accidents due to the large cluster of this accident type. This is also dependant on whether the declining trend in this accident type as discussed in Step 1 was attributable to a change in traffic/road/network conditions. This example highlights how the results of the Collision Diagram, Factor Matrix and any subsequent field investigations are integrated to determine appropriate countermeasure types as well as the level of effectiveness sought from the countermeasure (ie. whether a long term solution is needed or whether a less expensive or interim solution may be sufficient). Ultimately, the countermeasure options that may be discussed may include major works such as the installation of a protected right-turn bay; medium cost solutions such as banning the right turn, banning filtered right-turns, adding an arrow aspect on the signal displays; low cost solutions such as pavement and linemarking improvements; or the “do nothing” option.

The Collision Diagram and cluster analysis may also highlight other research needs. If right turn access is banned or restricted, then this may have implications on other access points along Beach Highway. In this case, the team would need to research access provisions at these points and undertake some analysis to determine whether such a change will lead to a migration in the accident problem. Subsequent versions of the Collision Diagram may also map the accidents at these other locations.

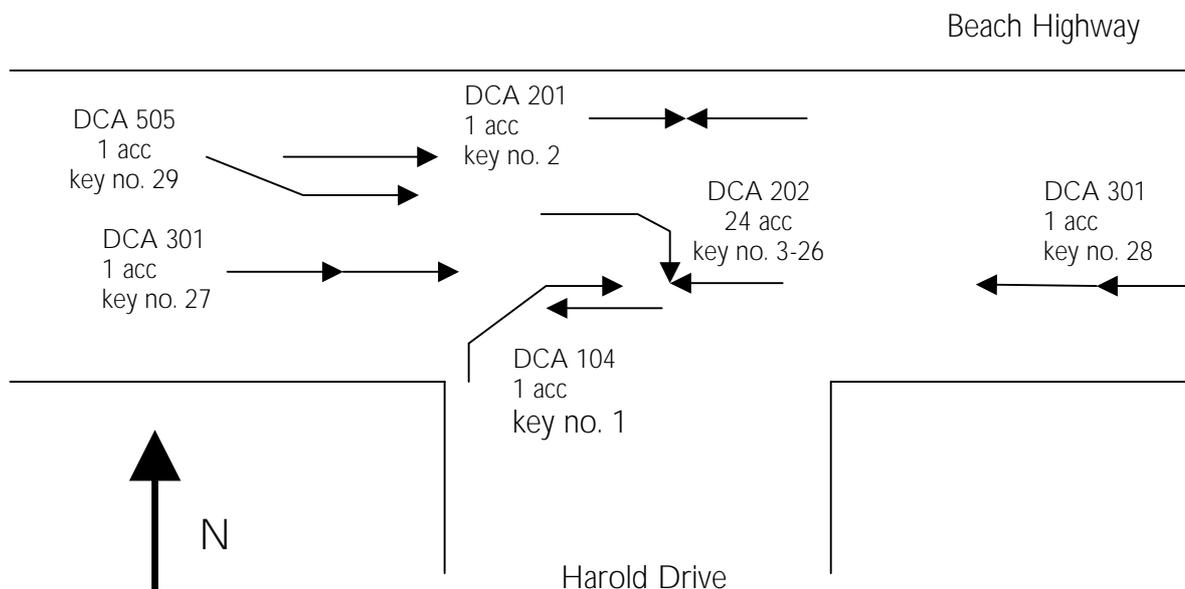


Figure 7.2: Collision diagram for the intersection of Beach Highway and Harold Drive

Step 3: Need for additional information

The need for additional information will become more apparent as the accident data is analysed. As highlighted in the above example, the Collision Diagram and cluster analysis may highlight other research needs and the year-by-year trends may prompt research into possible factors for a noticeable declining trend in DCA202 accidents.

The location of accidents can be difficult to determine, particularly in mid-block locations and in rural areas. In these circumstances reference to the original PP4 form can assist in confirming actual accident characteristics.

Often, the information available from the coded mass accident data does not give sufficient information for full diagnosis of the factors contributing to accidents at the site. It should also be acknowledged that the event that was reported is often the end result of the accident event. The team must use all information available in attempt to determine likely causes of the accidents. For example, an accident data record may state that a vehicle crashed into a tree. However, it may not state what the accident causation factors were, eg. Wet surface, gravel on road, the driver swerving to avoid an animal etc. Where no clear pattern is evident from the data analysis exercises or subsequent field investigations, the use of the PP4 forms could provide clues as to the underlying accident problem.

Additional information may also be collected when considering possible crash causation or severity factors. Such information can also assist in the development of targeted remedial treatments. Additional information sought may include skid resistance data, speed data, traffic volumes, pedestrian counts, origin-destination studies, observational studies (including videos and crash cameras) and vehicle classification surveys.

Step 4: List possible problems

At this stage, the Factor Matrix (from Step 1) enables the team to identify common characteristics in the dataset that can be treated by specific countermeasures. The Factor Matrix also enables a trend analysis to be undertaken to further discriminate between current and emerging safety problems and those that are declining to a mean low. The collision diagram (from Step 2) enables the analyst to identify clusters of similar accident types and the locations where they occurred. These analysis tools should enable the team to identify possible crash causation and severity factors. This may also enable the team to identify concept solutions prior to undertaking a site investigation.

Using the Beach Hwy and Harold Drive example, the team may conclude that possible countermeasures should use a car as the design vehicle (since most of the accidents involved light vehicles), and that the countermeasure should be able to improve safety by restricting the number of right turn movements into Harold Road (Figure 7.3). The trend analysis and any subsequent research may also determine the level of effectiveness required by the countermeasure (ie. long, medium or short term solution).

It is essential that any findings are treated as preliminary (concept) solutions and should not proceed without formally undertaking the field investigations detailed in Section 8.

If a clear accident pattern does not emerge, it may be necessary to re-visit Step 3 and seek further information. This may include on-site behavioural analysis, the use of crash cameras, or liaising with the police or local community. If there are still uncertainties about the accident problem, then the project may even be abandoned without further investigation. Unclear patterns provide no prediction about future accident patterns and so make selection of appropriate cost beneficial treatments very unreliable.

7.2 Mass Action analysis

Mass Action treatments involve the application of a known effective treatment to address a hazardous feature at all locations where it occurs, regardless of whether or not accidents are occurring at all of them. This approach involves identifying accidents that can be attributed to the hazardous feature, identifying all locations with the hazardous feature and evaluating the viability of applying the proven treatment to all or particular subset of these features.

Mass Action analysis enables the identification and evaluation of treatments that may be effective in Mass Action treatments. Mass Action analyses can be broadly separated into two types:

- Route-based Mass Action analysis which identifies routes or long sections of road with a common hazardous feature.
- Area-based Mass Action analysis which identifies area with common hazards as well as the treatment that can be applied to the area.

Site treatments (blackspots) are effective when the benefits of reducing accidents are achieved at a relatively low cost to enable a favourable benefit cost ratio. The benefits and costs of the blackspot project are centralised at the same location. Contrastingly, Mass Action treatments require the benefits and costs to be aggregated over all individual locations treated. Mass Action treatments are effective (albeit not always offering the same economic returns as a blackspot) when the aggregated benefits outweigh the aggregated costs. The benefit of reducing the frequency and severity of accidents at each accident locations needs to outweigh the costs of applying the treatment to all the locations (including locations with low or no accident histories) in order for the project to be viable. The Mass Action approach ensures that locations that require safety improvement, which may otherwise not be treated as part of a blackspot program, are cost-effectively treated.

The aggregation of benefits and costs associated with mass action treatments will inevitably yield lower benefit cost ratios compared with treatments at single crash sites. However, the benefits of the mass action approach include (but are not limited to) the following:

- It achieves better uniformity of treatments across the area or section being treated.
- The treatment of locations with lower accident frequencies avoids migration of the problems. It is assumed that in a homogenous section or area, similar hazards will carry a similar risk. Therefore, addressing the hazards that had been involved in accidents may lead to a migration in the accident problem to the untreated locations (which were left untreated due to their lower accident histories).
- The mass action approach may negate the need to identify discrete accident cluster locations if the boundaries of the area or section are carefully selected to envelope the “whole” problem.

Often a mass action project can be carried out with little or no initial knowledge of the accident history. However, in these cases, the project should be justified with supporting research and experience. For example, in the analysis of accident rates for different road stereotypes, research has shown that high-speed rural roads with wide sealed shoulders have a significantly better road safety performance than those with narrow or no sealed shoulders. A mass action approach to widening sealed shoulders on rural roads could be undertaken based on this research and with little initial knowledge of the accident history. However, accident data analysis would still be required at a later date to evaluate the effectiveness of the treatment.

7.2.1 Route-based Mass Action analysis

Mass Action analysis and treatment can be route-based. This involves the systematic investigation of accidents along a route where the road environment is relatively homogeneous. As mentioned in Section 5.3.2, homogenous sections of a route that can be classed by pre-determined “stereotypes” (eg. Four-lane divided roads with speed limits greater than 90km/h) may be selected for Mass Action analysis if the accident rate for that route exceeds the state’s average for that road stereotype by a pre-determined amount.

Route-based Mass Action analyses will require the investigation of locations along the route with accident clusters as well as the identification of commonalities of accidents and treatments along the entire route. Figure 7.3 illustrates how a Mass Action analysis of a route may incorporate accident clusters (sites) along the route. Route-based Mass Action analyses can be integrated with the development of a traffic calming strategy for a route, or integrated with a road safety audit (particularly in rural areas). The measures adopted for the route would be consistent along its length. The investigation of an entire route could also enable a more structured approach to public consultation to be made.

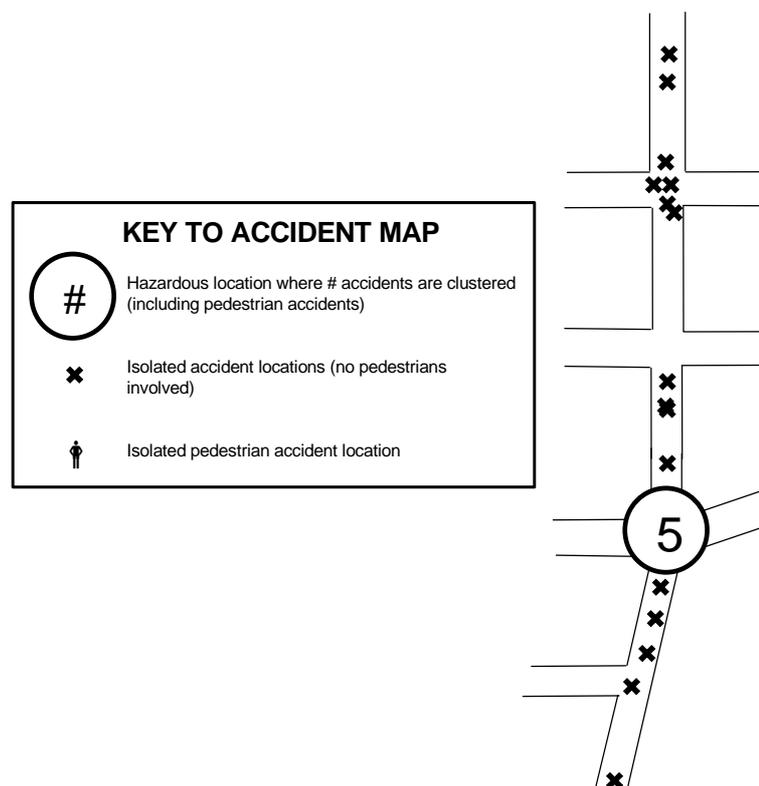


Figure 7.3: A route-based Mass Action analysis may also identify some site clusters.

Some examples of route-based Mass Action studies are provided below along with explanations of the typical “Mass Action Treatment” characteristics:

- Delineation improvements:** On a homogenous section of road exhibiting accidents due to poor delineation, a Mass Action treatment would involve the upgrading of delineation along the whole section regardless of whether individual locations had experienced delineation-related accidents. The benefit achieved through delineation improvements at the individual accident clusters should outweigh the costs of upgrading and maintaining the new delineation devices for the whole section.
- Off carriageway to the left on right-hand bends:** In a homogenous section of road with a number of curves, it may be possible to target off-carriageway to the left on right-hand bend accidents. In this case, all curves in the pre-defined section would be treated regardless of whether this accident type was prominent. Possible Mass Action treatment include providing sealed shoulders on the approach side of the curve and flattening embankments/batter slopes. The benefit of applying these treatments to the individual accident cluster locations should outweigh the costs of applying the treatment to all curves treated within the homogeneous section. A case study example of this type of Mass Action analysis is contained in Appendix B.
- Shoulder sealing:** Shoulder sealing projects can be applied as a Mass Action by treating all sections along a homogenous section of road which have no sealed shoulders regardless of whether accidents had occurred at these sections. The benefit achieved through sealing shoulders at the accident cluster locations should outweigh the costs of sealing and maintaining shoulders for all sections sealed.
- Pole removal or relocation:** On a homogenous section of road exhibiting a large number of off-carriageway accidents into road side poles, a Mass Action treatment would involve the relocation or removal of all hazardously located poles in that section. This is provided that the benefit achieved through relocating the frequently impacted poles greatly outweighed the costs of relocating all poles within that homogenous section.
- Upgrading of safety barrier terminals:** Similarly, if a section of road exhibited a large number of high severity accidents into safety barrier terminals, a Mass Action approach could be adopted to upgrade all substandard barrier terminals in that section. Provided that the benefit of upgrading the terminals

directly involved in accidents outweighs the cost of upgrading and maintaining all safety barrier terminals, the project will be a viable Mass Action Treatment. The added benefit here is that it negates the need to identify discrete locations where safety barrier terminals had contributed to high severity crashes.

- **Pavement skid resistance improvements:** Similarly, if a multi-lane road had exhibited a high number of aquaplaning accidents, a skid resistance resurfacing treatment could be applied as a mass action treatment. Regardless of whether the accidents were evenly distributed over each lane, the Mass Action treatment would seek to upgrade skid resistance in all lanes to avoid migration of the problem to adjacent traffic lanes.

Step 1: Construct factor matrices

As previously indicated, the Factor Matrix enables the identification of common accident characteristics along a whole route to be determined. Generic countermeasure treatments to address these accident problems may be applied as a Mass Action treatment.

Additional Factor Matrices can also be constructed for subsections of the route, the end points of which can be identified by changes in the environmental characteristics of the route. These Factor Matrices may or may not contain the accidents which occur at the sites where clustering occurs, depending on the nature of these sites.

Step 2: Draw collision diagrams

Route diagrams can be prepared following the same principles as in Step 2 of the Site Analysis. The only difference in approach is that instead of a site drawing, a drawing of the route will be used. As well as each route diagram, separate diagrams should be produced for those locations where accidents are clustered.

The accidents that are depicted on the Collision Diagram depend on the type of Mass Action analysis being undertaken. For example, if a Mass Action analysis was undertaken in attempt to find countermeasures for all off-road accidents, then only the off-road accident types (from the DCA 700 and 800 series) would be depicted on the Collision Diagram.

The added benefit of the Mass Action approach is that it may not always be necessary to identify discrete locations of accidents. For example, if a route-based Mass Action study aimed to treat all off-carriageway accidents between two points X and Y, then the team would only be required to determine the number of off-carriageway accidents between X and Y. The actual location of each accident is less relevant as the Mass Action treatment would be applied to the whole (homogenous) section from X to Y. If the team can easily identify the number of off-carriageway accidents between X and Y, the mapping of accidents on a Collision Diagram may not be required.

Step 3: Need for additional information

Similar to Site analysis, Steps 1 and 2 may raise questions regarding the location or coding of one or more accidents along the route, or it may be considered more information is required to identify common factors. This may include PP4 forms (these may provide more accurate location information), skid resistance data, Gipsicam images and road asset inventories, traffic volume data, speed data, pedestrian counts, origin-destination studies, observational studies (including videos and crash cameras) and vehicle classification surveys

Step 4: List possible problems

The analysis tools as undertaken above should enable the team to speculate possible road safety problems and conceptualise likely treatments. This may be possible for the route as a whole, subsections of the route or individual cluster locations along the route. The field investigations should be used to confirm these speculated problems as well as identify any problems that were not apparent from the data analysis.

7.2.2 Area-based Mass Action analysis

Mass Action analysis and treatment can also be area-based. The area may be defined as a local precinct bounded by a number of major arterial roads or the built up area of a country town. Area-based Mass Action treatments involve the systematic investigation of locations within the area with accident clusters, the identification of commonalities of accidents and treatments in the entire area and possibly even investigations of accident clusters around the area. Such studies would also aim to identify correlations between traffic network and management problems and accident problems, e.g. motorists using short cuts along residential streets in order to avoid delays along the arterial road network. Solutions resulting from area-based Mass Action studies should be integrated into a total scheme to ensure that new safety problems are not created elsewhere. In urban areas, an area-based study

could also be integrated with LATM studies, as this could also enable a more structured approach to public consultation to be made.

Figure 7.4 shows an area with a number of evenly distributed accident clusters. The treatment of individual intersections (site/blackspot approach) may lead to changes in traffic behaviour and possibly even a re-distribution of traffic to other competitive routes thereby increasing accident potential at neighbouring sites. Contrastingly, an area-based Mass Action treatment would aim to eliminate or reduce the prominence of a common hazard at all locations as well as ensuring that the accident problem does not migrate to neighbouring sites or routes.

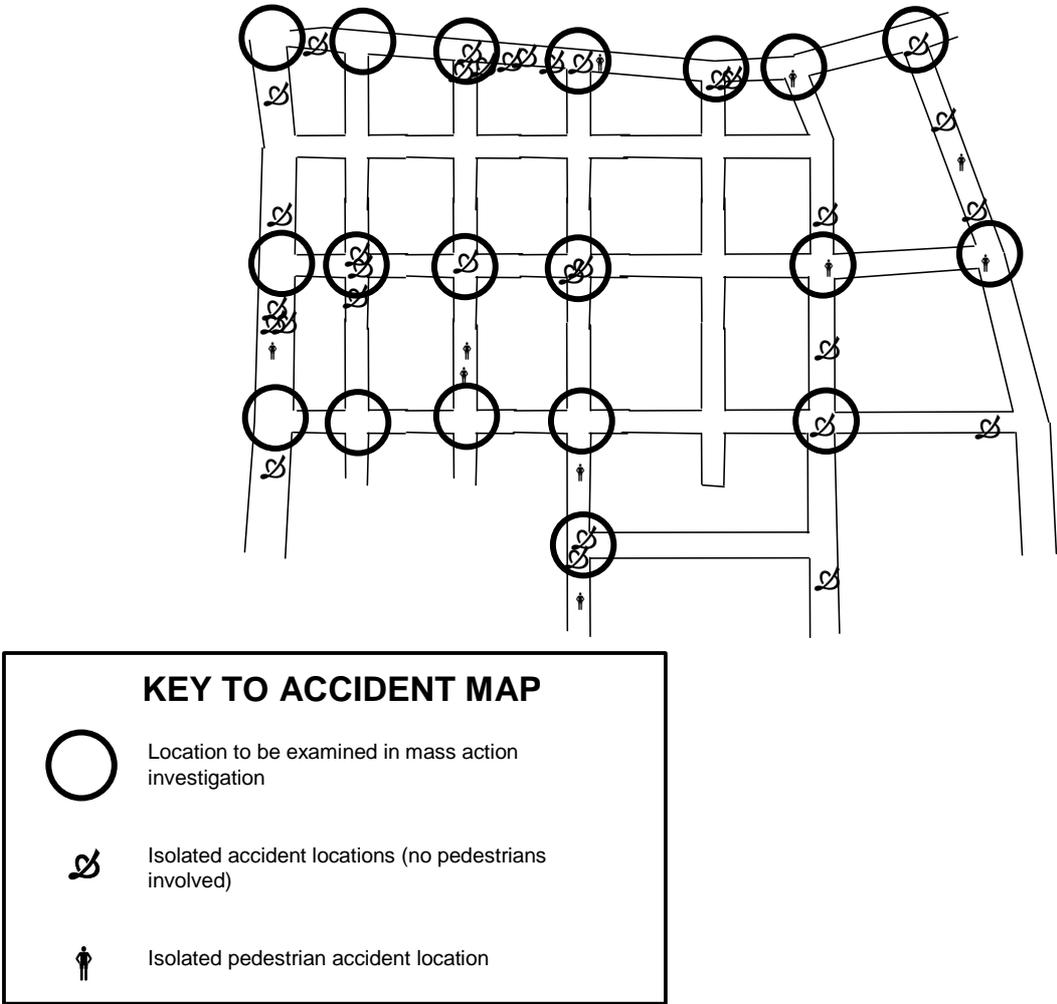


Figure 7.4: Mass action treatments can be applied to a number of intersections of similar character provided that the benefits of reducing accidents outweighs the costs of treating all intersections

Some examples of area-based Mass Action treatments include:

- Area-wide pedestrian safety improvements including wider, better-lit footpaths, and crossing points. The benefits of improving sites which had experienced pedestrian accidents should outweigh the costs of applying the treatment to all locations within the area with pedestrian safety demands.
- Adjustments to the co-ordination of signal phasing for closely located signalised intersections to maximise traffic capacity and minimise conflicts between competing traffic streams. The benefits of reducing accidents at the cluster sites should outweigh the costs of applying this treatment to all signalised intersections in the study area.

The preliminary analysis of the accident component of area-based Mass Action studies is similar to that outlined for routes and sites. However, in listing possible problems and solutions, there is the added emphasis on linking these to inadequacies across the road network under investigation.

Step 1: Construct factor matrices

As well as an overall Factor Matrix for the entire area, separate Factor Matrices should be constructed for each location where accidents cluster and for each route or street within the area. It may also be possible to identify precincts within the area. Additional Factor Matrices can also be constructed for subsections of major routes.

It can also be useful to construct Factor Matrices for the area not including those locations where accidents clustered. This is because a few locations with accident clusters can act to distort the overall accident pattern within the area. For example, there could be right angle accidents clustered at two locations but few elsewhere in the area. A Factor Matrix including these two locations could give the impression that a right angle accident problem is a characteristic of the entire area.

Step 2: Draw collision diagram

For area-based Mass Action studies, the Collision Diagram will depict accidents and accident clusters for the entire area. It can be beneficial to identify smaller accident clusters, since physical treatments on local roads may be considerably cheaper than the equivalent treatments on higher volume roads. In addition to being low cost treatments, some of these treatments may not be appropriate on high volume roads (eg. traffic calming measures).

The added benefit of the Mass Action approach is that it may not always be necessary to identify discrete locations of accidents. For example, if an area-based Mass Action study aimed to treat all pedestrian accidents in an area, then the team would only be required to determine the approximate locations of pedestrian accidents. It may not be necessary to determine the precise location of each accident as the Mass Action treatment would be applied to the whole (homogenous) area. This will simplify the Collision Diagram which may be beneficial if a large area is being studied or there are a large number of AIPs to complete.

Step 3: Need for additional information

Similar to Site analysis, Steps 1 and 2 may raise questions regarding the location or coding of one or more accidents in the area, or it may be considered more information is required to identify common factors. This may include PP4 forms (these may provide more accurate location information), skid resistance data, traffic volume data, speed data, pedestrian counts, origin-destination studies, observational studies (including videos and crash cameras) and vehicle classification surveys. The team may also be required to compare this additional information with landuse/property plans as well as the existing road hierarchy.

Step 4: Relate accident characteristics to apparent network deficiencies

Using the analysis tools as described above, an attempt should be made to correlate the identified accident patterns to apparent network deficiencies. For example a grid pattern layout on residential streets may result in right angle accidents at intersections. Also accidents at intersections of major and minor roads may be due to the use of minor roads by through traffic or the provision of inadequate access to residential areas (sometimes the result of inadequate planning for land use changes).

Step 5: Identify possible countermeasures

For an area-based Mass Action study, countermeasures will be aimed at:

- Treating specific locations where accidents are clustered.
- Decreasing exposure by diverting traffic from certain routes, where appropriate.
- Increasing traffic friction on certain routes to either divert or slow traffic by traffic calming measures.
- Treating those locations to which traffic may be diverted.

By considering individual cluster locations as well as road safety problems in the area as a whole, the team should develop possible Mass Action treatments that can be implemented for the whole area. Any proposed measures should take into consideration the function and traffic characteristics of the road. Suggested countermeasures could be at locations where no accidents occur, on the basis that traffic would be diverted to these locations by measures being considered elsewhere.

The application of a treatment on a Mass Action basis also aims to improve the uniformity and consistency of the treatment in the area. For example, if roundabouts are considered for the intersection of local streets on a grid network where accidents are clustered, then similar roundabouts could be suggested for those intersections with lesser or no accident history. This also minimises the potential for migration of the identified accident problems.

If it appears that devices are required in residential or commercial areas, then the study should probably be widened to include a wider amenity based approach, incorporating a structured public consultation component.

8. Field Investigations

Field Investigations associated with AIP projects primarily involve site, route and area inspections by the team. However, these can also include any additional on-site information that is warranted following the analysis stages. This may include traffic counts, origin-destination surveys, vehicle classification surveys, observational studies, and skid resistance and pavement condition tests.

The preceding analysis work may have enabled the team to identify possible causal factors of the accidents as well as countermeasure options that may be effective in addressing the problems. At the very least, the completion of the analysis work should have identified some issues that need to be further assessed through Field Investigations. In either case, the team can more effectively carry out the Field Investigations by summarising the analysis findings either in a list or on a base map of the site, route or area. As such the site inspections will have the following functions:

1. To confirm accident causal factors as suspected from the analysis.
2. To determine whether concept countermeasures will be effective and practical.
3. To correlate analysis findings and additional information with the site, route or area to gain a better appreciation of the problems.
4. To identify any accident causal factors that were not apparent through the analysis of the data.
5. To develop any additional countermeasures that were not foreseeable at the data analysis stage.
6. To view and “experience” the site, route or area in simulation of a typical road user. This would be conducted within reasonable limits and in accordance with Occupational Health and Safety (OHS) requirements.
7. To observe traffic and road user behaviour.
8. To document site findings and take photographs.
9. To determine whether any additional information or research is needed.
10. To measure and survey the site with respects to countermeasure design.

The effectiveness of the Field Investigations depends on the extent of background work that is undertaken. A well prepared team having completed a holistic desktop analysis of the site, and having obtained and analysed all available additional information prior to the investigation will have a better understanding and appreciation of the accident problems.

The extent of background work also governs the equipment and expertise required for the Field Investigations. Typical equipment that is required for all site, route and area inspections includes retroreflective high visibility safety vests, an instrumented vehicle with flashing lights, a camera (possibly even a video camera) and measuring wheel. For specific situations, the team may require additional equipment such as an inclinometer, a ball-bank indicator, or engage specialist services such as a skid resistance tests, additional traffic counts, origin-destination surveys, vehicle classification surveys, or road safety audits/findings. The background work may also highlight various expertise required in Field Investigations such as expertise in road design and safety barriers, maintenance and pavement condition, a representative from Police highway patrol, local government engineers and asset managers, landuse planners etc.

Where it is practical and safe to do so, the team may benefit more from conducting the Field Investigations under conditions that were prevalent for a large proportion of accidents such as during wet weather, night-time, or during peak-periods.

Any site, route or area inspections should include both a drive-over and walk-over inspection. These have been described in Sections 8.1 and 8.2.

8.1 Drive-over inspection

The drive-over allows the team to correlate accident data to road characteristics, traffic behaviour and driver perception. It encompasses the total road environment including topography, landscape, road and traffic facilities. It provides an opportunity to relate driver expectation with the facilities provided including checking that messages to drivers are clear and concise.

For practical reasons a car is normally used for the drive-over inspections. However it should be recognised that vehicle characteristics are often an important factor in accidents, such as the driver eye-height variations with different vehicles. In exceptional circumstances it may be necessary to experience the road as the 85th percentile⁶ road user involved in an accident. For example, in the past, motorcycle riders have been engaged under a stringent set of OHS requirements, to ride along several routes which had a high volume of motorcycle riders and report on their perceived safety concerns. Although this was conducted as a part of a Motorcycle Safety Thematic Road Safety Audit, this practice could also be used for AIPs if warranted.

In a drive-over, the investigation team should use all approaches to the site, route or area and repeat manoeuvres (within reason and in accordance with traffic rules and OHS guidelines⁷) featured in the accident data.

On a route study there is a heavy emphasis on road continuity and driver expectation. The route is treated as one continuous site. However locations with some degree of accident clustering should be examined in more detail and reported separately, with any measures recommended being consistent with the rest of the route.

A common deficiency encountered on a route involves driver expectation not being met. Thus the "drive-overs" of a route-based Mass Action study should involve checking that clear and concise warning is consistently given.

For an area-based Mass Action study, drive-over inspections should be carried out in a logical sequence with the emphasis on consistent area and route treatments, paying particular attention to those locations having histories of accident clustering. The team should be mindful of the objectives and proposed treatments for the entire area as well as the potential for accident migration.

Participants involved in the drive-over are likely to know the road to varying degrees. Therefore the following arrangements should be adopted to make the drive-over inspection as objective as possible:

- The driver should be the least familiar.
- The front seat passenger the next least.
- The remaining person(s) in the rear, the most familiar.

Each participant has a specific task as detailed in Table 8.1.

Table 8.1: Involvement of each participant involved in the drive-over of the site, route or area.

Participant	Tasks
Driver	To approach the site or drive the route "normally" and inform the others of the level of risk (see note below) perceived and any difficulties in reading the road ahead, such as, "didn't get much warning of that" or "sign missing" or "that curve has a poor alignment".
Front Passenger	To concentrate on surrounding and abutting land, and interpret what message the external environment is passing to the driver. Matters which should be covered are topography, vegetation (near and far), natural views, false indicators of road alignment, items of specific visual interest, advertising or other distractions including degree of development and number of accesses, parking or manoeuvring.
Rear Passenger(s)	Can fulfil up to three functions as required. The first is to document team observations. A tape recorder may assist. The second is to identify the site, route or area to be studied prior to approaching. The third task is to note any roadside or background changes and any breaks in the consistency of the driving environment such as width of carriageway or shoulders.

⁶ This is an example figure only.

⁷ The team should undertake all drive-over inspections in accordance with the RTA's Traffic Control at Worksites. Manual. Any potentially unsafe work practices should be identified and addressed by a Safer Work Method Statement or abandoned for a safer methodology.

Note: It is important to be aware of the relationship between perceived and actual risk. A road element can become hazardous when the actual risk is greater than the perceived risk, for example on the approach to a curve which tightens as a vehicle negotiates it and where this tightening is obscured on approach to the curve. Also a road that is perceived as safe by a driver may increase vehicle speeds, thereby increasing accident likelihood and severity. Also, such roads may not have an adequate level of safety for other road users, (for example 15 metre wide local or collector street may seem a safe road for drivers but will encourage high speeds and increase risk for pedestrians).

Only particular problems signalled by car movement or driver remarks during the drive over should be noted. The physical state of the road can be dealt with during the walk-over inspections.

On completion of the drive overs, the team should discuss the journey and note any special points of concern, any lapses of consistency and any appreciable changes in environment.

8.2 Walk-over inspection

The walk-over inspection is a more detailed examination of the location and driver behaviour. Where it is practical and safe, the walk-over should be carried out during conditions that were prevalent for most of the accidents to more accurately determine the potential accident causal factors. The physical details of the site, route or area can be obtained under any conditions and at the team's convenience.

For practical purposes, the team will need to be more selective with locations of walk-over inspections of routes and areas. It is clearly not feasible to carry out a walk-over inspection of a 5km long route. In this instance, the team will carry out most of the inspections via the drive-over and select a number of individual locations to carry out the walk-over inspection. As a minimum, a walk-over would be required on a route or area at all cluster locations as well as locations where the Mass Action treatment would be applied (even those without accident clusters).

The walk-over is the most convenient time to:

1. Confirm accident causal factors as suspected from the analysis.
2. Determine whether concept countermeasures will be effective and practical.
3. Correlate analysis findings and additional information with the site, route or area to gain a better appreciation of the problems.
4. Identify any accident causal factors that were not apparent through the analysis of the data.
5. Develop any additional countermeasures that were not foreseeable at the data analysis stage.
6. Document site findings and take photographs.
7. Measure and survey the site with respects to countermeasure design.

In cases, where there was a large incidence of pedestrian accidents, the walk-over also allows the team to view the site, route or area as a pedestrian.

Similar to the drive-over, all walk-over inspections should be undertaken in accordance with relevant OHS guidelines. Where work practices are potentially unsafe, a Safer Work Methods Statement should be prepared or the task should be abandoned for a safer alternative.

8.3 Determining and documenting countermeasure options

At this stage, the team would be able to correlate the analysis results with the drive-over and walk-over inspections and develop appropriate countermeasures to reduce or eliminate the accident problems. Proposed countermeasures should be realistic and not an unachievable "wish list".

When determining a suitable countermeasure, the viability of the proposal should be taken into consideration. In particular:

- Is the measure likely to result in a reasonable safety benefit cost ratio? If not then it is unlikely to be implemented in the short term.
- Is there a lower cost solution which would allow the accident problem to be addressed with a greater priority?

- Is the countermeasure likely to result in accident migration as a result of vehicles using alternative routes, (this could result from vehicle delay being increased due to inappropriate levels or from the re-routing of traffic)?
- Is the countermeasure likely to result in community opposition making its later implementation doubtful?

In cases where the team is having difficulty determining countermeasures, it may be necessary to repeat the walk-over and drive-over, as well as consult with relevant experts or obtain additional information.

Once the countermeasures have been determined, the team should document the site, route or area findings and take photographs where practical and safe to do so. Photographs should highlight the problems, show locations of proposed countermeasures and show the facilities that will be altered by countermeasures. The location and direction of camera shots should be noted on the collision diagram.

Sufficient preliminary design measurements should be taken to enable costs of countermeasures to be estimated.

8.4 Field Investigation Checklist

The following checklist questions are intended as prompts to ensure that a holistic Field Investigation has been carried out. The Checklist is not intended to be an exhaustive list.

- Have the analysis findings been correlated with field investigation findings?
- Is any further information or specialist advice required? (Policy, standards, best practice notes, information from local residents and businesses)
- Is there a need to consult with other authorities? (Energy authorities, Local Government, Police)
- Are there any further Field Investigations needed? (skid resistance testing, traffic surveys)
- Is a re-visit to the site, route or area required?

9. Economic evaluation of proposed countermeasures

The economic assessment of the proposed countermeasures should be carried out using the standard benefit cost spreadsheet model supplied by the Road Safety, Licensing & Vehicle Management Directorate. The parameters in this model are updated annually in the RTA's Economic Analysis Manual to provide updated accident costs and levels of effectiveness for each countermeasure. The use of this model ensures a uniform approach to the calculation of benefits associated with safety countermeasures resulting from AIP investigations. This model is shown in Figure 9.1.

The following information should be used in the calculation of the safety benefit cost ratios:

- The type of countermeasure proposed. *Appendix C: Percentage Reduction in Accidents due to Countermeasure treatments* contains (i) a list of standard countermeasure treatments numbered from 1 to 133 and (ii) assumed levels of effectiveness for each of the countermeasures in reducing accidents (expressed as “percentage reduction in accidents”). The percentage reductions in accidents are provided for both high and low speed intersections and midblocks. The tables also provide accident costs for each accident type or group.
- The assumed percentage accident reduction values should be used whenever possible. Only in cases where the countermeasure is not a standard treatment in the benefit cost model, or in specific situations which can be justified, should custom reduction figures be used instead. Examples of this include cases where external or indirect consequences of the countermeasure treatment may result in an added accident reduction. It is equally important to ensure that any potential negative percentage reduction (i.e. an increase) in accidents is accounted for. For example, while median safety barriers will have a reduction in head on accidents, these accidents will be converted into collisions into the barrier (“off carriageway on curve into object”). This increase must be accounted for in the benefit cost analysis as a negative percentage reduction.
- The speed limit. This governs whether the site, route or area is classed as a low or high speed site. Accident costs on high speed roads tend to be higher than equivalent accidents on low speed roads.
- The estimated initial cost of the proposed countermeasure. Effort should be made to ensure that the estimate is as accurate as possible.
- Any ongoing or maintenance costs associated with the countermeasure. For example the running costs of improved lighting or the costs of running traffic signals.
- Any annual growth expected in traffic volumes over the study period expressed as a percentage.
- The number of accidents of each type which are expected to be affected by the countermeasures proposed. In most cases, this information would be easily extracted from the Factor Matrix.
- The “service life” of the countermeasure. This is the duration that the countermeasure can be expected to remain effective for. This is translated into the period for which benefits can be accrued over and the period for which ongoing annual maintenance costs will apply.

9.1 Calculation of benefits and costs

When calculating the benefit cost ratio (BCR) for a project to be funded under the Blackspot or Mass Action program, the *benefits* will be calculated using accidents savings only. While other quantifiable benefits such as improved access and network efficiency as well as “negative” benefits (eg. increased delays) are not included in this benefit cost analysis, they should still be considered and recognised before implementing the countermeasure(s).

Figure 9.1 shows the spreadsheet model to be used to calculate the BCR and Net Present Value (NPV). Notes for the use of this model are provided in Appendix D.

LOCATION:			TREATMENT A				TREATMENT B				TREATMENT C			
50	Speed Limit of Main Road	50	4: New Traffic Signals: No Filter Turns Allowed				34: New Signing - Intersection Warning (can include flashing lights with sign)				35: Move Limit Lines Forward Using Kerb Extensions on Priority Road			
2.0	Expected Annual Traffic Growth (%)	200%	Initial Cost of Treatment			Initial Cost of Treatment				Initial Cost of Treatment				
10	Assumed Project Life	10	Annual Maintenance			Annual Maintenance				Annual Maintenance				
5.75	Years of Accident Data/Start	Jan-97	Treatment Code	4		Treatment Code	34			Treatment Code	35			
DCA Codes	Descriptions	Total Accidents	Target Accidents	Assumed Reduction	Custom Reduction	Discounted Benefits (RTA 7%)	Target Accidents	Assumed Reduction	Custom Reduction	Discounted Benefits (RTA 7%)	Target Accidents	Assumed Reduction	Custom Reduction	Discounted Benefits (RTA 7%)
101-109	Intersection, adjacent approaches			60		\$0		15		\$0		20	5	\$0
201	Head-on			0		\$0		0		\$0		0		\$0
202-206	Opposing vehicles; turning			90		\$0		0		\$0		0		\$0
207; 304	U-turn			0		\$0		0		\$0		0		\$0
301-303	Rear-end			-40		\$0		25		\$0		0		\$0
305-307	Lane change			0		\$0		10		\$0		0		\$0
308-309	Parallel lanes; turning			0		\$0		0		\$0		0		\$0
406; 407	Vehicle leaving driveway			0		\$0		0		\$0		0		\$0
503-506	Overtaking; same direction			0		\$0		0		\$0		0		\$0
601	Hit parked vehicle			0		\$0		0		\$0		0		\$0
903	Hit railway train			0		\$0		0		\$0		0		\$0
001-003	Pedestrian crossing carriageway			10		\$0		0		\$0		0		\$0
605	Permanent obstruction on carriageway			0		\$0		0		\$0		0		\$0
609	Hit animal			0		\$0		0		\$0		0		\$0
701; 702	Off carriageway, on straight			0		\$0		0		\$0		0		\$0
703; 704	Off carriageway on straight, hit object			0		\$0		0		\$0		0		\$0
705; 502	Out of control on straight			0		\$0		0		\$0		0		\$0
801; 802	Off carriageway, on curve			0		\$0		0		\$0		0		\$0
803; 804	Off carriageway on curve, hit object			0		\$0		0		\$0		0		\$0
805	Out of control on curve			0		\$0		0		\$0		0		\$0
	TOTAL	0	0	TOTAL		\$1,275,889	0	TOTAL		\$0	0	TOTAL		\$0
	BCR Combining Treatments A & B for RTA (7%)		B/C Ratio @ 7%	NPV/Cap Cost	NPV @ 7%	Discounted Costs	B/C Ratio @ 7%	NPV/Cap Cost	NPV @ 7%	Discounted Costs	B/C Ratio @ 7%	NPV/Cap Cost	NPV @ 7%	Discounted Costs
	BCR Combining Treatments A, B & C for RTA (7%)				\$0	\$0			\$0	\$0			\$0	\$0

Figure 9.1: Spreadsheet Model for the Calculation of Road Safety Benefit / Cost Ratios and Net Present Value (Release 02)

Costs are determined by adding the initial cost to install the countermeasure treatment with the ongoing maintenance costs throughout the life of the treatment. The installation of the countermeasure(s) would incur a cost due to the supply and delivery of the material, the actual work involved, as well as the project management costs and any overheads. Ideally, the determination of the costs for installing the countermeasure(s) would rely on a detailed cost estimate or quotation from a service provider which itemises each cost element following an investigation of the site and identification of all geometric and environmental constraints. By properly scoping each cost item involved in the installation of the proposed countermeasure treatments the estimated *cost* component and hence the BCR would be as accurate as possible. Where there is insufficient time or resources to obtain a cost estimate in this manner, it is acceptable to base the cost estimate on historic costs. However, where this method is used, the year-by-year changes in supply and installation costs should be accounted for, eg. A cost estimate for a section of guardrail based on a project completed five years earlier would not be accurate. A comparison of estimated costs to *actual* costs should be used to refine the accuracy of future cost estimates. For example, one Region may find that over time, it has consistently overestimated the cost of curve warning signs. By recognising this, they may adjust future cost estimations accordingly.

In a similar manner, the estimation of maintenance costs would be more easily achieved by using historic costs.

For a site analysis, the benefits and costs are centralised at one location, such as an intersection or a short section of a route. This has been illustrated in Figure 9.2 using the Beach Highway/Harold Drive example from Section 7.1. One possible countermeasure for this example is to ban the filtered right turn movements into Harold Drive (assuming that the intersection is signalised). In this respect, the *benefits* would be calculated by determining how many of the 24 accidents of type DCA202 would be reduced by this countermeasure. The costs would be calculated by estimating the costs to install any hardware adjustments (ie. right turn arrow aspects on the signal lanterns), software adjustments in adjusting the phasing of the signals and the ongoing maintenance costs throughout the life of the signals. The benefit cost analysis for this countermeasure has been shown in Figure 9.3.

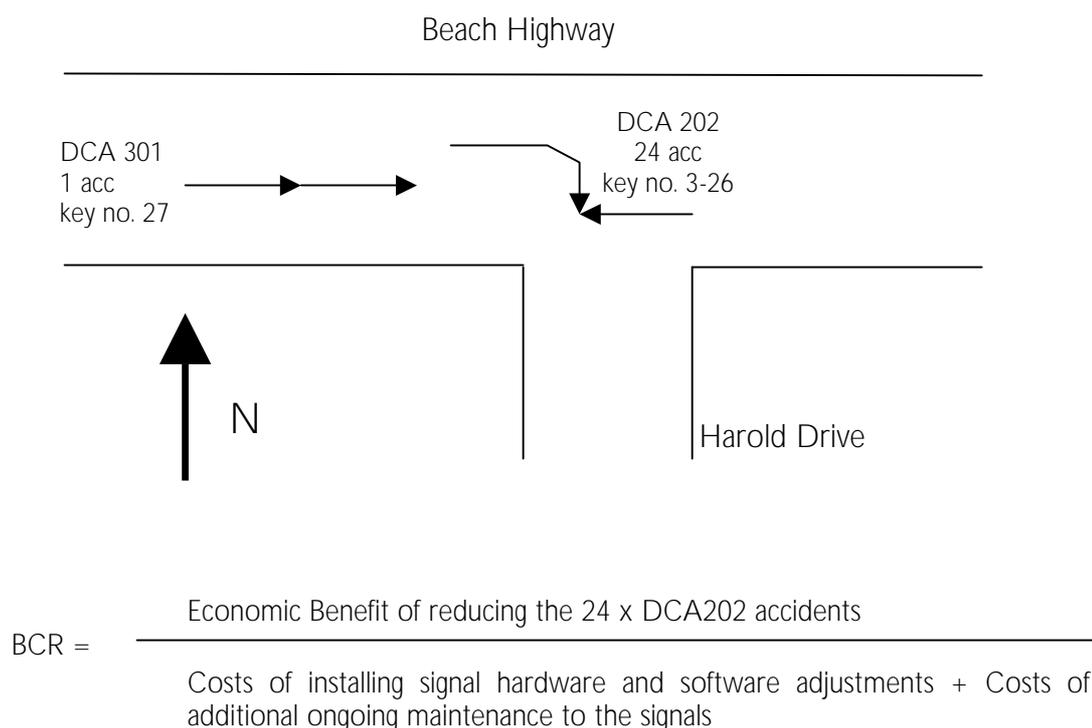


Figure 9.2: For a site analysis, the benefits and costs are centralised at one location

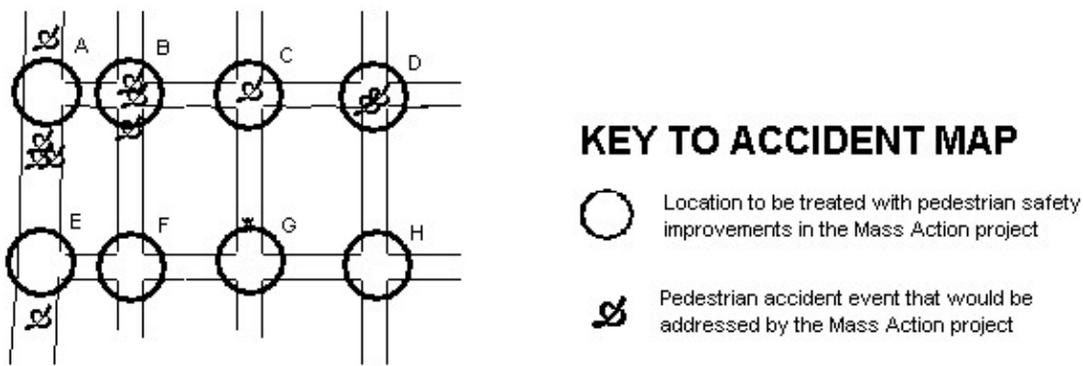
As seen in Figure 9.3, a BCR of 16.4 was calculated for the installation of additional signal hardware, and phasing changes to effectively ban the filtered right-hand turn into Harold Drive. Some points to note about this benefit cost analysis are:

- The treatment is described as being “4: New Traffic Signals: No Filter Turns Allowed” which implies that there were no signals to begin with. This item number (item 4) was selected because it most closely reflects the type of countermeasure treatment that is proposed. Therefore, the assumed percentage reductions for each accident type are likely to be similar. Appendix C has a list of countermeasures for which there are assumed percentage accident reduction figures.
- The assumed percentage reduction in DCA202 accidents as a result of installing **new** signals with no filtered right turns is 90%. However, it is incorrect to assume that DCA202 accidents will be reduced by 90% by simply banning the filtered right turn on an **existing** signalised intersection. Therefore, a custom reduction value of 70% has been used. Any non-zero percentage value entered in the custom reduction automatically overrides the default value of 90%.
- The negative benefit in rear-end accidents implies that rear-end accidents will actually increase (by 40%) as a result of installing new signals. To make keep the BCR calculation conservative, it is assumed that banning of the filtered right turn on an existing signalised site will have a similar “negative benefit”. This also highlights the importance of accounting for all accidents that stand to be increased as a result of the works.

LOCATION		Intersection of Beach Highway and Harold Drive		TREATMENT A		
Speed Limit of Main Road		90	4: New Traffic Signals: No Filter Turns Allowed			
Expected Annual Traffic Growth (%)		2.0	Initial Cost of Treatment		\$160,000	
Assumed Project Life		10	Annual Maintenance		\$8,000	
Years of Accident Data		5.00	Treatment Code		4	
DCA Codes	Descriptions	Total Accidents	Target Accidents	Assumed Reduction	Custom Reduction	Discounted Benefits (RTA 7%)
101-109	Intersection, adjacent approaches			60		\$0
201	Head-on			0		\$0
202-206	Opposing vehicles; turning	24	24	90	70	\$3,581,783
207; 304	U-turn			0		\$0
301-303	Rear-end	1	1	-40		(\$41,771)
TOTAL		25	25		TOTAL	\$3,540,011
			B/C Ratio @ 7 %	NPV/Cap Cost	NPV @ 7%	Discounted Costs
			16.4	20.8	\$3,323,824	\$216,187

Figure 9.3: The BCR calculation for the banning of filtered right turns at the intersection of Beach Highway and Harold Drive

The benefits and costs for a Mass Action analysis are usually distributed over the whole route or area being treated. As described in Section 7.2, Mass Action treatments are applied to locations within the route or area where the hazardous feature is present regardless of whether there were accident clusters at those locations. For a Mass Action treatment to be economically viable, the benefits of reducing accidents at the cluster locations should outweigh the costs of applying the treatment to all locations (cluster locations and non-cluster locations). In this respect, since the Mass Action treatment may be applied to locations where few or no accidents occurred and for which there is no quantifiable benefit, there will usually be more locations within the Mass Action route or area that accrue *costs* compared with those that accrue *benefits*. This is illustrated in Figure 9.4.



$$\text{BCR} = \frac{\text{Benefit of reducing pedestrian accidents at sites B, C and D}}{\text{Installation and maintenance costs accrued for sites A, B, C, D, E, F, G, H}}$$

Figure 9.4: For a Mass Action analysis, the benefits and costs are aggregated over all treated locations

The collision diagram and equation in Figure 9.4, further illustrates how *costs* are accrued at more locations than *benefits* with Mass Action treatments. It also shows how aggregation of benefits and costs over several locations often results in a BCR which is less than if individual BCRs were calculated for each of the cluster locations (B, C and D). However, the advantages are that there is less potential for the accident problem to migrate to a neighbouring intersections/routes and there is better uniformity of treatment across the route or area being treated under the Mass Action project.

9.2 Consideration of other impacts of countermeasures

The benefit cost analysis on the Beach Highway/Harold Drive intersection in Section 9.1, highlighted the possibility of countermeasures having a potential negative effect on some accidents. In this example, the installation of new signals, or the enhancement of existing signals was assumed have a negative effect on rear-end accidents by increasing them by 40%. Another example is the installation of a median safety barrier, which would accrue benefits by reducing the occurrence of head-on accidents. However, it will significantly change the nature of off-carriageway to the right accidents, particularly where there was no object impacted. These off-carriageway accidents would be converted into off-carriageway into object type accidents which is a *negative benefit* that should be accounted for.

It is important that the benefit cost analysis is diligently carried out to account for any possible negative impacts. Failure to identify these will lead to an overestimation of accident-saving benefits.

Another potential negative impact of countermeasures is the way they may change traffic flows and road user behaviour. For example, if right-turns are banned at an intersection to reduce accidents involving right turners, then the extra traffic that is shifted to nearby intersections may lead to a migration of accidents to these intersections. Traffic calming measures may also result in a shift of traffic to more competitive routes thereby increasing accident exposure on these routes.

Countermeasures can also have an adverse effect on road user behaviour. The installation of traffic signals to prevent right-angled accidents may increase delays and driver impatience, leading to non-conforming behaviour such as "running the red light" and speeding.

The benefit cost analysis technique used for RTA site and Mass Action studies incorporates ongoing maintenance of the countermeasure throughout its design life. Some countermeasures that are inexpensive to implement may carry a high maintenance liability. It is important to give a conservative estimate for the ongoing annual maintenance costs as well as make a reasonable estimate of the countermeasure's design life. A durable countermeasure will have a long replacement cycle and offer countermeasure's design life. A durable countermeasure will have a long replacement cycle and offer accident-saving benefits for a longer period. As well

as maintenance costs, which are quantifiable, the team should acknowledge any other maintenance burdens introduced by the countermeasure. The countermeasure may be supplied by an overseas manufacturer and hence adds difficulty in replacing or repairing damaged units. The countermeasure may also be difficult to access or have significant OHS implications.

Where the countermeasure proposed will have an adverse effect on traffic flow, road user behaviour, and maintenance liability, the viability of the countermeasure should be taken into consideration. The relevant sections of the RTA or Council should be consulted to properly account for any negative impacts.

A package of countermeasures to be applied as a part of the same project should also be scoped to ensure that the function of one countermeasure does not affect the performance of other countermeasures. For example, if a number of guidance and warning signs are installed at a site, some of the signs may end up obscuring other signs.

9.3 Multiple countermeasures

For sites, routes or areas, multiple countermeasures may be developed as:

- separate options to be compared by BCR allowing the most effective option to be selected; or
- multiple countermeasures to be implemented as a package.

For the evaluation of separate options, a separate entry should be made for each option to enable the BCRs to be compared. Figure 9.5 shows an example of two countermeasure options, Treatment A and Treatment B, proposed for a fictitious route with the objective of addressing a large number of off-carriageway accidents.

In this example, the BCRs for the two options can be compared to determine which option would offer better value for money. From the analysis, it appears as though Treatment A offers better value for money by having a BCR of 11.3 compared with that of Treatment B which has a BCR of 3.3. Treatment A also performs better in absolute terms in reducing \$905,276 worth of accidents compared with Treatment B which only reduces \$153,928 worth of accidents. If discounted benefits predicted for each countermeasure option are compared, and where those options are mutually exclusive⁸, care should be taken to ensure that the “project life” (ie. service life) of the countermeasures used in the analysis is the same. It is incorrect to compare a treatment that will remain effective for 10 years with a treatment that will remain effective for 25 years.

As described in Section 3.2, it is also worth considering the overall benefits of proposed treatment options. BCRs are a good measure of cost effectiveness and “value for money” invested in the road safety project. However, comparison by BCRs may not always identify the most effective project for the long term. It is important to acknowledge that very few treatments will eliminate 100% of accidents occurring at a location. In this respect, it is necessary to examine the residual accidents and the feasibility for addressing these once an initial treatment has been implemented. For example, it is more difficult to upgrade a roundabout (initial treatment) to a traffic signal controlled intersection (subsequent treatment) as opposed to constructing the traffic signal controlled intersection from the outset as the first treatment.

⁸ “Mutually exclusive” refers to countermeasure options where one or the other (but not both) can be implemented at a site. These may be due to one countermeasure option limiting or hindering the success of the other (ie. a sign placed in front of another sign), or cases where it is physically impossible to have both options installed (ie. a roundabout and a set of traffic signals).

		TREATMENT A			TREATMENT B		
Speed Limit of Main Road	100	Initial Cost of Treatment	\$80,000	Initial Cost of Treatment	\$47,000		
Expected Annual Traffic Growth (%)	3.5	Annual Maintenance	\$0	Annual Maintenance	\$0		
Assumed Project Life	5	Assumed Project life	5	Assumed Project life	5		
Years of Accident Data/Start	5.00	Treatment Code	47	Treatment Code	45		
DCA Codes	Descriptions	Target Accidents	Assumed Reduction	Discounted Benefits (RTA 7%)	Target Accidents	Assumed Reduction	Discounted Benefits (RTA 7%)
301-303	Rear-end	1	0	\$0	1	5	\$3,049
605	Permanent obstruction on carriageway		25	\$0		5	\$0
609	Hit animal		0	\$0		0	\$0
701; 702	Off carriageway, on straight	6	30	\$159,663	6	5	\$26,611
703; 704	Off carriageway on straight, hit object	15	30	\$474,995	15	5	\$79,166
705; 502	Out of control on straight		30	\$0		5	\$0
801; 802	Off carriageway, on curve	4	30	\$105,899	4	5	\$17,650
803; 804	Off carriageway on curve, hit object	6	30	\$164,719	6	5	\$27,453
805	Out of control on curve		30	\$0		5	\$0
TOTAL		32		\$905,276	32		\$153,928
		B/C Ratio @ 7 %	NPV/Cap Cost	Discounted Costs	B/C Ratio @ 7 %	NPV/Cap Cost	Discounted Costs
		11.3	10.3	\$80,000	3.3	2.3	\$47,000

Figure 9.5: The comparison of two route-based countermeasure options for addressing off-carriageway accidents

It is important to recognise that benefit cost analysis is simply an indicative tool used to give some meaning to an otherwise unquantifiable decision. As such it is important that the benefit cost ratios generated by the model are not a substitute for good engineering judgement and experience. For example, the reasons for the success of Treatment A were due to the higher percentage reductions in each off-road accident type leading to higher accident savings (benefits). Experience, continual evaluation and ongoing research may lead to adjustments to these reduction percentages and it may be found that its performance over time is not as good as predicted.

In addition, the model relies on several assumed parameters listed in Table 9.1. Table 9.1 also describes the effect of overestimating and underestimating these parameters:

Table 9.1: The effect of poor assumptions with input parameters in the Benefit Cost model.

Assumed parameter	Effect of overestimating and underestimating this parameter
Project life (ie. service life)	The project life has a bearing on how many years the accident-reducing treatment will be effective for. It also has a bearing on how many years the treatment will have to be maintained for. However, since the benefits of reducing accidents are usually much higher than maintenance costs, overestimation of the project life will yield a higher BCR
Initial cost of treatment	Overestimation of the initial cost will yield a lower BCR. Underestimation will yield a higher BCR.
Annual maintenance costs	Overestimation of the annual maintenance cost will yield a lower BCR. Underestimation will yield a higher BCR.
Assumed percentage reductions in accident type	Overestimation of the percentage reductions will lead to higher accident savings and hence a higher BCR.

Multiple countermeasures can also be applied as a part of the same package of works. In this case, care should be taken to ensure that the same accidents are not targeted for reduction by more than one treatment. Figure 9.6 shows an example of a signalised T intersection that has experienced 15 rear-end accidents in a three year period.

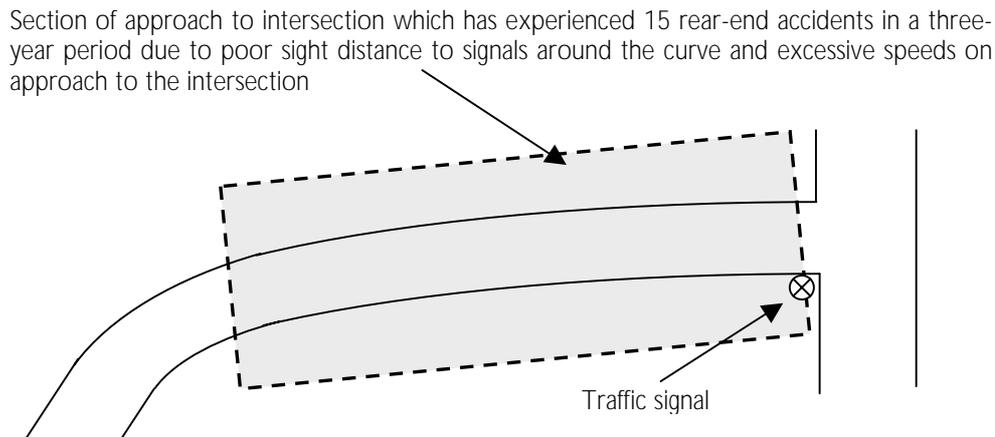


Figure 9.6: An example showing the section of the intersection approach that has experienced a high number of rear-end accidents

In response to the 15 rear-end accident events, two countermeasures have been proposed:

1. The installation of advanced warning signs to the intersection to reduce speeds of vehicles approaching the intersection.
2. The upgrade of the signal posts to a mast arm support posts to increase sight-distance and conspicuity of the signals.

In such situations, it is incorrect to assume that each countermeasure will individually target all 15 rear-end accidents. In reality, the advanced warning signs would lead to a reduction in approach speed which would reduce the probability of a rear-end accident occurring to some degree. The rear-end accident population to be treated by the installation of mast-arm supported signals would be less than 15, as some of these accidents would have been addressed by the first countermeasure. In the benefit cost analysis in Figure 9.7, the assumed percentage reduction in rear-end accidents due to new advanced warning signage (Treatment A) was 25%. However, a more conservative figure of 15% was entered in the custom reduction column to override the default value of 25% due to site-specific reasons limiting the success of this treatment compared with other locations. If 15% of the 15 rear-end accidents are reduced by this treatment, then 85% of the rear-end accidents (12 events) remain to be treated by Treatment B. Therefore at the very most, it can be assumed that the installation of mast-arm signals (Treatment B) will target 12 rear-end accident events. To remain conservative, and as no solution (or package of works) is ever 100% effective in targeted all accidents, only 9 of the remaining rear-end accidents have been targeted by Treatment B. If all 15 accidents were targeted by both treatments then the benefits would be “doubled up”, which incorrectly overestimates the benefits.

		TREATMENT A				TREATMENT B				
Speed Limit of Main Road	60	34: New Signing - Intersection Warning (can include flashing lights with sign)				27: Upgrade signal display (mast arm/additional lanterns)				
Expected Annual Traffic Growth (%)	2.0	Initial Cost of Treatment		\$2,000	Initial Cost of Treatment		\$70,000			
Assumed Project Life	10	Annual Maintenance		\$200	Annual Maintenance		\$300			
Years of Accident Data/Start	3.00	Treatment Code		34	Treatment Code		27			
DCA Codes	Descriptions	Total Accidents	Target Accidents	Assumed Reduction	Custom Reduction	Discounted Benefits (RTA 7%)	Target Accidents	Assumed Reduction	Custom Reduction	Discounted Benefits (RTA 7%)
101-109	Intersection, adjacent approaches			15		\$0		20		\$0
201	Head-on			0		\$0		0		\$0
202-206	Opposing vehicles; turning			0		\$0		10		\$0
207; 304	U-turn			0		\$0		0		\$0
301-303	Rear-end	15	15	25	15	\$140,233	9	25		\$140,233
TOTAL		15	15		TOTAL	\$140,233	9		TOTAL	\$140,233
BCR Combining Treatments A & B			B/C Ratio @ 7%	NPV/Cap Cost	NPV @ 7%	Discounted Costs	B/C Ratio @ 7%	NPV/Cap Cost	NPV @ 7%	Discounted Costs
3.7			41.2	68.4	\$136,829	\$3,405	1.9	1.0	\$68,126	\$72,107

Figure 9.7: A benefit cost analysis of two treatments applied as a part of the same package of works.

This also applies for cases where one low-cost short term solution is implemented first and then followed by a higher cost long term solution after a considerable period. For example, if upgraded signposting and marking is recommended at an intersection as a low-cost measure and if the high-cost measure involves installation of a roundabout, then the benefit cost ratio for the signposting and marking will target all the accidents whereas the roundabout will use those existing accidents minus those which are expected to be saved using the signposting and marking, (where the signposting and marking will be installed as a shorter term measure).

10. Report production

This section covers two types of report production, which are:

- Individual reports of AIP projects.
- A report summarising the results of the whole AIP program.

10.1 AIP project reports

Each AIP project should be documented separately as a formal report. The purpose of the report is to document all research, data analysis exercises, field investigations and site findings, countermeasure development, economic evaluations and recommendations. It should also contain photographs as well as any other information that was researched or obtained during the analysis and investigative stages.

As a guide to the required content of the report it is useful to consider each AIP stage as detailed Table 10.1. The report does not need to be long, but sufficient detail should be given.

Table 10.1: A review of AIP stages to identify key areas for reporting in the Project Reports

AIP Stage	Reference	Details of reporting requirements
Developing a Program of AIP studies	Section 5	This should be mainly reported in the AIP Program Summary Report (Described in Section 10.2). However, in the Project Reports, a limited extent of background information can be provided such as how the project was selected for inclusion in the AIP program. In the Introduction and background of the Project Report, details on the type of AIP being undertaken, and location details and description should also be included.
AIP team, roles and responsibilities	Section 6.1	The Project Report should provide details on the AIP team members or specialists that were consulted for additional information.
Data Collection	Section 6.2	The Project Report should summarise the data collection process. Details of the data and additional information obtained for analysis should be included
Data Analysis	Section 7	The Project Report should provide a summary of the accident history, data analysis methodologies used as well as the analysis findings, including any speculated road safety problems and concept solutions. A copy of the Collision Diagrams and Factor Matrix should also be included in the report.
Field Investigations	Section 8	The Project Report should summarise the field investigation methodology as well as the findings of the drive-over and walk-over inspections. The report should include any photos, maps and sketches taken during this field work.
Countermeasure development	Section 8.3	The Project Report should provide details of the various countermeasures proposed for each accident problem identified as well as the reasoning behind each option and likely impacts of each option.
Economic Evaluation	Section 9	The Project Report should also provide copies of the benefit cost analysis spreadsheets used to evaluate the economic viability of each countermeasure option. All assumptions and reasoning should be included.
Conclusions and recommendations		The Project Report should also correlate analysis findings with field investigations and make recommend viable treatments. A countermeasures diagram may also be included.

A sample report for an AIP study for a *site* has been attached in Appendix E.

10.2 AIP Program Summary Report

In addition to completing a report for each AIP project undertaken, a Summary Report for the whole AIP program needs to be compiled. The purposes of the Summary Report are to:

- Provide the RTA Regions and the Road Safety, Licensing & Vehicle Management Directorate with the information necessary to enable the treatments recommended in individual studies to be combined in a prioritised safety improvement program.
- Form a historical record for checking and monitoring implemented works and designing future works.

The Summary Report should contain details of all studies undertaken, i.e. Site and Mass Action, even if no recommendations were made. Table 10.2 describes some important area to include in the Summary Report.

Table 10.2: Important areas to include in the Summary Report

Component	Reference	Details of reporting requirements
Developing a program of AIP studies	Section 5	<p>Details should be provided on the methodology for selecting Sites, and route and area-based Mass Action studies for inclusion in the AIP Program. Reasons for excluding any studies should be included (eg. problems being rectified by earlier road safety, maintenance or development programs)</p> <p>The Summary Report should document the timeframe in which each AIP project was undertaken</p> <p>The Summary Report should also state whether culled AIPs project would be included in future AIP programs.</p>
Summary of each project		<p>The Summary Report should contain a short summary of each AIP project completed as a part of the program. Details such as proposed countermeasures and their BCRs should be included, and some maps and photographs.</p>
Ranked list of countermeasure/projects		<p>The Summary Report should also provide a ranked list of Site treatments and a ranked list of Mass Action treatments based on BCR. Where there is additional critical information, this should be noted. For example, a proposed countermeasure may have a favourable BCR to proceed but may be faced with a number of site-specific constraints that prevent it from being delivered in the short-term future. Tables 10.3 and 10.4 are examples of a ranked list that may be used to summarise the results of an AIP program for Sites and Route-based Mass Actions respectively.</p>

Table 10.3: Ranked list of sites following an AIP program

<i>Name</i>	<i>Problem</i>	<i>Solution*</i>	Number Accident (5 Yrs)	Accidents Addressed (5 Yrs)	Accident Savings (5 Yrs)	Estimated Cost of selected option	Cumulative Cost	Benefit cost Ratio	Basic Signing Required	Basic Maintenance Required
Colin Rd, 300 metres nth of John St	Tight curve on grade and inadequate guard-rail	Reinforce advisory speed where at apex of where curve tightens for northbound and southbound traffic, RRPM's on outside edgeline. Replace existing guard fencing.	5	5	\$109,900	\$7,000	\$7,000	15.7	YES	YES
Crest Rd/Queen St	No turn bay, narrow road and poor sight distance at intersection	(i) Install markings at throat of intersection and widen and seal shoulder at on western side of Old Northern Rd.	6	5	\$89,000	\$10,000	\$17,000	8.9	YES	YES
Colin Rd, 100 metres nth of Ridge	Deceptive curve, narrow road and inadequate guard-rail	Reinforce advisory speed where at apex of where curve tightens. RRPM's on edgeline. Replace existing guard fencing.	13	10	\$278,850	\$50,700	\$67,700	5.5	YES	YES
Colin Rd, 500 metres nth of Ridge	Narrow Road and sharp curve beyond crest	Widen and seal shoulder. Reinforce advisory speed at apex of curve in both directions. RRPM's outside edgeline. Replace guardrail.	5	5	\$90,240	\$19,200	\$86,900	4.7	YES	YES
Alan Rd West of Crest St	Curve located beyond crest	Widen and seal shoulders, install additional yellow chevrons. Consider later pavement widening and painted median.	4	4	\$185,000	\$37,000	\$123,900	4.5	YES	
West Rd/Kay Dr	Lack of marking and right turn bay	(i) Implement pavement markings at throat of intersection, widen and strengthen sealed shoulder on eastern side of road.	8	5	\$40,000	\$10,000	\$133,900	4.0	YES	
Crest Rd/Sale Pde	No turn bay and narrow road at intersection.	(ii) Implement local road widening and install right turn lanes and painted seagull.	7	6	\$370,000	\$100,000	\$233,900	3.7		YES
Crest Rd/Queen St	No turn bay, narrow road and poor sight distance at intersection.	(ii) Implement local road widening and install right turn bay and painted seagull island.	6	5	\$175,000	\$50,000	\$283,900	3.5		YES
Alan Rd/Cast St	No turn bay and poor sight distance at intersection.	(i) Provide pavement markings at intersection and chevron for side road traffic. Widen shoulder at intersection.	4	4	\$27,810	\$10,300	\$294,200	2.7	YES	
West Rd/Kane Dr	Lack of marking and right turn bay.	(ii) Widen road and introduce right turning lanes and painted seagull island	8	5	\$172,500	\$75,000	\$369,200	2.3		
Alan Rd/Cast St	No turn bay and poor sight distance at intersection.	(ii) Widen road pavement to provide a full right turn bay and improve curve and intersection delineation.	4	4	\$60,000	\$50,000	\$419,200	1.2		
West Rd/Hope St	Lack of marking and right turn bay.	(ii) Widen road and introduce right turning lanes and painted seagull island.	5	2	\$67,500	\$75,000	\$494,200	0.9		
East Rd/Hope St	Lack of marking and right turn bay	(i) Implement pavement markings at throat of intersection, widen and strengthen sealed shoulder on eastern side of road.	5	2	\$6,000	\$10,000	\$504,200	0.6	YES	

* At some sites a lower and higher cost solution has been given. Accident savings for these solutions have been separated.

Table 10.4: Ranked list of Route-based Mass Action Treatments following an AIP program

Name	Problem	Solution	Number Accident (5 Yrs)	Accidents Addressed (5 Yrs)	Accident Savings (5 Yrs)	Estimated Measure Cost	Cumulative Cost	Benefit/cost Ratio	Basic Signing Required	Basic Maintenance Required
Mid-Block	Grade and fast speeds	Ped Refuge/Kerb Blisters and parking lanes	4	3	75,600	\$10,500	\$146,200	7.2		
South Road	Layout promotes high through speed	Roundabout at Boundary	5	5	\$156,000	\$30,000	\$30,000	5.2		
Mid-Block	Gradient	Centre blister at or north of Rubicon	3	2	\$87,000	\$30,000	\$60,000	2.9		
Jan Cres	Poor visibility and fast through traffic	Roundabout	3	2	\$84,240	\$31,200	\$92,700	2.7		
Justin Drive	Fast curve	Super Flaps and mid-block threshold	5	4	\$175,000	\$35,000	\$181,200	5.0		
Spray Pde	Grade and fast speeds	Roundabout and road marking	2	2	71,500	\$32,500	\$135,700	2.2		
		Total	32	27	\$1,026,590	\$181,200	\$181,200	5.7		

11. Formulation of a Ranked Program of Works

As mentioned in Section 10, there are two outputs to an AIP Program:

1. AIP Project Reports.
2. AIP Program Summary Reports.

The AIP Program Summary Reports should contain separate lists of Site and Mass Action countermeasure treatments ranked by project BCR and which also contain cost estimates. These lists will form the basis of a prioritised Blackspot or Mass Action Program. The entries in each list are referred to as “projects” in this section.

The ranked list of projects would then be used in the annual submission for Blackspot and Mass Action Treatment funding in accordance with the Road Environment and Light Vehicle Standard's (RELVS's) Annual Regional Program Development Process (“Bidding”) Guidelines. These Guidelines outline any specific criteria that must be met before projects are eligible for funding under program positions *16301 – Blackspot Treatments* and *16303 – Mass Action Treatments*. Any projects that fall under the responsibility of other funding sources should be referred to relevant sections (eg. RTA Asset Management Programs, Local Government). This will ensure that the maximum number of road safety projects can be delivered for the available budget.

Blackspot Projects may also be proposed under RTA *Program position 16309: National Blackspot Program*. The National Blackspot Program *Notes on Administration* provides guidance and criteria with respects to the nomination of projects seeking Federal funds.

Projects will need to meet the “bidding” criteria and be approved by the relevant RTA Core Client before they can be commenced.

11.1 Size of program

Each program year, it is inevitable that some projects will be reduced in scope and some will be abandoned altogether. This can be for a variety of reasons including:

- Poor initial scoping/estimation of the project costs.
- Environmental, geometric or on-site constraints, or opposition from the community.
- Rectification of the problem through other programs such as road development, maintenance or upgrades funded by other sources.
- Abandonment of the project due to planned upgrades or solutions funded by other sources.

In this respect, the cost of the prioritised list of projects should always exceed the available budget by five times to demonstrate the following:

- That the projects ranked at the top of the list are indeed the best, ie. those offering the best value for money.
- That the Region will be able to utilise any additional funds that may become available following the initial allocation of funding.
- That the Region will have a forward program with projects that can be commenced earlier than scheduled in the event that additional funding becomes available (see Section 11.3)

It is also recommended that each Region commences the program year including a number of projects in addition to those funded under the available budget. If the program is not managed in this way, any projects that are abandoned or reduced in scope in the latter part of the program year will leave insufficient remaining time for additional projects to be commenced and completed in the same year. To determine the extent to which each Region should “overprogram” in this manner, the relevant Road Safety Programming representatives from each Region should review the Region's performance in delivering Road Safety programs in previous years and also liaise with the relevant Core Client.

11.2 Program proposals (“bidding”)

Each year, the relevant RTA Core Clients will request program proposals in accordance with the Annual Regional Program Development Process (“Bidding”) Guidelines. The bids for all projects in program positions 16301-16308 should be entered into the Accident Blackspot Database. This database is intended to document each project and monitor the ongoing effectiveness of the project. Any changes in project scope or abandonment of projects should be reflected in the database. Section 13 describes the use of this database for monitoring and evaluating the program.

11.3 Forward programming

Generating five time more projects than the available budget will allow for will also enable some projects to be proposed for future programs. The data for each of the non-funded projects should be updated annually and its position in the program adjusted accordingly. As a minimum, this updating should include the addition of an extra year of accident data and re-calculation of the BCR and also include any changes in the accident costs, assumed effectiveness of the countermeasures proposed and implementation cost estimates. Any changes in accident costs and assumed levels of effectiveness would be provided by the Road Safety, Licensing & Vehicle Management Directorate.

12. Implementing Countermeasures

Once the Site or Mass Action Treatments are approved as projects in *16301 – Blackspot Treatments*, *16303 – Mass Action Treatments*, or *16309 – National Blackspot Program* the projects can be commenced. The most likely sequence of events will be:

1. The projects are approved by the Core Client as funded works or to a lesser extent, unfunded works.
2. Designs are prepared and approved. This may also be completed in the previous year's program with development funding.
3. The RTA conducts any community consultation or environmental assessment required, including liaising with Local Traffic Committees.
4. The works are carried out by the relevant authority or service provider (RTA, Local Government, utility authority, construction contractor).

12.1 Community consultation

Community consultation should be carried out where appropriate to ensure that the proposed measures do not stall as a result of community opposition. The RTA's (1998) *Community Involvement Practice Notes and Resource Manual* is a useful reference providing guidance on which projects require community consultation and the extent of community involvement that is appropriate for each project.

Small projects that have little impact on the environment, community or traffic flows may require very little community consultation. Larger projects may require letterbox drops and media releases to inform the community of changed traffic/access conditions and may require public forums and opportunities for the community to comment on designs. Where traffic flow or accessibility stands to be affected, the proposal must also get the approval of the Local Traffic Committee.

Raising public awareness of the need for major safety improvements is an important part in gaining community acceptance of the countermeasures. Road safety treatments can result in the following impacts:

- Disruption to the road user, (for example by banning turns at junctions).
- Changes in perceived amenity to local residents, (for example devices outside residences could be perceived as restricting access or causing noise).
- Accessibility concerns from business, (for example it can be claimed that changes in traffic flow or parking arrangements could discourage customers).
- Increased traffic at alternative locations.

Often structured community consultation will provide overall support for proposals while an ad-hoc approach only attracts the objections of a minority of affected persons. It is equally important that any consultation exercise does not create a false expectation from the community. For isolated site treatments, publicising countermeasures helps the public:

- accept delays and disruption during implementation; and
- understand the need for change.

Particularly where the roads have an important residential or retail access function, community consultation has an important function. Structured public consultation is recommended for instigating changes that redistribute traffic or cause other major disruptions for the road user. Consultation may involve:

- Seeking the opinions of residences/businesses via household questionnaires or telephone surveys on the problems in the area and acceptable treatments.
- Promulgating information using local press and leaflets, exhibiting proposals at a number of locations throughout the study area.
- Holding public meetings to allow debate.

Even with consultation, substantial public resistance may be encountered. The public might perceive the changes as causing:

- Increases in accidents due to increased traffic flows at some locations.
- Inconvenience caused by restricted traffic movements and lower travel speeds.
- Higher delays during peak hour traffic.
- Reductions in trade for some businesses.
- General disbenefit to the majority in order to benefit the few.

Such situations require skilful and tactful liaison.

12.2 Environmental assessment

Any project likely to have a significant impact on the environment may require an Environmental Impact Assessment (EIA) or Review of Environmental Factors (REF) in accordance with the *Environmental Planning and Assessment Act, 1979*. The RTA's Environmental Impact – Policy and Guidelines document should be referenced to determine the need for these assessments.

12.3 Design and installation

Following approval of the projects, the design and installation of the works can proceed. Ideally, the designs would be completed in the preceding year's program to enable the project to be commenced at the start of the program year. Prior to commencement of design or construction activity, the scope of works, expected outcomes and benefits and known constraints (including funding) should be fully described in a project brief.

Road Safety Audits should be undertaken of the project design as well as at the completion of construction to ensure that no unsafe elements are designed or built into the project. The RTA Technical Direction *RS03 – Policy for Road Safety Audits of Construction and Reconstruction Projects* details the minimum intervention levels for undertaking Stage 1 to 4 Road Safety Audits on Blackspot and Mass Action projects. Any deficiencies identified through the audit should be addressed as quickly as is practicable. Time and money will be saved by effective communication between investigation, design, works and utility authorities.

For those major measures which require detailed design and public consultation, the lead time between a decision to fund the measure and actual implementation can be protracted. Accordingly the design of these measures should be completed as soon as possible. As mentioned above, where possible, the design and other background work can be completed in the previous year's program using any development funding that is allocated. This will enable construction to commence as soon as possible in the new program year.

During the study, investigators should keep the decision makers informed (in particular local government) and liaise with staff in other sections of the road controlling authority; especially those responsible for planning, designing and implementing road works. Costs may be significantly reduced and measures installed more quickly by:

- Avoiding conflicting and hence unnecessary work ensuring smooth implementation of works.
- Allowing small scale countermeasures to be installed in conjunction with or by a slight alteration to maintenance works, construction projects or traffic schemes.

As a part of the brief, a copy of the AIP Project Report should also be made available to those undertaking the design and implementation of the project.

13. Monitoring and evaluating Blackspot and Mass Action programs

The AIP process also includes monitoring and evaluation of completed Blackspot and Mass Action Programs. The monitoring and evaluation applies for both the individual Blackspot and Mass Action projects as well as the Program as a whole. This requires each Region to submit data on each completed project to the Road Safety, Licensing & Vehicle Management Directorate.

Monitoring and evaluation of such project is required for the following reasons:

- To ensure that road safety has improved and that accidents have been reduced.
- To identify countermeasure treatments that work most effectively.
- To identify countermeasure treatments that failed to achieve their predicted safety improvements.
- To enhance future predictions enabling continual optimisation of funds.

The Accident Blackspot Database has been developed to facilitate monitoring and evaluation of all road safety infrastructure projects including Blackspot and Mass Action projects. This database is also used to submit project proposals (“bids”). The fundamental means of evaluating the success (or otherwise) of the project is to compare the pre-construction BCR with post-construction values, at the same time acknowledging all other external factors and variables.

The pre-construction (or “perceived”) BCR relies on the following assumptions:

- Estimation of traffic percentage growth which is used to assume a proportional increase or reduction in accident “exposure”.
- Estimations of project construction costs.
- Estimations of annual ongoing maintenance.
- Assumed percentage reductions for each accident type due to the treatments selected.

Following construction and after several years of operation, the following information would be known and no longer assumed:

- Actual percentage traffic growth.
- Actual construction costs.
- Actual maintenance costs⁹.
- Actual percentage accident reduction.

This enables RSL&VM to recalculate the BCRs replacing all assumed figures with the actual figures. This “before and after” analysis can be carried out for each project as well as for the program as a whole. Where “after” BCRs are equal or greater than the predicted BCRs, the projects can be regarded as being successful. Over time the accuracy of cost estimations and accident-reduction forecasting will improve, and more effective countermeasures will be selected.

The minimum data required for each blackspot project to enable evaluation of the program includes:

- Accident data for a considerable period before the start of construction and a considerable period after the completion of construction. The “before” data should be in accordance with the period discussed in section 6.2.1.
- Actual project costs.
- Project commencement and completion dates.

⁹ Although this would be known, it may still be assumed or estimated due to possible difficulties in obtaining the information or quantifying maintenance costs to specific items implemented in Blackspot/Mass Action projects. For example, a blackspot treatment may involve the provision of a sealed shoulder but the annual maintenance may involve treatment to all sealed sections.

- Annual maintenance costs (where these can be obtained).

This data should be forwarded to the Road Safety, Licensing & Vehicle Management Directorate using the Accident Blackspot Database at the end of each financial year. It should be re-emphasised that for Blackspots and Mass Action projects in urban locations, three years of "after" accident data should be used to determine the actual percentage reductions in accidents as well as the actual percentage traffic volume growth. For sites, routes and areas in rural locations, five years of accident data and traffic volume information should be used.

Appendix A: Definitions for Coding Accidents (DCA) chart

Cited in (1) Andreassen, D.C. (1991) ARRB Technical Manual 29: Road accident data and accident types and (2) AUSTROADS (2003), Guide to Traffic Engineering Practice: Part 4 - Road Crashes (2nd ed.)



Definitions for Coding Accidents - DCA Codes

This code is recorded for the first impact according to the table below.
 Note : The key vehicle is represented by the dark arrow. → and is recorded as the first vehicle in the accident.

	0	1	2	3	4	5	6	7	8	9
	PEDESTRIAN on foot, in toy / pram	INTERSECTION VEHICLES FROM ADJACENT APPROACHES	VEHICLES FROM OPPOSING DIRECTIONS	VEHICLES FROM SAME DIRECTION	MANOEUVRING	OVERTAKING	ON PATH	OFF PATH, ON STRAIGHT	OFF PATH, ON CURVE	PASSENGERS & MISCELLANEOUS
00	OTHER 000	OTHER 100	OTHER 200	OTHER 300	OTHER 400	OTHER 500	OTHER 600	OTHER 700	OTHER 800	OTHER 900
01	NEAR SIDE 001	CROSS TRAFFIC 101	HEAD ON (not overtaking) 201	REAR END 301	LEAVING PARKING 401	HEAD ON (incl. side swipe) 501	PARKED 601	OFF CARRIAGEWAY TO LEFT 701	OFF CARRIAGEWAY ON RIGHT BEND 801	FELL IN / FROM VEHICLE 901
02	EMERGING 002	RIGHT-THRU FROM LEFT 102	RIGHT-THRU 202	REAR LEFT 302	ENTERING PARKING 402	OUT OF CONTROL 502	DOUBLE PARKED 602	OFF CARRIAGEWAY TO RIGHT 702	OFF CARRIAGEWAY ON LEFT BEND 802	STRUCK WHILE BOARDING OR ALIGHTING 902
03	FAR SIDE 003	LEFT-THRU FROM LEFT 103	RIGHT-LEFT 203	REAR RIGHT 303	PARKING VEHICLES ONLY 403	PULLING OUT 503	ACCIDENT OR BROKEN DOWN 603	LEFT OFF CARRIAGEWAY INTO OBJECT 703	OFF CARRIAGEWAY ON RIGHT BEND INTO OBJECT 803	STRUCK TRAIN / AEROPLANE 903
04	PLAYING, WORKING LYING, STANDING ON CARRIAGEWAY 004	RIGHT-THRU FROM RIGHT 104	RIGHT-RIGHT 204	U-TURN 304	REVERSING 404	CUTTING IN 504	VEHICLE DOOR 604	RIGHT OFF CARRIAGEWAY INTO OBJECT 704	OFF CARRIAGEWAY ON LEFT BEND INTO OBJECT 804	
05	WALKING WITH TRAFFIC 005	TWO RIGHT TURNING 105	LEFT-THRU 205	LANE SIDE SWIPE 305	REVERSING INTO FIXED OBJECT 405	PULLING OUT REAR END 505	PERMANENT OBSTRUCTION ON CARRIAGEWAY 605	OUT OF CONTROL ON CARRIAGEWAY 705	OUT OF CONTROL ON CARRIAGEWAY 805	
06	FACING TRAFFIC 006	RIGHT-LEFT FROM RIGHT 106	LEFT-LEFT 206	LANE CHANGE RIGHT 306	EMERGING FROM DRIVEWAY 406	OVERTAKING RIGHT TURN 506	TEMPORARY ROADWORKS 606	LEFT TURN 706		PARKED VEHICLE RAN AWAY 906
07	DRIVEWAY 007	LEFT-THRU FROM RIGHT 107	U-TURN 207	LANE CHANGE LEFT 307	EMERGING FROM LOADING BAY 407		STRUCK OBJECT ON CARRIAGEWAY 607	RIGHT TURN 707		UNKNOWN 907
08	ON FOOTWAY/ MEDIAN 008	RIGHT-LEFT FROM LEFT 108		RIGHT TURN SIDE SWIPE 308	FROM FOOTWAY 408			MOUNTS TRAFFIC ISLAND 708	MOUNTS TRAFFIC ISLAND 808	
09		TWO LEFT TURNING 109		LEFT TURN SIDE SWIPE 309	U-TURN INTO FIXED OBJECT 409		ANIMAL (not ridden) 609	OFF END OF ROAD/ T INTERSECTION 709		
10				PULLING OUT (LANE CHANGE) 310			LOAD OR MISSILE STRUCK VEHICLE 610			

Appendix B: Mass Action Analysis:

Case study –

Off carriageway to the left on a right hand bend.

B1.0: Introduction

Throughout the six-year period between 1/1/1995 and 31/12/2000, there was an average of 3,079 run-off-road crashes on high speed, undivided roads in NSW per annum. The average cost to the community for these crashes has been more than \$190 million per year.

A Mass Action Analysis technique was developed to identify high-risk sites with respects to run-off-road crash events. By identifying sites with a high risk of recurrence of this crash type, appropriate remedial work could be implemented along selected routes as Mass Action treatments. The high cost to the community resulting from these crashes indicates that there will be high economic returns on any effective treatments.

The run-off-road crashes throughout this six-year period were comprised of the following types as shown in Table B1.

Table B1: The percentage breakdown in off-road crash types

DCA	Crash description	Percentage
701, 703	off left on straight	24%
702, 704	off right on straight	16%
801L, 803L	off left on r/h curve	27%
802R, 804R	off right on l/h curve	12%
802L, 804L	off left on l/h curve	9%
801R, 803R	off right on r/h curve	12%

Figure B1 shows the number of each of these crash types and further breaks these down by severity.

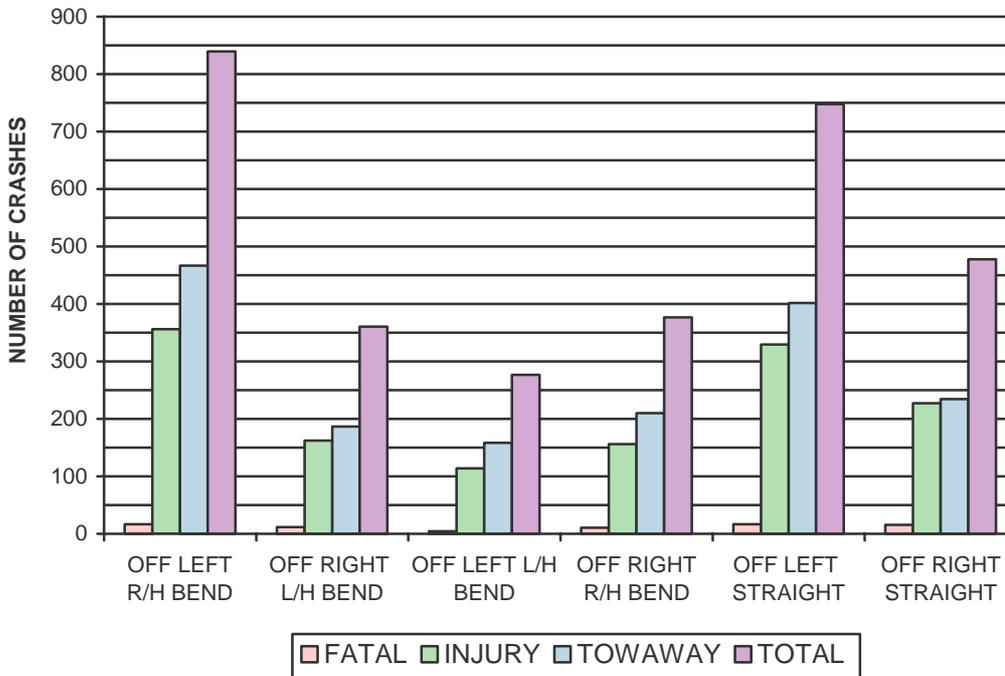


Figure B1: The break-down of off-road crashes throughout the 6 year period between 1/1/1995 and 31/12/2000 on undivided high speed sections (all NSW)

B2.0: Description of project

AIP Mass Action projects have three stages:

1. Identification of routes, areas to include in a program of Mass Action analysis studies.
2. In-depth Mass Action Analysis and Investigation of each route or area.
3. Implementation of Mass Action countermeasure treatments.

The project described in this Appendix is an example of the Stage 1 with the Mass Action theme being *off road to the left on right hand bends crashes*. As a Stage 1 (preliminary analysis), the project aims to identify sections along a 17km section of the Atlantic Highway between Aggregate Hill and Binder where *off road to the left on right hand bend crashes* could be targeted for reduction.

B3.0 Methodology

The methodology for determining the relative risk of off road to the left on right hand bend crashes is outlined below:

- Calculate the Curve Alignment Exposure (CAE) Ratio. This is a ratio of the *length of straight to length of curve*. This ratio, or *weight* can be multiplied to populations of crashes on curved alignment, to make them comparable with populations of crashes on straight alignment.
- Multiply the CAE Ratio to the annual crash rates (crashes/year) for each type of off-road crash on a curve, ie. off-road to left on right hand bend. The product of the CAE and the crash rate per year gives the relative exposure of vehicles to the different types of road alignment along the selected study length. This exposure ratio is called a Relative Crash Index (RCI). The higher the RCI, the higher the priority for Mass Action treatment.
- Compare these with other off-road crash types both within and outside of the study route.
- Use the results to identify sections of the route to investigate for Mass Action Treatments. Using the RCI, each candidate site could be ranked enabling the allocation of available funds for a more in-depth AIP Mass Action analysis (Stage 2) as well as the optimal allocation of funds for treatment (Stage 3).

Relative crash index calculations for the study route

The study route is a 17km section of the Atlantic Highway from Aggregate Hill to Binder. This section of road has the following features as shown below:

Total curve length (one direction).....	3.1 km
Total road length (both directions).....	34 km
Total curve length (both directions).....	6.2 km
RH or LH curve length (both directions).....	3.1 km
Total length of straight (both directions)	34 - 6.2
.....	= 27.8 km
CAE ratio (straight / curve type)	27.8 / 6.2
.....	= 8.97 / 1

This means that any population of off-carriageway crashes on curves would have to be multiplied by a CAE of 8.97 to make them comparable to any population of off-carriageway crashes on straights.

During the 5 year period between 1/1/1997 and 31/12/2001 period, there was a total of 40 off-road crashes as shown in Table B2:

Table B2: The number of each crash type as well as the Relative Crash Index (RCI)

DCA	Crash description	No. of Crashes	Crashes/year	RCI*
701, 703	off left on straight	14	2.8	2.8
702, 704	off right on straight	5	1.0	1.0
801L, 803L	off left on r/h curve	9	1.8	16.15
802R, 804R	off right on l/h curve	6	1.2	10.76
802L, 804L	off left on l/h curve	3	0.6	5.38
801R, 803R	off right on r/h curve	4	0.8	7.2
Totals		41		

*Relative Crash Index (RCI) = CAE x crashes/per for crashes on curved sections, where CAE = 8.97. For crashes on straight sections, the crash rate per year is to be multiplied by a weighting (CAE) or 1.0

The Relative Crash Index of 16.15 indicates that, relative to other off-road crash types, the *off-road to the left on right hand bends* crash should be targeted for Mass Action treatment. For every curve treated for this crash type, there is also a potential reduction in *off-road to the right on a left hand bend* crashes for the opposing direction. The RCI of 10.49 for off-road to the right on left hand bends crash indicates that Mass Action treatments will have economic benefits in reducing both crash types.

B4.0 Site investigation issues

As this project involves the preliminary analysis to identify locations to undergo further Mass Action analysis (Stage 1), an inspection of curves sections of road was not required. It would be expected that Stage 2 works would involve Field Investigations. As Field Investigations were not undertaken as a part of this project, this section merely highlights some issues related to Field Investigations for such a Mass Action project.

The calculations provided above have highlighted that off-road to the left on right hand bends should be targeted by any subsequent in-depth Mass Action study and treatment projects. In most cases, there will be funding constraints limiting how many curves could be treated under such a Mass Action project. Therefore it is important to further differentiate between high and low risk curves. In this respect, the following curve types should then be targeted for more in-depth site investigation:

- Isolated right hand curves.
- The right hand curve after a long straight.
- Right hand curves with advisory speeds more than 10km/h less than the signposted speed.
- Right hand curves that fall within a 250m to 500m radii range.

Some of the remedial treatments in Table B3 may be effective in addressing the off-road crash problem at the identified curves. The site investigations will determine whether these countermeasures will be suitable as well as practical to implement and maintain.

Table B3: Possible Mass Action treatments for off-road to the left on right hand

Possible mass action treatment	Comments
Install profile edgeline on the LH side (around the outside of the curve) from the start of the approach transition to the end of the departure transition	This will reduce the probability of fatigue related off-road crashes.
Widen and seal the LH shoulder (around the outside of the Curve) through the transitions and the curve	This makes the roadside more forgiving to loss-of-control crashes and allows errant vehicles to regain control.
Increase superelevation on sealed shoulder on the outside of the curve.	This reduces the probability of loss-of-control when cornering
Install curve alignment markers (CAMs).	This improves guidance and delineation around the curve and assists drivers in determining a safe approach speed
Remove roadside hazards where a run off area is available at the back of the curve and flatten the batter slope where possible.	This makes the roadside more forgiving and allows errant vehicles to either regain control or decelerate to a safe stop.
Install appropriate safety barriers where a hazard-free run off area is not available.	This reduces the severity of the crash by allowing errant vehicles to be contained and possibility re-directed by the barrier

Benefit cost analysis

As stated above, this is only the preliminary analysis to identify sections in the subject 17km section of the Atlantic Highway to be targeted for more in-depth Mass Action analysis and subsequent treatment. The Mass Action treatment would need to be economically evaluated by a benefit cost ratio where the benefits and costs are aggregated across all curves treated under the Mass Action. The success of the project relies on the benefits of reducing crashes at some of the curves outweighing the costs of applying the Mass Action treatment to all curves targeted.

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Appendix C: Percentage reduction in accidents due to countermeasure treatments

Table C2: Percentage reduction in accidents for midblock treatments: Low speed environment (cont'd next page)

Accident Group Number	Two vehicle accidents											Single vehicle accidents									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
DCA Codes	101-109	201-501	202-206	207-304	301-303	305-307	308-309	401-409	503-506	601	903	001-008; 901-902	605	609	701-702; 502;706-709	703-704	705;502	801;802	803-804	805	
Description	Intersection, adjacent approaches	Head-On	Opposing vehicles; turning	U-turn	Rear-end	Lane change	Parallel lanes; turning	Manoeuvring	Overtake; same direction	Hit parked vehicle	Hit railway train	Hit pedestrian	Permanent obstruction	Hit animal	Off carriageway; straight	Off straight; hit object	Out of control; straight	Off carriageway; curve	Off curve, hit object	Out of control; curve	
Accident Costs	\$39,400	\$112,200	\$39,700	\$35,400	\$24,100	\$31,300	\$26,300	\$28,400	\$39,700	\$38,600	\$201,500	\$123,200	\$64,100	\$32,800	\$51,800	\$69,100	\$57,300	\$58,500	\$76,200	\$52,700	
40: Install Arterial Route Lighting	20	20	20	20	25	20	20					20	25	25	25	25	25	25	25	25	
41: Install Street Lighting	20	20	20	20	25	20	20					20	25	25	25	25	25	25	25	25	
42: Reflectors on Guideposts According to Accepted Standards				15	15							15	15	15	15	15	15	15	15	15	
43: RRPM's on Centre Line Only				10	10							10	10	10	10	10	10	10	10	10	
44: RRPM's on Centre and Edge Lines				15	15							15	15	15	15	15	15	15	15	15	
45: RRPM's on Edge Lines				5	5							5	5	5	5	5	5	5	5	5	
46: Lighting – Pedestrian Crossing Point																	10	10			
47: Raised Profile Edge Line																	10	10			
48: Raised Profile Centre Line (Rumble Bars in Urban Areas)		20											20	30	30		30	30			
49: Painted Line to Separate Through and Parking lane												40									
51: Marking of Barrier Line		15				10				50				10	10						
52: Painted Median Greater Than 1.5 Metres Wide		40	20		10					30											
60: Pedestrian – Refuge Without kerb Blisters, Marked Ped. Crossing		60											25	15	15	15					
61: Pedestrian – Refuge Without Kerb Blisters, No Crossing Marked								40				5	15	15	15						
62: Pedestrian – Refuge With Kerb Blisters, Marked Pedestrian Crossing		60						40	90	50		35									
63: Pedestrian – Refuge With Kerb Blisters, No Crossing Marked												30									
64: Raised Threshold at Crossing Point	30	40	30	30	30	30		50	30	60		80	40	40	40	40					
65: Marked Pedestrian Crossing					-50							-30									
66: Pedestrian – Guard Rail/Fencing		20										20									
67: Pedestrian – Kerb Extensions, marked Pedestrian Crossing								40		50		40									
68: Pedestrian – kerb Extensions, No Crossing Marked								40		50		30									
69: Pedestrian – Mid-block Signals					-10							50									
70: Pedestrian – Mid-Block Signals (PELICAN)					-10							70									
71: Other School Pedestrian Treatments												30									
72: Pedestrian – Grade Separation												30									
80: Improve Sight Distance: Remove Impediments on Main Road				25	25			40	50			25	40	30	30	30	30	30	30	30	
85: Limit Access to Roadside Development	50		50	50	50	30		60		50		15									
86: Route traffic Calming Scheme	40	40	40	40	40	40	40	25	40	40		30	40	40	25	25	25	40	40	40	
87: Slow Point on Urban Road, (Raised Threshold/horizontal Deviation)	30	40	30	30	30	30		50	30	60		60	40	40	40	40	40	40	40	40	
88: Main Street Treatment (Kerb Extension/Median)	30											50									
89: Duplicate Road	30	100		30	30			50	80	15		50									

Table C3: Percentage reduction in accidents for intersection treatments: High speed environment

Accident Group Number	Two vehicle accidents											Single vehicle accidents									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
DCA Codes	101-109	201-501	202-206	207-304	301-303	305-307	308-309	401-409	503-506	601	903	001-008; 901-902	605	609	701-702; 502,706-709	703-704	705,502	801,802	803-804	805	
Description	Intersection, adjacent approaches	Head-On	Opposing vehicles; turning	U-turn	Rear-end	Lane change	Parallel lanes; turning	Manoeuvring	Overtake; same direction	Hit parked vehicle	Hit railway train	Hit pedestrian	Permanent obstruction	Hit animal	Off carriageway: straight	Off straight: hit object	Out of control: straight	Off carriageway: curve	Off curve, hit object	Out of control: curve	
Accident Costs	\$160,800	\$275,800	\$137,400	147,000	\$67,300	\$157,400	\$118,900	\$106,100	\$89,300	\$123,700	\$348,900	\$328,900	\$109,200	\$40,200	\$97,900	\$116,500	\$102,500	\$97,400	\$101,000	\$86,100	
1: Roundabout 1-Lane	70	70	60	50				20				0									
2: Roundabout 2-Lane	70	70	60	50				20				-20									
3: New traffic Signals: Filter Turns Allowed	60		-50		-40							10									
4: New Traffic Signals: No Filter Turns Allowed	60		90		-40							20									
5: Street Closure – Cross Intersection	70	50	50		50							60									
6: Street Closure – T intersection	100	40	100	100	100							50									
7: Grade Separation of Intersection	100		100									70									
8: Median Closure	100	100	100				100					50									
10: SEAGULL Island Without Acceleration Lane, Raised island	10	10	40	20	60	40	40		70			25									
11: SEAGULL Island With Acceleration Lane, Raised island	20	10	40	20	50	40	40		70			25									
12: SEAGULL Island With Acceleration Lane, Painted island	10	10	40	20	60	40	40		70			25									
13: SEAGULL island With Acceleration Lane, Painted island	20	10	40	20	50	40	40		70			25									
20: New Signing - Stop	50				-50							10									
21: New Signing – Give Way	15																				
23: New Signing – Prohibit Turns	50		50				50														
24: Fully Control Right Turn With Arrows			90																		
25: Introduce Right Turn Phase While Leaving Filter			-20																		
26: Red Light Camera at Existing Traffic Signals	50				-30																
27: Protected Right Turn Lane, S-Lane/Channelisation	15	10	40		60	40	40		70			20									
28: Upgrade signal display (mast arm/additional lanterns)	20		10		25																
29: Protected Right Turn Lane, S-Lane/Painted	15	25	40	20	60	40	40		70			30									
30: Left Turn Acceleration Lane		30		70	50	50			30												
31: Separate Left Turn Deceleration lane, Painted or Channelised	15		10		60	30	30														
32: Install Additional Priority Signs on Median islands	15																				
33: Move Limit Lines Forward Using Paint Markings	15																				
34: New Signing – Intersection Warning (can include flashing lights with sign)	40		40																		
35: Move limit Forward Using Kerb Extensions on Priority Road	20																				

Table C4: Percentage reduction in accidents for midblock treatments: High speed environment (cont'd next page)

Accident Group Number	Two vehicle accidents											Single vehicle accidents									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
DCA Codes	101-109	201-501	202-206	207-304	301-303	305-307	308-309	401-409	503-506	601	903	001-008; 901-902	605	609	701-702; 502;706-709	703-704	705;502	801;802	803-804	805	
Description	Intersection, adjacent approaches	Head-On	Opposing vehicles; turning	U-turn	Rear-end	Lane change	Parallel lanes; turning	Manoeuvring	Overtake; same direction	Hit parked vehicle	Hit railway train	Hit pedestrian	Permanent obstruction	Hit animal	Off carriageway; straight	Off straight; hit object	Out of control; straight	Off carriageway; curve	Off curve; hit object	Out of control; curve	
Accident Costs	\$160,800	\$275,800	\$137,400	\$147,000	\$67,300	\$157,400	\$118,900	\$106,100	\$89,300	\$123,700	\$348,900	\$328,9000	\$109,200	\$40,200	\$97,900	\$116,500	\$102,500	\$97,400	\$101,000	\$86,100	
40: Install Arterial Route Lighting	25	25	25	25	25	25	25					25	25	25	30	30		30	30	30	
41: Install Street Lighting	25	25	25	25	25	25	25					25	25	25	25	25		25	25	25	
42: Reflectors on Guideposts According to Accepted Standards		10													10	10		30	30	30	
43: RRPM's on Centre Line Only		20			5	5			20			5	5		5	5	5	10	10	10	
44: RRPM's on Centre and Edge Lines		30			10	10			30			10	10		10	10	10	15	15	15	
45: RRPM's on Edge Lines		10			5	5			10			5	5		5	5	5	5	5	5	
46: Lighting – Pedestrian Crossing Point					20							25									
47: Raised Profile Edge Line													25		30	30	30	30	30	30	
48: Raised Profile Centre Line		15																10	10	10	
49: Painted Line to Separate Through and Parking lane										40					10	10		10	10		
50: Marking of Edge-lines Rural Road													15		15	15	15	15	15	15	
51: Marking of Barrier Line		50							50												
52: Painted Median Greater Than 1.5 Metres Wide		30	30		40				70			40									
69: Pedestrian – Mid-block Signals					-10							50									
72: Pedestrian – Grade Separation												50									
80: Improve Sight Distance: Remove Impediments on Main Road				40	40		40	40		40				40							
81: Increase Shoulders by 1.0 Metre, Unsealed		5			10				15			3			10	10	10	5	5	5	
82: Increase Shoulders by 2.0 Metres, Unsealed		5			15				15			3			15	15	15	10	10	10	
83: Sealed Shoulder 1.0 Metre from Through Lane		5			10				15			3			10	10	10	10	10	10	
84: Sealed Shoulder 2.0 Metres from Through Lane		5			15				15			3			20	20	20	10	10	10	
85: Limit Access to Roadside Development	50		50	50	50	30		60		50		15									
89: Duplicate Road	30	100		30	30			50	50	15		50			10	10	10	10	10	10	

Table C4 (cont'd): Percentage reduction in accidents for midblock treatments: High speed environment

Accident Group Number	Two vehicle accidents											Single vehicle accidents									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
DCA Codes	101-109	201-501	202-206	207-304	301-303	305-307	308-309	401-409	503-506	601	903	301-008; 901-902	605	609	701-702; 502-706- 709	703-704	705:502	801:802	803-804	805	
Description	Intersection, adjacent approaches	Head-On	Opposing vehicles; turning	U-turn	Rear-end	Lane change	Parallel lanes; turning	Manoeuvring	Overtake; same direction	Hit parked vehicle	Hit railway train	Hit pedestrian	Permanent obstruction	Hit animal	Off carriageway; straight	Off straight; hit object	Out of control; straight	Off carriageway; curve	Off curve, hit object	Out of control; curve	
Accident Costs	\$160,800	\$275,800	\$137,400	\$147,000	\$67,300	\$157,400	\$118,900	\$106,100	\$89,300	\$123,700	\$348,900	\$328,900	\$109,200	\$40,200	\$97,900	\$116,500	\$102,500	\$97,400	\$101,000	\$86,100	
90: Install Extended Length of Raised Median	90	20	100	100	60			20	90			25			10	10	10	10	10	10	
91: Overtake/Climbing Lanes		25							40						30	30	20	20	20	20	
92: Change Horizontal Alignment		30		30	30				30		30	30					30	30	30	30	
93: Alignment – Change Vertical		45		45	45				45		45	45			45	45	45	45	45	45	
94: Alignment – Change Horizontal & Vert.		60		60	60				60		60	60			60	60	60	60	60	60	
95: Provide Acceptable Superelevation		50															50	50	50	50	
96: Bridges (Widen or Replace)		40							40			40			40	40	40	40	40	40	
97: Provision of Median Guardrail, Dual Carriageway	20	100		30				50	100			50									
99: Recessed Bay for Stopping Vehicles		30		10	10				30			30									
100: New Signing - Guide	15		15																		
101: New Signing – Road Feature													20		10	10	10	20	20	20	
102: New Signing – Curve & Advisory-REDUCED SPEED Sign				15	15			10				30									
103: Clearway/Parking Restrictions, Peak				20	20			20		50		30									
104: Clearway/parking Restrictions, All Hours				20	20			20		50		30									
105: Reduce Speed Limit to 80/90 km/h		15						10				15			10	10	15	15	15	15	
106: Yellow Chevrons on Outside of Curve		45															30	30	30	30	
107: Yellow Chevrons With reinforcement of Advisory Speed		5															5	5	5	5	
110: Install New Seal on Poor Surface		40												20	20	20	30	30	30	30	
111: Install New Seal on Unsealed Surface	10	40	10		30												30	30	30	30	
112: Install New Seal on Unsealed Approach to Sealed Road																	15	15	15	15	
113: Non-Skid Surfacing	15	10															30	30	30	30	
114: Treatment of Roadside Hazards - Removal					35								80		70				70	40	
115: Treatment of Roadside Hazards – Set back													40		40					40	
116: Treatment of Roadside Hazards – Frangible (slip base/impact absorbent)													40		40					40	
117: Treatment of Roadside Hazards – protection (Guardrail)													40		40						
118: Fencing of Stock		10												90	10	10					
119: Rest Area Provision		15												15	15	15	15	15	15	15	
120: Grooving of Existing Pavement																	20	20	20	20	
130: Railway Level Crossing - Signs																				15	
131: Railway Level Crossing – Bridge/Underpass																				100	
132: Railway Level Crossing - Barriers																				90	
133: Railway Level Crossing – Flashing Lights																				50	

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Appendix D: Notes on the use of the Safety Benefit Cost Spreadsheet Model

D1.0: Introduction

This model has been produced to assist practitioners in calculating the safety benefit cost ratios for treatments at a site. For the purposes of the model a site can either be a single location (intersection/isolated curve) or a homogeneous section of road where a treatment is being uniformly implemented (shoulder widening/street lighting).

The model has been produced both to simplify the calculation of safety benefit cost ratios and to ensure that submissions for funding have been evaluated in a consistent and supportable manner.

D2.0: Use of the model

D2.1 Computer requirements

The spreadsheet model is written in Microsoft Excel V5.0. Each copy of the spreadsheet requires approximately 330 kilobytes of hard disk storage.

D2.2 Cell protection

The Model has been write-protected for cells, which perform calculations, hold background data or contain labels. This has been done so that critical parts of the spreadsheet cannot be inadvertently changed. The print area of the spreadsheet has also been pre-set.

D2.3 General inputs and outputs for the Benefit Cost Model

D2.3.1 General inputs

The general inputs required by the benefit cost Model is described below. The reference letter, [A] gives the position of the cell on the worked example spreadsheet contained at the end of these notes.

Local [A]. This cell should contain a brief location description of the site being evaluated.

Speed limit of Main Road [B]. The speed limit determines the accident costs to be used. That is, if the speed limit is 70 km/h or less, then urban accident costs are used. If the speed limit is 80 km/h or greater then rural accident costs are used. If the site involves roads with differing speed limits intersecting, the greater speed limit should be selected.

Expected annual traffic growth [C]. This is the estimated traffic growth at the site over the assumed project life. Where there is an increase in traffic volumes assumed that model assumes that accidents will also increase. That is in the years following the implementation of treatments, reductions in accidents will increase in line with the increase in traffic volumes.

Assumed project life [D]. This is the assumed project life, that is the period for which the benefits of the project are assumed to occur. The RTA has compiled a list of assumed project life for the treatment types. (The model allows for project lives up to 30 years).

Years of accident data [E]. Normally at least three years (in urban areas) and five years (in rural areas) of accident data should be used (check requirement with the bidding guidelines produced by the relevant Road Authority). However in special circumstances greater or lesser accident periods could be used. For example, the site being investigated could have been treated with a measure which has only been installed for two years, but which had already resulted in a demonstrated accident history. In these circumstances the two year figures could be used.

Start [F]. This is the start of the period for which accident data is used. This parameter together with the number of years of accident data defines the years over which the accident data used in the benefit cost calculations have been taken.

Total accidents [G1 - G5]. The total number of accidents reported at the site during the study period, grouped into 20 categories according to DCA code. These accident numbers are not directly used in any of the calculations, but are provided to give the total accident picture at the site.

2.3.2 General outputs

TOTAL [G6]. This cell sums the total numbers of accidents within each category and gives the total number of reported accidents at the site over the study period.

D2.4 Evaluation of proposed treatments

D2.4.1 Standard treatments

A standard list of site treatments has been produced. These standard treatments are listed in Tables A1 to A4 in Appendix A. These treatments should cover most circumstances but not necessarily all possible treatments. They do not specifically account for combinations of treatments at a site.

For each treatment assumed accident reductions have been estimated. These accident reduction are also shown tables A1 to A4 in Appendix A.

Where possible these accident reductions have been derived by consideration of before and after studies conducted both in Australia and overseas. Where this information was not available for a particular treatment, the assessment of benefits has been derived by an assessment of the likely impact of the treatment on risk at the site.

The continued monitoring of treatments and their effectiveness (via the upkeep of RTA's Accident Blackspot Program Database) will lead to further refinements of these accident reduction factors.

D2.4.2 Inputs For evaluation of a single treatment

The model allows for up to three treatments to be evaluated on the same sheet. For each treatment the following information should be entered into the model:

Treatment code [H]. This is a number, which can be read off from the description of the treatment shown in the tables in Appendix A. When the treatment code is entered the description of the treatment will be automatically displayed as will be the assumed accident reductions associated with this treatment.

Initial cost of treatment [K]. This is the initial cost of the treatment, which is generally the cost incurred up to the completion of the treatment.

Annual maintenance [L]. These are the annual maintenance or running costs of the treatment. If there are no ongoing costs, then a 0 (zero) should be inputted.

Target accidents [M1 - M5]. This is the number of target accidents associated with each accident group. In some cases this will be the total accidents reported at the site. In others, this will be a lesser number of accidents, which result from the specific deficiency, which is to be addressed by the treatment. Appendix A provides a guide as to whether all accidents at the site should be used as the target accidents or only those which relate to specific deficiencies to be addressed by the treatment. For example, if the treatment involves a right turn lane, then only turning and rear-end accidents associated with the approach for which this lane is proposed will be entered as the target accidents.

Custom reduction [N]. The model provides for a custom reduction of any of the accident types to be made for any treatment. Once a non-zero number is added into custom treatment, this value rather than the custom reduction is used in the model calculations. The use of a custom reduction should only occur after a systematic on-site investigation has been conducted. Full documentation of the reasons for the use of alternative reductions should be made available.

D2.4.3 Outputs for each treatment evaluated

Treatment A [I]. This cell automatically displays the description of the treatment, which corresponds to the treatment code entered in [H].

Assumed reduction [J]. This cell automatically displays the percentage reductions in accidents expected from the nominated treatment. These reductions are shown in Tables A1 to A4 in Appendix A. A negative number indicates that the treatment is expected to result in an increase in accidents.

TOTAL (Target accidents) [M7]. This cell gives the total of target accidents for the treatment selected.

TOTAL (Discounted benefits) [O1]. This is the total discounted benefits at the appropriate discount rate over the assumed project life. A bracket around this figure (or any of the individual discounted benefits in the column above it) represents a negative benefit (disbenefit).

Discounted costs [O2]. This is the total discounted costs of the Treatment. It is calculated by adding the estimated cost over the life of the project to the Annual Maintenance costs, extrapolated over the assumed life of the project.

NPV @ 7% or 5% [O3]. This is the total discounted benefits of the treatment minus the total discounted costs (note: the NPV value is calculated at 5% for National Blackspot Program nominations).

NPV/Cap cost [O4]. This is the NPV divided by the Capital Cost, (Capital Cost is the Initial Cost of the Measure and does not include Annual Maintenance).

BC ratio @ 7% or 5% [O5]. This is the total discounted benefits divided by the total discounted costs.

It should be noted that not all of the standard treatments apply for both low and high speed limit roads. Where a treatment type does not apply to the respective speed limit selected the model displays the words, "Check code/speed" in the cells in the Assumed Reduction column [J].

D2.4.4 Evaluation of alternative treatments on the same sheet

Where the treatment at the site can be described by one treatment code the model provides the safety benefit cost ratio and the NPV of the treatment. When this is the case two or three different treatments at a site can be examined on the same sheet and the more cost-effective or practical treatment recommended for implementation.

D2.4.5 Evaluation of a combination of treatments

Where more than one treatment is being examined at a site the model can be still be used, but caution must be taken when assessing the target accidents.

That is, the target accidents of a second treatment should not include those accidents which would have already been reduced as result of the first treatment.

For example, if the two treatments proposed on the approach to an intersection involve both installing an additional priority sign on median islands and moving limit lines forward using line marking and kerb extensions on the main road, then if there were 10 right angle accidents on that approach, there would be 10 target accidents for the median island treatment, but only 8.5 target accidents for moving the limit lines forward (as the signs on median islands are expected to save 15% or 1.5 accidents).

The overall safety benefit cost ratio of both treatments can be derived by adding the discounted benefits and discounted costs together and dividing the two totals to give the overall safety benefit cost ratio.

D2.4.6 Use of custom reductions

The use of a custom reduction should be utilised when the treatment proposed is not in the tables supplied or the user has validated research background after a systematic on-site investigation has been conducted.

D2.5 Summary of parameters and formulas used in the model

The various parameters and formulae used in the model are summarised at the foot of the main worksheet. A copy of this information is contained in Table C at the end of these notes. The parameters include the accident costs currently being used in the model.

D3.0: Updates To Model

The safety benefit cost model is updated at yearly intervals. Updates include:

- Annual updates of accident costs.
- Additional standard treatments based on the identified need for additional categories.
- Changes in treatment effectiveness in response to monitoring the effects of implemented treatments.

D4.0: Worked example

A worked example has been prepared to illustrate the use of the model. The example involves the evaluation of traffic signals installed at a cross intersection. On the main road approach it is intended to install 100 metres of raised median either side of the new signals. There is also intended to be no right turn filters on the main road approaches to the intersection (right turns controlled by arrows), whereas filters will be used (common phasing) on the side-road approaches to the intersection.

The cells of the spreadsheet model required to be filled in to undertake this evaluation are described in the following table.

Cell label	Description of cell	Entered in example	Ref.
Location	User enters the description of the site where the evaluation is taking place.	Intersection of North Road and South Road, Westville	A
Speed limit of main road	The speed limit at the site (or on the main road if lower speed limit on side road).	60	B
Expected annual traffic growth	Expected traffic growth during the payback period. To give 2.2% traffic growth "2.2" should be entered into this cell.	2.2	C
Assumed project life	Enter the time period over which benefits from the treatment are assumed to accrue.	15	D
Years of accident data	The years of accident data used in the analysis. In the example assumed to start at the beginning of the second quarter of 1992 (April) and end after the second quarter of 1997, that is 5.25 years.	5	E
Start	The start of the time period when accidents commenced. To indicate the beginning of January 1997 enter 1/97.	1/97	F
Total accidents (DCA codes 101 - 109)	Enter the total accidents which have occurred at the site during the study period classified into accident groupings. For this example there are 20 accidents in the category DCA 101 - 109.	20	G1
Total accidents (DCA codes 201;501)	Enter 2 accidents in this category.	2	G2
Total accidents (DCA codes 202-206)	Enter 8 accidents in this category.	8	G3
Total accidents (DCA codes 301-303)	Enter 3 accidents in this category.	3	G4
Total accidents (DCA codes 001- 003)	Enter 3 accidents in this category.	3	G5
TOTAL	Automatically provides the total accidents at the site (36 in this example)		G6
Treatment code	Enter the number which is in front of the Treatment. Lists of treatments and their codes are given in Tables A and B. For traffic signals with no filter turns the treatment code is 4.	4	H
TREATMENT A	Automatically displayed when a treatment code is entered in H.		I
Assumed reduction	Automatically displays the percentage reductions in accidents expected from the nominated treatment. These reductions are shown in Table B. The [-40] displayed for rear-end accidents indicate an expected 40 increase in this category of accidents.		J
Initial cost of treatment	Enter the initial cost of the treatment. This should be the total costs estimated to be incurred on the implementation of the treatment up until the time the treatment is completed.	120000	K
Annual maintenance	Enter the estimated annual maintenance/running costs of the treatment.	6000	L

Cell label	Description of cell	Entered in example	Ref.
Target accidents (DCA codes 101 - 109)	Enter the accidents which are targeted by the proposed treatment. This should be based on application of the accident investigation process. Enter all 20 accidents in this category.	20	M1
Target accidents (DCA codes 201)	Enter 2 accidents for this category.	2	M2
Target accidents (DCA codes 202-206)	Enter 4 accidents for this category. For this example target accidents of 4 have been selected since 4 of the accidents in this category have occurred on approaches to the intersection for which it is not proposed to install filter turns.	4	M3
Target accidents (DCA codes 301-303)	Enter 3 accidents for this category.	3	M4
Target accidents (DCA codes 001-008,901,902)	Enter 2 accidents for this category. For this example target accidents of 2 have been selected since 1 of the accidents in this category has occurred on where the pedestrian movement would conflict with a filter turn movement.	2	M5
TOTAL	Calculates the total number of target accidents for this treatment.		M7
Custom reduction	Enter the percentage reduction which overrides the Assumed Reduction that is displayed by the model. A custom reduction should only be implemented where it is considered that exceptional circumstances exist. In this example the provision of an extended median in association with the signals would be expected to reduce the incidence of head-on accidents by 20% (see treatment 90 in Table B).	20	N
<i>[Economic parameters]</i>	Cells giving outputs of the model for TREATMENT A.		O1- O5
Treatment code	Enter Treatment code for traffic signals with right turn filters. For this example this treatment has been selected to account for those accidents which have not been targeted by the portion of the traffic signals with right turn filters. This treatment code could also be used to account for an alternative treatment.	3	P
Target accidents (DCA codes 202-206)	Enter those accidents which were not targeted by the portion of the signals without right turn filters.	4	Q1
Target accidents (DCA codes 001-008,901,902)	Enter the accident which was not targeted by the portion of the signals without right turn filters.	1	Q2
BCR combining treatments A & B	Calculates a safety BCR by combining the discounted costs and benefits of Treatments A & B. In this example this is the final Safety BCR for the project. It also incorporates the additional benefits (which are negative) associated with the portion of the signals which have right turn filters as well as the negative impact on rear-end accidents.		R

D4.1: Worked Example:

D4.1.1: Cell References

LOCATION:	[A]		TREATMENT A				TREATMENT B			
[B]	Speed Limit of Main Road		[I]							
[C]	Expected Annual Traffic Growth (%)		Initial Cost of Treatment		[K]		Initial Cost of Treatment			
[D]	Assumed Project Life		Annual Maintenance		[L]		Annual Maintenance			
[E]	Years of Accident Data/Start	[F]	Treatment Code		[H]		Treatment Code		[P]	
DCA Codes	Descriptions	Total Accidents	Target Accidents	Assumed Reduction	Custom Reduction	Discounted Benefits (RTA 7%)	Target Accidents	Assumed Reduction	Custom Reduction	Discounted Benefits (RTA 7%)
101-109	Intersection, adjacent approaches	[G1]	[M1]	[J]		[O1]				
201	Head-on	[G2]	[M2]	[J]	[N]	[O2]				
202-206	Opposing vehicles; turning	[G3]	[M3]	[J]		[O3]	[Q1]			
207; 304	U-turn			[J]						
301-303	Rear-end	[G4]	[M4]	[J]		[O4]	[Q2]			
305-307	Lane change			[J]						
308-309	Parallel lanes; turning			[J]						
406; 407	Vehicle leaving driveway			[J]						
503-506	Overtaking; same direction			[J]						
601	Hit parked vehicle			[J]						
903	Hit railway train			[J]						
001-003	Pedestrian crossing carriageway	[G5]	[M5]	[J]		[O5]				
605	Permanent obstruction on carriageway			[J]						
609	Hit animal			[J]						
701; 702	Off carriageway, on straight			[J]						
703; 704	Off carriageway on straight, hit object			[J]						
705; 502	Out of control on straight			[J]						
801; 802	Off carriageway, on curve			[J]						
803; 804	Off carriageway on curve, hit object			[J]						
805	Out of control on curve			[J]						
	TOTAL	[G6]	[M7]		TOTAL				TOTAL	
[R]	BCR Combining Treatments A & B for RTA (7%)		B/C Ratio @ 7 %	NPV/Cap Cost	NPV @ 7%	Discounted Costs	B/C Ratio @ 7 %	NPV/Cap Cost	NPV @ 7%	Discounted Costs

D4.1.2: BCR Calculation

LOCATION	[A] Intersection of North Road and South Road, Westville		TREATMENT A				TREATMENT B			
60	Speed Limit of Main Road		4: New Traffic Signals: No Filter Turns Allowed				3: New Traffic Signals: Filter Turns Allowed			
2.2	Expected Annual Traffic Growth (%)		Initial Cost of Treatment	\$120,000			Initial Cost of Treatment			
15	Assumed Project Life		Annual Maintenance	\$6,000			Annual Maintenance			
5.00	Years of Accident Data/Start	Jan-97	Treatment Code	4			Treatment Code	3		
DCA Codes	Descriptions	Total Accidents	Target Accidents	Assumed Reduction	Custom Reduction	Discounted Benefits @ 7%	Target Accidents	Assumed Reduction	Custom Reduction	Discounted Benefits @ 7%
101-103	Intersection, adjacent approaches	20	20	60		\$1,001,313		60		\$0
201	Head-on	2	2	0	20	\$95,105		0		\$0
202-206	Opposing vehicles; turning	8	4	90		\$302,863	4	-30		(\$100,354)
207; 304	U-turn	0		0		\$0		0		\$0
301-303	Rear-end	3	2	-40		(\$40,856)	1	-40		(\$20,428)
305-307	Lane change			0		\$0		0		\$0
308-309	Parallel lanes; turning			0		\$0		0		\$0
406; 407	Vehicle leaving driveway			0		\$0		0		\$0
503-506	Overtaking; same direction			0		\$0		0		\$0
601	Hit parked vehicle			0		\$0		0		\$0
903	Hit railway train			0		\$0		0		\$0
001-003	Pedestrian crossing carriageway	3	2	10		\$52,215		0		\$0
605	Permanent obstruction on carriageway			0		\$0		0		\$0
609	Hit animal			0		\$0		0		\$0
701; 702	Off carriageway, on straight			0		\$0		0		\$0
703; 704	Off carriageway on straight, hit object			0		\$0		0		\$0
705; 502	Out of control on straight			0		\$0		0		\$0
801; 802	Off carriageway, on curve			0		\$0		0		\$0
803; 804	Off carriageway on curve, hit object			0		\$0		0		\$0
805	Out of control on curve			0		\$0		0		\$0
	TOTAL	36	30		TOTAL	\$1,411,233	5		TOTAL	(\$121,382)
7.4	BCR Combining Treatments A & B for RTA (7%)		BCR Ratio @ 7%	NPV/ Cap	NPV @ 7%	Discounted Costs	BCR Ratio @ 7%	NPV/ Cap	NPV @ 7%	Discounted Costs
7.4	BCR Combining Treatments A, B & C for RTA (7%)		8.1	10.3	\$1,236,533	\$174,646	#####	#####	(\$121,382)	\$0

Appendix E: Case Study: Accident Blackspot (site analysis)

Accident Investigation and Prevention (AIP) Study

Location: Sydney Road / Swan Street, South Sydney

Investigation Team:

Michael Roads, Team Leader

Kate Highway, AIP Specialist

William McTraffic, Local Government Representative

June 2001

E1.0 Introduction

E1.1 Background

E1.2 Objectives

E2.0 Analysis of accident data

E2.1 Factor matrix

E2.2 Collision diagram

E3.0 Site investigation

E3.1 Inspection

E3.2 Traffic studies

E3.3 Photographs

E4.0 Development of accident countermeasures

E4.1 Countermeasure options

E4.2 Economic analysis

E4.3 Recommended treatment option

E1.0: Introduction

E1.1 Background

Sydney Road is a four-lane undivided road that runs east-west through the suburb of South Sydney. The road has dual local access/mobility function in carrying approximately 16,000 vehicles/day, while also having a high density of driveways and property accesses. The landuse surrounding the road is mostly comprised of low density residential properties as well as small commercial properties. There are a number of schools and shopping centres along this road. Swan Street is the main collector route for the housing estates in Abbots Park. Swan Street joins Sydney Road at a signalised T-intersection.

The intersection of Sydney Road and Swan Street was identified in the 2001-02 Annual AIP Review. This Review has the function of identifying all sites, routes and areas to undergo a more in-depth AIP analysis as either a Site or a Mass Action study. The criteria established for identifying Sites for AIP assessment was that the subject site needed to have more than 10 accidents within a 10m radius of the intersection. In the Annual Review, approximately 20% of the Sydney Main Road network was covered in order to identify the Sites and Mass Action study locations.

E1.2 Objective

The primary objective of the study is to identify factors that may have contributed to the causation or severity of accidents, and to develop targeted cost-effective countermeasures. To achieve this objective for this site, an AIP study was undertaken. The key tasks of the AIP comprise:

- Undertaking the detailed analysis of accidents that had occurred at the site;
- Carrying out a comprehensive on-site investigation;
- Identification of factors that may have contributed to accident occurrence or severity;
- Development of cost-effective accident countermeasures;
- Economic evaluation;
- Preparation of an AIP report.

The study comprises the collation, investigation analysis and recommendation of countermeasures in accordance with the RTA's *Accident Reduction Guide, Part 1: Accident Investigation and Prevention*, to enable the RTA to determine program priorities.

E2.0 Analysis of accident data

E2.1 Accident data

The accident data records for a 3 year period from July 1997 to June 2000 were reviewed in attempt to identify recurring accident types. The sites were then inspected during the time period where accidents most frequently occurred to investigate and identify possible causes of accidents.

The accident history data has been provided in geocoded electronic format from the RTA's Crash Database. The analysis has included an assessment of the accident DCA code, direction of travel, time of occurrence, weather conditions, vehicle type(s), lighting, road surface condition, year, accident severity and day of the week. The results of this analysis are presented in the Standard Factor Matrix Tables and Collision Diagrams presented as follows.

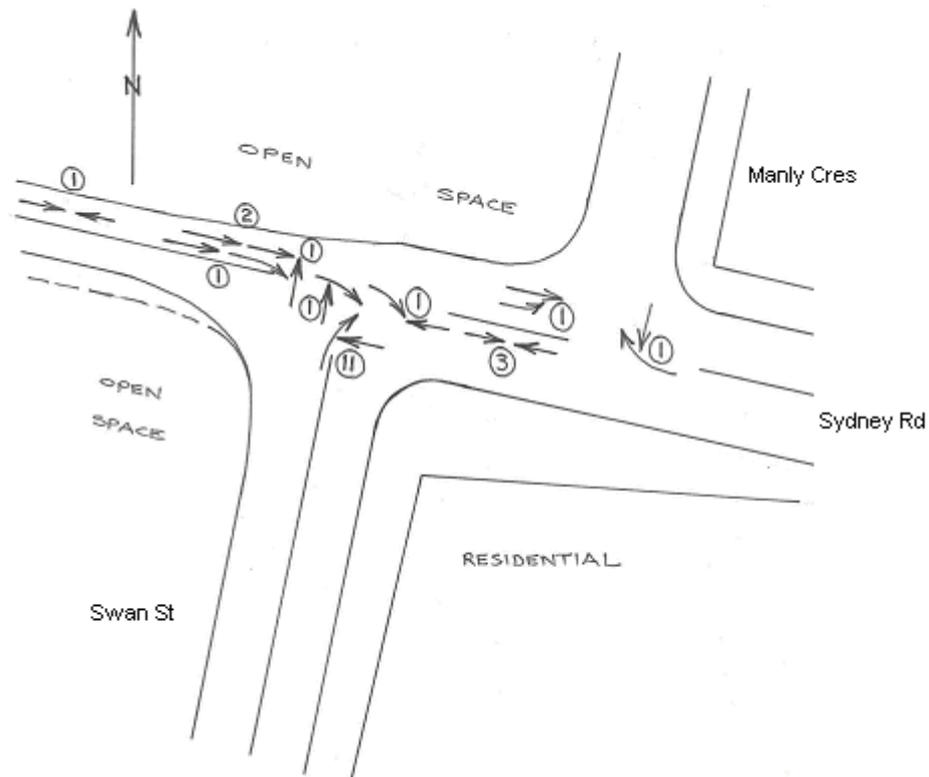


Figure E1: Collision diagram

2.2 Analysis of accident data

A review of the Factor Matrix Table for this site reveals that nearly 35% (11/23) of crashes involve vehicles northbound in Swan Street turning right into Sydney Road, colliding with westbound vehicles in Swan Street. There are a further 4 head-on crashes occurring at the site under rainy conditions with 3 of these at night. The remaining accidents appear to be random and typical of such a busy intersection.

Table E1: Factor matrix for the Intersection of Sydney Road and Swan Street, South Sydney.

DCA CODE	KEY DIRECTION	YEAR OF ACCIDENT			TOTAL	OTHER DIRECTION				TYPES OF VEHICLES INVOLVED						WEATHER			LIGHTING		TYPE OF DAY			
		1997 (JULY TO DECEMBER)	1998	1999		2000 (JANUARY TO JUNE)	EAST	NORTH	SOUTH	WEST	CAR	TRUCK	BUS	MOTORCYCLE	BICYCLE	OTHER	FINE	RAIN	OVERCAST	NIGHT	DAY	WEEKENDS	WEEKDAY	WEEKDAY PEAK HOURS
101	N		1			1	1				2						1			1			1	
104	N	1	5	3	2	11				11	20	2						2	1	5	6	2	6	3
104	W				1	1			1		1	1					1			1				1
104	E			1		1		1			2						1			1				1
201	E	1		1	1	3				3	5		1					3		2	1		2	1
201	W			1		1	1				2							1			1	1		
202	E			1		1				1	2						1				1			1
301	E	1	1			2	2				4						1	1		1	1	1		1
303	E		1			1	1				2						1			1			1	
307	E				1	1	1				2						1				1		1	
TOT		3	8	7	5	23	6	1	1	15	42													

E3.0 Site investigation

A detailed field investigation has been conducted for the site. This investigation gathered information using the methods listed below.

- Drive-Over.
- Walk-Over.
- Traffic Count.
- Site inspection.

Photographic images of the site have been taken, and a schematic plan of the site and surrounds prepared.

E3.1 Inspection

The field investigations for this site were conducted on 8th of August, 2001 at 2.00pm. Due to the high percentage of night time accidents, a supplementary inspection was conducted on the night of the 10th of August at 11.00pm to assess the night time conditions at the site. The site inspection of 8th February was carried out in daylight hours under fine conditions. The site inspection of 10th February was carried out in night time hours under fine conditions. Swan Street is a collector road accessing primary and high schools and a shopping centre and hospital. Sydney Road is constructed to 4 lanes with kerb and gutter to the east of Swan Street, and to 2 lanes without kerb to the west of Swan Street. A local road (Manly Crescent) intersects with Sydney Road immediately east of Swan Street. The intersection is controlled by a give way sign in Swan Street (see Figure 1).



Figure E2: Looking westbound in Sydney Road towards the "left lane ends merge right signs

The inspections revealed the following issues:

- Vehicles travelling westbound in the kerbside lane of Sydney Road encounter 2 “left lane ends merge right” signs immediately before the intersection with Swan Street, yet there is no line marking or physical structure forcing the drivers to merge right before the intersection. Several vehicles were observed merging either in or after the intersection. It is concluded that vehicles waiting to turn right out of Swan Street into Sydney Road may be expecting vehicles in the kerbside lane to turn left into Swan Street and when the occasional vehicle continues through the intersection, a potential conflict exists;
- Humps in the vertical alignment of Sydney Road exist for westbound traffic at a location immediately east of the intersection and at the intersection due to the grading of Swan Street through to the centreline of Sydney Road. These may be contributing to the wet weather head-on accidents at the site;
- A crest in Sydney Road limits sight distance of eastbound traffic in Sydney Road from Swan Street;
- Eastbound vehicles in Sydney Road regularly need to drive onto the verge/shoulder to avoid vehicles queued to turn right into Swan Street; and



Figure E3: Looking west along Sydney Road from Manly Crescent (right side of photo)

- The roadway lighting is all located on the northern side of the road to the west of intersection and is alternately on both sides of the road to the east of the intersection. This may be giving false cues to drivers under wet, dark conditions where the road formation and linemarking may be difficult to perceive. This may be a factor in the 4 head-on crashes at the site though it was not during the night time inspection. A street light on the south west corner of the intersection was not working.

E3.2 Traffic studies

The intersection was surveyed on the 8th of November, 2001 between 06:00 and 19:00. The weather conditions were fine and there were no reported traffic incidents or major constructions in the area. The peak hours surveyed during the survey period were:

■ Morning peak hour

8:30 to 9:30	South			West			East			Total
	Swan Street			Sydney Road			Sydney Road			
	Left	Right	Total	Through	Right	Total	Through	Left	Total	
Light	160	37	197	612	91	703	495	82	577	1,477
Heavy	2	3	5	18	2	20	37	2	39	64
Total	162	40	202	630	93	723	532	84	616	1,541

■ Midday peak hour

12:00 to 11:00	South			West			East			Total
	Swan Street			Sydney Road			Sydney Road			
	Left	Right	Total	Through	Right	Total	Through	Left	Total	
Light	140	25	165	530	152	682	474	83	557	1,404
Heavy	2	1	3	22	0	22	26	2	28	53
Total	142	26	168	552	152	704	500	85	585	1,457

■ Afternoon peak hour

16:00 to 17:00	South			West			East			Total
	Swan Street			Sydney Road			Sydney Road			
	Left	Right	Total	Through	Right	Total	Through	Left	Total	
Light	108	11	119	664	276	940	780	167	947	2,006
Heavy	0	3	3	16	0	16	23	5	28	47
Total	108	14	122	680	276	956	803	172	975	2,053

Only 4 pedestrians were recorded during the 13 hour survey period. The proportion of heavy vehicles during the survey period was 3.3%. During the morning peak it was 4.6%, during the midday peak it was 3.6% and during the afternoon peak it had declined to 2.3%.

■ Traffic temporal pattern

Figure 4 shows the temporal fluctuations in traffic volumes along Sydney Road throughout the typical weekday.

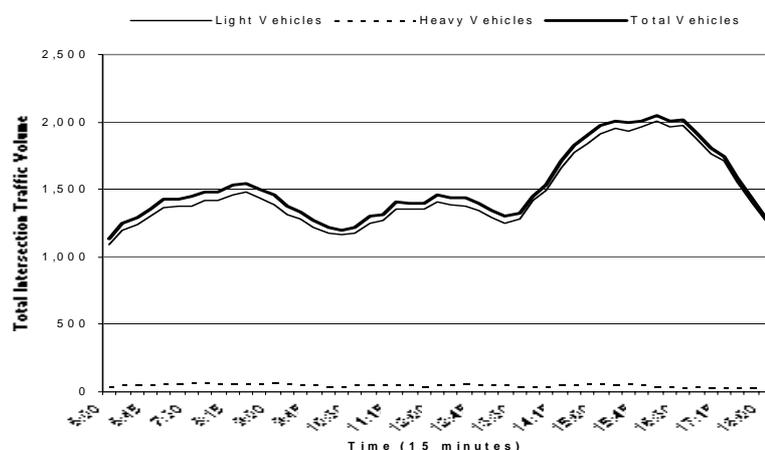


Figure 4: The temporal fluctuations in traffic volumes throughout a typical weekday

■ Estimated AADT (Veh)

The AADT on each approach to the intersection was estimated using traffic data from a nearby RTA pattern station. The count station selected was 02.111, Sydney Road, south of Longhurst Street. The data was obtained from the RTA *“Traffic Volume Data for Sydney Region 1999”* publication.

Approach	NB/EB	SB/WB	Total
Sydney Road (West)	8,668	8,858	17,525
Sydney Road (East)	7,367	8,403	15,770
Swan Street (South)	2,015	2,863	4,878

3.2 Photographs

The following photographs have been taken of the site looking at the intersection from each approach:



Figure E4 - Looking north in Swan Street



Figure E5 - Looking east in Sydney Road, to the west of Swan Street



Figure E6 - Looking west in Sydney Road, towards Swan Street

E4.0 Development of accident countermeasures

E4.1 Countermeasure options

The countermeasures identified for this intersection have been developed to address the specific accidents relating to northbound vehicles turning right from **Swan Street** into **Sydney Road** colliding with westbound vehicles in **Sydney Road**. The following countermeasure options have been proposed for this intersection:

- **OPTION 1** Adjustment of sign posting to "Left Lane Must Turn Left", left turn pavement arrows and an unbroken lane line in the westbound kerbside lane approaching **Swan Street**. This will minimise the occurrence of vehicles merging at or past the intersection. A countermeasure diagram is not required to describe this option;
- **OPTION 2** Enhancement of the above option to include a raised island to enforce the left turn only and moving the yield line in **Swan Street** further north to provide improved sight distance down **Sydney Road** to the east. In conjunction with this, widening of the eastbound lanes to provide a dedicated right turn lane for vehicles to turn into **Swan Street** with a seagull treatment. This will improve the ability of vehicles turning right out of **Swan Street** to pick a gap and hence reduce the likelihood of forcing into too small a gap in westbound traffic. A raised median on the westbound approach would be incorporated with this option to provide enhanced delineation to address the wet, night head-on crashes. The adjacent **Manly Crescent** would be configured to left in and out only. Traffic turning right out of **Swan Street** would not be allowed to turn left into **Manly Crescent**. This could even be emphasised by using a back-to-back SF kerb between the acceleration lane from **Swan Street** and the through lane on **Manly Crescent**. Left turn access into **Manly Crescent** for vehicles leaving **Swan Street**, and right turn access into **Manly Crescent** would be provided via the next intersection to the east, at **Wainwright Street**. A countermeasure diagram is presented in Figure E7 for this option;

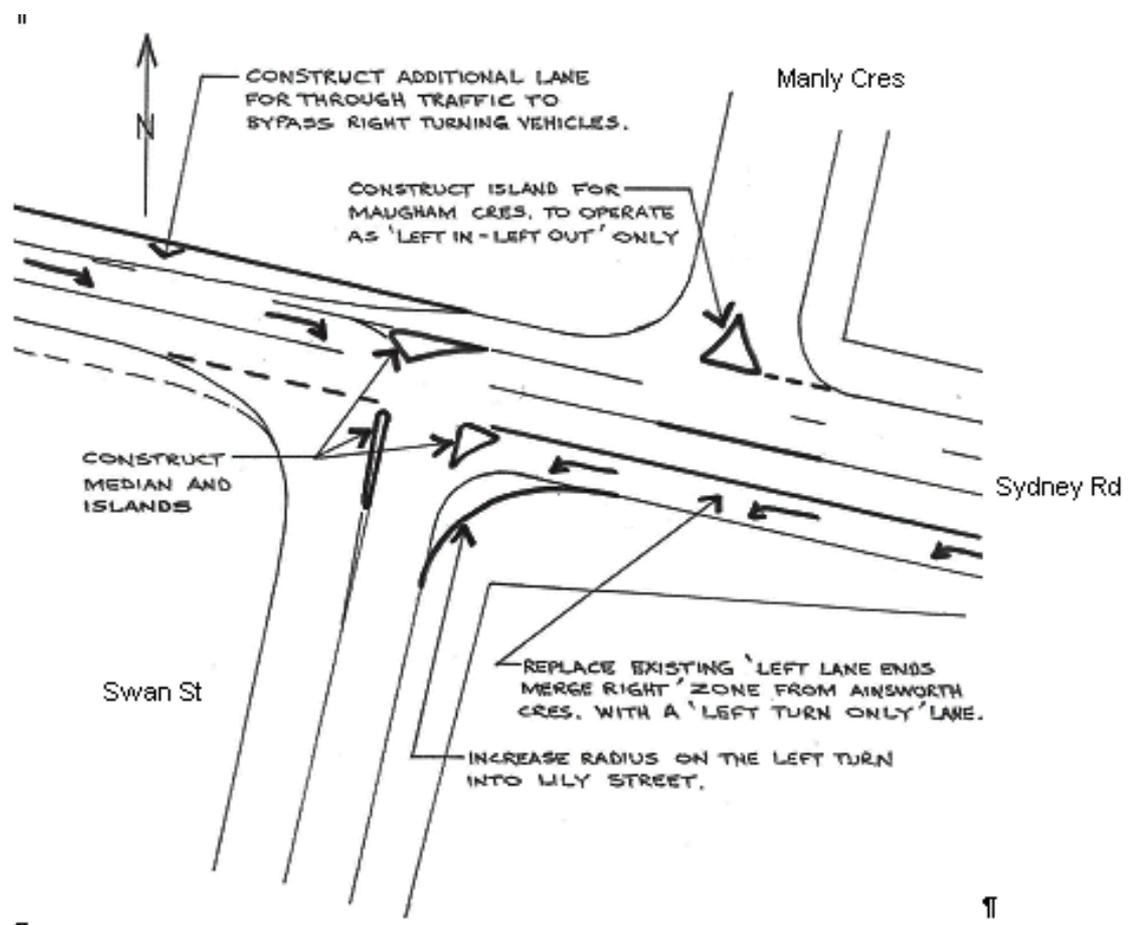


Figure E7: Countermeasure Diagram for Option 2

- OPTION 3 Complete reconstruction of the intersection to 4 lanes with a separate right turn lane into Swan Street and installation of traffic signals. This will require the construction of **Sydney Road** to 4 lanes past the crest to the west of the site to ensure adequate stopping site distance is available of vehicles queued at the intersection for eastbound traffic. A raised median on the westbound approach would be incorporated with this option to provide enhanced delineation to address the wet, night head-on crashes. This option may also include a full or partial closure of Manly Crescent with its intersection with **Sydney Road**. A countermeasure diagram is not required to describe this option.
- Alternate countermeasures considered but not adopted included banning of right turns out of Swan Street. This was not considered feasible due to the high traffic demand due to the number of major generators accessed via Swan Street.

No definitive causes for the head-on accidents during wet weather were observed. The change in roadway lighting location may be factor but it is not clear that this is the case. It is recommended that the site be inspected during a combination of rain and night time conditions to re-evaluate the site.

E4.2 Economic analysis

Option 1:

The estimated cost of Option 1 is \$2,000. This resulted in a predicted BCR of 26.0 as shown in Figure E8.

Intersection of Sydney Road and Swan Street, South Sydney			Option 1		
Speed Limit of Main Road		60	31: Separate Left Turn Deceleration Lane, Painted or Channelised		
Expected Annual Traffic Growth (%)		2.0	Initial Cost of Treatment	\$2,000	
Assumed Project Life		10	Annual Maintenance	\$50	
Years of Accident Data/Start		3.00	Treatment Code	31	
DCA Codes	Descriptions	Total Accidents	Target Accidents	Assumed Reduction	Discounted Benefits (RTA 7%)
101-109	Intersection, adjacent approaches	11	6	10	\$61,136
201	Head-on			0	\$0
803; 804	Off carriageway on curve, hit object			0	\$0
805	Out of control on curve			0	\$0
TOTAL		11	6	TOTAL	\$61,136
		B/C Ratio @ 7 %	NPV/Cap Cost	NPV @ 7%	Discounted Costs
		26.0	29.4	\$58,785	\$2,351

Figure E8: BCR Calculation for Option 1

Option 2:

The estimated cost for Option 2 is \$175,000 which gives a BCR of 5.3 as shown in Figure E9.

Speed Limit of Main Road		60	31: Separate Left Turn Deceleration Lane, Painted or Channelised			11: SEAGULL Island With Acceleration Lane, Raised Island		
Expected Annual Traffic Growth (%)		2.0	Initial Cost of Treatment		\$15,000	Initial Cost of Treatment		\$160,000
Assumed Project Life		20	Annual Maintenance		\$100	Annual Maintenance		\$400
Years of Accident Data/Start		3.00	Treatment Code		31	Treatment Code		11
DCA Codes	Descriptions	Total Accidents	Target Accidents	Assumed Reduction	Discounted Benefits (RTA 7%)	Target Accidents	Assumed Reduction	Discounted Benefits (RTA 7%)
101-109	Intersection, adjacent approaches	16	6	10	\$99,022	5	20	\$165,036
201	Head-on	4		0	\$0	3	40	\$563,971
202-206	Opposing vehicles; turning	1		15	\$0	1	40	\$66,517
207; 304	U-turn			0	\$0		15	\$0
301-303	Rear-end			60	\$0		60	\$0
305-307	Lane change	1		40	\$0	1	40	\$52,443
308-309	Parallel lanes; turning			40	\$0		40	\$0
805	Out of control on curve			0	\$0		0	\$0
TOTAL		22	6	TOTAL	\$99,022	10	TOTAL	\$847,967
BCR Combining Treatments A & B for RTA (7%)			B/C Ratio @ 7%	NPV @ 7%	Discounted Costs	B/C Ratio @ 7%	NPV @ 7%	Discounted Costs
5.3			6.2	\$82,962	\$16,059	5.2	\$683,730	\$164,238

Figure E9: The BCR calculation for Option 2

Option 3:

The estimated cost for Option 3 is \$1,988,000 which resulted in a BCR of 0.3. This option is not recommended.

With respects to the BCRs calculated above, Option 1 is considered the most preferred option. The proposal is considered likely to have significant accident reduction benefits and is unlikely to have community opposition to its implementation.

The construction of the separate through and right turn lanes on the eastbound approach would improve the traffic conditions by reducing the delay to through vehicles caused by right-turning vehicles. Similarly, the changing of the westbound kerb-side lane to a 'left turn only' lane would make the right turn from Swan Street easier as these vehicles would only have to find an acceptable gap in one lane of westbound traffic instead of two. The banning of right turn movements from the intersection of Sydney Road and Manly Crescent would create a minor increase in travel time for those residences on Manly Crescent. There are, however, right-turn opportunities at Wainwright Street and a number of other side streets along Sydney Road, hence all existing access would be maintained. Residents on Manly Crescent should be consulted if it is decided to proceed with option 2.

E4.3 Recommended treatment option

The Option 1 countermeasure can be implemented as soon as practical. Option 2 will require preparation of further design, analysis and approvals.

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