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Guide to Road Safety Part 6

Road Safety Audit

Austroads

Guide to Road Safety Part 6:
Road Safety Audit

Sydney 2009

Guide to Road Safety Part 6: Road Safety Audit

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Abstract

This guide revises and updates the 2002 second edition of the Austroads *Road Safety Audit* guide. It provides a comprehensive introduction to the road safety audit process. Easy to read and implement, the guide is suitable for use by any person with a responsibility for, or an interest in, road safety.

Designed for use by road safety and traffic engineers, police, academics, local, provincial, state and national government officers, clients, students, researchers, consultants and many others, the guide provides both a comprehensive overview to, and application of, the road safety audit process.

Clear details of the audit process are provided, together with a number of audit case studies. The guide includes chapters on legal liability, costs and benefits, the audit process, safety principles and technical issues which need to be considered in road safety engineering.

The guide includes updated checklists for use in assessing road designs and inspecting project sites at the different stages of a project's development. These checklists may be printed off from the electronic version of the guide for use in the field.

Keywords

Road safety audit, road safety engineering, legal liability, proactive engineering safety, road safety system

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About Austroads

Austroads is the peak organisation of Australasian road transport and traffic agencies.

Austroads' purpose is to support our member organisations to deliver an improved Australasian road transport network. To succeed in this task, we undertake leading-edge road and transport research which underpins our input to policy development and published guidance on the design, construction and management of the road network and its associated infrastructure.

Austroads provides a collective approach that delivers value for money, encourages shared knowledge and drives consistency for road users.

Austroads is governed by a Board consisting of senior executive representatives from each of its eleven member organisations:

- Roads and Maritime Services New South Wales
- Roads Corporation Victoria
- Queensland Department of Transport and Main Roads
- Main Roads Western Australia
- Department of Planning, Transport and Infrastructure South Australia
- Department of State Growth Tasmania
- Department of Infrastructure, Planning and Logistics Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- The Department of Infrastructure, Regional Development and Cities
- Australian Local Government Association
- New Zealand Transport Agency.

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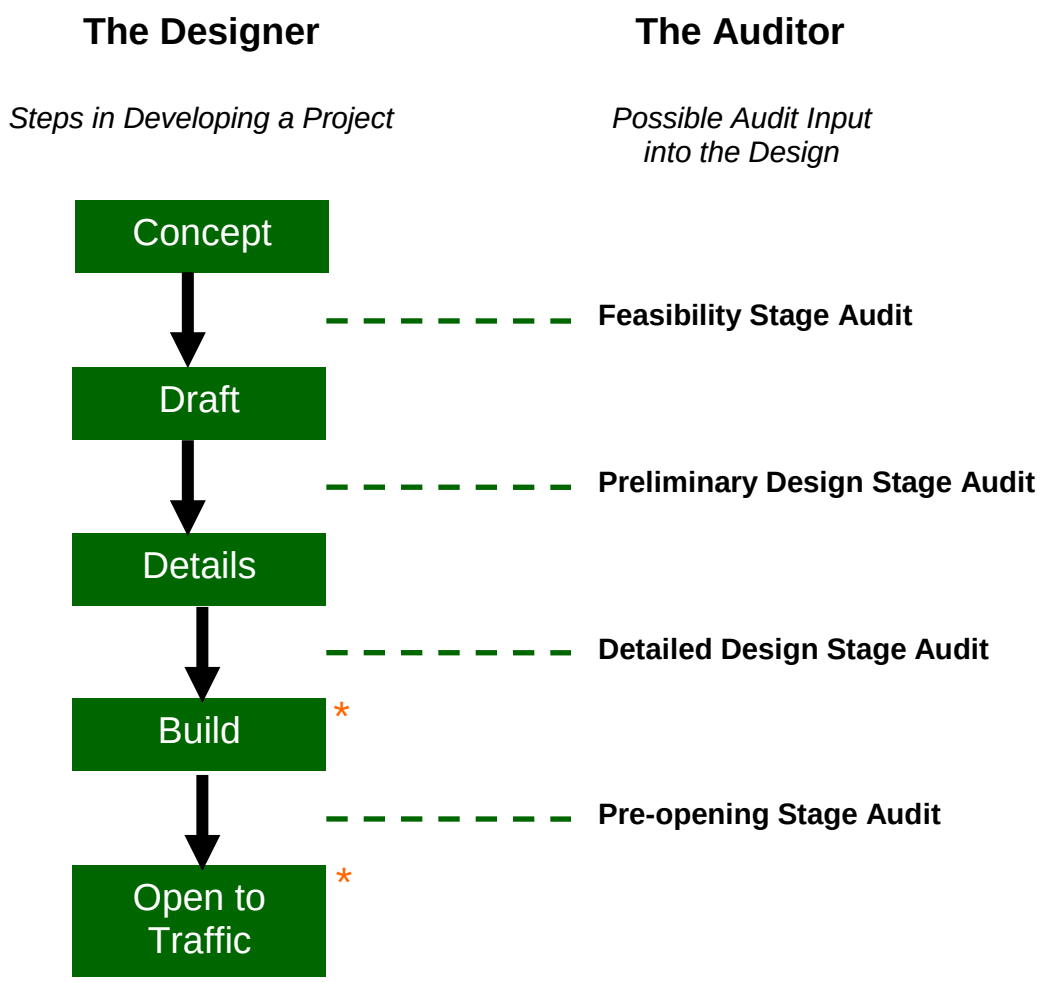
1. Introduction

1.1 Road Safety Audit

A road safety audit 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 crash potential and safety performance.

A road safety audit has the greatest potential for improving safety and is most cost-effective when it is applied to a road or traffic design before the project is built. It can be conducted on any design proposal that involves changes to the ways road users will interact, either with each other or with their physical environment. It is a formal process using a defined procedure. To be effective it must be conducted by people who are independent and who have appropriate experience and training.

Figure 1.1: How audits fit into the planning, design and development process



* Audits can also be undertaken to assess the safety of:

- temporary traffic schemes for roadworks, and
- the new road, some time after it has been opened.

Road safety audit needs to be a routine and common practice in the same way as independent structural checking or benchmarking is a routine and common practice.

When a road safety audit is conducted, the designer of the new project remains responsible for the design. As a matter of good practice and as part of a quality management approach, the designer should make regular, informal checks of the physical safety of a design as it progresses. Road safety audits do not alter the need for this 'safety first' approach amongst designers. The road safety audit process provides, at regular intervals, for an independent assessment to be made by a team specifically skilled in the areas of crash prevention and road safety engineering (Figure 1.1). That assessment and its findings or recommendations are then considered by the client and/or the designer.

1.2 About this Guide

This guide is closely based on the Austroads *Road Safety Audit*, second edition, 2002 publication.

Significant changes incorporated in this edition include:

- link to the safe system approach to road safety
- an update of the legal issues associated with road safety audits and quality assurance within Australia
- the legal issues associated with road safety audits and quality assurance within New Zealand
- review and updating of checklists to increase emphasis on heavy vehicle safety
- the term 'road safety review' for existing road audits has been replaced by 'road safety audit'
- updating of selected diagrams and some photographs
- the application of an evidence based approach to the prioritisation of the treatment of deficiencies identified during a road safety audit of existing roads and pre-opening stage audits
- tools to assist with road safety audit.

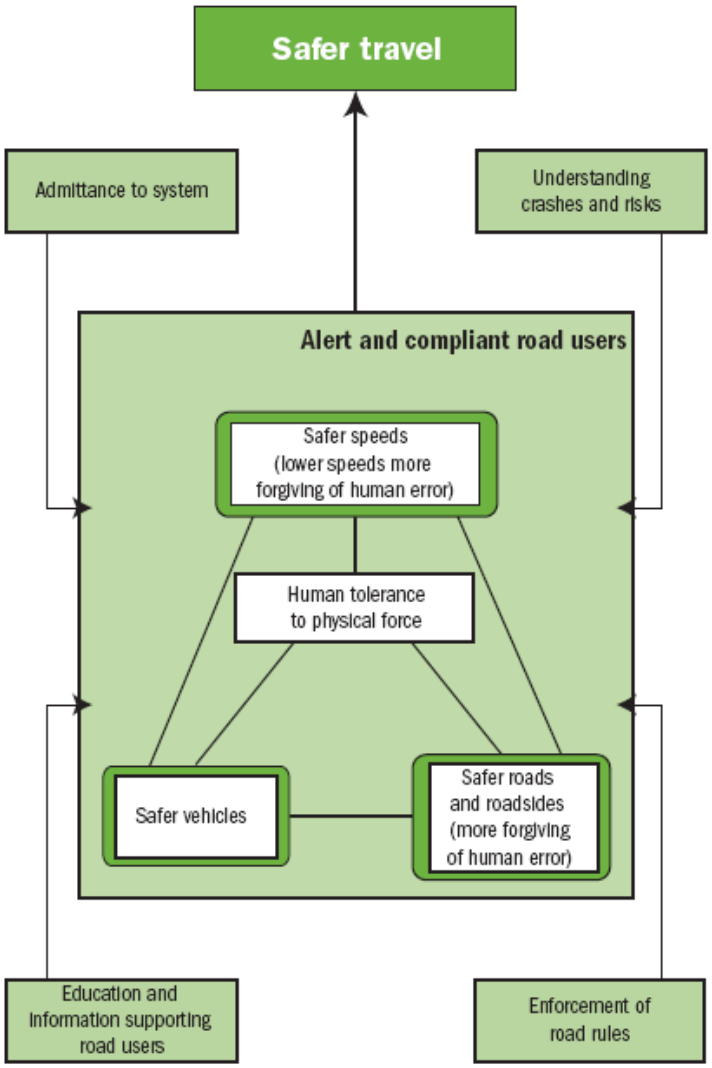
1.3 Building a Safe Road System

The identification and removal or treatment of road elements which may contribute to crash occurrence or crash severity is a key component of the *safe system* (Figure 1.2) approach to road safety. A safe system acknowledges that human error within the transport system is inevitable, and that when it does occur the system makes allowance for these errors so as to minimise the risk of serious injury or death. In a safe system, therefore, roads (and vehicles) should be designed to reduce the incidence and severity of crashes when they inevitably occur.

The safe system approach requires, in part (Australian Transport Council, 2006):

- designing, constructing and maintaining a road system (roads, vehicles and operating requirements) so that forces on the human body generated in crashes are generally less than those resulting in fatal or debilitating injury
- improving roads and roadsides to reduce the risk of crashes and minimise harm: measures for higher speed roads including dividing traffic, designing 'forgiving' roadsides, and providing clear driver guidance. In areas with large numbers of vulnerable road users or substantial collision risk, speed management supplemented by road and roadside treatments is a key strategy for limiting crashes
- managing speeds, taking into account the risks on different parts of the road system.

Figure 1.2: Safe system framework



Safer road user behaviour, safer speeds, safer roads and safer vehicles are the four key elements that make up a safe system. In relation to speed the Australian Transport Council (2006) reported that:

- Speed in urban areas greater than 5 km/h above average and 10 km/h above average in rural areas doubles the risk of an injury crash.
- Reductions of as little as 1 to 2% in average speed result in substantially greater reductions in fatalities and serious injuries.
- Chances of surviving a crash decrease markedly above certain speeds, depending on the type of crash i.e.:
  - pedestrian struck by vehicle → 20 to 30 km/h
  - motorcyclist struck by vehicle (or falling off) → 20 to 30 km/h
  - side-impact vehicle striking a pole or tree → 30 to 40 km/h
  - side-impact vehicle to vehicle crash → 50 km/h
  - head-on vehicle to vehicle (equal mass) crash → 70 km/h

As a means of improving road safety the OECD/ECMT (2006) highlighted speed management as the 'central element of any road safety strategy (which) aims to achieve appropriate speeds on all parts of the road network'.

Road safety auditing, which takes a proactive approach to road safety, in combination with the reactive treatment of existing blackspot locations also forms an integral part of the safe system approach.

1.4 Road Safety Audit is More than Checking Standards

Standards are an important starting point with any road design. A designer should be familiar with the relevant standards, attempt to comply with them and be aware of where any standard cannot be achieved.

However, standards do not guarantee safety as:

- standards are developed for a range of reasons, e.g. cost or traffic capacity, as well as safety
- standards are often a minimum requirement; combining a series of minimums is undesirable and can leave no room for error, either on the part of the designer, the builder or the final road users
- standards usually cover general or common situations, not all situations
- the standard may not be applicable to the circumstances in the design
- individual road elements, designed to standard, may be quite safe in isolation but may, when combined with other standard elements, be unsafe (i.e. lead a significant number of road users to make errors)
- the particular standard may be based on old information
- a designer may be using an inappropriate standard or an outdated standard.

Rather than checking for compliance, a road safety audit is checking fitness for purpose: will the road or treatment work safely for its expected road users? Auditors should also fully understand the safe system and be able to integrate this approach, as appropriate, into the audit process.

1.5 Costs and Benefits of Road Safety Audits

1.5.1 Cost of Auditing Road Designs

The cost of a road safety audit can range from several thousand dollars (for a relatively minor traffic project at one design stage) to ten thousand dollars or more per stage for a major road project. This is typically less than 4% of the road design costs (although the percentage could be higher on minor projects). As design costs can be in the order of 5% to 6% of total implementation costs for larger projects, the increase in total project cost is usually quite small. The cost of rectifying any inadequacies depends on how early in the design process they are identified and the consequent amount of redundant design time.

1.5.2 The Benefits

The benefits of road safety audit range from the more obvious direct improvements in a design to things as broad as enhancement of corporate safety policies. They include:

- safer new highways through crash prevention and crash severity reduction
- safer road networks
- a more uniform road environment that is more easily understood by road users and becomes self explaining to road users. This adopts the self explaining roads approach to sustainable road safety as adopted in the Netherlands (OECD/ECMT 2006)
- reduced whole of life costs of road schemes

- providing one component of local and state crash reduction targets
- a reduced need to modify new schemes after they are built
- a better understanding and documentation of road safety engineering
- eventual safety improvements to standards and procedures
- more explicit consideration of the safety needs of vulnerable road users
- the encouragement of other personnel in road safety.

A study by Austroads (Macaulay and McInerney 2002), identified substantial benefits from the road safety audit process. The evaluation considered the benefits of implementing appropriate treatments identified in response to detailed design and existing road safety audits.

The conclusions were based on estimated safety benefits calculated using the Road Safety Risk Manager, a software tool developed by ARRB in association with Austroads that allows an assessment of risk before and after the recommended or proposed treatments. For a wider economic evaluation, including effects on travel time and vehicle operating costs, refer to the Austroads *Benefit Cost Analysis Manual* (Austroads 1996).

Their evaluation of recommendations emanating from design stage audits found that:

- Of the nine design stage audits assessed, the benefit cost ratio (BCR) of implementing the recommendations from individual audits ranged from 3:1 to 242:1.
- The BCRs of individual recommendations within the design audits ranged between 0.06:1 and 2,600:1.
- Over 90% of all implemented recommendations had BCRs > 1.0.
- Approximately 75% of all implemented recommendations had BCRs > 10.
- The majority of design audit findings required only very low-cost responses (65% of recommendations had a cost < $1,000). Of these low-cost responses 85% had BCRs > 10.

An evaluation of the proposed actions emanating from existing road safety audits resulted in the following findings:

- The analysis of a range of existing road safety audits indicated BCRs of implementing the proposed actions between 2.4:1 and 84:1.
- The BCRs of individual proposed actions within the existing road audits ranged between 0.003:1 and 460:1.
- Over 78% of all proposed actions had BCRs > 1.0.
- Approximately 47% of all proposed actions had BCRs > 5.0.
- Approximately 95% of proposed actions with a cost less than $1,000 had BCRs > 1.0.

The completion of design and existing road safety audits will also result in many qualitative benefits. In addition to the safety related benefits of proactively identifying and treating specific hazards the other benefits of the audit process include:

- identification of improved design, construction and maintenance standards that influence safety performance on an ongoing basis
- the role the audit plays in improving the general road safety awareness of operational staff
- the role the audit plays in providing the designer/asset owner with confidence in the safety performance of the proposed project or road network.

An important element of the audit process is the recognition that an audit with no deficiencies identified will still retain significant value in providing assurance of safety. As with all audit processes an audit with no deficiencies identified is a positive and desirable outcome.

2. An Explanation of a Road Safety Audit

2.1 What is a Road Safety Audit?

A road safety audit 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 crash potential and safety performance. The road safety audit process concerns the safety of all road users, such as those shown in Figure 2.1.

The essential elements of the definition are that it is:

- a formal process and not an informal check
- carried out by people who are independent of the design or the road authority if an existing road
- carried out by people with appropriate experience and training
- restricted to road safety issues.

Figure 2.1: Road safety audit concerned with the safety of all road users

A road safety audit:

- is **not** a way of assessing or rating a project as good or poor
- is **not** a means of ranking or justifying one project against others in a works program
- is **not** a way of rating one option against another
- is **not** a check of compliance with standards
- is **not** a substitute for design checks
- is **not** a crash investigation
- is **not** a redesign of a project
- is **not** something to be applied only to high-cost projects or only to projects involving safety problems
- is **not** the name used to describe informal checks, inspections or consultation.

The outcome of a road safety audit is a Road Safety Audit Report, that identifies any road safety deficiencies and which may make recommendations to remove or reduce the deficiencies.

2.2 Why Conduct Road Safety Audits?

The benefits of conducting road safety audits are that:

- the risk of crash occurrence is reduced
- the severity of crashes can be reduced
- road safety is given greater prominence in the minds of road designers, traffic engineers and road funders
- the need for costly remedial work is reduced
- the total cost of a project to the community, including crashes, disruption and trauma, is reduced.

2.3 When Should a Road Safety Audit be Done?

There are typically four opportunities within the design and development process for a road or traffic project when a road safety audit can be conducted, regardless of the size or nature of the project:

- at the **feasibility** stage
- once the **preliminary design** stage has been developed
- once the **detailed design** stage is complete
- at the **pre-opening** stage (or soon after the project is complete).

A road safety audit may also be conducted:

- for roadwork traffic management required during construction of significant projects
- on the existing road network.

A road safety audit can also be undertaken at any stage of a project's life cycle or in stages throughout the design or construction of large projects.

The earlier a project is audited within the design and development process the better. If an inappropriate concept or treatment (i.e. one with inherent safety problems in the particular context) is chosen at the feasibility stage, it is very difficult and often impossible to remove the safety problems at later design stages or once traffic is using it. Early auditing can also lead to the early elimination of problems and, consequently, minimisation of wasted design time at later stages.

2.4 What Types of Projects Should be Road Safety Audited?

Road safety audits are applicable to all types of road projects, on all types of roads. It is not the scale of the project that is important, but the scale of any potential hazard the design may unwittingly hide. Developing a safe initial design is fundamental to the safety performance of a road. Figure 2.2 for example, shows that the progressive adding of signs is not a substitute for a safe initial design.

Figure 2.2: Adding signs is no substitute for safe initial design

Road safety audits can be conducted on road projects as diverse as:

- new freeways
- major divided roads
- reconstruction and realignment projects
- intersection projects
- pedestrian and bicycle routes
- deviated local roads near major projects
- local area traffic management schemes and their component parts
- signal upgradings
- subdivision proposals
- crash reduction schemes
- safe routes to school projects
- maintenance with improvement activities, such as seal widening in conjunction with rehabilitation.

Some road authorities require a percentage of design projects on major roads to be audited. Others require all projects, or a percentage of projects, above a set value to be audited. When deciding which projects should be audited ahead of any other, the effective allocation of resources should be a deciding factor. Choose a range of project sizes and seek to audit them earlier rather than later.

Audits can also be conducted on projects that are 'off-road', but which affect nearby roads or create off-road areas that effectively operate like roads. For example, a commercial development might result in the following activities that may affect the safety of road users:

- vehicle/pedestrian conflicts in the new car park
- increased numbers of pedestrians crossing the adjacent road
- a spillover of parking onto an adjacent busy road
- restricted visibility or delays where vehicles access the development
- changed public transport circulation and access by users
- changed access/egress/unloading for delivery trucks
- changed traffic patterns on the adjacent road network.

2.5 Who Should Perform a Road Safety Audit?

2.5.1 Skills

Experience in road safety engineering is the one essential ingredient in any road safety audit team. This should be linked to an understanding of:

- traffic engineering and traffic management
- road design and road construction techniques
- road user behaviour.

Different stages of an audit require different skills and experience (Section 4.1).

2.5.2 Experience

People who engage auditors should ensure the team leader has adequate road safety engineering experience for the stage of audit and is a Senior Road Safety Auditor. A Senior Road Safety Auditor has:

- successfully completed a recognised audit training course, of at least two days duration
- at least five years experience in a relevant road design, road construction or traffic engineering field (this is a minimum and team leaders for audits of more complicated projects should have significantly more experience)
- undertaken at least five formal road safety audits, including at least three at design stages
- kept their professional experience current by undertaking at least one audit per year.

Some jurisdictions require that road safety auditors be formally accredited and/or registered. The accreditation and registration formally acknowledges the auditor's successful completion of a recognised audit training course and their relevant auditing experience.

2.5.3 Independence

The road safety auditor must be independent, so that the design is viewed with 'fresh eyes'. Nonetheless, good communication between the parties must be established and maintained if the audit is to be done effectively and without wasted time and effort. Further, the sensitivity associated with having design work 'judged' should be recognised. Auditors need to be objective in their assessments, yet sensitive to the fact that no one likes criticism. Designers and clients need to consider audit findings or recommendations objectively and gain from the experience, and recognise that the project helps avoid their project being constructed with safety problems.

2.5.4 The number of auditors

It is advisable to have a road safety audit team of two or more experienced and qualified people. Benefits of having a multi-member audit team, rather than a single person, include:

- the diverse backgrounds and different approaches of different people
- different skill sets for different aspects of the project
- the cross-fertilisation of ideas which can result from discussions
- having more pairs of eyes.

It may not always be practical to have a multi-member team conducting an audit. An audit of a low-budget project could consist of some phone calls, an examination of a single plan, a site inspection day and night and a short report (Section 4.1).

2.6 Organising a Road Safety Audit

There are a number of ways of organising a road safety audit, but specialist expertise must be incorporated. The most effective way to organise a road safety audit is to engage a specialist audit team that has road safety engineering skills and experience that are appropriate and independent of the project.

Specialist, independent audit teams can be established within large road authorities, large consultant companies or consortia. For other organisations involved with road and traffic design, individual specialist road safety audit consultants are available.

There needs to be a clear understanding, prior to commencement of an audit, about how the audit findings or recommendations will be dealt with. Someone has to consider the findings or recommendations and resolve the inevitable trade-offs with other factors (for example, project cost, road capacity, etc.). It is preferable that a senior person within the design organisation or its client organisation does this and decides whether to accept or not accept each finding or recommendation. In every case where an audit finding or recommendation is not accepted, the reasons must be documented.

2.7 How is a Road Safety Audit Conducted?

Depending on the type of project and the stage of development a project has reached, each road safety audit will consider different issues. However, the steps to be followed will generally be similar. The steps are described in the flow chart in Figure 4.1 and can be thought of as a three-phase process:

The designer or client:

- selects an audit team
- provides all the documents
- holds a commencement meeting with the auditor.

The audit team:

- road safety audits all the documents and drawings
- inspects the site (including at night-time)
- repeats these two steps (as required)
- writes the audit report
- holds a completion meeting with the designer or client.

The designer or client:

- decides on the action required in response to the audit report, and its findings and recommendations[1]
- documents these decisions
- implements the decisions by amending the design
- feeds the experience back into the organisation, to avoid similar design problems recurring
- where possible sends a copy of the documented decisions to the audit team leader.

The road safety audit process may use checklists to assist the auditor in considering the relevant issues. Different checklists have been developed for the different stages of a project's development. These are provided in Section 11. The checklists are intended to be used as a prompt; they are not exhaustive lists which cover every detail. The auditor should use individual judgement about the safety of any feature. The checklists are not a substitute for knowledge and experience: they are an aid for the application of that knowledge and experience and to make sure all factors are considered.

2.8 Road Safety Audits and Quality Assurance

Quality assurance is a management process in which the provider of goods or services assures the customer or client about the quality of those goods or services, without the customer or client having to check each time. This is done by the implementation in the provider's organisation of a set of procedures designed to ensure that agreed standards are met. Quality assurance procedures provide a level of protection to the client and customer in any investment project.

Part of the quality assurance procedure for the design and implementation of new road or traffic projects is to input road safety engineering expertise into the design through road safety audit.

'Getting it right the first time' is the underlying theme of quality assurance. With each task and at each step, the objective is to have people make fewer mistakes (and preferably none) so that work is completed without wasted time or unnecessary cost. The similarity with road safety audits is apparent: audits seek to ensure the road operates 'right the first time' once it opens and that the road users make fewer mistakes. Figure 2.3 provides a line and pavement marking example of not getting it right the first time. Increased costs are incurred while failure to properly remove old markings may create some confusion amongst road users which could increase their crash risk.

1 If requested by the client.

Figure 2.3: Getting it right the first time prevents this happening

Rather than one negating the need for the other, quality assurance and road safety audits are complementary. Each day, as people in a quality assured organisation design a road, they apply quality assurance techniques by following established procedures and regularly checking the details of their own work. This regular checking includes checking safety aspects. This self assessment is not 'road safety auditing' because it is not done with a 'fresh pair of eyes' (it is not independent) and it probably is not applying road safety engineering skills and experience to the task. So, at stages, an independent safety audit of the design is sought, to permit independent road safety engineering advice to be input for the benefit of the road's future customers.

A road design organisation's quality assurance procedures can also state what is expected in connection with road safety audits: the frequency of audits, the required skills and experience of auditors, the number of auditors for different size design projects, how auditors are selected, the audit process to be followed and the format/content of the audit report.

2.9 Practical example: Avoiding misunderstandings

Good, clear communication is essential in any road safety audit

The example that follows shows the importance of good, clear communication. The situation concerns an audit report on a scheme for an inner city bus priority scheme; the audit team has written that the way buses will re-enter the traffic from a bus bay 'is dangerous and the design must be changed'.

The audit procedures within the organisation require the designers to incorporate all audit recommendations, but the designers are upset that their design has been misunderstood by the auditors. They firmly feel it is not unsafe in the traffic environment at the site and a dispute ensues.

How might these problems be overcome?

The company has set out clear procedures and lines of responsibility. It is good that they have sought to do this. However, the benefits of road safety audit could be better achieved if these procedures were altered and the audit team's role reassessed:

- Independence of auditors is important, but so too is a good rapport and good communication between designers and auditors. It is the auditors' job to help the designers develop a better (safer) design. It is natural for designers to be fearful of peer review and see audit findings or recommendations as criticism or uninformed comment – especially when communication with the auditors is not available. The opportunity for auditors and designers to communicate with each other needs to be provided.

- The audit process requires a commencement meeting. This meeting provides an opportunity for auditors to ask questions and for designers to explain the purpose of a scheme and any unique aspects. After this meeting, it is important that auditors can contact the designers to discuss any queries. Memorandums are no substitute for direct communication.
- The audit team's written comment that one design aspect 'is dangerous and the design must be changed' is unhelpful for the designers. Designers need guidance about the nature or source of the identified problem. A comment like 'buses will swing out into the oncoming traffic; check the swept paths and redesign to avoid this conflict' would help the designers know what the auditors see as the problem. The anticipated crash type could be identified. It would also let them make judgements about the risks associated with the problem, which in turn would help them decide whether or not to change the design. The company could check whether its audit team has sufficient experience and skills.
- Audit team comments like 'the design must be changed' suggest a misunderstanding of the auditors' role. Unless the audit team is very experienced in road safety engineering and is highly respected by the designers (which at least requires good communication), it is not appropriate to give auditors a 'power of veto'. It is vital that designers retain responsibility for their own designs. They can do this by giving due consideration to audit findings and recommendations[2], carefully documenting the reasons for any rejection of a finding or recommendation.

2 If requested by the client.

3. Legal Issues

3.1 Introduction

The law plays many roles with regard to behaviour that affects collisions on the roads. Through legislation, it allocates responsibility between central road authorities and local government; it creates both duties and powers in those governmental units. The criminal law prescribes a system of fines and imprisonment for those who violate road rules. The common law, i.e. the law made by judges through decided cases, awards damages to persons injured on the road against drivers and against road authorities that fall below the required standard of care. It is this particular aspect of the law that is examined here.

The process of road safety audit has been shown to heighten an awareness of safety and to promote a safer road environment. This parallels the objectives of the law in this area. The common law promotes safety by awarding damages against a driver or a road authority which has fallen below the required standard of care; this is expected to cause the wrongdoer to modify their behaviour in the future. The desire to avoid injury, and to avoid having to pay damages, is expected to have a general deterrent effect. Therefore the law will applaud the development and use of the process of road safety audit and encourage its widespread adoption. Another aim of the law in this area, perhaps the primary aim, is to provide compensation to those road users who can show that they have been injured as a result of someone else falling below the expected standard of care. When the injured road user is able to show that a road authority has done something which a reasonable road authority would not have done, or has failed to do something which a reasonable road authority would have done, then compensation is ordered to be paid from the road authority to the injured road user.

This section is intended to highlight the way in which the common law functions to give advice as to how to minimise the risk of incurring liability, and to explain the legal implications of road safety audit. This chapter is intended to sensitise readers to the legal issues involved.

This section describes the legal situation for Australia. The general principles are based upon developments both in Australia and in England. The legal position elsewhere may vary markedly from that in Australia and caution should be used in assuming the situation would be governed by similar principles. In particular, the legal situation in New Zealand differs, in part, from that of Australia. In both Australia and New Zealand there are very clear requirements that road authorities and local government authorities act in the interests of the safety of the public and road users. In both countries road authorities must create a safer road environment through providing direction, through delivery of crash reduction strategies, and through management control which ensures that road safety engineering processes will be used. Australia, in addition to these, through the law of tort, condemns those authorities who fail to deliver reasonably safe roads to pay damages to road users who are injured as a result of that failure.

The powers and duties of road authorities in Australia are controlled by legislation and by regulations made pursuant to that legislation. At the present time, road safety audit is not specifically mentioned. The decision whether to adopt road safety audit and in what form is left to the individual road authority and is not mandated by parliament. This section will assume that the adoption of the process of road safety audit is a power which may be undertaken rather than a duty imposed on a particular road authority.

The process of road safety audit has not featured prominently in the decisions of courts of Australia in recent times. No road authority has yet been sued for failing to subject a project or road to a road safety audit. Nor is that likely in the future when the process becomes even more widespread.

3.2 State of the Road

The courts of Australia are concerned with the state of the road at the time of the crash. Courts of law concern themselves with the factors that cause road crashes, including driver behaviour, the road environment, the vehicle, or any combination of those. With regard to the road environment, courts have been made aware that there are several methods by which roads can provide the road user with a reasonable level of safety. The law leaves the method by which hazards on the road, obstructions, deterioration and the like are to be discovered and remedied to the experts – the road authorities. It would be unusual that a court would consider whether a road safety audit had been conducted on any particular stretch of road. The court will be concerned with the operating conditions that caused or contributed to the damage, rather than the methods by which such conditions could have been eliminated.

The potential for liability appears an important factor for road authorities in deciding whether or not to undertake certain activities. The process of road safety audit, along with other recognised procedures of road safety delivery, including crash reduction studies, data collection, regular inspection and maintenance will detect hazards, put in train repairs and new projects. While the law encourages the use of all these processes, it is largely unconcerned with the method by which the state of the road is achieved; it will concentrate on whether the level of safety on the road is reasonable or not.

3.3 Tort of Negligence

The area of law which controls the awarding of damages to a person injured is tort. It is not a matter of criminal law but rather it is a civil law matter between one road user and another or, in this instance, a road user and the organisation responsible for the road (usually a government body). The particular tort involved is negligence. It is said that road safety audit promotes a lower whole life cost for a road. The whole life costs of a road include the cost of crashes which occur on the road. Though judges, guided by economists, will have to choose whether road users themselves should bear those costs or whether they should be attributed to, say, government bodies, the decision is usually taken by asking who can most effectively reduce the incidence and severity of collisions.

The claimant will have to demonstrate to the court that four elements are satisfied in order for the loss to be shifted from the claimant to the defendant. The claimant will have to show:

- there was a duty of care
- there was a breach of the standard of care
- causation: the breach caused damage
- damage occurred.

The claimant will have to adduce proof in order to satisfy the court that each of the four elements are fulfilled. Only when the claimant has discharged that burden and shown the defendant road authority was negligent does the issue of whether the claimant was also, in part, responsible for the incident arising.

The tort of negligence was created by judges in order to provide compensation for those who were injured as a result of activities undertaken by members of society both in private and public sectors. Recently it was felt that the balance which had been reached between encouraging desirable activities, such as providing roads and infrastructure and compensating those who were injured through the fault of those engaged in activities had gone too far in favour of the injured person. Insurance groups were facing bankruptcy, damage awards were constantly increasing and laws were changing to favour claimants.

A committee, chaired by a judge, Mr Justice Ipp, was convened to determine whether the law had become imbalanced, threatening the withdrawal of some products and services. The committee made several recommendations to help reach a state of law balancing fairly the interests of both claimants and those undertaking activities. Each Australian state and territory legislature was free to adopt these recommendations in whole or in part. Many were adopted by most legislatures. Where they affect road authorities, they will be mentioned in this section.

3.3.1 Duty of care

The law imposes a duty of care upon anyone who should foresee that their acts or omissions are likely to affect someone else. Thus, the road authority owes a duty of care to road users including drivers, cyclists, passengers, pedestrians, and adjoining land users. In most instances, a duty of care will be conceded when the road authority which is named as a defendant has planned or constructed or maintained a road upon which the road user was injured.

3.3.2 Exceptions

(i) Nonfeasance

Until recently, the law conferred special immunity only on road authorities on the grounds of nonfeasance, i.e. their failure to do something. A road authority that took no action and simply allowed a road to deteriorate through the forces of nature and time, resulting in potholes or unevenness in the road surface, was granted an immunity from prosecution for negligence. On
31 May 2001 the High Court of Australia abolished the defence of nonfeasance for road authorities. The High Court emphasised in its judgement that the abolition of nonfeasance did not mean that road authorities would now be held liable; they will only incur liability if they fail to exercise a reasonable standard of care.

Many state legislatures, on the recommendations of the Ipp committee, re-introduced this immunity for nonfeasance, at least in part. A road authority which has a road condition which has developed without any action on the part of the authority, such as a pothole, aggregate on the road, or a deteriorating bridge will not be held liable if the condition causes or contributes to an injury suffered by a road user. If however, the road authority knows of the condition, say, through a ratepayer report, or a road safety audit report, or an inspection, then a duty of care will be owed.

(ii) Policy decisions

Protection is also being granted to public authorities, including road authorities, for broad ranging decisions made with regard to the way in which they decide to allocate scarce funds. Acting upon the Ipp committee recommendations, legislation has been passed in some jurisdictions to say that policy decisions regarding the division of expenditure, e.g. between roads, education, health, employment and the like cannot be reviewed by judges in deciding, for instance, that more should have been devoted to new road projects. Nor, in general, can the division of expenditures into project design, construction, maintenance and repair be reviewed unless it is so unreasonable that no sensible council could have reached such a division. The State of Victoria, in its *Road Management Act*, has gone even further to protect policy decisions and promote Codes of Practice.

3.3.3 Standard of care

The standard of care is generally the battleground on which it is decided whether or not a claimant can recover damages from a statutory body. The issue for the court is whether an authority acted in a reasonable manner or whether its actions were unreasonable. The court, in an informal way, balances certain factors to determine whether the act of the defendant was reasonable or unreasonable. The first element is the likelihood of a crash occurring. The court does not attempt to calculate the likelihood in arithmetical terms but rather merely uses common sense to say that the more likely a situation is to produce a crash, the greater care must be exercised by the actor. The second element to consider is the gravity of the risk. Is it likely that there will be merely minor property damage, or is it likely to produce a serious casualty crash or a multiple fatality? The magnitude of the risk and its gravity indicates the degree of precaution which should be taken. On the other side of the balance is the cost of preventing the harm. Cost is usually measured in dollars but sometimes takes account of inconvenience and prioritisation.

The final factor in balancing whether the standard of care has been breached is to consider whether there are any social or 'soft' factors that should be considered in order to determine what is reasonable. Some measures taken by road authorities such as putting safety barriers along the road may well be the cause of a crash when a vehicle hits the barrier, but on balance it may be thought to be appropriate because of the importance of lessening the severity of impact. Environmental factors may also be prominent here; the use of trees or other vegetation on the roadside may create a roadside hazard but at the same time serves to beautify the countryside.

Detailed crash investigation and reconstruction has made it easier for the claimant to prove, through expert witnesses, that the road environment contributed to a crash. Road authorities are now increasingly called upon to provide evidence to the contrary.

3.3.4 Causation

The third element to be satisfied is causation. The question for the law is whether the action or the inaction of the defendant could have been said to have materially contributed to the injury suffered by the claimant. There may be more than one cause to any injury producing event. The road authority will have to bear its share of the compensation if its action is found to have been one of the causes.

3.3.5 Damage

The final ingredient is damage of a type that is recognised by law. In road crashes, recognised damage would include fatalities, physical injuries and property damage suffered by the road user or adjoining land user.

3.4 Liability Arising from the Conduct of an Audit

Can an individual auditor or an audit team be held liable for the conduct of an audit? Let us suppose that an audit is conducted on a project or on a particular stretch of existing road and the audit team fails to detect a safety problem which later is the cause of an injury in a crash. Auditors are not guarantors of the safety of any road or project that they audit. The expectation is that the audit team will act reasonably. If they fall below the standard of care of an auditor acting reasonably, it is possible that there could be liability imposed upon the auditor. In such a scenario, the injured road user would claim against the road authority responsible for the project or responsible for the construction, management or maintenance of the road in question. It is likely that the defendant road authority could consider adding the audit team or the responsible auditor to the litigation on the basis that it relied upon the findings of the audits to discover safety concerns. Examples of conducting an audit in a negligent manner could include failing to include a night-time inspection when so required, or relying wholly upon the plan rather than visiting the site.

The likely danger is not a negligently conducted audit but rather a person who undertakes to lead an audit team on a project which is in an area beyond their competence. Auditors undertaking their first audits of sites or projects should work within an audit team supervised by a senior auditor. Only after participating in a sufficient number of audits should the person then feel able to head an audit team. Similarly, the person should be aware of the limits of their competence and experience in various technical areas.

3.5 Rejecting Audit Findings or Recommendations

The findings of an audit should be recorded in a written report that is tendered to the client, usually the project manager or the road authority. Those findings, together with any recommendations that may have been made, should be carefully considered by the client. Each decision reached on a finding should be recorded in writing. It is not anticipated that every finding or recommendation of an audit should immediately be accepted by the client. When they are accepted by the client, a follow-up order should be made, specifying the means of correction and the source of funding for such corrections, if necessary.

If an audit report finding or recommendation is not accepted, it is important that the client record both the decision not to accept it and the reasons that led the client to reject it, modify it or not immediately implement the recommended course of action. It is likely that a response to an audit report will become available to any claimant for damages who suffers injury on the audited road through the operation of freedom of information or the discovery of documents during civil litigation. A judge or judge and jury reviewing the actions or inactions of a road authority will take greater cognisance of what was said and done at the time of responding to the audit, rather than justifications after the crash has taken place. If a particular audit or review finding does require attention, consider assigning to the work a priority classification such as:

- immediate
- within the current budget period
- as and when funds permit.

3.6 Vicarious Liability

The person who is responsible for the act or omission which is alleged to have been unreasonable is a potential defendant to a claimant injured in a road crash. If that action or inaction was taken during the course of that person's employment by a road authority, the authority will be vicariously liable as well for the actions of its employee. Because the claimant wants to be certain that its judgement will be paid, the likely defendant to be named is the authority which will have either arranged insurance cover or acted as a self insurer. In each case, while both the individual employee and employer could be named, the preferable defendant is generally the road authority with the deeper pocket. In some states, the employees of the road authority enjoy a statutory immunity from being named as a defendant.

3.7 Recent Changes to the Law

As indicated earlier in the section, the recommendations of the Ipp report have been adopted by the states and territories in legislation entitled *Civil Liability Act* or *Wrongs Act*. This new legislation recognises that statutory instrumentalities, such as state road authorities and councils have multiple responsibilities and limited funds. The Acts extend a level of protection to these authorities when they give consideration to prioritising their tasks and deciding which projects to undertake. In terms of liability the legislation has placed caps upon the amount recoverable for non-economic losses; limited recovery for loss of wages to, say, three times average earnings; and relieved authorities from taking special steps to protect individuals whose intoxicated state has caused them to become injured.

The process of road safety audit has become increasingly ordered by courts to advise on road safety considerations during land use development applications. It is important that the audit teams chosen be sufficiently qualified and independent as the court may regard the findings in a road safety audit report as final and binding.

3.8 The Future

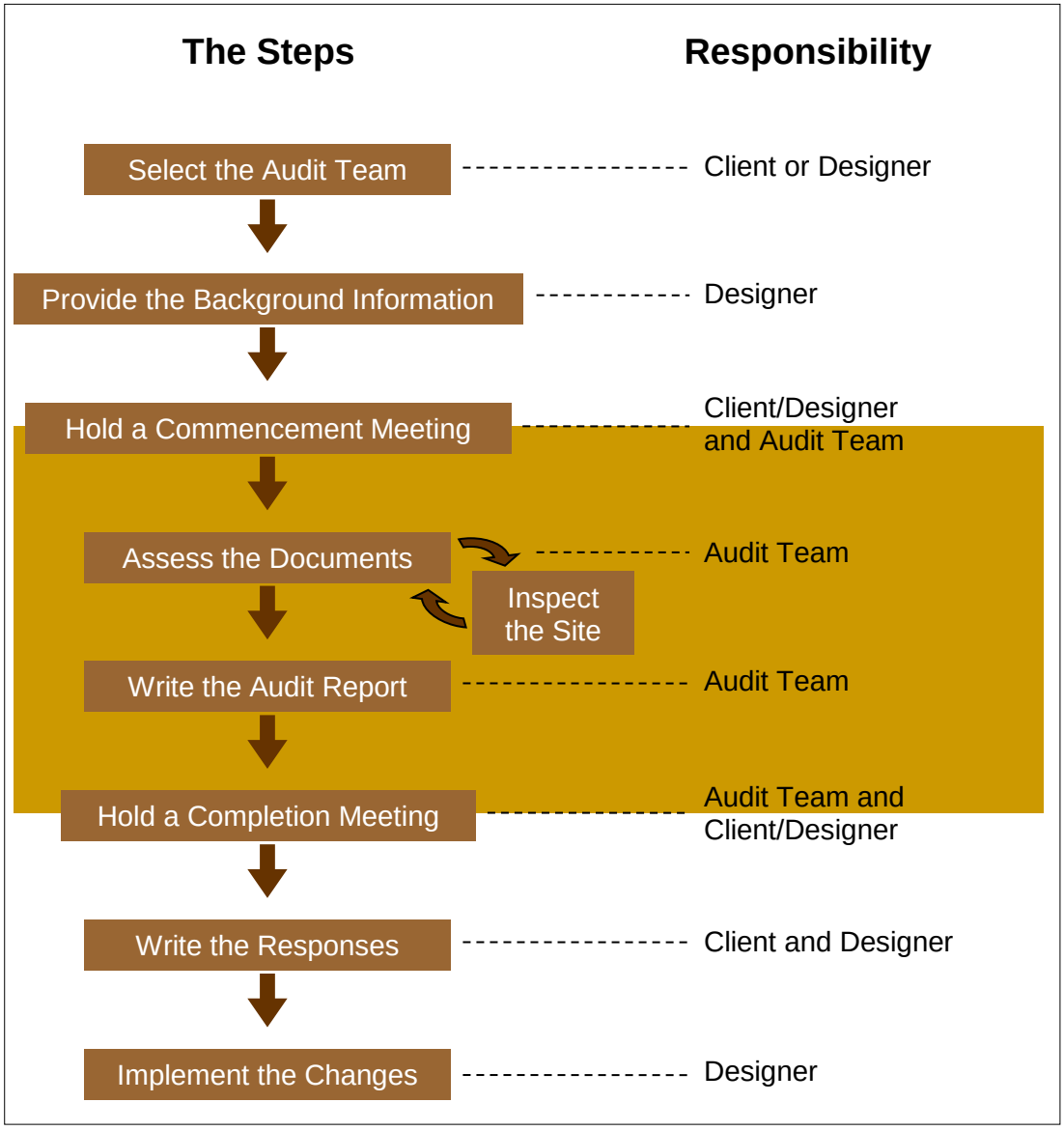
As the process of road safety audit becomes more widely practised, legislation may well include mandatory adoption of certain road safety audit procedures. Time frames and documentation of responses to audit findings may be specified. Presently, it is left to the road authority to determine how to provide reasonable safety on the roads. Perhaps in the future the failure to conduct audits during various stages of the road life cycle will constitute evidence of negligence. Prudent authorities will begin to plan for that eventuality.

Road authorities may also enact policy that compels developer funded works to include road safety audit requirements. Such an approach has been adopted by VicRoads in response to the findings of a Coroner's Inquiry into a fatal crash at Crystal Waters.

4. The Audit Process, Step by Step

A road safety audit is a relatively straightforward process. The steps in the process are illustrated in the flow chart in Figure 4.1. In some organisational structures, and for some more minor projects, some of the steps may be brief, but the sequence of steps will still apply. The steps apply equally to design stage audits (Section 5) and other audits (Section 6).

Figure 4.1: The steps in a road safety audit



The details in each step of the flow chart should be adapted to suit the nature and scale of a particular project. For example, an audit of a small-scale, single-site project may involve a phone call rather than a commencement meeting, documentation may consist of a few pages of information and a single plan and the report may be as short as one or two pages if there are no significant problems. At the other end of the scale, a road safety audit of a major road design project is likely to involve meetings, a large number of plans and a report of several pages.

Responsibility for planning, design and construction of the project remains with the client and the implementation team. It is not the role of the road safety auditor to take over or redesign the project. The role of the auditor is to provide independent advice documenting their findings and recommendations[3]. This advice is then considered by the designer and/or the client (depending on who engaged the auditor) and a formal decision is made by them on whether or not to adopt each of the recommended safety alterations.

Before you commence . . .

Is a road safety audit what you need? If you want to examine a design before it is built to see if there are any potential safety problems that can be removed ('designed out') before it is built, the answer is 'yes'. But perhaps you want to compare one design against another, or you want to identify causes of crash problems and solve them. In Section 2.1, there is a list of tasks an audit is not suitable for. Check that out first.

4.1 Selecting the Road Safety Audit Team

Objective: To select an audit team which is independent and has appropriate skills for the particular project.

The most appropriate size of an audit team depends on the size and complexity of the audit task; there is no optimum number of people, although teams of more than four people can be unmanageable. Significant projects require at least two people.

The one essential ingredient in any road safety audit team is road safety engineering experience. In addition, select people with relevant experience: is the project a freeway/a local street/urban/rural, etc.?

For small projects, an audit by one person can be effective; it depends on their skills and experience (Section 2.5). Avoid having a one-person team just because of cost; consider including someone from within your organisation who is independent from the project. Every audit can be a training exercise and it gives the audit team another pair of eyes.

Audits at the different stages of design call for different skills (Institute of Highways and Transportation 1996). Look at including the following skills:

- Feasibility stage: The issues to be examined are quite different (broader and often more subtle) from later stages and these audits should be undertaken only by very experienced auditors. Include an experienced road design professional(s) who is familiar with road design standards and can visualise the layout in three dimensions. Include specialists in any unusual aspect of the project and/or someone else with safety skills who can generate discussion.
- Preliminary design stage: Similar skills are required as described for feasibility stage audits, but not all team members need be as experienced. Include team members with local knowledge of road user activities. For some audits it might be useful to include team members with relevant specialist experience (e.g. of different road user groups, human factors experience etc.).
- Detailed design stage: In addition to the skills described for preliminary design stage audits, include team members familiar with the types of details the project includes, for example, those with expertise in traffic signal control, traffic signs, street lighting, bicycle facilities, crash barriers or any other particular local road user issue.
- Pre-opening stage: Consider including a police officer who has experience in traffic and safety, a maintenance engineer, someone familiar with traffic control devices, experts with experience with relevant road user groups (e.g. buses, cyclists etc.) and someone involved with the behavioural side of road safety.

3 If requested by the client.

- Temporary traffic works (during construction): Include someone with experience in managing road works sites and an engineer familiar with the details of the traffic control and safety devices typically used at work sites.
- Road safety audit of existing roads: Include people with similar skills to those for the pre-opening stage.

4.2 Providing the Background Information

Objective: To provide the audit team with all the necessary information to allow an adequate assessment of the project.

All relevant information must be provided to the audit team. The project designer should collect all the necessary and relevant information in a usable form for the audit team. Information will include scheme reports, data, drawings and relevant sections of contract documents. This step may need to be initiated well before it is time to engage the road safety audit team. It may be necessary to collect additional information, such as traffic volumes. This should be considered early enough to avoid delays. The audit team also needs to be given a clear understanding of what tasks are to be included in the audit.

Information to be provided to the audit team will typically include:

a) A clear statement of the expected outcome from the audit

This may require a written brief or a simple reference to the procedures and optional audit report formats in these guidelines.

This concisely sets out the purpose of the project (i.e. the design project, not the audit), how it is to be achieved, any deficiencies that need to be addressed, any design compromises that have been made and the reasons, and any community input from prior discussion, correspondence and consultations. For large projects, some of this information may be in reports used to support earlier funding or programming decisions.

b) Site data

Site data includes:

- the design standards that have been used and any locations where they were not achieved
- traffic volumes including commercial and non-commercial components, cyclists and pedestrians
- any previous road safety audit reports and the written responses to them; any known safety issues which remain unresolved from earlier audits
- any environmental effects relevant to the location or the design, for example, weather conditions (ice, fog, snow, etc.), animals, services, trees, historic buildings and topography.

c) Plans and drawings

These include:

- A set of drawings, at a scale suitable for the stage of design, showing the vertical and horizontal alignment and other items relevant at the particular stage of audit. For example, sign, linemarking and street lighting plans are essential at the detailed design and pre-opening stages.
- Any other plans to cover adjacent roads or to describe adjacent land and its uses which might be affected by the proposal or by the traffic changes it induces.

4.3 Holding a Commencement Meeting

Objective: To ensure the design team understands the audit process; to provide the audit team with any additional information, identify key issues, constraints and potential issues requiring specific consideration.

The most effective and efficient way to acquaint the road safety audit team with the background to the project, and (if needed) to acquaint the designer/client with the audit process and the purpose of the audit, is to convene a formal commencement meeting.

The commencement meeting provides the opportunity to explain to the audit team the project's purpose, any issues particular to this project, and any problems which have been experienced in achieving planning, design or construction objectives. The designers may already have safety concerns or queries about a particular aspect of their design. The audit team will not be able to inspect the site under all traffic or weather conditions, so if particular conditions are important (for example, traffic conditions at the end of each school day), the auditors should be advised. Plans and background information are handed to the audit team, if this has not occurred before the meeting.

If members of either party are unfamiliar with aspects of the audit process, this meeting is a good time to explain the process and distinguish between the task of the audit team and the task of the client. The audit team's task is to identify and document any road safety concerns and recommendations (if requested), while the client's task is to respond to and act on those concerns and recommendations (if requested).

4.4 Assessing the Documents

Objective: To safety audit the designs and background information and form conclusions about the safety performance and crash potential of the road.

This phase takes place in parallel with site inspections; documents will need to be safety audited before and after inspections. Before inspecting the site, initially peruse the documents (including the plans) to record first impressions; list possible issues to be checked on site. Drawings, traffic and crash data, field notes and other information should be assessed, using the checklists as required. Identify any areas of the project which contain potential safety problems. If the documents raise any questions, explanation should be sought from the designer or client before the road safety audit report is written. Sometimes designers can be apprehensive about 'outsiders' coming in and commenting on their work; auditors can make use of the opportunity to ask questions and allay designers' fears.

The audit should confine itself to road safety aspects although a broad view of this should be taken. For example, there can be road design elements which cause frustration or nuisance to road users, where a direct relationship with crashes may be difficult to establish.

Aspects like amenity or aesthetics, unrelated to safety, should not be included in the auditor's report. Likewise, traffic capacity issues should not be included unless they have a bearing on safety.

4.5 Inspecting the Site

Objective: To see how the proposal interacts with its surroundings and nearby roads; to visualise potential impediments and conflicts for road users.

It is essential for the road safety audit team to visit the site in daylight to appreciate any problems relating to the present arrangements and, if appropriate, to visualise the future proposals and their effects. Consider when is the most effective time to inspect the site as traffic conditions can vary throughout the day or week.

A night-time inspection is also essential except where, in the experience of the client, there will be nothing additional to observe. However, these circumstances should be rare. The visual information available to road users can be markedly different at night-time and it can be surprising what additional issues can be identified on a night-time inspection, even where work has not yet commenced. Figure 4.2 shows two photographs of a site. The features on a road may be obvious in daylight, but deceptively hidden at night-time. A night-time inspection permits a check on readability of the road and the effectiveness of signs, markings and street lighting.

Figure 4.2: Daytime and night safety inspections

When on site, look beyond the limits of the design plans (or the limits of works at the pre-opening stage); the inspection should include the adjacent sections of road. Transition or terminal zones, where the new (and usually higher standard) road matches into the existing road system can often be locations of greater hazard, as:

- road layouts and devices which previously operated safely can fail to do so once traffic volumes, speeds or movements alter
- motorists may be unaware of the need to adjust their behaviour.

In addition, new roads or new traffic arrangements can often disrupt existing traffic and pedestrian movement patterns.

The inspection should be undertaken from the point of view of all the likely road user groups and not just motorists. Young and elderly pedestrians, truck and bus drivers, cyclists, motorcyclists, elderly and disabled drivers have quite different safety needs:

- Child pedestrians have a lower eye height to observe vehicles. Being small, they can be easily hidden from a motorist's view. They can act impulsively.
- Elderly pedestrians may be less agile, have poorer sight or hearing, or may have a poorer ability in judging gaps and the speed of traffic.
- Truck and bus drivers have a higher eye height but this can lead to issues with delineation and their visibility can be more easily affected by overhanging foliage. Their vehicles take longer to stop and start moving, they are wider, and blind spots can be a problem.
- Cyclists are more seriously affected by surface conditions (for example, grates, potholes and gravel) and gradients.
- Elderly drivers may be less able to recognise some traffic control features or judge gaps due to cognitive difficulties.
- People with disabilities can be affected by poor eyesight and hearing or difficulties moving around objects, near edges, between levels or at typical pedestrian speeds.

- Motorcyclists have rapid acceleration, but are susceptible to poor pavement conditions and to 'squeeze points'.

Consider how well the design caters for the different types of movements such as crossing the road, entering the traffic stream or leaving it, as well as for travelling along the road. Consider these for the different road user groups and the effects of different weather conditions.

Taking photographs or videotapes allows for later reference and possible inclusion in the report, but they must not be used as a substitute for a site inspection; all audit team members should inspect the site.

4.6 Writing the Road Safety Audit Report

Objective: To report on the audit's findings, and if requested by the client, recommendations regarding how identified safety deficiencies may be addressed.

The main task of the road safety audit report is to succinctly report on aspects of the project that involve hazards and if requested by the client, recommendations about corrective actions. The recommendations will usually indicate the nature or direction of a solution, rather than precise details. Responsibility for that will rest with the client. The report provides the formal documentation on which decisions about corrective action will be based.

A positive element of the design that improves safety can be mentioned in a road safety audit report, but it is not necessary to mention them. The purpose of the report is not to rate the design, but rather to address any road safety concerns.

In some cases, safety concerns may be identified but a recommendation, even a broadly directive one, may not come to mind. In this case the safety issue should not be ignored; simply record the finding (i.e. the safety concern) and under Recommendation write 'Investigate treatment and implement it' or a similar comment.

In what order should items be listed? Sequentially along the length of a project? In the order in the checklists? Grouped by common issues? There is no single best way of ordering findings and recommendations, but the most important consideration is that the order be logical and helpful for the report's recipients when they consider the corrective actions. For example, where there are three distinct intersections and ramps at a grade separated interchange and each one has identified problems with the four elements of alignment, cross-section, delineation and visibility, it may be better to discuss each site in turn, rather than discussing each design element about the different sites in turn. In this way, any possible interaction between the problems at each site is more likely to be recognised and addressed effectively. On long road projects, it may be more appropriate to split the project into sections. In any event, if there is any concern that mutually dependent recommendations are separated in the report, they should be cross-referenced.

Austroads Road Safety Audit Toolkit has been developed to assist in completing road safety audits, and has the facility to create tailored reports based on the findings from the audit. For further details on the internet based tool, see Section 9.2.

An audit report's contents

The audit report should contain the following material:

(a) Project information

- A report title which includes the name of the road, the extent of the audited project (length of road or intersecting road name), the locality (for example, suburb), the design stage of the audit*.

- A brief description of the project, its objectives and any special road users or special aspects.

(b) Background information

- The audit team member names (plus mention of who is the team leader) and the client's name*.
- The audit team members' affiliations and qualifications.
- An overall plan of the project or road length, with audit findings, and where requested by the client, recommendation item numbers added to the plan.
- Advice that both a daytime and a night-time inspection were undertaken and commencement and completion meetings were held (even if only by telephone for small projects), with dates included.
- A list of documents used during the audit, including the version of audit guidelines referred to and all drawing numbers with their dates/amendment numbers.
- Photos of significant issues (optional).
- There is no need to include the checklists or crash information.

(c) Findings and recommendations

- A series of findings about all the safety deficiencies which were identified, with recommendations (of an appropriate nature) if required by the client, directly after each finding. This will be the most substantial part of the report.
- A brief listing of major findings and recommendations, or repeated issues of concern, drawn out and placed ahead of the main body of findings and recommendations (optional).

(d) Formal statement

- A concluding statement (as set out in the case study in Section 7.1), signed by all audit team members, advising they have undertaken the audit.

In summary, the road safety audit report should be a concise and succinct report on aspects of the project which involve hazards, with findings or recommendations about corrective actions.

* Asterisked items, and the date, should also be included on the front cover.

The format of a typical audit report is provided in Section 7.1. Depending on the type of project, the audit findings and recommendations may be written in 'prose style' or written in a tabular format. A tabular format has the advantage that it can be used directly by the client to create a table of corrective action responses.

Framing audit findings and recommendations

Findings

Audit findings are a listing of identified safety deficiencies: what is potentially dangerous about the design or what could lead to crashes occurring or injury resulting. Findings should not be framed in terms of a 'solution'. For example, where there is a high, steep embankment carrying a road, a finding might be:

'The embankment at . . . is too steep and high for an errant vehicle to traverse or regain control'.

The finding should not be described as 'The embankment at . . . has no guard fence', because that is not the problem, it is one solution.

Recommendations

Recommendations provided should be appropriate for the class of road, type of project and stage of audit. An audit recommendation should indicate the direction in which a solution should be sought, rather than specifying the solution. After all, the auditors usually do not know all of the project constraints and possibilities. With the above example finding, the solution may be to flatten the embankment or shield it, with one of several barrier types. An appropriate recommendation may be:

'Flatten the embankment or shield it', whereas 'Install guard fence' is too prescriptive, as it focuses on only one possible solution, even ignoring different crash barrier types.

But sometimes there is a fine line between a 'recommendation' and a 'solution'. If traffic may go the wrong way down a one-way street, there may be no other option but to use a standard sign. Equally, the recommendations need to take account of the client's understanding of safe road design practices; a recommendation to the sole engineer at a small rural council may need to be more specific or give more advice about where the solution can be found, than would be necessary with a recommendation to an experienced freeway design unit.

When framing recommendations:

- be constructive about how the safety problem might be resolved
- be realistic, considering the severity of the problem and the cost of solutions
  provide feasible recommendations
- bear in mind there may be high-cost/low-cost and short-term/long-term solutions
- avoid redesigning or specifying solutions in detail, but equally do not be so obscure or general that the client does not understand the point being made.

4.7 Holding a Completion Meeting

Objective: To discuss the findings and recommendations[4] for corrective action.

This meeting should involve the auditor and the client and/or the designer. It should not be viewed as an opportunity to disagree with the findings or recommendations. Misunderstandings can be resolved at this meeting, but it is preferable that this be done before the report is written. The meeting can provide an opportunity for the client and/or the designer to ask for suggestions for overcoming the identified problems.

4 If requested by the client.

In addition the completion meeting can be a useful opportunity to assist in training by familiarising participants with the full process and the nature of findings and recommendations.

4.8 Responding to the Audit Report

Objective: To deal with audit findings or recommendations in an effective manner; to judge whether the recommendations of the road safety audit should be implemented and, where it is decided otherwise, to give reasons in writing for the decision; to put agreed audit recommendations into effect.

A. Procedures to deal with audit findings or recommendations

- This procedure needs to include well defined and documented procedures for dealing with audit reports:
  - who will respond to an audit report?
  - who will sign off the corrective action report?
  - who will ensure the agreed actions will be followed through?
- For each audit report: the action to be taken in response to each finding or recommendation, by when, by whom and the current status of actions (has it been done yet?).

B. Responding to an audit report in writing

Road safety audit is a formal process. The audit report documents the audit team's identified safety concerns and recommendations (if requested by the client), to improve the safety of the design. This must be responded to by the client (or the designer) with a written response to each audit finding or recommendation. The response document must be signed by a representative of the client. This response document, for example, may be a 'corrective action report' (CAR).

Audit recommendations are not mandatory. In the event of a crash, the audit documentation may be sought by representatives of an injured person. It is important that audit recommendations are given due consideration. If it is not possible to adopt a recommendation (for example, due to high cost implications), is there another effective way of partly addressing the problem or can a solution be staged over time? Reasons for not accepting findings and recommendations should be adequately documented.

The client or designer may wish to call in an independent assessor for assistance with details of how to respond to each audit findings or recommendation. It should be borne in mind that the audit report will not include the design details of a solution to any problem.

Each finding or recommendation in the road safety audit report can be responded to by either:

- accepting it completely and designing a solution to overcome or reduce the problem, in line with the audit findings or recommendation or in another equally effective way
- accepting it in part or in principle but, due to other constraints, implementing changes which go only part of the way to resolving the safety problem
- not accepting the finding or recommendation at all.

With the first point, the proposed action (for example, by whom and when) should be recorded. In the case of the second or third points the reasons must be set out in writing. Also, with the third point, if the finding is accepted, but the recommendation is rejected, this should be reflected in the response.

How does the client decide whether or not to accept an audit finding or recommendation?

Part of the answer can lie at the start of the design process: could an audit have been undertaken earlier? Certainly, the earlier an audit is undertaken, the sooner a potential problem can be addressed. This generally means it will be easier or cheaper to resolve the problem.

Faced with an audit finding or recommendation that is difficult to resolve, the client needs to consider the:

- likelihood that the identified problem will result in harm
- severity of that harm
- effectiveness of a remedy in reducing the harm
- the designer's advice/response to the audit
- cost of remedying the problem (there may be several alternative treatments).

This requires engineering judgement and additional road safety engineering advice about managing the risk.

There may be occasions that the audit recommendations require consideration of issues outside the original scope of the project. This should not be an excuse to dismiss these and they still require consideration by the appropriate authority or person. It may be that the original scope of the project needs to be altered.

C. Risk ranking of safety issues

The following tables may be useful to provide an indication of the level of risk and how to respond to it. Determine into which category in Table 4.1 and Table 4.2 the issue best fits. From this select the risk category in Table 4.3 and its suggested treatment approach in Table 4.4. This is not a scientific system and professional judgement should be used. Section 9.3 provides an evidence based approach to prioritising the treatment of works emanating from road safety audits of existing roads.

Table 4.1: How often is the problem likely to lead to a crash?

Frequency	Description
Frequent	Once or more per week
Probable	Once or more per year (but less than once a week)
Occasional	Once every five or ten years
Improbable	Less often than once every ten years

Table 4.2: What is the likely severity of the resulting crash type?

Severity	Description	Examples
Catastrophic	Likely multiple deaths	High-speed, multi-vehicle crash on a freeway. Car runs into crowded bus stop. Bus and petrol tanker collide. Collapse of a bridge or tunnel.
Serious	Likely death or serious injury	High or medium-speed vehicle/vehicle collision. High or medium-speed collision with a fixed roadside object. Pedestrian or cyclist struck by a car.
Minor	Likely minor injury	Some low-speed vehicle collisions. Cyclist falls from bicycle at low speed. Left-turn rear-end crash in a slip lane.
Limited	Likely trivial injury or property damage only	Some low-speed vehicle collisions. Pedestrian walks into object (no head injury). Car reverses into post.

Table 4.3: The resulting level of risk

	Frequent	Probable	Occasional	Improbable
Catastrophic	Intolerable	Intolerable	Intolerable	High
Serious	Intolerable	Intolerable	High	Medium
Minor	Intolerable	High	Medium	Low
Limited	High	Medium	Low	Low

Table 4.4: Treatment approach

Risk	Suggested treatment approach
Intolerable	Must be corrected.
High	Should be corrected or the risk significantly reduced, even if the treatment costs is high.
Medium	Should be corrected or the risk significantly reduced, if the treatment cost is moderate, but not high.
Low	Should be corrected or the risk reduced, if the treatment cost is low.

D. Implementing the agreed changes

Once the corrective action report has been finalised, the agreed actions need to be implemented. The designer has to develop design changes that address the safety problems. If one is at the pre-opening stage, the actions need to be implemented as soon as possible on site. Temporary warning, delineation or other treatment may be needed until the agreed solution is implemented.

Actions taken should be recorded (for example, description of work, by whom and when). This is to fully close out the road safety audit finding as well as to factual record what works were completed. Reasons for any variations from the proposed action must also be set out in writing.

Framing responses to audit findings or recommendations

When an audit finding or recommendation is not accepted, or is accepted only in part, care should be taken about framing the corrective action report, bearing in mind that it may become a public document in the event of a crash occurring.

Consider the following responses to findings or recommendations made during a pre-opening audit of a project to widen the carriageway of a two-lane, two-way road to provide an overtaking lane:

Safety issues:

'Fixed objects within the new clear zone. These include a concrete bus shelter and stockpiles of aggregate and box culverts.' Three sections of guard fence are now nearer the edge line, but do not have safe end treatments.

Findings or recommendations

Take action to reinstate appropriate clear zones for this road. Pay attention to the guard fence.

Responses:

'The bus shelter was constructed before work on the overtaking lane. It is 4 m from the edge line. The expense of moving it is not considered justified. Most of this highway has objects within the clear zone, for example 3 km to the south there are 150 trees within 1.5 m to 6 m from the edge line. The stockpiles cannot be removed as there are few stockpile sites in the area. All the guard fence was constructed before construction of the overtaking lane. Compared with other guard fence in this region, it is not considered a priority and no action is planned to install the correct end treatment.'

How might these responses be viewed by someone injured in a collision with the bus shelter, a stockpile or a guard fence end (or by a lawyer)? It would be of little comfort for drivers to know they would have been even worse off had the car veered off the road 3 km further on, or that the road authority had a problem finding stockpile sites, or that it's not the client's problem because the fixed objects were put in earlier by someone else. What these responses lack, and what any response needs, is a consideration of points in the previous inset ('How does the client decide whether or not to accept an audit finding or recommendation', in B above), an explanation of why action cannot be taken (for example, financial implications) and consideration of other possible options to reduce the risk associated with significant problem.

E. The need for a subsequent audit

If it is decided to make significant changes to the design, a further audit of the revised design may be appropriate, rather than waiting for the next design stage's audit. This is a particularly important consideration if the project has reached the detailed design stage and is to be built soon.

4.9 Closing the Loop – Feeding Back the Knowledge Gained

Objective: To disseminate the knowledge gained from an audit, for the wider benefit of road and traffic designers.

Unless the knowledge gained from audits is fed back into the design process, there is a risk that the same mistakes will be made again and again. Audits should be the catalyst for change, so that the road safety engineering experience applied to one design can benefit future designs.

The opportunities for feedback include:

- Feedback into the current project.
- Feedback into other projects within the same organisation. Ensure audit reports and corrective action reports are widely circulated and discussed within the office. Deal with any problem issues associated with peer review, standards vs safety, etc. Have designers included in audit teams (on projects they are not associated with). Every couple of years, review audit reports to see if there are common or repeated issues.
- Feedback generally to the profession. Include audit topics in professional development seminars. Use road safety e-mail discussion groups and Internet sites.
- Feedback into revised standards. Contact your state road authority custodians of manuals and standards about any examples of standard treatments which have compromised safety, and request changes.
- Feedback to auditors. To improve future audits, advise your auditors about how you responded to their audit (for example, send them a copy of the corrective action report). This step is essential when audits occur at successive stages of a project.

As a way of gaining knowledge from audits, audited and un-audited design projects need to be monitored for one to three years after they are built, to see whether crash problems are occurring and, if so, whether the problems were anticipated in an audit. This can provide valuable feedback into audit procedures: are sufficient designs being audited; do audit teams have the right mix of people; are significant problems being identified; are the responses to audit reports appropriate?

Figure 4.3 provides an example of how feedback from safety inspections can lead to the adoption of safer design standards. Structures such as those depicted pose less risk to road users than old-style headwalls and culverts.

Figure 4.3: Benefits from a safety audit of design standards

5. The Audit of Road Designs

5.1 General

Road safety audit has the greatest potential for improving safety when it is applied to a *design* before a road or traffic project is built. It can be conducted on any proposal that is likely to alter interactions between different road users, or between road users and their physical environment.

A road safety audit may be undertaken at one or more of the following stages as a design proceeds from concept to implementation:

- the feasibility stage (including audit of the design brief)
- the preliminary design stage
- the detailed design stage
- the pre-opening stage (or post-opening if done just after the project opens).

5.2 Feasibility Stage Audits

By providing specific road safety engineering input at the feasibility stage of a project, road safety audit can influence fundamental issues such as design standards, route choice, impact on and continuity with the existing adjacent network, and intersection or interchange type, location, number and layout.

For traffic management schemes or small-scale improvements this stage may be less significant, but, until an audit is conducted, its value may be hard to judge. Where the basic choice of treatment will affect safety performance, an audit, however brief, can be beneficial. The selection of an inappropriate concept can be costly to rectify.

With larger projects, the selection of an inappropriate concept or design criteria at this stage may be almost impossible to rectify later. Consider how difficult it would be to later try changing designs if the following concepts are initially selected and designed, but are later judged to be deficient in safety:

- a roundabout, rather than traffic signals
- a bypass to one side of a town, rather than the other
- an emergency breakdown lane on one side, rather than both sides of a bridge.

Before design starts – audit the design brief

With any project that is designed according to the requirements of a design brief, a road safety audit of the design brief should be considered. Typically, design briefs are used to specify design standards and other requirements when a project is to be designed by an external design team.

The design brief may contain problems like:

- reference to standards that are out of date or are no longer world's best practice
- reference to standards that are not appropriate minimum design requirements and that are too rigid and do not allow for better designs, where these prove to be possible
- a lack of appreciation about how one specification can have an adverse safety impact on other elements of the project
- the absence of design criteria for the safe operation of trucks
- basic road safety requirements not included.

Only auditors with design and road safety engineering experience and skills relevant to the particular area of design should be used.

A poor choice of design criteria can have an adverse impact on basic safety issues like sight distance and readability of the road. An audit of the design brief can save an enormous amount of time trying to fix up a poor design later. However, it does not negate the need for audits at later stages.

Inputting road safety engineering skills at the start: an alternative to a feasibility stage audit

Organisations should consider involving experienced auditors right from the start, in pre-design issues meetings where new projects are brainstormed.

This early, direct inclusion of road safety engineering is applicable with major road schemes, minor schemes and private developments like residential and industrial subdivisions. It provides an opportunity to involve the client in the safety discussions, rather than only the designer. The client can often have a different or broader view and may have alternative ways of incorporating comments about safety.

This process does not negate the need for an independent road safety audit at later stages of design. A road safety engineer who becomes involved directly with a project's design can be as prone as any other professional to missing issues through familiarity.

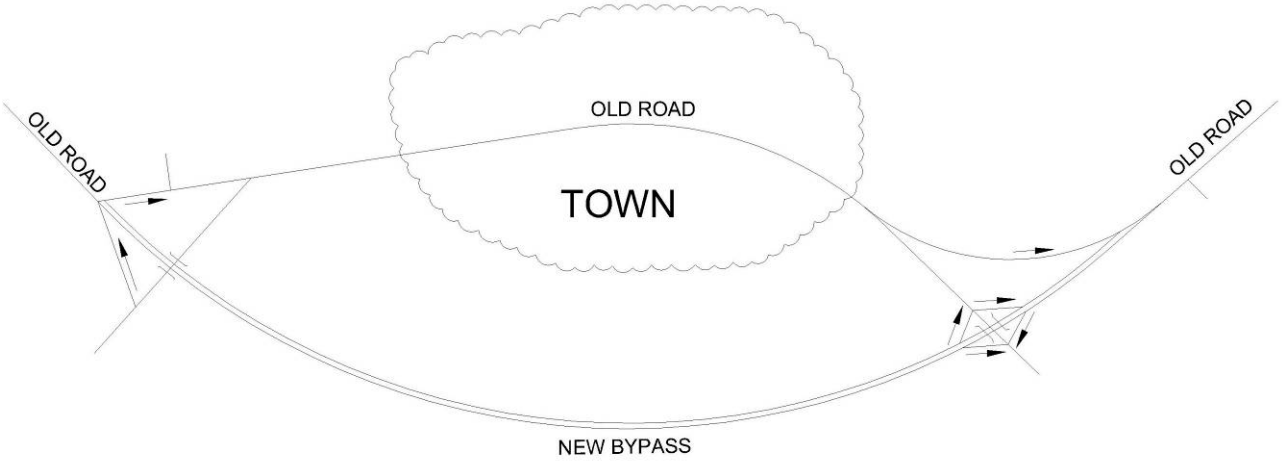
Why audit at the feasibility stage?

- to input safety engineering into the consideration of options
- to influence safety when there is the greatest scope for change
- to avoid obvious safety problems that can be locked in once designs commence or land is acquired
- to ensure all likely road user groups have been considered in the design
- to check that the concept is compatible with the type of road and road user expectations
- to check that the design standards are compatible with the type of road and road user expectations
- to look beyond the project and consider effects in transition areas and away from the project
  - how does it fit into its environment?
  - is it consistent?
  - will staging involve compromises or be unsafe?
  - is the scope of the project adequate, or are additional works needed elsewhere?

5.2.1 Practical examples: Feasibility stage audits

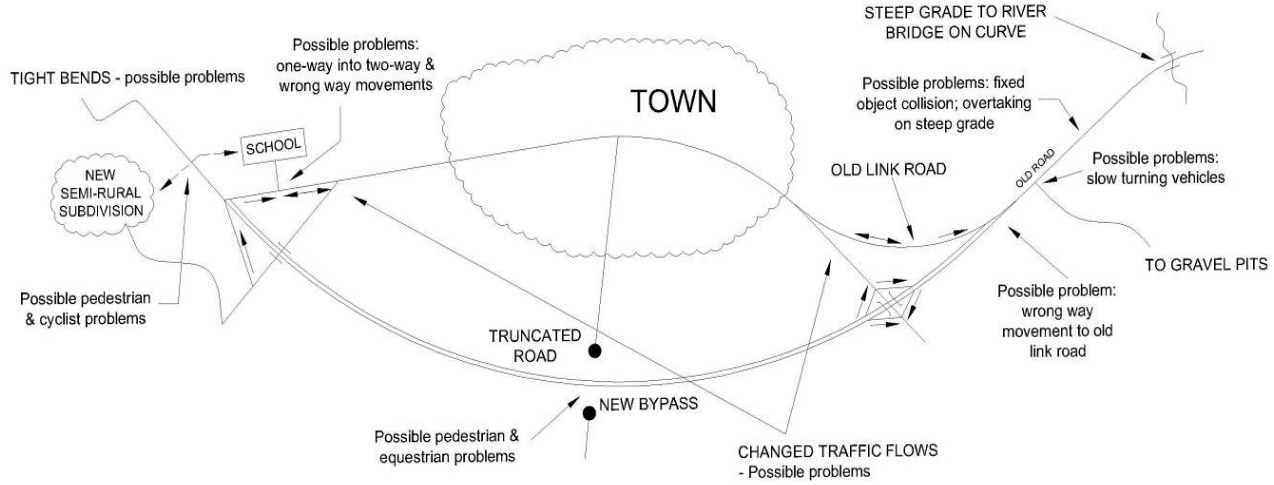
i. A town bypass has been proposed and the concept plan shows the general alignment to the south of the town, with the interchange configurations and the extent of duplicated carriageways (Figure 5.1).

Figure 5.1: What the concept plan shows



A feasibility road safety audit has assessed the concept (in relation to the other concepts), the broad safety issues on the bypass and how the concept fits within its environment. Figure 5.2 shows some of the safety problems which were identified. Many of these problems are well away from the bypass boundaries, but are a direct result of the proposed layout.

Figure 5.2: The fuller picture



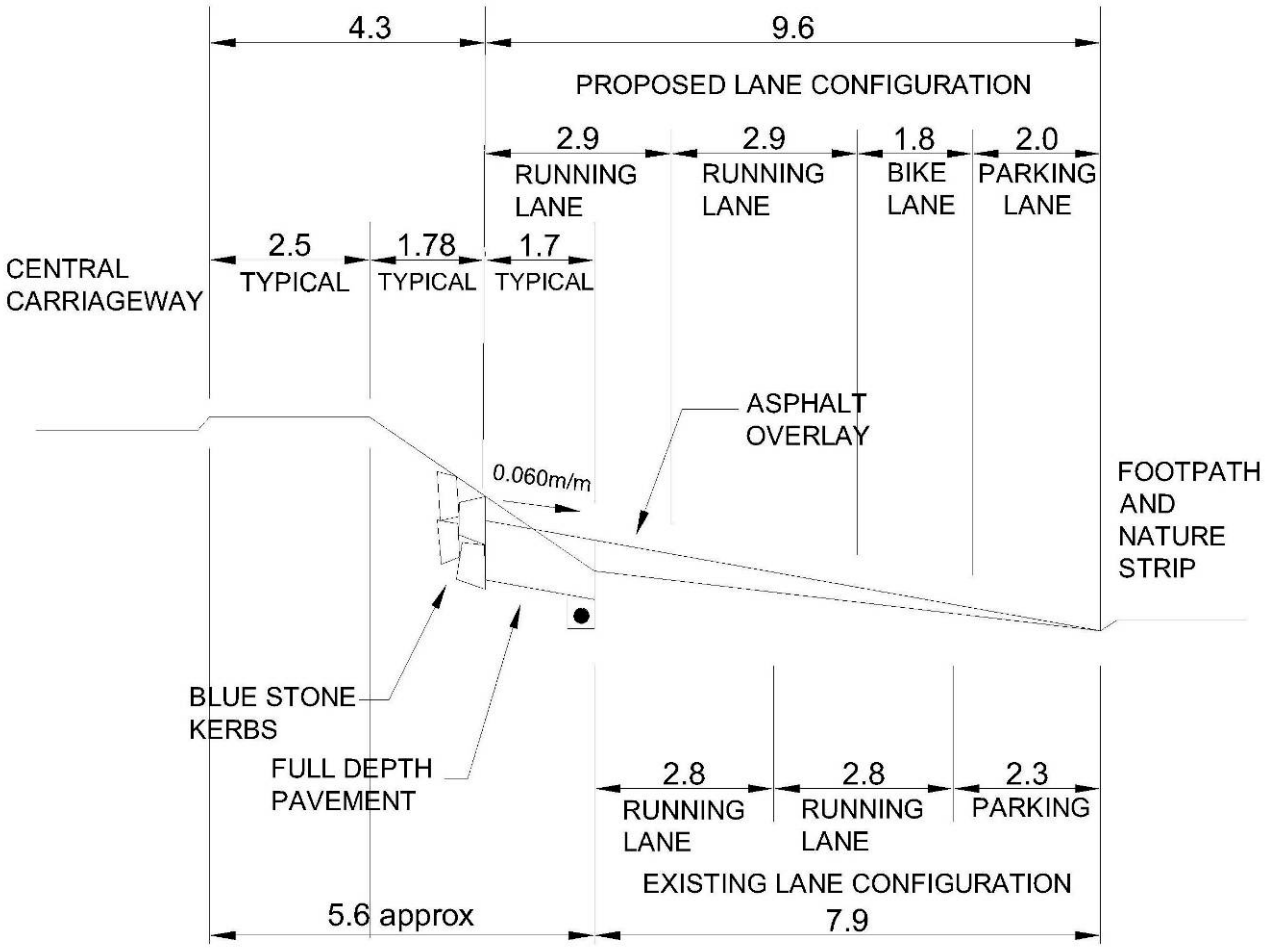
As a consequence of the audit, the client will have to consider issues such as:

- whether to extend the bypass to avoid tight bends
- whether to extend the length of divided road
- whether to alter ramp locations
- how to provide safe pedestrian and equestrian access or crossing points
- how to treat intersections near the town, where traffic movements will alter
- how to accommodate various local traffic movements which use the highway.

Making fundamental safety improvements at this early stage helps designers to avoid redesign due to audits at later stages.

ii. Figure 5.3 describes a situation where a 5.6 m wide plantation is being narrowed to 4.3 m to provide a bicycle lane. A feasibility stage audit would identify the hazard this concept would create for vehicles stopped in a break in the plantation. Other possible hazards (like vehicles tracking sideways due to the steep crossfall) may not be identified until the preliminary design stage.

Figure 5.3: Creating hazardous situations



5.3 Preliminary Design Stage Audits

This audit occurs on completion of the preliminary road design or functional layout. If alternative schemes have been developed for public consultation, each should be audited.

Drawings at approximately 1:1000 can be appropriate for the general alignment and 1:500 scale for intersections and other specific locations of interest. Typical considerations will include horizontal and vertical alignments, intersection layouts, the appropriateness of adopted standards generally or at specific locations, access locations, whether all likely road user groups have been considered and staging.

For larger projects, subsequent significant changes in road alignment become much harder to achieve after this stage, as land acquisition and other associated legal matters commence.

The audit may identify unusual features. These may or may not be safety problems: engineering judgement is required. Inconsistent or unexpected features can be a hazard where road users may use them wrongly. Care is needed to ensure that an audit does not stifle an innovation that has a good level of safety, simply because it is not a standard way of dealing with an issue.

Why audit at the preliminary design stage?

- an audit may not have been done previously
- to identify anything missed in a previous audit
- to avoid wasting costly design time if only a detailed design stage audit is done
- to check what standards have been used and what departures there have been from standards
- to check that all likely road users have been considered, for example:
  - can vehicles turn safely?
  - can road users see each other?
  - can road users see devices?
  - is alignment and cross-section appropriate?
  - is property access catered for?
- to check the adequacy of the road reservation width and its effect on batters
- to check intersection layouts and other conflict points
- to alert designers to areas where attention will be needed at a detailed design stage
- to check details at the connections to the existing road, for example:
  - consistency
  - fixed objects may be in a more vulnerable position.

5.3.1 Practical examples: Preliminary design stage audits

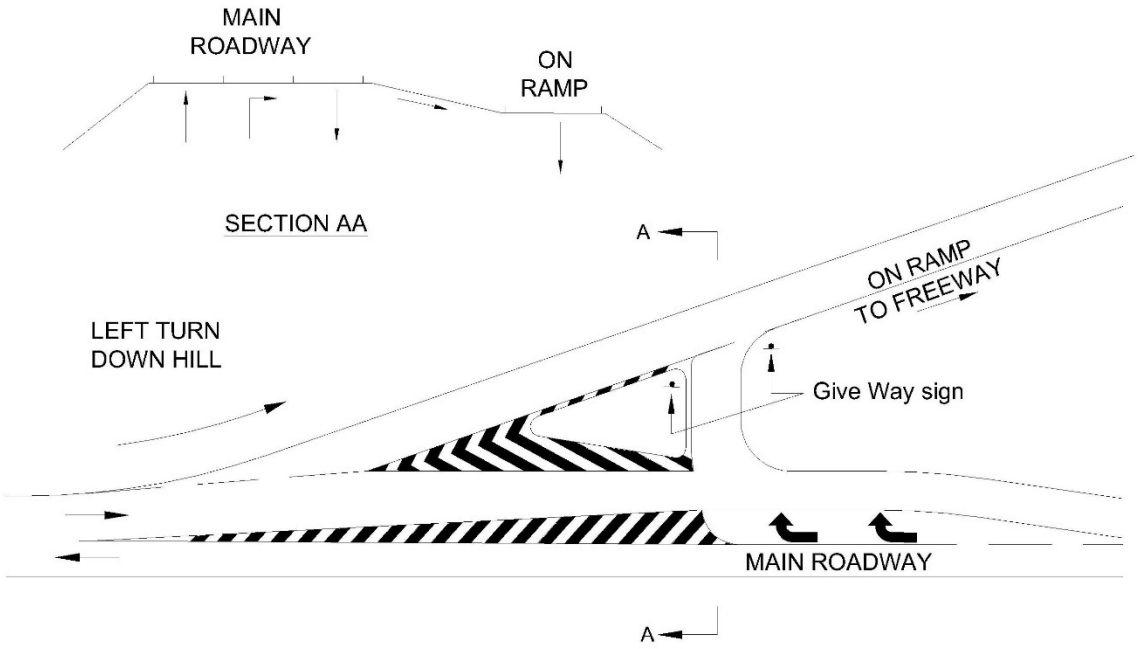
i. A rural highway on-ramp was audited at the pre-opening stage. The audit highlighted the hazard of using the usual layout of Give Way signs facing the left turn slip lane, as left turn traffic will enter at speed, downhill and on an uninterrupted alignment. Drivers are unlikely to be able to give way.

The alternative layout, with Give Way signs facing the right turning traffic (Figure 5.4), also has safety problems:

- The vertical alignment of the right turn roadway means the holding line is not visible from the main roadway.
- The layout is unexpected.
- If two cars turn right from the main roadway and the first car has to give way at the holding line, the second car will have to stop across the oncoming traffic lane on the main roadway.

At the pre-opening stage there is no low-cost solution to this safety problem. A preliminary design or detailed design stage audit would have allowed the layout to be changed on paper, before it was built.

Figure 5.4: Give Way signs on left turn slip lane



ii. Because of an inadequate road reservation, the design of the off-ramp shown in Figure 5.5 is too tight. It has a narrow gore area which is sloping instead of flat. Errant vehicles are at great risk of rolling over or impaling on the guard fence end which is at the wrong level. An audit at the preliminary design stage could alert the designers to the need to acquire more land or modify the design.

Figure 5.5: Tight off-ramp

5.4 Detailed Design Stage Audits

This audit occurs on completion of the detailed road design but before the preparation of construction contract documents and finalisation of any land acquisition. This stage is the last opportunity to change the design before construction commences. The audit reviews the plans that will be used to build the project.

Drawings need to be at 1:500 or 1:200 scale (or larger), covering not only the general road layout and alignment, but also intersection layout details, signing, linemarking, drainage, lighting, fencing, landscaping, roadside objects, barriers, details of any signals, etc. The audit team considers how these aspects of the design will affect the operation of the scheme for all the different road user groups likely to use it.

This audit is very much concerned with the details especially of the road layout and the traffic arrangements. Attention to detail at this design stage can do much to reduce the costs and disturbance associated with last-minute changes that may otherwise occur if problems are not identified until the pre-opening stage. Thus it is important that the auditors are provided with drawings that contain the required details.

Why audit at the detailed design stage?

audits may not have been done at previous stages

- to identify anything missed in previous stages and last chance to alter designs on paper
- to check what standards have been used and what departures there have been from standards (if this has not been done during an earlier audit)
- to check the signing, linemarking and landscape plans
- to check that all likely road users have been considered, for example:
  - can vehicles turn safely?
  - can road users see each other?
  - is alignment and cross-section appropriate and are fixed hazards present?
- to check the interaction of the detailed elements
- to check details at the connections to the existing road (especially consistency).

5.4.1 Practical example: Detailed design stage audit

(a) Introduction

The purpose of this audit is to identify possible deficiencies in the detailed road design that could result in road safety problems. Is it intended that these matters be referred back to the designing group for their attention and re-evaluation.

(b) Project description and scope

- The proposed freeway extension (Williamson Road to South Road), consists of a divided carriageway with four lanes plus an emergency stopping lane/sealed shoulder running in each direction between Williamson Road and Jacksons Road. The remaining section of the freeway, Jacksons Road to South Road operates with three lanes plus the emergency stopping lane/sealed shoulder in each direction (separated by 1.0 m). Trafficked lanes are 3.5 m wide, the emergency stopping lanes are 3.2 m wide and the median which has concrete barrier running down the middle is 6.7 m wide.
- Ramps and interchanges within the freeway section under examination were not reviewed. The safety auditing of these elements is to be dealt with under separate Design and Construct contacts.

(c) Audit findings

1. Citybound merge from South Road south (Dwg no. 299919), occurs between the right hand lane and the left hand lane of the through carriageway. No suitable escape or refuge is available for motorists avoiding a collision. It would be preferable to merge the left hand lane of the entry lane with the shoulder.
2. (Dwg no.s 299912 & 13) – The regulatory 100 km/h speed restriction signs (no. 5) are offset too far and therefore may lack conspicuity.

Signs and linemarkings (reference to signs and linemarking plans)

1. (Dwg no. 299913) – Support of the overhead gantry (no. 15) southern side, needs to be protected.
2. (Dwg no. 299913) – Exit gore markings are incorrect.

3. (Dwg no. 299915) – The gantry on the north side (no. 28) should be located about halfway along the gore (i.e. approximately 50 m from the nose of the island) and be protected. The eastbound exit ramp gore is also incorrectly stripped.
4. (Dwg no. 299918) – The location of the 'Trip Time' sign is not indicated. Should it be erected within the clear zone it will require protection.
5. (Dwg no. 299920) – South Road exit ramp requires (painted) right turn arrows. The lack of arrows does not give positive advice to exiting motorists (i.e. that they can only turn left or right ahead, and that they can do so from particular lanes). It should also be noted that the support for the gantry northern side (CH 17768) will require to be protected.

Barriers (reference alignment plans)

1. (Dwg no. 338983 sheet 3A-26) – It is considered that guard fencing is required on the south side, westbound CH 15340 to 15000) due to the proximity of the culvert endwall.
2. (Dwg no. 338985 sheet 3A-29) – Consider the need to extend the concrete barrier on the northern side of the eastbound ramp back from CH 1600 to CH 16220, in view of the creek behind the noise barrier.
3. (Dwg no. 338987 sheet 3A-31) – Consider the need to extend the concrete barrier on the northern side of the eastbound ramp back from CH 16740 to CH 16800, in view of the creek behind the noise barrier.

Paths (reference to alignment plans)

1. Insufficient information has been provided with regard to bike paths. A final plan will need to ensure that the bike paths have appropriate barriers/fencing to protect cyclists/pedestrians where the distance to the creek becomes narrow.
2. (Dwg no. 33893 sheet 3A-26) – Consideration should be given to extending the fencing from secondary path on the south side (path CH 31400) by about 60 m to provide safer separation with the creek.
3. (Dwg no. 33894 sheet 3A-28) – Need to resolve the manner in which the secondary shared path on the southern side of the westbound carriageway is managed through the vegetation that is to be retained.
4. Between CH 17240 and CH 17540 (through carriageways), does the bike path follow the ROW, and does it conflict with the drainage?
5. (Dwg no. 384767) – At Middleborough Road there is no road lighting indicated on the easterly orientated ramps. This is inconsistent with the treatment at Jacksons Road.
6. (Dwg no. 384776) – At South Road the westbound exit and eastbound entry ramps are lit on Dwg no. 384775 but not on Dwg 384776. The citybound entry loop is not shown as lit; this is an important and tight manoeuvre and should be lit to aid in lane discipline.
7. Where lamp pedestals on ramps are adjacent or near to concrete barrier, consideration could be given to placing the pedestal either behind or on the concrete barrier.

5.5 Pre-opening Stage Audits

The opportunities to rectify safety problems at this stage are limited, compared with audits at earlier stages, but it is important to ensure detail is correctly implemented.

This audit involves a detailed inspection of a new scheme, its approaches and connections prior to its opening. The new road or treatment is driven, ridden and walked (as appropriate) by the audit team to ensure that the safety needs of all likely road users have been provided for.

The pre-opening audit is not simply an as-built check of the approved design, but also an acceptance procedure on behalf of the travelling public. At this time, small modifications to some aspects of the new work may be required to ensure that wrong messages will not be conveyed to the road users in ways that compromise their safety.

A night-time inspection is essential. While it is needed for the obvious darkness-related issues like signing, delineation and lighting, it is now recognised that a road layout that appears perfectly acceptable during the daytime can give a totally different impression to its road users after dark, causing specific safety problems.

If any major changes take place while the project is under construction, the client should seek road safety engineering advice at the time, rather than relying on the pre-opening audit.

A post-opening audit can also be undertaken after a short period of operation, to assess how the road is actually being used. Errors with the concept, or the detail implementation, are usually quick to surface and these can be put right while contractual resources are still available.

Where a road carries traffic during the construction period and there is no 'opening to traffic', the audit should be undertaken immediately following completion of construction activities, preferably prior to removing any temporary traffic management or speed restrictions.

Why audit at the pre-opening stage?

- audits may not have been done at previous stages
- to identify anything missed in previous stages
- to check the inter-relationship of elements
  - vertical and horizontal alignment
  - things can look alright on plans, but not on site (in 3-D)
- to check that it's built as designed
- designs and 'incidentals' can get changed on site
  - spoil areas, services can get in the way
  - landscaping gets added or expanded
- to check it at night-time
  - confusion, visibility
- unplanned hazards can eventuate, like poles and pits not meant to be there
- signs can get lost in their background.

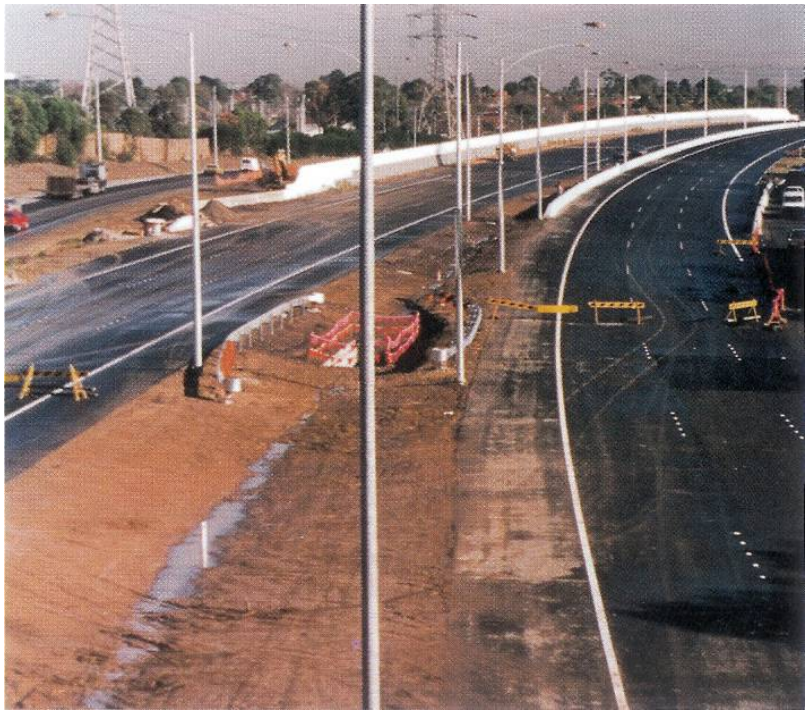
5.5.1 Practical examples: Pre-opening stage audit

1. A sign has been designed and installed incorrectly, so that the arrows do not align over the lanes (Figure 5.6). A pre-opening audit provides the last opportunity to correct such errors before the project is finished.

Figure 5.6: Incorrect sign installation

2. A safety barrier, as shown in Figure 5.7, has been installed behind a lighting pole. The guard fence is not long enough to shield the pit. On the oncoming carriageway the concrete barrier ends part way around a curve, leaving lighting poles exposed. Although all the lighting poles are frangible, they are in needlessly exposed locations and increase risk to passing motorists.

Figure 5.7: Safety barrier placement

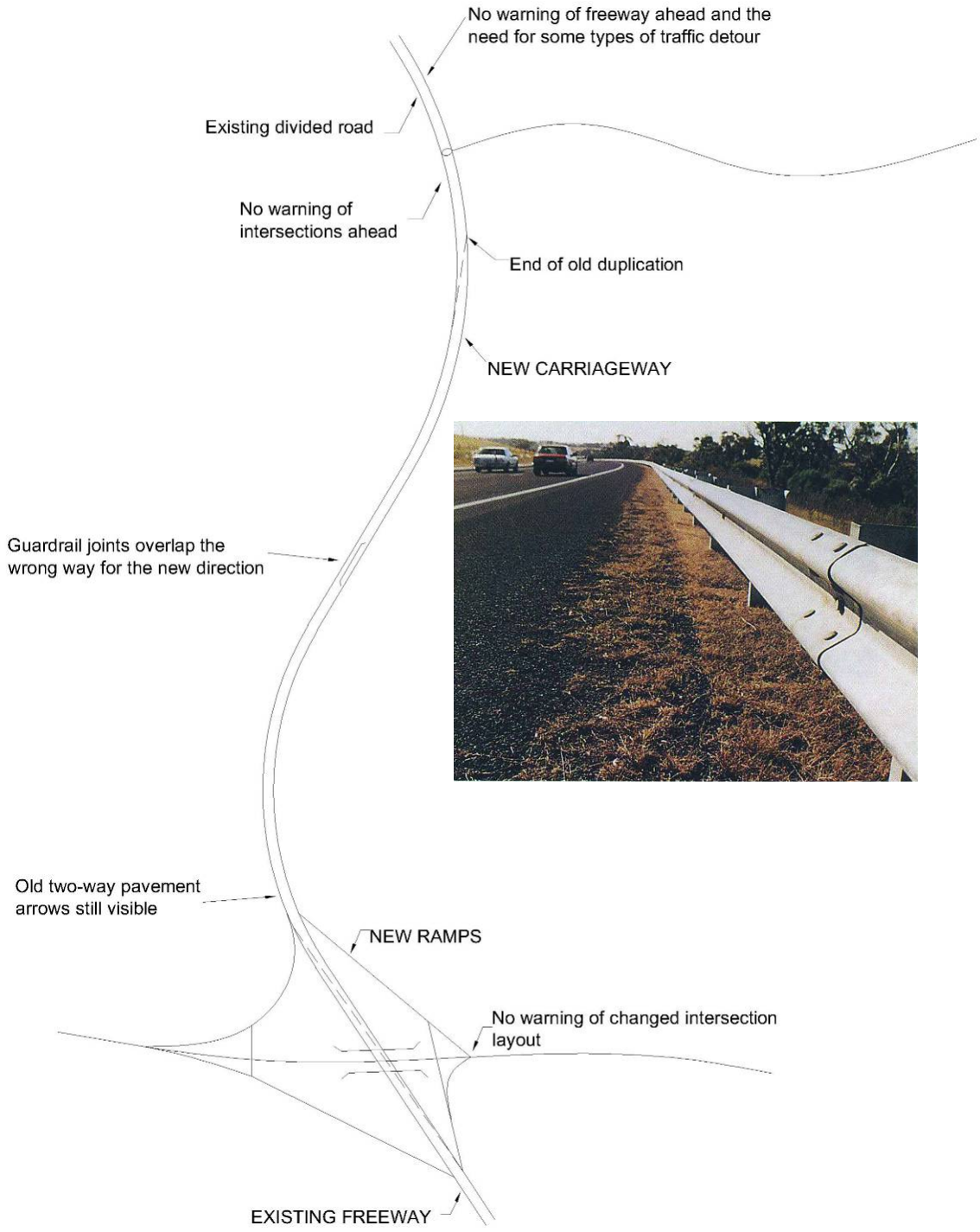


3. Safety barrier posts have been deleted due to the location of drainage pits. This weakens the rail and can snag an errant vehicle (Figure 5.8).

Figure 5.8: Deletion of safety barrier posts

4. A freeway link has been built in stages. The final stage is to duplicate a single carriageway link between the existing freeway and an existing divided road. A pre-opening audit revealed several safety problems. The photograph in Figure 5.9 shows how the safety barrier joints overlap the wrong way. This could snag a vehicle or cause a section of rail to pierce a vehicle in a collision.

Figure 5.9: Pre-opening audit can highlight problems previously missed



6. Other Types of Road Safety Audits

This section describes how the step-by-step process can be applied to temporary traffic schemes during roadworks, off-road land use developments, the needs of specific road user groups and to existing roads.

6.1 Audit of Roadwork Traffic Schemes

All road and traffic construction projects interact with the travelling public. At all these locations, there is a potential for crashes due to:

- changes in the road layout
- drivers or pedestrians not adjusting their behaviour to match the changed conditions
- conflicting uses of road space between works traffic and the public
- conflicting messages between permanent features and temporary features
- the limited space in which errors of judgement can be safely accommodated.

Great effort has been taken by road authorities to provide adequate safety by the development of worksite safety manuals and roadworks codes of practice. It may be considered that these practices provide sufficient safety without the need for audits of the temporary traffic arrangements. This may be the case but, as with design standards, standards do not necessarily equal safety due to factors such as:

- standards and codes of practice only cover the most common situations
- the particular layout of a site may make application of the standard difficult
- the wording of a standard may not be understood, as it relates to a particular location
- the person responsible for traffic arrangements may be 'blind' to a particular hazard
- familiarity or a concern about other issues.

Thus there are benefits in seeking independent road safety engineering advice in the form of a safety audit.

The audit should involve an assessment of the proposed temporary traffic management plans, for each different configuration or staging of traffic, before they are implemented. The site should be inspected, taking note of any existing features that will need to be covered or removed (e.g. signs, lines and pavement markers) or shielded (e.g. roadside hazards that are to be close to traffic). Once each temporary traffic arrangement is in place, it should be inspected in daylight and at night-time for all likely traffic movements, and reported upon. Finally, when the temporary traffic arrangements are removed, an inspection should be made to ensure all temporary devices (especially lines and pavement markers) have been effectively removed. This audit may be combined with a pre-opening audit.

The step-by-step process described in Section 4 should generally be followed, but it will have to be more dynamic and responsive to the changes in traffic conditions. Inspections of the site and formal reports and responses are required.

Why audit roadwork traffic schemes?

- Roadworks sites typically involve a change of speed environment, additional conflicts and confined road space, which can increase the potential for crashes.
- Traffic arrangements during roadworks can change several times and can bear no resemblance to permanent arrangements. Audits at design stages can give little indication of the safety of temporary works.

- Construction contractors may not appreciate the finer points of traffic management, roadside safety and the operation of safety devices.
- To check that standard arrangements are applied, for consistency.
- To assess whether standard arrangements are adequate for the particular conditions.
- To avoid conflicting messages from permanent and temporary devices and between lines, signs, delineation and other devices.
- To check that signs are used for their correct purposes.
- To provide safely for works personnel as well as the travelling public.
- To ensure that any connection or crossing point of works traffic and public traffic is safe.

Typical issues

A road safety audit of temporary traffic works might typically address issues like:

- adequacy of advance warning
- the proposed speed limits
- the appropriateness of the selected standard layout
- conflicts between permanent and temporary features
- any aspects of layout or devices that could be misread by drivers
- the likelihood of mud or dust obscuring devices
- the appropriateness of traffic barriers and the correct installation
- adequate provision for pedestrians, including less agile ones
- conflict points between works traffic and the general public.

6.1.1 Practical examples: Roadwork audits

1. The movement of works traffic to and from the work site needs to be considered. The trucks, shown in Figure 6.1, leaving a work site and making uncontrolled U-turns on a freeway, create the potential for severe, high-speed collisions.

Figure 6.1: Potential hazard from movement of works traffic

2. A concrete crash barrier is installed to protect workers and passing traffic, but the end of the barrier must be shielded, otherwise it can present a severe hazard to the occupants of any errant vehicle (Figure 6.2). The trailing end of the barrier will also need to be shielded on a two-way road if it is within the clear zone for opposing traffic.

Figure 6.2: Unshielded barrier end

3. A road safety audit of the work site shown in Figure 6.3 has resulted in a concrete crash barrier being realigned so that it will operate correctly and not snag an errant vehicle.

Figure 6.3: Realigned safety barrier

4. Figure 6.4 shows how temporary changes to line marking often receive inadequate attention at work sites. This creates hazards where, for example (left), the lines are confusing and direct opposing traffic into the same section of road, or (right) where old lines direct traffic into the works.

Figure 6.4: Confusing line markings

6.2 Audit of Land Use Developments

Land use developments can have an impact on the roads they connect with or another road some distance away. Developments of any magnitude have their own car parks, driveways and footpaths. Thus they have traffic interactions in the same way as do roads.

6.2.1 Types of developments that warrant audits

Not all developments warrant a road safety audit. The greatest road safety gains can be achieved if audits are conducted on:

- all strategic plans
- every town planning (land use development) application of a significant size (for example, subdivisions of more than 20 lots, major shopping centres and car parks with space for more than 50 cars)

- every application which interacts directly with an arterial road or other significant traffic route; matters as simple as safe driveway access are sometimes overlooked in development applications, particularly when the plan extends only to the site boundary
- every application where significant numbers of pedestrians or cyclists are nearby.

The types of developments can include anything that fits the above description, including:

- residential subdivisions and industrial subdivisions
- shopping centres (new and expanding)
- petrol stations, convenience stores, offices, medical consulting rooms, other commercial developments
- recreational developments
- increased density developments on single sites.

6.2.2 Incorporating audits into the town planning approvals process

The incorporation of road safety audit into the town planning approvals process needs to be coordinated and controlled by the planning authority. Clear procedures need to be established for deciding:

- which projects require a road safety audit
- at which stages in the design a road safety audit is required
- who obtains the road safety audit report (the client or the planning authority)
- who are acceptable audit team members (pre-qualification)
- to whom the audit report is addressed (it should be addressed to the planning authority)
- how audit findings or recommendations are to be dealt with and what mediation, arbitration or third-party assessment arrangements are to be followed if there is disagreement
- whether further audits of redesigns are required.

It is recommended that an audit of a development be done separately from any traffic impact assessment, as these assessments are usually part of the design process and are not independent.

6.2.3 Before a feasibility stage audit

Experience in the United Kingdom has shown that the approach of including road safety engineers right at the start in a pre-design issues meeting also has benefits with land use developments, particularly subdivisions. In some UK counties initial negotiations between the developer and the county's road safety engineers take place to discuss and resolve fundamental safety issues. Following initial reluctance by developers, this approach (together with formal audits at later design stages) has been welcomed because:

- it saves the developer time and money; arguments about poor safety are removed from decisions and planning inquiries/appeals are rarely required
- it avoids costly last-minute redesigns
- developers are able to use safety as a positive selling feature.

This approach has similarities to the concept of 'safety conscious planning' (Roberts 1998), which seeks to input safety engineering into the earliest planning phases of developments and transport networks, in order to minimise exposure, risk and conflicts. Some examples of the safety issues are provided in Table 6.1.

Table 6.1: Safety issues and considerations

Safety conscious planning principles	Some considerations
Minimising exposure	
• reduce the need to travel	• compact urban form • location of trip generators
• reduce travel distances	• location of trip generators • location of access points
• promote safer modes	• transit-oriented developments
Minimising risk	
• provide functionality	• adequate arterial network • prevent 'rat runs' by route management • location of access points
• minimise conflicts	• number and location of access points • intersection configuration and control
• minimise friction	• avoid on-street parking and loading • cater for turning movements • avoid differential speeds
• promote predictability	• provide visibility • driver information, for example, street name signs • consistency
Minimising conflicts	
• provide facilities for vulnerable road users	• pedestrian/cycle routes and crossings
• provide a forgiving roadside	• tree locations • transit facility locations and layout
• reduce speeds	• speed management/signal progression • self-explaining/self-enforcing measures
• provide emergency response routes	• access for emergency vehicles (internal and external network)

Why audit land use developments?

- Most land use developments need to accommodate road users, for example, pedestrians, car park users, delivery vehicles. Road safety is just as important as on public roads. Some large developments operate like road systems (for example, large car parks).
- Safety problems can occur where a development connects with the public road system.
- A development (or several in combination) can result in safety problems on the public road network some distance away, due to changes in traffic patterns.
- Some developments become public roads (for example, residential or industrial subdivisions).
- Designers of land use developments typically do not have road safety engineering experience. Audits permit the input of that experience and expertise.
- If development costs are initially avoided through inadequate design, the cost can be transferred to later road users as crash costs and possibly to the community as remedial costs incurred by the road authority.
- Typical planning code design standards for access roads and car parks do not provide adequately for safety.

Typical issues

A road safety audit of a development might typically address issues like:

- the safety impact of congestion in peak periods, including changes to turning movements and the use of nearby streets
- the generation of pedestrian movements across existing arterial roads
- the safe provision for public transport and its patrons
- vehicular and pedestrian site access, including driveway locations and shape, new turn lanes, swept paths of large vehicles, footpath locations near traffic
- the adequacy of parking provision and the need to avoid parking overflow onto nearby roads (i.e. into traffic lanes on traffic routes)
- pedestrian–vehicle conflicts on-site and adjacent to the site, the type, layout and operation of adjacent intersections
- speeds within the site and at access/conflict points
- visibility at conflict points.

6.2.4 Practical example: Land use planning audit

A clear urban road hierarchy (as shown in Figure 6.5), in which there is an adequate provision (in spacing and size) of arterial roads, separate from roads with a local access traffic function, will result in fewer crashes than an inadequate provision or the mixing of traffic functions. Decisions about these matters can only be made at the early stages of urban network planning.

Figure 6.5: Clear road hierarchy

6.3 Specialist Audits for Road User Groups

All safety audits need to consider the needs of all road user groups; however, there may be instances where audits are undertaken from the perspective of individual user groups or needs.

The audit process may also be used on existing roads (or other existing facilities like bicycle paths) to identify potential safety problems for particular road user groups. In this case, the audit focuses on the safety needs of that one group. The results can be used as an input to other traffic or safety programs such as the safe (child pedestrian) routes to school program, safety involving heavy vehicles along key freight routes, motorcycle safety along major travel and tourist routes, or cyclist safety on the road network and safety awareness programs.

Examples of specialist road safety audits include:

- major highway safety audit for passenger coaches and/or heavy vehicles
- audits of roads for cyclist and pedestrian safety
- audits of shared bicycle and/or pedestrian paths
- audits of roads for motorcycle safety
- pedestrian audits of shopping centres
- railway crossings
- audits of safe access for people with limited mobility (e.g. older pedestrians and disabled persons).

An audit for a particular road user group requires the auditors to use the mode of travel in question: ride the bike, get into a truck, walk the route, have the road ridden by a motorcyclist or ride a motorcycle, etc. If the audit is looking at the needs of the elderly, the audit team should include an elderly member.

Checklists for some of these audits have been developed and accompany these guidelines. Otherwise, general checklists should be used, with questions prepared relevant to the issues of the road user group.

6.4 Road Safety Audit of Existing Roads

The road safety audit process can be applied to the existing road network, either in a route specific manner (which yields detailed safety issues), or in a network wide manner (which yields more general safety issues).

Throughout this guide the term road safety audit of existing roads is used but readers are advised that other terms are equally applicable (e.g. road safety review and road safety inspection).

There is no single best way of carrying out a road safety audit of an existing road. Different ways are discussed below: select one which suits your needs, making your primary aim to improve the level of safety for the road's users. The flow chart of activities in Figure 4.1 should still be followed, making appropriate adjustments as required. Always include a daytime and night-time inspection.

The road safety auditing of existing roads is only one component of the assessment of existing roads. The safety performance of existing roads should also include a crash investigation, discussed below.

When conducting audits on unsealed roads practitioners may refer to Chapter 11 of the *Unsealed Roads Manual - Guidelines to Good Practice* (ARRB 2008 edition in press). This manual provides assistance in the review of the safety requirements for unsealed roads

6.4.1 Is it a safety audit or a crash investigation?

Safety audits of existing roads aim to identify any features which may lead to *future* crashes, so that remedial treatment may be implemented before crashes happen. *Past* crash information may not necessarily be a good indicator of this. Crash investigation and prevention programs or crash location treatment programs, as they are also called, look only at *past* crashes and aim to modify features which have contributed to the occurrence or severity of these crashes.

While generally the treatment of known crash sites across the existing road system has provided greater economic returns than treating sites where crashes are yet to occur, the proactive, complementary road safety audit practice is an underpinning feature of a safe system. The value of a road safety audit of existing roads is that it allows:

- Identification of types of features that, in total across the network, are hazardous (for example, one particular unshielded bridge end wall, or a specific pole on the outside of a curve, may not yet have been struck, but it is known that similar features are regularly struck through the road network). Identification of these features assists in prioritising remedial works.
- Identification and treatment of other potential hazards at a crash location, at the same time that the crash causes are being treated. This may be done for little extra cost.

6.4.2 Should crash records be considered in the road safety audit of existing roads?

A road safety audit of an existing road involves informed judgements about the potential for future crash types along a road. Crash records can be an important part of the information to be assessed in a road safety audit, but extreme care should be taken to ensure that their consideration does not focus attention away from other potential hazards. Also, consideration of past crashes without assessing the potential for other, future crashes is not auditing or safety inspecting, but rather is crash investigation work. This is covered in the *Guide to Road Safety - Part 8: Treatment of crash locations* (Austroads 2008c). To avoid such problems, some auditors wait until after their initial inspections before reviewing crash records. One option might be to have only one team member look at the crash records before the inspection, so that other members can focus on other issues. If considering crash records, check that they are all still relevant and whether any recent changes to the road layout have removed the problem.

6.4.3 Do the road safety audit from the road users' perspective

The road should be inspected from the point of view of each likely road user group and for the different types of movement, such as crossing the road, entering the traffic stream or leaving it, as well as for travelling along the road. This can best be achieved by using the road as road users do; for example, by driving or riding at normal road user speeds, at night and day, in the dry and in the wet, and by crossing the road where pedestrians would be expected to cross. Consider ways of getting the comments of local road users.

6.4.4 What is a hazard?

During the road safety audit of an existing road, it can be easy to identify features that are not to current standards or which are not 'perfect'. Remember that standards do not necessarily equal safety. A simple test to decide whether a feature is a potential hazard is to ask 'What type of crash, or what additional injury, could occur as a result of this feature?' If you cannot think of a type of crash resulting from the feature, it probably is not a hazard.

6.4.5 Road safety audit the whole network or parts of it?

Some road authorities seek to conduct a road safety audit of their whole road network on a regular basis. Others select a random sample of roads, while others again limit their road safety inspections of existing roads to sections of the network that are regarded as being of greatest potential hazard to road users.

6.4.6 Types of road safety audits of existing roads

The aim of a road safety audit is to identify any existing safety deficiencies of design, layout and road furniture. There should be a consistency of standards such that the road users perception of local conditions assists safe behaviour.

6.4.7 Detailed single route or single site road safety audits

These road safety audits will result in comments about specific hazards along a route or at a single site being road safety audited, with details about the nature of the hazard, its location and possible options for remedial treatment. Unfortunately, there is almost no limit to the number of physical deficiencies which can be identified on an existing road, compared with current guidelines on safe road environments. These types of road safety audits, if undertaken over any significant length of road, can result in a long 'shopping list' of identified deficiencies and a 'wish list' of recommendations that is unlikely to be economically justified in the foreseeable future.

This raises the following issues:

- Typically, many of the identified deficiencies are maintenance issues. These could be addressed by an appropriate maintenance program, rather than relying on infrequent formal road safety audits.
- There is little benefit in conducting detailed road safety audits if resources do not permit a majority of findings to be addressed within a foreseeable time.

Consequently, this detailed approach is best applied to specific, high-risk locations identified through previous inspections or enquiries. It is also a useful complement to a crash location investigation.

6.4.8 Broad network road safety audits

These audits will result in broad observations about consistency, adequacy of provision and extent of maintenance. They will also identify any specific high-risk locations for later detailed inspection. Typical issues can include:

Urban: street lighting: inconsistencies and pole placement; direction signs and street name signs: provision and condition; road markings: level of maintenance; road surface condition (as a safety issue); intersections: visibility and controls – provision and consistency.

Rural: guard fence: provision and end treatments; clearance to hazards intersections: visibility and controls – provision and consistency; alignment: provision of warning at deficient locations; delineation: adequacy and condition.

For any identified high-risk locations, a second detailed level of inspection can follow.

As a result of these road safety audits:

- inadequate road management practices can be identified
- new works programs can be initiated (e.g. a direction signing program and mass action programs)
- changes in emphasis and priorities can be made to existing programs
- maintenance procedures can be changed to meet road users' needs.

6.4.9 Following up the road safety audit

Once potential safety problems and corrective actions are identified, the next key task requires determining the priority of corrective actions to be made. While some of the corrective actions may be dealt with though road maintenance programs (e.g. faded or damaged signs, provision and placement of advisory or regulatory signs, renewing of pavement markings, etc.), other corrective actions may be more substantial and would require capital works funding (e.g. pole relocation, provision of safety barrier, flattening of batters, etc.). Where capital works funding is a requirement, and where the funding is not sufficient to correct all of the safety deficiencies deemed as either intolerable or high-risk, then a road safety risk management approach should be undertaken.

Application of crash risk models developed by ARRB Group in association with Austroads allows road authorities to prioritise the treatment of potential safety problems so as to maximise the crash risk reduction that may be achieved for the limited funds that are available. The evidence based crash risk model is termed the Road Safety Risk Manager (RSRM). This may be applied to prioritise the deficiencies for treatment so as to optimise the level of crash risk reduction for available funding. This tool takes into consideration treatment costs, exposure and crash risk reductions expected. Further information on RSRM can be found in Section 9.3.

Why conduct a road safety audit of existing roads?

- to complement a program of crash blackspot treatment
- to specifically address safety, rather than relying completely on routine maintenance
- to identify problems in routine maintenance procedures
- to identify locations for mass action treatments (e.g. removal of horizontal pipe railing)
- to attend to changes before they lead to crashes; uses of the road and land beside the road can change over time
- to check the consistency of the road features
- to check the adequacy of provision of traffic management features
- landscaping grows and obscures devices and sight lines
- devices age over time, affecting conspicuousness, reflectivity, accuracy of messages
- accepted practices change with experience.

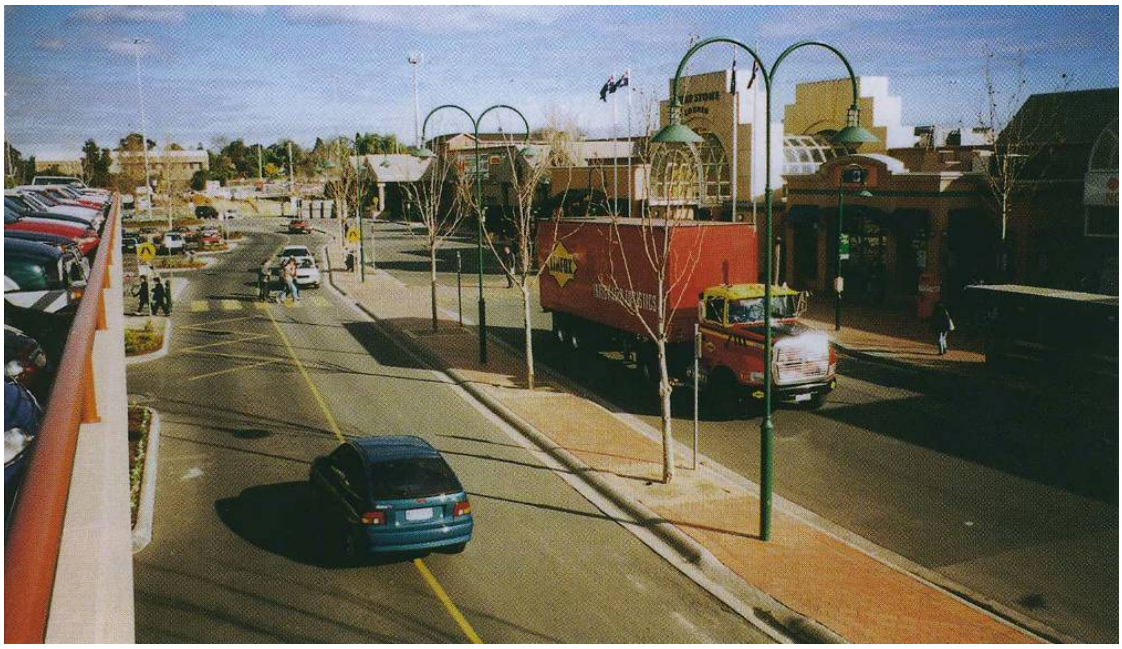
6.4.10 Practical examples: Road safety audits of existing roads

1. A decision to adopt a cross-section standard on a three-lane freeway without a full-width median-side shoulder will increase the likelihood of secondary nose-to-tail crashes as drivers attempt to pass any vehicles stopped in the median-side lane after an initial crash (Figure 6.6). An audit can alert designers to these types of safety issues at the feasibility stage.

Figure 6.6: Three lane freeway without a full-width shoulder

2. The two-way road (left) and one-way service road (right) at a shopping centre (Figure 6.7) can easily be mistaken for a divided road, with serious consequences for pedestrians.

Figure 6.7: Mistaken divided road



3. Figure 6.8 shows how direction signs are lost within their background environment. This problem can be difficult to anticipate at the design stage.

Figure 6.8: Sign conspicuity

4. Figure 6.9 depicts brick paving, islands and local street roundabouts which give mixed messages about how people should use this traffic route. Cyclists are squeezed. The roundabouts at side streets with low traffic volumes are likely to have crash problems due to the low expectation of conflicting traffic.

Figure 6.9: Mixed messages – brick paving, islands and local street roundabouts on a traffic route

5. The project in Figure 6.10 has resulted in confusing line marking, and the potential for drivers to be 'blind' to the first intersection. These problems could have been identified during a detailed design stage audit. An inspection is an important part of an audit at each design stage. In this case it could have heightened awareness about the close proximity of the two intersections.

Figure 6.10: Confusing line markings

6. Landscaping details need to be provided for a detailed design stage audit. Landscaping should not be a hazard, either by blocking sight lines or, as in Figure 6.11, by introducing a rigid roadside hazard which will increase the severity of injury in any run-off-road crash.

Figure 6.11: Hazardous landscaping

7. The layouts in Figure 6.12 show yellow lines and brick paving across a road; each may be interpreted incorrectly by pedestrians as giving them right of way over traffic. The later 'fix-up' with notices to pedestrians will never eliminate the problem created by the inappropriate design concept.

Figure 6.12: Ambiguous linemarking

8. An audit looks beyond the limits of the project. A non-traversable culvert end wall has been left, just beyond the limit of the project (Figure 6.13). This reduces the benefit of the new drivable roadside environment.

Figure 6.13: Non-traversable culvert end wall

9. Figure 6.14 shows that instead of protecting a vehicle from this pole, the safety barrier actually increases the risk of this pole being struck.

Figure 6.14: Hazardous pole

10. Non-frangible light poles, especially in exposed places close to the carriageway on a bend, are a definite road hazard as shown in the left photo in Figure 6.15. The removal of the centre of the road lighting pole, however, has made the road safer, as seen in the right hand photo.

Figure 6.15: Non-frangible pole and the benefit of its removal

11. Concrete poles, as shown in Figure 6.16 left photo, are unforgiving to errant vehicles and can cause serious damage and injury. A slip-based pole (used in a location where there is no pedestrian activity), as shown in the photo on the right, however, would have caused minimal property damage only when impacted. Should there be pedestrian activity an energy absorbing pole would have been used instead.

Figure 6.16: Concrete pole (left) and slip-base pole (right)

12. In this example traffic travels on the right side of the road. The turned-down end treatment of the safety barrier is to an old standard which has been found to be unsafe (Figure 6.17). The safety barrier had been used because the standard 10 m clear zone could not be achieved at the bridge abutment. An experienced road safety engineer will ask whether installing safety barrier as shown (but with a crashworthy end), is as safe as altering the bridge abutment or modifying the roadside around the abutment.

Figure 6.17: Hazardous turn-down barrier end treatment

7. Case Studies

This section contains summarised case studies based on actual road safety audits. The examples are illustrative only; several elements of the original audit reports have been altered for presentation purposes. They illustrate audits of different-sized projects, as well as different styles of reporting. It should be noted that the numbering of sections within each case study is provided as if presented in a stand-alone report.

7.1 Feasibility Stage Audit

This example is an example of a complete road safety audit report.

Background

A rural highway is to be duplicated (Figure 7.1). The duplication generally follows the existing alignment, but the project includes a minor realignment of one curve and a major deviation to reduce the route length and avoid a difficult intersection and railway level crossing. Ultimately the road will be a fully grade separated freeway, but some at-grade intersections will remain initially. Along one section of duplication there is an existing Avenue of Honour with trees 7 m from the traffic lanes. A previous road safety audit had been carried out on a number of other alignment options, prior to the favoured option being determined.

1. Introduction

1.1 Auditor and audit process details

This report results from a feasibility stage road safety audit on the proposal to duplicate and deviate a section of the Goulburn Valley Highway. The audit has been carried out for the Design Department of the State Road Authority.

Figure 7.1 shows the layout of the site, together with reference numbers for the audit findings in Section 3 of the audit report.

The audit was carried out by:

- (name, qualifications, position, organisation)
- (name, qualifications, position, organisation)

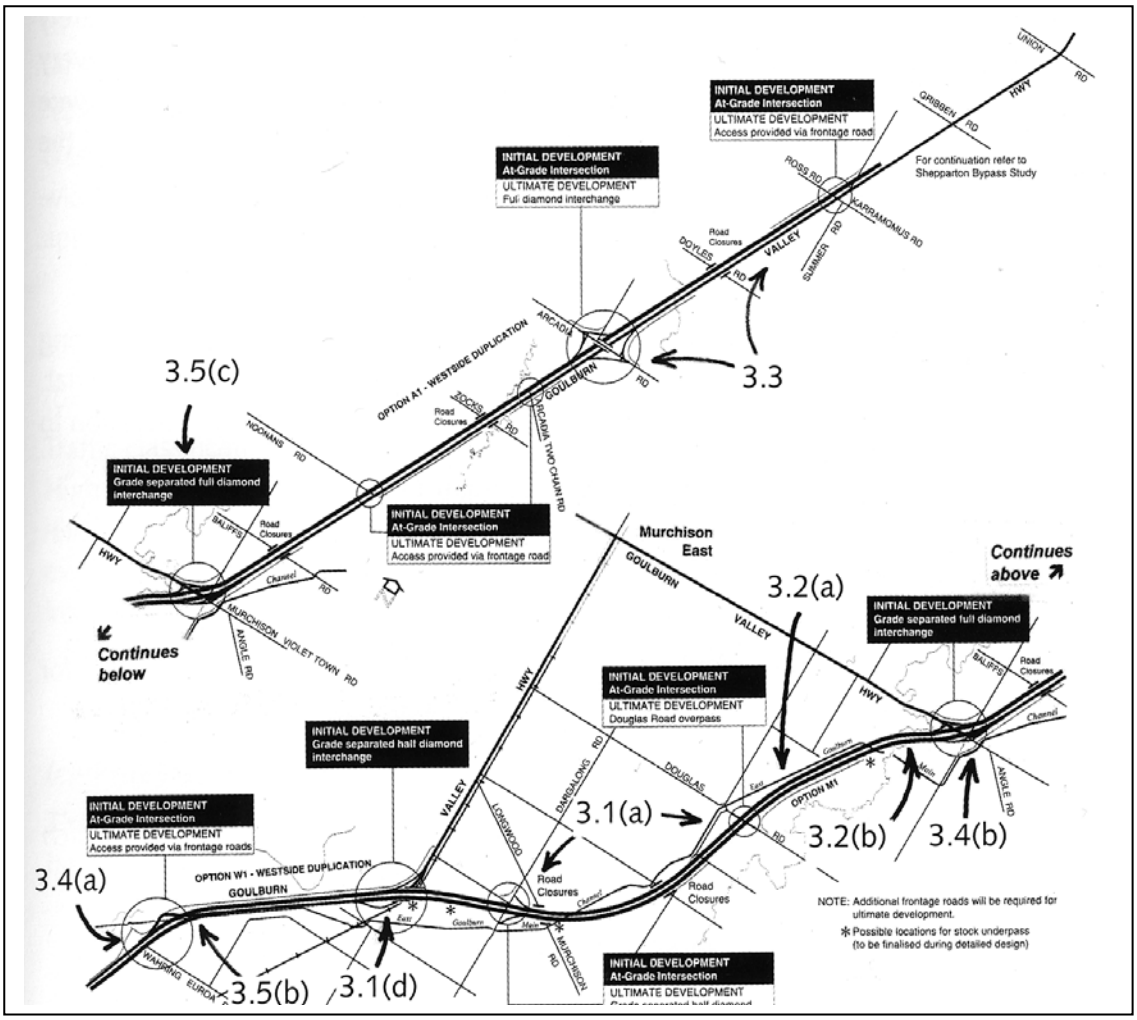
In addition, the following people joined the audit team as observers, for the purposes of training:

- (name, qualifications, position, organisation)
- (name, *qualifications*, position, organisation)

The audit comprised an initial meeting with the design team on 13 January (year) at the State Road Authority offices, examination of the documents listed in Appendix 1 (of this case study), an inspection of the site and nearby sections of road late in the afternoon and at night on Wednesday, 13 January (year) and a completion meeting with the design team manager on 15 January (year).

The audit has been carried out following the procedures set out in the *Austroads Guide to Road Safety - Part 6: Road Safety Audit (2008)*. The audit covers physical features of the project which may affect road user safety and it has sought to identify potential safety hazards. However, the auditors point out that no guarantee is made that every deficiency has been identified. Further, if all the recommendations in this report were to be followed, this would not guarantee that the site is safe; rather, adoption of the recommendations should improve the level of safety of the facility.

Figure 7.1: Duplication of a rural road



Note: Numbers refer to recommendations in Section 3 of this case study.

1.2 Project and site details

The project involves the duplication of the Goulburn Valley Highway between Wahring and Arcadia, including a deviation to bypass East Murchison. The land is generally flat. The road will initially have some intersections, with provision for ultimate conversion to a freeway. The speed limit on the road will be 110 km/h.

1.3 Ranking of findings or recommendations

Some findings or recommendations have been ranked as:

- Important: a problem requiring the most effort to resolve, as the potential for danger is considered greatest.

Other problems which are unranked are not unimportant, but are simply unranked. A client, however, may wish the audit team to provide findings or recommendation rankings which indicate the level of risk, similar to that provided in Table 4.4.

1.4 Responding to the audit report

As set out in the road safety audit guidelines, responsibility for the road design always rests with the client, and not with the auditor. A client is under no obligation to accept all the audit recommendations. Also, it is not the role of the auditor to agree to or approve of the client's response to the audit. Rather, the audit provides the opportunity to highlight potential problems and have them formally considered by the client, in conjunction with all other project considerations.

This formal road safety audit report should be responded to in writing, giving reasons for each rejection of an audit finding or recommendation. Acceptance of a recommendation may require no further comment, but explanation of how or when the action will be taken may be useful.

2. Findings or recommendations from previous audit stages

The issues identified in the previous audit of alignment options have all been addressed with the current proposal, except the previous audit's item number is listed, the outstanding issue is described and a finding or recommendation is made.

3. Feasibility stage audit findings and recommendations

3.1 General issues

a. Wide median treatments: Wide median treatments are proposed at all the initial at-grade intersections. Due to crash experience with these types of intersections, the design guide requires that the median width be 24 m minimum where these are proposed as the initial development. It appears that the median will be only 18 m wide in some sections.

   Recommendation: Increase median width at intersections. (Important)

b. Design for trucks: Traffic classification counts show 24% of traffic is trucks on the Goulburn Valley Highway. This means that the freeway elements should be designed for trucks, and in particular that truck stopping sight distance for the design speed of the road is likely to exceed car safe intersection sight distance along the main carriageways at all at-grade intersections and will be a controlling parameter.

   Recommendation: Use truck design criteria. (Important)

c. Provision for cyclists: There does not appear to be any direct consideration of the needs of cyclists. Will they be directed along the existing highway, or will they be permitted on the freeway?

   Recommendation: Determine bicycle route and design accordingly.

d. Headlight glare screening: Headlights of vehicles on frontage roads may distract or confuse highway drivers.

   Recommendation: Make provision in cross-section and in landscape planning for headlight glare screen planting in all cases where a frontage road is parallel to the main carriageways. Also, at Wahring, provide a glare screen fence between the railway and the adjacent part of the southbound entry ramp.

3.2 Alignment

a. Water depths in superelevation developments: The alignment generally consists of curves of about 2,000 m radius. However, the grading is flat (0%) and this means there will be flat spots – where water may drain away too slowly – on every superelevation development.

   Recommendation: Check the water flow depth on the pavement at each supertwist. Introduce an additional crown if necessary.

b. Between approx Ch 12,000 and Ch 14,000 there is the opportunity to a curve of 4,000 m minimum radius, which would allow adverse crossfall to be used on one carriageway and eliminate two flat spots.

Recommendation: Reserve land to allow this as a future option.

c. Superelevation development on bridge: Near Ch 15,000 a superelevation development appears to occur across the bridge. If the alignment cannot be adjusted, the superelevation should be introduced south of the bridge so there is constant crossfall across the structure.

   Recommendation: Redesign the alignment or superelevation.

3.3 Cross-section

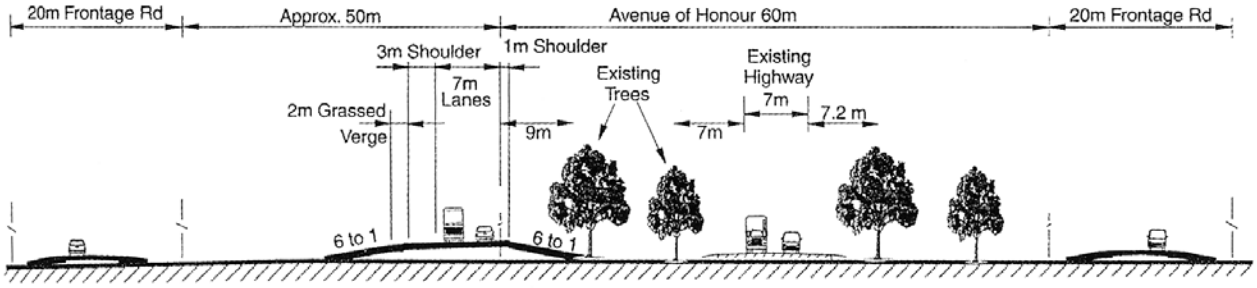
The main cross-sectional issue is the Avenue of Honour on the Arcadia section (Figure 7.2). The crash data seem to indicate that the run-off-road characteristics are similar along the whole highway section, but that the Arcadia section has more casualty crashes because the trees in the Avenue of Honour are about 7 m from the traffic lane.

The replacement of dead trees away from the traffic lanes is a reasonable long-term policy, but the audit team does not agree with the proposal to plant an additional row of trees in the proposed freeway median as shown in the route adoption report. This will only perpetuate the problem.

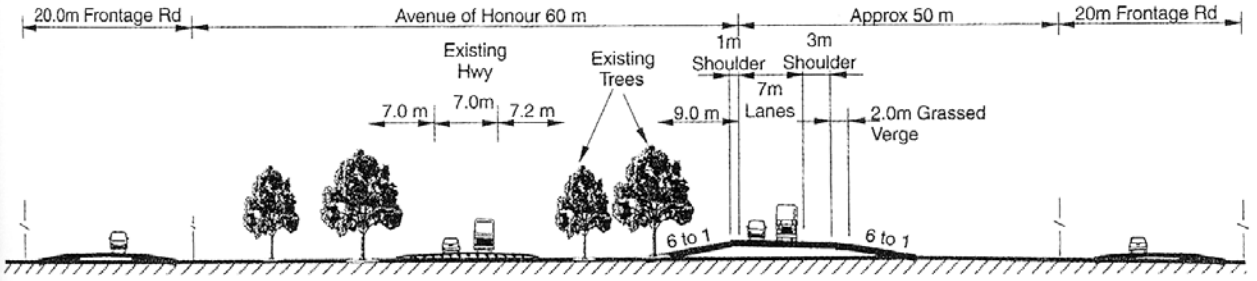
The adoption of a 10 m clear zone requires discussion. Only 80% of run-off-road vehicles stop or recover control within this clear zone width. This is implicitly the level of risk that the highway authority accepts under normal circumstances. However, the design guide points out that if a life- threatening hazard lies just outside the clear zone, provision of protection should be considered.

Recommendation: Review the provision of clear zones. In Arcadia section, provide the existing highway with tactile edge lines in the near future to see if the number of run-off-road casualty crashes can be reduced. Otherwise, use wire rope safety barrier at an offset of 5 m from the traffic lanes (that is, allowing about 2 m for barrier deflection clear of the trees). (Important)

Figure 7.2: Arcadia section (widening on west and east side)



ARCADIA SECTION (WIDENING ON WEST SIDE)



ARCADIA SECTION (WIDENING ON EAST SIDE)

3.4 Intersections

a. Wahring–Euroa (Moss) Road: Sketches of several options for development at this site were seen. Arrangements for entry and exit at the adjacent roadhouse are complicating factors.

Recommendation: Carefully consider the layout of the intersections in this area. Ensure the chosen solution is able to be converted to the ultimate access-controlled arrangement easily.

b. Pascoe Street: The proposed intersection of Pascoe Street with Murchison – Violet Town Road just west of the irrigation channel is unlikely to provide safe intersection sight distance for westbound traffic on the main road, due to the channel embankment, bridge railing and existing trees. The audit team suggests that although the design speed chosen for the arterial road is 80 km/h, the operating speed westbound on the Murchison – Violet Town Road is more likely to be 100 km/h.

Recommendation: Review the design speed and provide safe intersection sight distance. (Important)

3.5 Stage construction

a. Staging strategy: No specific strategy appears to have been developed for stage construction.

Recommendation: Assess the safety factors for each staging strategy.

b. Construction at Wahring: Although a gradeline was not available, it appears that the new carriageways just north of the East Goulburn Main Channel (Ch 2,400 – 3,000) will cross the existing highway with a level difference of about 2 m.

Recommendation: Pay particular attention to traffic arrangements during construction.

c. Bridge at the Murchison – Violet Town Road Interchange: The proposed bridge abutment filling will cover the existing highway. There is an option to construct the northbound entry ramp to two lanes at a high standard for use by highway traffic during construction, temporarily relocating the intersection with Murchison – Violet Town Road.

   Recommendation: Consider this option.

4. Concluding statement

We have examined the plans and documents listed in Appendix 1 (of this case study). We have inspected the site. The audit has been carried out for the sole purpose of identifying any features of the design which could be altered or removed to improve the safety of the proposal. The identified issues have been noted in this report. The accompanying findings and recommendations are put forward for consideration by the Client for implementation.

/ /

(Name), Road Safety Engineer

AUDIT TEAM LEADER

/ /

(Name), Senior Road Design Engineer

Appendix 1

Documents used during the audit

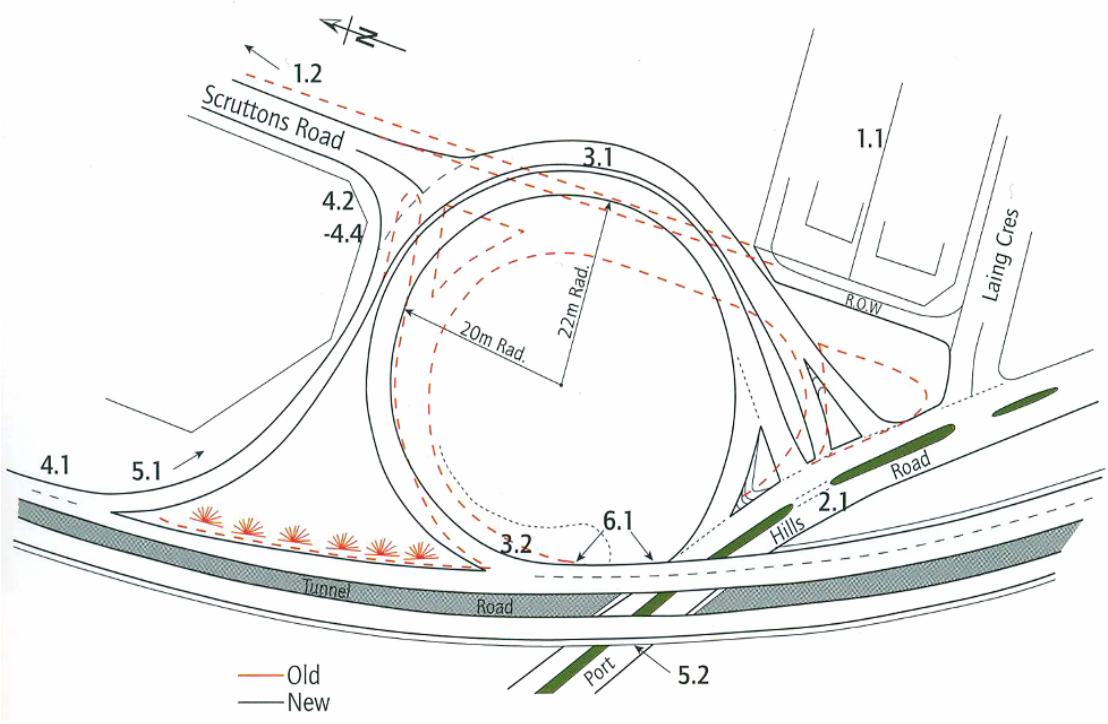
1. Austroads, Guide to Road Safety – Part 6: Road Safety Audit (2008)
2. State Road Authority, Goulburn Valley Freeway Project, Plans GVF 290750 to 290771
3. SRA Road Design Manual
4. SRA Road Design Group, Feasibility Stage Road Safety Audit of Alternative Alignment Options. Goulburn Valley Freeway Murchison East Section (date).

7.2 Preliminary Design Stage Audit

Background

An intersection on Tunnel Road was grade separated 30 years ago, with twin bridges taking the highway over Port Hills Road. Away from the grade separated intersection, Tunnel Road is a high-speed two lane, single carriageway road. Ramps connect the road with at-grade intersections on Port Hills Road, catering for movements in all directions. The ramps on and off the southbound carriageway use a local road (Scruttons Road) to connect with Port Hills Road. Some geometric elements of this connection are substandard and it is proposed to redesign the ramps to improve the geometry, make it easier for the large number of trucks to negotiate and give emphasis to the major movements, rather than to the local roads. The proposed works are shown in Plan No. P201 (Figure 7.3).

Figure 7.3: Plan No. P201 of the proposed road layout



Note: Numbers refer to recommendations within this case study.

1. Access to property and development

- Access to the two houses in Scruttons Road is proposed via a right of way which intersects with Laing Crescent only a few metres away from the Port Hills Road/Laing Crescent intersection. These intersection points are too close for safety. Also, it is evident that the two houses constrain options for design of the on ramp and that recommendations elsewhere in this report may lead to greater difficulties providing access to these two houses.

  Recommendation: Consider acquiring these two houses, or acquire the more northerly one and require vehicle access to the more southerly one to be only via its Laing Crescent frontage. If this cannot be done, reopen the feasibility study for the project and look for other ways or other locations to make the improvements. (Important)

- It is not evident that access has been maintained into Scruttons Road, except via a left turn off the off-ramp. This could lead to dangerous U-turns on Tunnel Road, or wrong-way movements elsewhere. The interchange has very little area available for improving the access onto Tunnel Road (Figure 7.4).

  Recommendation: Provide adequate access to/from Scruttons Road via the local road system. (Important)

Figure 7.4: Limited area available for improving access onto Tunnel Road

2. Intersection of Port Hills Road with the on and off-ramps

- Moving the right-turn point off Port Hills Road closer to the bridge reduces sight distances. There is only 45 m of forward sight distance for a motorist turning right onto the on-ramp, due to the position of the bridge piers (Figure 7.5). This is inadequate at likely traffic speeds. Also, the design results in two closely spaced intersections onto Port Hills Road (at Laing Crescent and at the on/off-ramps). This is dangerous as motorists may misinterpret the movements of a vehicle intending to turn into one of these side roads.

  Recommendation: Redesign the intersection to avoid these problems. Bear in mind that the bridge piers will limit visibility of southbound motorists to any signal, sign or conflicting vehicle south of the bridge. Subject to the above comment, a roundabout including Laing Crescent may provide a solution. (Important)

Figure 7.5: Bridge piers restrict forward sight distance at the location proposed for a new right turn

3. Southbound on-ramp

- When considering the number of large trucks using this ramp, at 1.2 m the width of the median between the on-ramp and the off-ramp is too narrow to give adequate clearance between opposing large vehicles or to allow for any signs.

  Recommendation: Increase the width of the median to at least 2.0 m.

- Where the on-ramp meets the through carriageway of Tunnel Road, the radius is greater than at present but is still inadequate. It requires a transition curve of greater radius to join the curved ramp to the highway on the bridge. Otherwise trucks will encroach into the right-hand lane (which will have 100 km/h traffic) (Figure 7.6). Strong delineation is required to separate the two lanes on the bridge and on the two approach lanes. Warning of the 'added lane' should be given to traffic on both approaches.

  Recommendation: Redesign the on-ramp and its connection to Tunnel Road to include a geometric transition. Pay particular attention to delineation and warning around the intersection of the on-ramp and Tunnel Road.

Figure 7.6: Large trucks enter Tunnel Road

4. Southbound off-ramp

- The southbound off-ramp consists of a short taper off the single southbound through lane, followed by a reverse curve on the ramp. The grade is downhill. Given that approach speeds will be 100 km/h and the safe ramp speed is considerably lower, an adequately long and wide deceleration lane is needed in advance of the curved ramp (to avoid nose-to-tail crashes in the through lane and run-off-road crashes at the start of the curved ramp).

  Recommendation: Redesign the deceleration lane for the likely vehicle speeds, permitting deceleration clear of the through lane. Consider flattening the curve radius, bearing in mind issues at the Scruttons Road intersection.

- At the intersection of the off-ramp and Scruttons Road, it will be important to advise motorists from Scruttons Road that they must turn left, and that traffic on the off-ramp may be coming from behind them at speed.

  Recommendations:

  Consider signs, delineation and/or a splitter island in Scruttons Road to ensure wrong- way movements are not made.

  Align Scruttons Road with the off-ramp so that vehicles exiting the highway are visible. (Important)

  Check that the line of sight from the intersection is clear of private land. Acquire land if necessary.

  Check the need for a left-turn deceleration taper into Scruttons Road.

5. Bicycle facilities

- Cyclists are permitted to use Tunnel Road north of Port Hills Road. Separate carriageway width should be provided in the area of the deceleration lane and off-ramp, as the proposed lane widths are inadequate for shared use by trucks and bicycles.

  Recommendation: Provide a separately delineated section of carriageway for cyclists from the start of the deceleration lane, to Port Hills Road. (Important)

- On Port Hills Road under the bridge, the road splits into two single lane carriageways, with bridge piers in the median and adjacent to the outer edges of the carriageways. These carriageways are too narrow for shared use by cyclists and motor traffic.

  Recommendation: Provide for bicycles by converting the footpath to a shared footway. Pay particular attention to the consequent bicycle paths through the nearby intersection(s). (Important)

6. Crash protection

- There are several existing fixed object hazards at this site.

  Recommendations: Provide a crash barrier to protect the existing hazards of:

  – the bridge piers on Port Hills Road

  – the left northern abutment of the southbound bridge, and the future high-risk run-off-road areas at the curved ramps.

7.3 Detailed Design Stage Audit

Background

An intersection on a multi-carriageway inner urban road has had numerous pedestrian crashes involving pedestrians crossing the road to and from a tram stop refuge island. The crashes involve pedestrians crossing between the tram stop refuge on the north-west approach in Flemington Road and the plantation to the north. The two traffic lanes they cross comprise one through lane and one right-turn lane, which can have green and red signal phases at different times. Some pedestrians have mistakenly believed that, with traffic stopped in one of the lanes, traffic would be stopped in both lanes. This has led to pedestrian casualty crashes. The project involves relocating the tram stop to two new islands, one on the south-east side of the intersection in Flemington Road and one on the south side of the intersection in Abbotsford Street. As the project is a crash blackspot treatment, the client is seeking an audit of the design to minimise the risk of creating new crash problems while solving the existing ones.

Table 7.1 presents the findings, recommendations and responses to the audit, while Figure 7.7, Figure 7.8, Figure 7.9 and Figure 7.10 depict the location.

The client for this design responded to the auditor's report, and these responses are also shown in the table. This table of responses, along with a covering memo, constitutes the client's corrective action report.

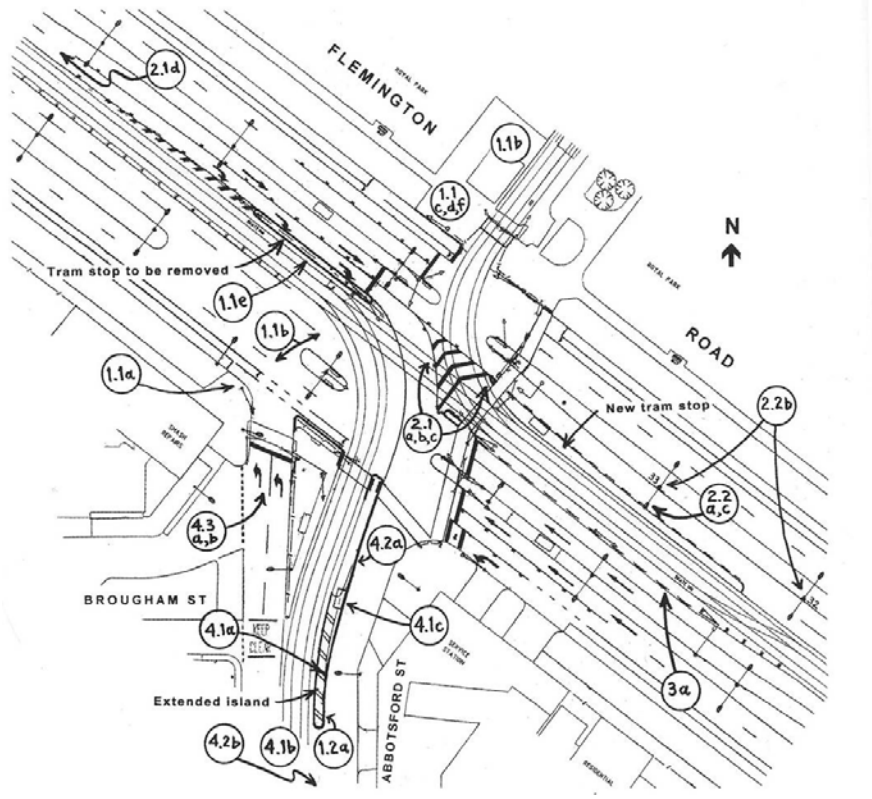
Figure 7.7: Looking south-east from the intersection to where the new refuge island will be built; poles 32 and 33 are on the left

Figure 7.8: Looking from the north-west approach; limited pavement marking and no signs to get straight-ahead traffic out of the right lane

Figure 7.9: In Abbotsford Street the tram stop refuge will be extended over the striped area

Note: Numbers refer to recommendations: Table 7.1 of this case study.

Figure 7.10: Intersection layout



Note: Numbers refer to recommendations: Table 7.1 of this case study.

Table 7.1: Findings, recommendations and responses for the detailed design stage audit

Audit findings	Recommendations	Ranking	Client	
			Accept Yes/No	Reasons/Comments
1. PEDESTRIAN SAFETY ISSUES				
1.1. Discouraging pedestrians crossing the north-west side of the intersection				
The main objective of the project is to restrict pedestrians crossing Flemington Road, on the north-west side of the intersection. Pedestrians on the south-west corner of the intersection may attempt to cross directly from here.	(a) Install pedestrian fencing around the south-west corner of the intersection.		Yes	
	(b) Consider whether there is a pedestrian desire line between the south-west corner and the tram stops within Royal Park, and whether these tram stops should be removed (as they are now redundant).		Yes	(b) Information will be provided to the tram company, and it will be requested to check this.
There appears insufficient discouragement or information for pedestrians considering crossing from the north side of the intersection either across the whole road or to the old safety zone.	(c) Extend the pedestrian fencing on the north corner.		Yes	
	(d) Remove existing paved areas on the north corner and grass them. Remove the rubbish bin.		Yes	(d) City council will include these items within the scope of its works.
	(e) Consider completely removing the island on the north-west approach.		No	(e) The advance tram lanterns (for points) require the island for protection.
	(f) install signs on the fence (e.g. for 6 months) advising that the tram stops are in ….. direction.		Yes	(f) Tram company will be advising passengers of the tram stop changes.
1.2 Tram stops in Abbotsford Street				
Some passengers will seek to cross at the south end of the extended tram stop island.	(a) Ensure the end of the pedestrian fencing is located so it doesn't obstruct pedestrians' view of oncoming traffic, or force pedestrians to stand off the road where there is turning traffic.		Yes	(a) Tram stop refuge fencing will be shortened by 2 m to allow pedestrians to stand on the island when waiting to cross the road.
Corrective action report: Responsible representative: Name:				
Agency and division:	Signed:			Date:

Audit findings	Recommendations	Ranking	Client	
			Accept Yes/No	Reasons/Comments
2. SOUTH-EAST BOUND IN FLEMINGTON RD				
2.1 Hazard of cars hitting the new safety zone				
The island at the start of the new safety zone is too small. While the proposed road surface delineation is good, there will be times (wet nights) when this cannot be relied upon. The island's Keep Left sign is likely to be often struck and flattened, leaving nothing to delineate the start of the safety zone.	(a) Modify the layout, to provide an island which is larger. This will provide more clearance to the Keep Lift sign and permit a larger sign. Options to consider include: • shifting the pedestrian crosswalk past poles 9 and 10 to the east • placing an island on the west of the northbound tram track (in the hatched area).	Important	Yes	(a) First option was investigated, but involved major changes to tram points, costing $300,000. Second option adopted. This requires shifting stop line on north-west approach back 10 m for adequate right-turn space. New signal conduits needed. Will be redesigned to include this.
There is an existing problem with straight through vehicles from the north-west using the right-turn lane, due to inadequate lane marking and signs upstream of the intersection. This will be more critical with the new layout.	(b) In addition, consider floodlighting the island (as done at standard safety zone prows).		Yes	
The RRPMs beside the large hatched area could be made more effective by extending them and reducing the spacings, especially on the curved edge.	(c) Make changes to RRPMs as discussed at left.		Yes	
On the north-west approach to the intersection there is inadequate information advising drivers the right lane is right-turn only. Unlike the present situation, it will be critical that all through traffic gets in the left lane.	(d) Well in advance, on the north-west approach: • mark both lanes • advise by standard signs that the right lane is for right turns and start the right-turn pavement arrows earlier.	Important	Yes	(d) This will be done ASAP, well before works start, so that drivers get used to it before it becomes critical for safety. Traffic will be merged to left lane, using striped painted island in right lane.
2.2. Single lane past new safety zone				
The road past the new safety zone is 4.0 m wide. There is inadequate delineation past the safety zone.	(a) Continue the white line of the large hatched area as an edge line beside the safety zone.		Yes	
Corrective action report: Responsible representative: Name:				
Agency and division:	Signed:			Date:

Audit findings	Recommendations	Ranking	Client	
			Accept Yes/No	Reasons/Comments
PTC poles 32 and 33 are located immediately behind the left kerb, giving no margin for error if a driver misreads the road alignment. Pole 33 is in direct line of the approaching left lane. The road surface past the proposed safety zone is in poor condition.	(b) Preferably, relocate these two poles away from the kerb. As a minimum, relocate pole 33. (c) Patch the holes, resurface the road before linemarking.	Important	No Yes	(b) Pole relocation cannot be included in project budget. However, a hazard marker will be placed on each pole.
3. HORIZONTAL PIPE RAILING				
The safety zone on the south-east approach has horizontal pipe rail fencing. This is a severe hazard in the event of a collision; it can pierce the driving compartment.	(a) Replace the pipe railing fence with a safety type.	Important	Yes	(a) This will be done as part of this project.
4. ABBOTSFORD STREET TRAFFIC MOVEMENTS				
4.1 Access to and from the service station				
Concern has been expressed by the designers that right turners off Abbotsford Street into the service station may not be able to see oncoming (southbound) traffic through the grille of the tram stop fence. It appears from observation that visibility is likely to be adequate. But this should be tested on site.	(a) Check the visibility through the proposed fencing by testing it on site.		Yes	(a) Removing the last 2 m of fencing will help visibility.
Where these vehicles turn right, some southbound vehicles in Abbotsford Street will be wanting to U-turn to reach Brougham Street. This conflict of opposite turns over the same area of tram tracks should be avoided.	(b) Consider banning southbound U-turns at the south end of the new tram stop island and permitting them further to the south.		No	(b) The occurrence of this problem will be monitored and the suggested treatment installed later if warranted.
Vehicles exiting the service station via the north driveway in Abbotsford Street may not see the extended island at night-time.	(c) Check the need for a hazard marker on the tram stop fencing.		Yes	(c) This access is to be marked as IN only, using signs and arrows.
4.2 Delineation				
For southbound traffic, the extended tram stop island curves to the left in front of them.	(a) Mark an edgeline along the length of the island; consider RRPMs or delineation of the fence as well.		Yes	
Corrective action report: Responsible representative: Name:				
Agency and division:	Signed:			Date:
The painted island area beside the tram tracks to the south is faded and gives poor delineation to traffic.	(b) Repaint the painted island beside the tram tracks.		Yes	(b) City council will be advised to include it in maintenance program.
4.3 Other matters				

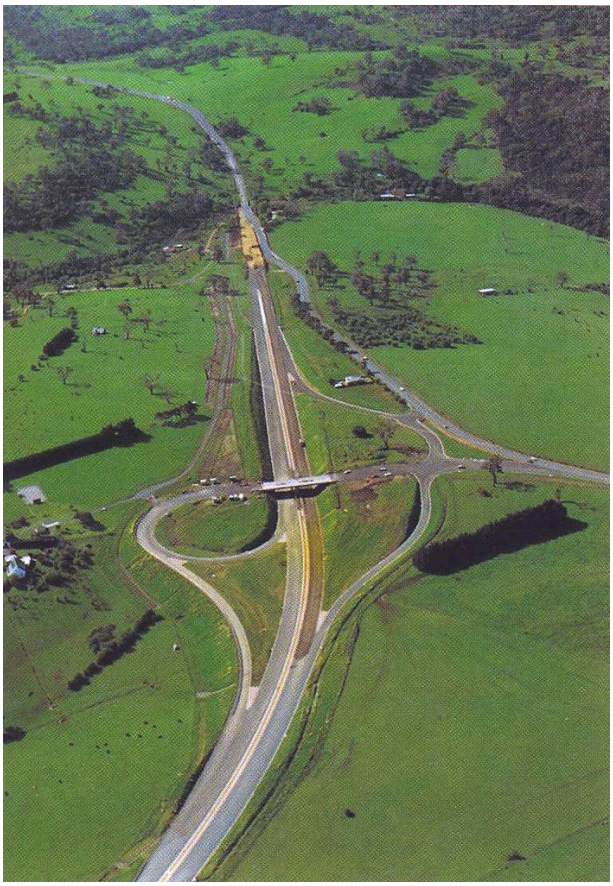
Audit findings	Recommendations	Ranking	Client	
			Accept Yes/No	Reasons/Comments
Northbound in Abbotsford Street, there is no indication that a right-turn is not permitted into Flemington Road, except for one left-turn pavement arrow in the right lane.	(a) Install a No Right Turn sign at the intersection. (b) Replace the full circle green signals with green left arrows.		Yes Yes	(a) Left Turn ONLY sign R2-14A will be installed instead. (b) This will be implemented if sufficient funds in project budget.
Corrective action report: Responsible representative: Name:				
Agency and division:	Signed:			Date:

7.4 Pre-opening Stage Audit

Background

A bypass has been built around the northern suburbs of a provincial city. It consists of a single carriageway extension to a recently upgraded divided highway from the south (Figure 7.11). The project ends at an existing bridge over Barnards Creek to the north of the city. A section of the bypass over a hill and through an interchange has been built as a four-lane divided highway. The bypass is 5.3 km long and has no access from adjacent properties. Traffic volumes are approximately 10,000 vehicles per day.

Figure 7.11: East Tamar Hwy at Landfall Interchange (looking north to Barnards Creek)



1. Signs and linemarking

- The Merging Traffic signs where both left-turn slip lanes enter the main carriageways at the Alanvale junction are inappropriate as the entry lane is an exclusive (no merge) lane.

  Recommendation: Replace these signs with the No Merge (W5-35) and Added Lane (W8-26) signs, which are the appropriate signs for this situation.

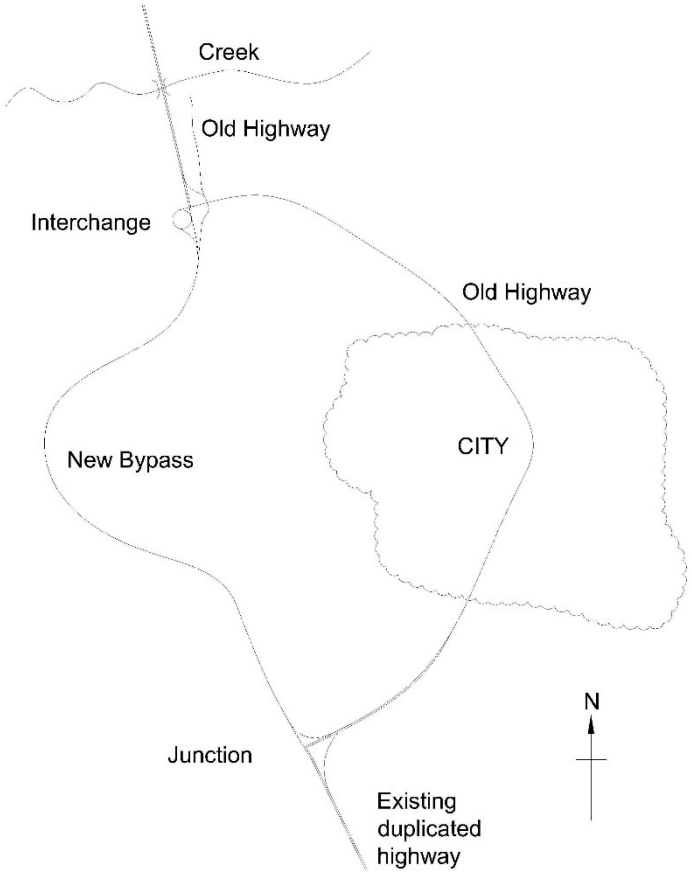
- The No Left Turn sign facing traffic from the old highway at the bypass carriageway at the Alanvale junction is not necessary. A driver who misses the left-turn slip lane need not be prevented from turning left here.

Recommendation: Remove the sign. If it is deemed necessary to prevent the left turn, alter the kerbline and use an All Traffic Turn sign (R2-14(R)), taking care that motorists are fully aware of the need firstly to give way.

- Where the Old Highway connection links to the southbound off-ramp at the Landfall Interchange, it is imperative to install signs to minimise the chance of traffic from the Old Highway entering the off-ramp.

  Recommendation: Consider replacing the No Right Turn sign (R2-6A) with an All Traffic Turn sign (R2-14A(L)) but ensure Old Highway traffic realises the need to give way before turning left; duplicate the No Entry (R2-4B) and Wrong Way (GE9-15B) signs to reinforce the prohibition. Figure 7.12 shows the Landfall Interchange and the Alanvale junction.

Figure 7.12: Landfall Interchange and Alanvale Junction



- At this location there is a need to ensure that drivers approaching on the off-ramp are given guidance to remain to the left as they approach the two-way section.

  Recommendation: Install a right-hand side edgeline along the off-ramp and taper it slightly towards the left on the approach to the Old Highway connection. Enhance the barrier lines on the two-way section by installing a painted (or preferably a kerbed) central island, approximately 1.8 m wide. (Important)

- The relatively tight radius of the curved on-and off-ramps at the Landfall Interchange requires adequate curve delineation, as well as the curve warning and advisory speed signs.

  Recommendations: Install chevron alignment markers, as per AS1742.2.

  Mark an edgeline on the outside of each ramp. An edgeline on both sides of each ramp would reinforce the tightness of the curve and encourage appropriate speeds.

- The continuity line at the throat of the southbound exit at the Landfall Interchange is too short and will lead to vehicles travelling over the painted gore area or slowing down at an undesirable rate in the through traffic lane.

  Recommendation: Lengthen the continuity line and shorten the painted gore area, so that the exit lane is wider opposite the start of the painted gore.

2. Crash protection

- An errant vehicle could pass behind the guardrail at Ch 3,100 (south side).

  Recommendation: Extend the guardrail on the south side of the road to the east by approximately 30 m to overlap with the cut batter.

- A guardrail is needed on both sides of the road between the cutting at the Landfall Interchange and the Barnards Creek bridge. It is understood this is scheduled to be installed, but it is not shown on Lane Lines and Overtaking Lanes.

  Recommendation: Install the guardrail prior to opening. Important

- A small culvert at Ch 1,380 is similar to the one at Ch 1,130, but unlike the latter one it has no guardrail.

  Recommendation: Investigate the need for a guardrail at this location.

3. Tie-ins to existing roads

- At the northern end of the scheme, where the bypass links into the existing highway where it crosses Barnards Creek on an existing bridge, there is a high potential for safety problems, due to the significant change in road environment from a wide divided freeway standard road to a single carriageway bridge with parapet walls. Vehicles from the south will be approaching on a long downhill grade, many of them at high speed. Approximately 20% of the traffic is trucks, many of them logging trucks. There will be a temptation for motorists to overtake trucks in each direction. Southbound vehicles will cross the bridge approximately 600 m (21 seconds of travel at 100 km/h) beyond the end of the two lane to one lane merge and 500 m (18 seconds of travel) beyond the end of the median. Barrier lines will be of limited value in preventing overtaking in this situation. Experience with similar squeeze points just beyond a new high-speed section of road suggests that there is a real potential for head-on and sideswipe crashes at the bridge. Figure 7.13 shows the long downhill approach to Barnards Creek bridge before the audit, while Figure 7.14 shows after the audit, delineation and safety barrier installation that have helped to minimise crash risk at this site, pending future widening.

  Recommendations: Urgent

  – Continue tactile edge markings across the bridge and approaches on both sides of the road.

  – Install an Overtaking Lane xxx m Ahead sign (G9-37) prominently 100 m north of the bridge and reinforce the message with an Overtaking Lane 1 km Ahead (G9-38), to minimise the risk of overtaking on the bridge.

  – Install guardrail on each approach to the bridge (both sides) and carry it through the bridge, given the type of parapet wall on the bridge.

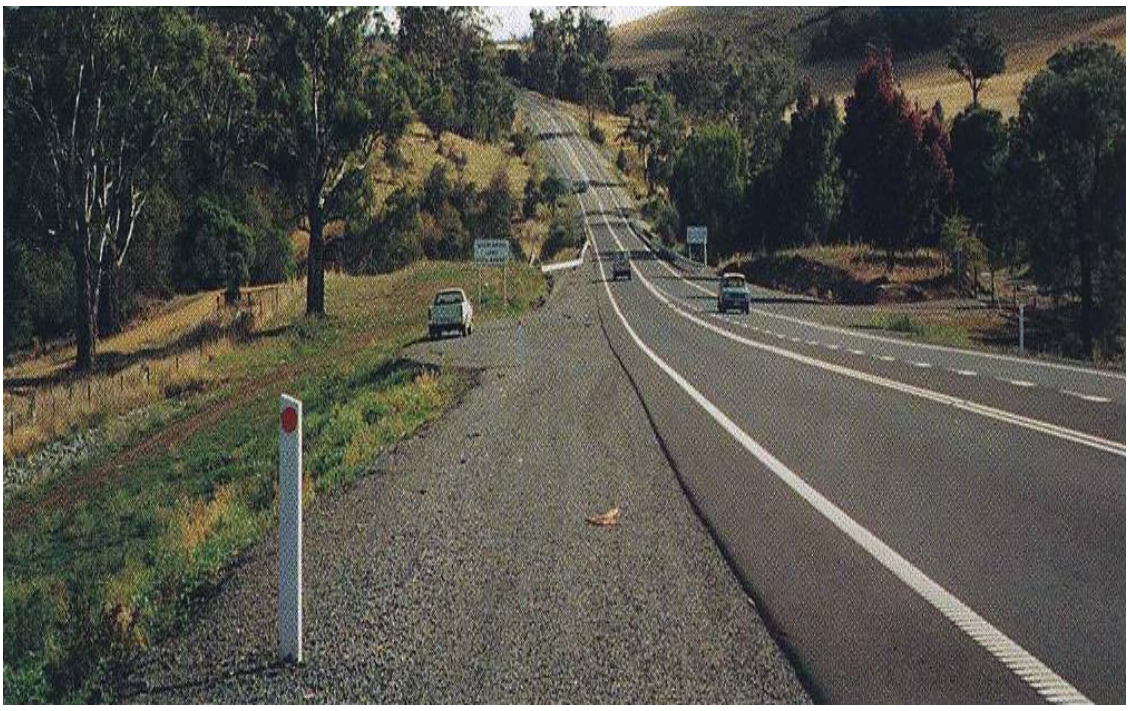
  – Install RRPMs along the barrier line through this section of road and through to the start of the divided road, at 12 m spaces.

  – Install Narrow Bridge (W4-1) signs on both approaches to the bridge, width markers (D4-3L&R) and regulatory No Overtaking on Bridge (R6-2) signs as per AS1742.2.

  – Give high priority to the duplication of the Barnards Creek bridge.

Figure 7.13: The long downhill approach to Barnards Creek bridge before the audit

Figure 7.14: After audit, the delineation and safety barriers helped to minimise crash risk



4. Publicity

- Good publicity of a new road opening can reduce driver confusion and consequent crashes in the first days of operation.

Recommendation: Ensure that adequate media publicity is carried out before the opening.

7.5 Roadwork Traffic Scheme Audit

Background

A fully grade-separated single carriageway urban motorway is being duplicated over several kilometres to provide two traffic lanes and an emergency stopping lane in each direction. As part of these works, a 100 m long bridge over a river is being widened. To provide adequate width for construction, the bridge lanes have been narrowed and a concrete (New Jersey) barrier has been installed between opposing traffic, in addition to barriers on the outside of the traffic lanes to shield workers. The road is unlit. Throughout the works area, the speed limit has been reduced to 70 km/h. Table 7.2 provides the summary of findings and recommendations.

Some of the audit findings are illustrated as follows:

- Figure 7.15 shows the tapered end of a concrete median barrier which upon impact can cause a vehicle to launch or overturn.
- Figure 7.16 depicts temporary safety barriers that are not connected or filled with water. This arrangement will fail to provide (low speed through work zone) containment.
- Figure 7.17 shows blacked-out pavement lines and arrows that are confusing, especially at night. The safety barriers are also shown to be incorrectly overlapped. This situation may lead to a vehicle having poor lane discipline (because of the blacked-out pavement markings) or a vehicle impacting with the rigid end of a barrier.

Figure 7.15: The tapered end of the concrete median barrier could result in a vehicle launching or overturning on impact

Figure 7.16: Safety barriers are not connected together or filled with water

Figure 7.17: Blacked-out pavement lines and arrows are confusing especially at night-time; barriers overlapped incorrectly

Table 7.2: Findings and recommendations at a roadwork traffic scheme

Audit findings	Recommendations	Ranking	Client	
			Accept Yes/No	Reasons/Comments
1. SAFETY BARRIERS				
There is no water in many of the Triton safety barriers on the south side, eastern approach. These will shift on impact and leave the following concrete barriers exposed.	(a) Fill with water.	Important, Urgent		
The cable link between sections of these Triton safety barriers has not been connected in many cases. Again, these will shift on impact.	(b) Connect the barriers correctly.	Important, Urgent		
No joining plate has been installed to link some of the concrete barriers sections, west of the above mentioned Triton barriers. These may dislodge on impact.	(c) Connect the barriers correctly.	Important, Urgent		
The Triton barrier has been overlapped the wrong way at the start of the concrete barrier, leaving the concrete end exposed for westbound traffic.	(d) Overlap the last Triton barrier in front of the concrete barrier.	Important, Urgent		
While there is a crash cushion at the western end of the concrete median, the eastern end has a tapered 'launch ramp'. This could result in a vehicle overturning on impact.	(e) Replace with a safer option, possibly commencing further east.	Important, Urgent		
2. DELINEATION				
The east median end is difficult to see at night.	(a) Add a hazard marker.	Important		
Several pavement lines and arrows have been painted out, but are visible and misleading at night.	(b) Consider sandblasting or other treatment.	Important		
3. DRAINAGE				
The median barrier has no drainage holes, except one near the west end of the bridge. This will restrict drainage of the westbound lane as drainage outlets are on the north side of the bridge. It could lead to hydroplaning.	(a) Check drainage requirements and alter barrier if required.	Urgent		
4. OTHER ISSUES				
There are steel bottles just behind the concrete barrier at the west end of the bridge. There is a danger, if the barrier is struck, of the steel bottles falling 8 m to the pedestrian walkway below.	(a) Relocate the bottles.	Urgent		
There is no breakdown lane or bay on the south side, although there is an emergency telephone on the north side. There is a risk of a driver stopping and crossing the roadway.	(b) Consider providing a stopping bay and phone or provide sign information on the location of the next phone.			

Audit findings	Recommendations	Ranking	Client	
			Accept Yes/No	Reasons/Comments
To the west, traffic is approaching on a 90 km/h divided road. There is no repeater signing to indicate there is two-way traffic through the works zone.	(c) Install two-way signs.			
Welding screens near the west end of the bridge restrict forward visibility to the left lane beyond the bridge.	(d) Alter the screens or realign the traffic lane.			

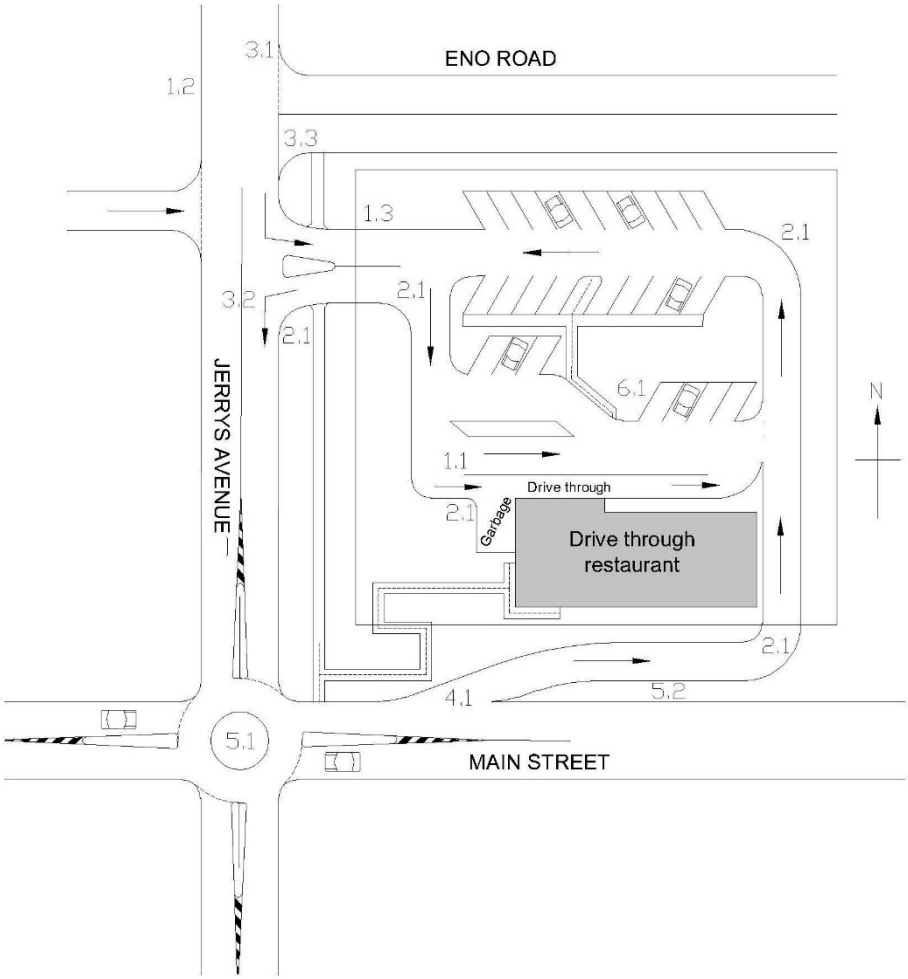
7.6 Land Use Development Audit

Road safety audit report on a fast-food restaurant proposal

Background

A dine-in and drive-through takeaway restaurant is proposed on a corner site (Figure 7.18), at the intersection of an arterial road (Main Street) and a collector road (Jerrys Avenue). The site has a steep slope down towards Main Street. Jerrys Avenue is also steeply graded to the intersection, which is controlled by a roundabout. Because of the site constraints, access is by two left turns in and one left turn out: some traffic movements to and from the site can only be made via a U-turn at the roundabout. There will be pedestrian access from the adjacent strip shopping centre and train station. The proposal involves ramped access and benching of the car park and restaurant area. Because of the location of the proposal on an arterial road, council's planning department has requested an independent road safety audit by an accredited auditor who has no interest in the development application.

Figure 7.18: Sketch plan of the proposed restaurant development



Note: Numbers refer to recommendations within this case study

1. Pedestrian safety

- All pedestrian movements between the car park and the restaurant must cross through the queue of traffic waiting in the drive-through lane. These pedestrians will include small children.

  Recommendation: Redesign the drive-through so it does not queue over the pedestrian access, or install a ramp designed to slow traffic and force waiting cars to keep clear.

- It is likely that children from the secondary school on the south side of Jerrys Avenue will try to cross to the restaurant at the driveway access in Jerrys Avenue. This will be dangerous, given the turning movements.

  Recommendation: Develop a plan to have them cross safely elsewhere (for example, using a pedestrian refuge, pedestrian fencing, etc.).

- The driveway exit left onto Jerrys Avenue results in the footpath along Jerrys Avenue having a crossfall of 1 in 4. This is far too steep and cannot be used by the frail, blind or disabled.

  Recommendation: Modify the exit driveway to flatten the pedestrian crossfall to 1 in 20 max.

- The safety of pedestrians crossing Main Street (just north of Jerrys Avenue) requires re-examination. Although the traffic impact report for this development advises that there will be an increase in traffic movements at the roundabout, it is possible that this impact has been underestimated, through an understating of traffic generated by the development. This has occurred because average peak traffic volumes have been used instead of 85th percentile peak traffic volumes. Should traffic movements through the roundabout be greater than predicted, pedestrians may have difficulty finding gaps in the traffic. If so, pedestrian crashes will result unless pedestrian signals are installed.

  Recommendation: Reassess the traffic generation using 85th percentile volumes for restaurants of this type surveyed in similar locations. Re-estimate the traffic volumes at the roundabout and determine whether pedestrian signals are required. (Important)

2. Truck access

- The design vehicle, a 10.7 m long heavy rigid truck, required for car parks of this type, does not appear to have been used. The design should permit delivery and garbage vehicles to access the site without over-running corner kerbs, reversing in pedestrian areas and car parks in order to proceed, or overturning on steep cross-grades. Locations requiring modification include:
  - the ramp off Main Street as it is not wide enough
  - the corners at each end of the upper car park as they are not wide enough
  - left turn after the drive through is too tight and has a 1 in 4 adverse crossfall
  - the garbage corral has inadequate manoeuvring space
  - the exit to Jerrys Avenue is too narrow.

  Recommendation: Check the dimensions of likely delivery trucks. Modify the identified locations to safely accommodate the design truck. Check all on-site locations and access points.

3. Jerrys Avenue left-in, left-out access point

- The exit onto Jerrys Avenue has inadequate sight distance (Figure 7.19). Tree foliage from No. 123 Jerrys Avenue restricts the view from the proposed driveway. With the foliage removed, about 63 m of sight distance is available. The traffic impact report quotes 85th percentile speeds of 42 km/h on this road. However, this data is from an automatic tube count and is not appropriate (free speeds are required for this calculation). At higher speeds, visibility is likely to be inadequate. In particular, stopping sight distance for trucks, down the hill, is unlikely to be provided (i.e. there is a real risk of a truck colliding with an exiting car).

Recommendation: Reassess the traffic speeds and relevant car and truck sight distance requirements. In the event of sight distance not being met, this exit point should not be used. (Important)

Figure 7.19: Looking down Jerrys Avenue from Eno Road; the driveway is proposed just after Eno Road

- The driveway, where it meets Jerrys Avenue, is very steep (1 in 4). There is nothing to physically prevent right-turns out. These would be dangerous, especially when cars queued back from the roundabout would block visibility.

  Recommendation: Flatten the driveway grades. Physically prevent right-turns out (for example, by installing a median in Jerrys Avenue).

- The driveway is very close to Eno Road and its design means the holding line in Eno Road will have to be set back.

  Recommendation: Check that sight lines out of Eno Road remain adequate.

4. Main Street left-in access point

- The entry off Main Street is too close to the roundabout and commences too steeply. Car drivers will have difficulty selecting the driveway and negotiating the turn. This will have repercussions back into the roundabout. There is also a possibility that the pedestrian steps up to the restaurant will partly block the view to the driveway entry (the plans are unclear). It is appreciated that shifting the driveway will make the ramp steeper, but relocation is required for safety.

  Recommendation: Relocate the driveway entry further from the roundabout. Flatten the entry so it can be negotiated more easily. Check the impact of the steps on visibility to the driveway pavement.

5. *Restrictions on the future layout of Main Street*

The highway authority should be made aware that this proposal cuts off options for the future management of the Main Street/Jerrys Avenue intersection and Main Street to the north.

- The restaurant proposal requires a roundabout in order to function, because some entry and exit movements can only be made by U-turning at the intersection. If it is considered safer at a later date (for example, for pedestrians) to operate the intersection using signals instead of a roundabout, it will not be possible to do so.

  Recommendation: Seek highway authority advice on the possible future control of the intersection using traffic signals. (Urgent)

- The ramp off Main Street is within the road reservation. This cuts off the option for any future widening of the road (even for a bus stop, taxi rank or footpath).

  Recommendation: Seek highway authority advice on the possible future widening of the Main Street road pavement or provision of a footpath along this property frontage. (Urgent)

6. Other matters

- Several driveways on site are very steep, which may result in cars going faster than desirable.

  Recommendation: Take steps to contain speeds where pedestrians will be present or where cars will be reversing or manoeuvring.

- No signs and linemarking plan was provided. This should be done.

  Recommendation: Request the proponent to provide a signs and linemarking plan and have it assessed by someone with the appropriate skills.

7.7 Road User Group Audit

Road safety audit report on a bicycle facility

Background

Shared bicycle/pedestrian paths have been developed beside a major road. A project to convert the major road to full freeway standard has involved modifications to bicycle facilities. The audit took place at the pre-opening stage of the freeway conversion project. Auditing the bicycle facilities was a specifically required part of the audit of the whole project.

1. Paths on the north/east side

- On the south side of Toorak Road there is poor sight distance between the link path from Toorak Road and the main path to the north (under the bridge). The acute angle of connection of these two paths makes movements between them very difficult.

  Recommendation: Consider options for improving safety at the junction of the paths, such as provision of signs to warn cyclists/pedestrians of the junction. Consider relocation and realignment of the two paths about 5–10 m further from Toorak Road. (Important)

- At a number of locations there are posts and ends of rails at the edge of the path that are a hazard to any errant cyclist.

  Recommendation: Review the design and location of all posts and rails beside the path and shield or modify those in exposed locations. (Important)

- The Keep Left markings at bends along the path include a left-angled arrow above the words. Northbound, just south of Toorak Road, the arrow gives a misleading message about alignment of the path and whether cyclists/pedestrians should use the link path to Toorak Road, which is on the right.

Recommendation: Remove the left pavement arrow from the Keep Left messages, or locate it across the centreline.

- At Toorak Road, the shared path crosses the road at pedestrian signals. At this point the path beside the road is too narrow and is overgrown (Figure 7.20).

  Recommendation: Widen the path beside Toorak Road.

Figure 7.20: The path to pedestrian signals is narrow and overgrown

2. Paths on the south/west side

- The shared path west of Burke Road (adjacent to Carroll Crescent) has a broken surface near the Gardiner railway station.

  Recommendation: Repair and maintain surface of the shared path. (Important)

- There is loose gravel on the shared path under the Tooronga Road bridge that is a safety hazard for cyclists.

  Recommendation: Remove the loose gravel from the shared path. Seal the path. (Important)

- There is no footpath across the railway line where the shared path reaches Toorak Road (Figure 7.21).

  Recommendation: Provide a footpath across the railway line on the south side of Toorak Road. Link it to the paths on each side. (Important)

3. General

- There is a lack of direction signs along the shared path. At many locations on the south/west side it is unclear exactly where cyclists are expected to travel.

  Recommendation: Review directional signing along the shared paths and provide additional directional signs.

Figure 7.21: The link path from Toorak Road joins at an acute angle, with restricted sight distance

7.8 Existing Roads – Single Route Road Safety Audit

Background

A council has engaged a road safety engineer to audit the safety of its existing road network. The council area includes urban areas, rural roads and rural townships. The case study example comes from the road safety audit report for one of the rural townships. The council is using the road safety audits to establish priorities for safety improvements on its local roads. Consequently, council needs to know the precise nature of the problems and has sought a detailed road safety audit.

Table 7.3 provides the findings and recommendations of a single route road safety audit.

Table 7.3: Audit findings and recommendations for the single route road safety audit

Item	Road name	Location on road	Deficiency	Treatment	Comment	Ranking
1.1	Salt Drive	West of Army Road	Is this two-carriageway road intended to be a pair of one-way carriageways?	If so, add a No Entry sign on right side at each end. Install a Give Way sign at Army Road.		
1.2	Sadler Place	Army Road	No Give Way sign at intersection onto important road.	Install Give Way sign.		
1.3	Army Road	50 m north of Jetty Road	West side: electricity pole < 1 m clear of road.	As a minimum, delineate it. Consider relocation.		
1.4	Army Road	Jetty Road intersection	Undefined intersection control at a split three way intersection.	Control the three intersection points with Give Way signs.		
1.5	Army Road	Jetty Road intersection	On the right curve (travelling SE to N) all the reflectors on guide posts are unserviceable.	Replace reflectors for adequate delineation.	Check general maintenance procedures.	
1.6	Army Road	Just south-east of Jetty Road	On the left curve from N to SE, cars park in the angled start of the indented parking bay at the shop. They jut out into the traffic lane at the end of a blind curve.	Install a No Stopping sign to keep the tapered end of the bay clear of parking.		Important
1.7	Beach Road	400 m south-east of Fort Road	Travelling to the SE, on the right curve, the seal is narrow, no shoulder, 0.8 m drop-off.	Warn of the narrowing. Consider curve delineation.	Low-speed road.	
1.8	Beach Road	500 m south-east of Fort Road	Travelling to the SE, the road changes to gravel without any warning.	Warn of gravel road.		

Item	Road name	Location on road	Deficiency	Treatment	Comment	Ranking
1.9	Fort Road	From 500 m to 1.1 km south-west of Army Road	Five deep culverts on the east side of the road, 0.3 m clear of road.	Delineate the culverts/reconstruct them to be less hazardous/shield them.	Delineate them, but other works are low priority.	
1.10	Blessington Street	Bagot Street intersection	Uncontrolled crossroad.	Install two Give Way signs on more minor road.		
1.11	North Terrace	300 m east of Army Road	Low horizontal pine log barriers used as fencing beside road on outside of curve.	It would be safer to use only log posts (which are frangible).	Low-speed road.	Low
1.12	Bayview Road	300 m east of Army Road	Horizontal pipe railing fence adjacent to road where path emerges from laneway (at No.36).	Replace the fence with a safe type.		Important
1.13	Bangor Road	Driftwood Drive intersection	On east approach, a large bush on the SE corner blocks visibility to the south.	Remove the bush.	Bush is located at centre of No. 27.	
1.14	Army Road	General: Highway to Fort Road	Centreline marking is in poor condition, numerous guideposts are missing.	Remark the centreline; replace missing guideposts.		

7.9 Existing Roads – Network Road Safety Audit

Background

An extended section of existing rural highway was given a preliminary road safety audit in the style of a broad network road safety audit (Section 6.4). Its purpose was to establish whether there were recurring safety issues which required changes to design or maintenance practices in the region. It was also intended that a detailed road safety audit would follow at any specific locations which were identified as having particular and significant safety issues.

The following categories were considered during the safety audit:

- road alignment
- pavement width
- pavement roughness
- intersection location and treatment
- changes in standard
- road shoulder condition
- road shoulder width
- lateral clearance to roadside objects
- guardrail
- table drains
- culverts
- embankments
- pavement edges, and drop-offs to shoulders
- signposting messages
- number of signs
- sign size
- sight distance to signs
- signs as hazards
- sign condition
- centrelines
- edgelines
- lane lines and overtaking lanes
- intersection delineation
- guide posts and guardrail reflectors
- bridge markers

Some typical problems from a selection of these categories are described below. During the audit, the locations of these problems would be recorded for later assessment.

Road alignment

- Horizontal curves starting just after a crest.
- Series of vertical curves on long straights. At night this alignment provides almost no guidance about where the road goes next.
- Horizontal S-curves on very flat terrain.
- Overtaking lane merges ending after crests.
- Poor sight distance and confusing alignment. Too few cues for drivers about where the road goes. At night in some places the road seems to disappear.

Pavement roughness

- Patching work usually quite rough, often on curves where roughness is most likely to contribute to loss of vehicle control.
- Patches sometimes left unsealed. At night this results in instantaneous loss of line-marking and therefore driver guidance.

- Sections which are particularly rough are also those with poor alignment and narrow pavement.

Intersection location and treatment

- Many minor intersections were hard to see, especially at night.
- Intersections, including major ones, located in the middle of a curve without separate turning lanes.
- Intersections located after crests and without separate turning lanes.
- Travel paths not defined or turning lanes not provided.
- Intersections poorly defined.
- Very short sight distance to intersections.

Road shoulder width

- No shoulders on 3 or 4-lane undivided sections (shoulders taken up for the extra lanes without being replaced).
- No shoulders on bridges and culverts. The road is narrower at these points and provides no escape routes for drivers.
- Insufficient shoulder width at some T-intersections.
- Shoulders on some new work not as wide as they could have been.
- Shoulders are often non-existent on sections of highway with poor alignment and narrow and rough pavement.

Sight distance

- Some intersection direction signs could not be read sufficiently far in advance at normal highway speeds.
- Insufficient advance warning of overtaking lane merges.
- Signs obscured or partly obscured by roadside vegetation or other signs.
- Signs located just after crests.
- Curve warning signs too close to the curve (related to sign size as well).

Lateral clearance to roadside objects

- Stands of trees and isolated trees within 1 m of the edge of the pavement.
- Some power poles within 1 m of the edge of the pavement.

Figure 7.22 depicts unshielded deep drains close to the road that pose a hazard to road users.

Figure 7.22: Unshielded deep drains close to the road are a hazard

8. Safety Principles

8.1 Designing for Road Users

While road safety audit is a formal process, best safety practice is achieved by constant reference to the basics of road safety engineering. A key element in safe road design and the overarching principles of a safe system requires the provision in design of *safe speeds* (Section 1.3).

When designing a road, focus on the needs of road users, asking:

- is the speed at which you can drive at unsafe for the users of the road?
- can the design be misunderstood by the road users?
- does it cause confusion?
- does it create ambiguity?
- does it provide insufficient information?
- does it provide too much information?
- does it provide inadequate visibility or obstructions to vision?
- does it contain obstacles or hazards?

If the answer is yes, a series of open questions (for example, 'how, why, when, where…..?) should be used to find the source of the problem.

Putting this more formally, drivers and other road users must perceive and process information, make decisions, act and monitor, within time constraints. Comfortable and safe driving and riding occurs when motorists are operating well below a stressful processing and decision making rate and above a minimum level of arousal. These are critical components in the development and maintenance of a safe road environment.

A safe road environment should:

- be forgiving and be designed so that it prevents death or serious injury when a crash occurs
- warn the driver of any substandard or unusual features
- inform the driver of conditions ahead
- guide the driver
- control the driver's passage through conflict points or sections
- make allowance for the driver's errant or inappropriate behaviour.

Similar situations should be treated in similar fashion. Things to be avoided are:

- inadequate treatment (not treating a situation to an appropriate level)
- inappropriate treatment (using the wrong treatment for the situation)
- excessive treatment (using 'more treatment for more safety,' thereby masking other similar situations which have already been treated to the appropriate level).

Optimum values for design parameters should be used as often as possible, consistent with the prevailing constraints such as terrain. Advance information and warning should be used to strengthen the delineation of a road. Driver overload should be avoided, as it may cause drivers to miss vital information. Overload can result from too many road signs, conflicting messages or a lack of delineation.

Therefore a safe road environment is one that:

- is forgiving of human error and does not penalise road users with death or serious injury when they inevitably make mistakes
- provides no surprises in road design or traffic control (expectancy factors)
- provides a controlled release of relevant information (not too much at once)
- provides repeated information where pertinent to emphasise danger.

Safety is influenced by a complex interaction of elements and strict adherence to standards does not always result in the safest possible design. This can be the case when the standards are designed for other purposes as well as, or instead of, safety.

A design should cater for all road users. Give special attention to the safety aspects associated with heavy vehicles such as trucks and buses. The needs of their drivers may be different from those of other drivers. Particular effort may be needed to seek data to assist the design in safely handling such traffic. Consider the special needs of cyclists, pedestrians and motorcyclists – the vulnerable road users.

Cyclists require connectivity of routes, lateral space, and a smooth riding surface. Motorcyclists also need particular safety attention – a smooth riding surface and lateral space without squeeze points are two important safety issues.

8.2 Designing for Safe Speeds

The management of speeds chosen by drivers and riders is a crucial element of the safe system. The chance of a crash is reduced at a lower travel speed because the road user has more time for decision making, is less likely to lose control, more able to take evasive action and can stop more quickly. At lower speeds, if there is a collision, there is less crash impact energy involved and this will result in reduced injury severity outcomes.

Managing the inter-relationship between travel speed, road infrastructure design and vehicle safety is central to the safe system approach which focuses on preventing crashes and, in the event of a collision, trying to keep the collision energy below the human tolerance limits highlighted in Section 1.3. Speed management needs to integrate the road, how it is designed and managed, and who uses it.

When designing for safe speeds, practitioners should also aim to provide enabling speeds that in the event of a crash will contribute to impact speeds being below the level of human physical tolerance (Section 1.3) to prevent serious injury or death.

Principles of ‘integration’ and ‘separation’ (derived from the Swedish Vision Zero philosophy) can be applied. For example, in areas where there are high levels of pedestrians, they should not be exposed to vehicle speeds any higher than 40 km/h and preferably less. This can be done through separating pedestrians from vehicles, or by lowering travel speed of vehicles to a maximum of 40 km/h, in a way ‘integrating’ the various road users.

Generally some form of traffic calming or signage is applied to assist road users in recognising the lower speed environment. Lower travel speed through temporarily reduced speed limits may also be applied for a specific time when pedestrian activity is highest, such as shopping precincts and near schools.

At intersections, car occupants should not be exposed to other adjacent approach motorised vehicles travelling at speeds higher than 50 km/h. This can generally be achieved through some form of traffic management, such as traffic signals or roundabouts in urban areas, and appropriate signage in rural areas.

In relation to roads where there is potential for head-on collisions the Vision Zero philosophy indicates vehicle occupants should not be exposed to speeds exceeding 70 km/h, or even lower speeds where there are heavy vehicles mixed with light vehicles. This also applies to roadside hazards; where these cannot be removed or the vehicle traffic separated, lower travel speeds should be considered. In some European countries, such as Norway, single carriageway roads with no central barrier, where there is the potential for head-on collisions, have speed limits of 70 km/h.

For higher design standard roads with high levels of roadside protection, and with little or no pedestrian or vehicle conflicts, safe speeds higher than 70 km/h may be achieved. Highways and freeways generally have higher limits, recognising the enhanced level of protection offered to road users and the minimisation of conflicts on these roads.

In Sweden, the application of 2+1 roads (i.e. a long section of road that has two lanes one way separated by wire rope barrier from one lane going in the opposite direction, then a long section with two lanes in the opposite direction and one in the other direction), allows for higher road speeds as the potential for head-on collisions has been reduced through the installation of the wire rope barrier and the passing opportunities with the double lane. Some Australian states are installing centre-of-the-road wire rope barrier on single carriageway roads, and many already have median wire rope barrier on divided carriageways.

Designing for safe speeds in this manner is consistent with the provision of self-explaining roads, a feature of a sustainable approach to road safety (OECD/ECMT 2006).

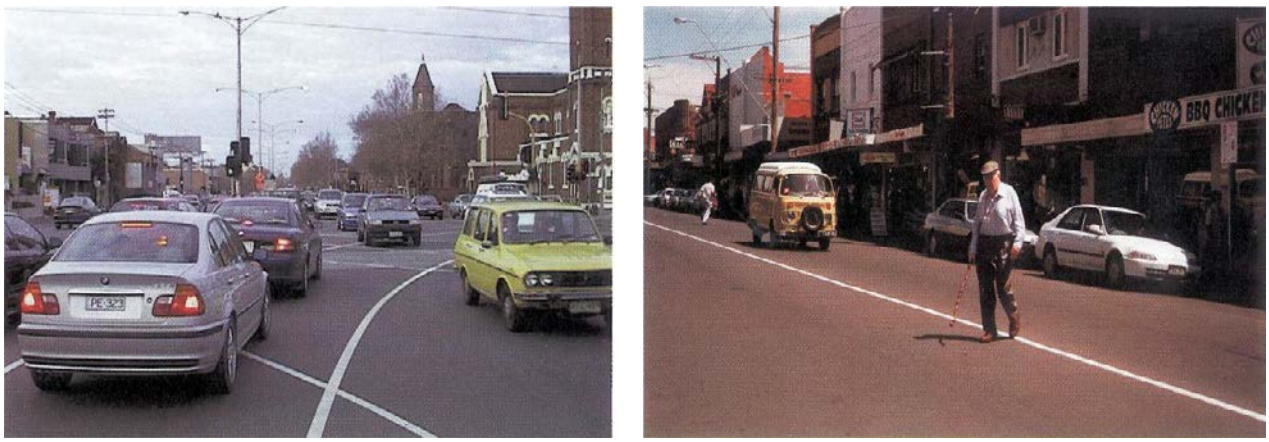
Part 3: Speed Limits and Speed Management (Austroads 2008b), of the Guide to Road Safety, and *Part 5: Road Management* (Austroads 2008a) of the Guide to Traffic Management, describe in detail from a road safety and a traffic management perspective, speed management and the application of speed limits within a safe system environment.

8.3 Designing for Older Road Users

Older road users are over-represented in crashes involving serious injury and death. Their crash frequencies are expected to increase with the projected increase in the proportion of the elderly in the population. As age increases, many abilities decline and health conditions become more frequent. Older road users have quite different crash patterns than younger road users.

Age-related decline in visual functions such as contrast sensitivity and the presence of cataracts can result in great difficulty reading signs, seeing kerbs and detecting other road users. In addition, diminished memory and mental processing abilities reduce the capacity to cope with complex situations. Figure 8.1 provides examples of situations that place older road users at increased risk. The example on the left requires older road users to undertake relatively complex turning manoeuvres within a large intersection which has poor sight distance, that carries high traffic volumes. The example on the right requires older road users to select a safe crossing gap across an undivided two lane road.

Figure 8.1: Complex high volume intersection with poor sight distance, and selecting safe crossing gaps along two-way undivided road



There are a number of road design features that can alleviate some of the problems that older road users experience when using the road system. They include:

- Provision of traffic signals with full right-turn phases eliminates the task of having to select safe gaps, and improves safety for all road users.
- Adequate placement, size, maintenance and repetition of signs help older drivers detect the presence of an intersection and make appropriate decisions.
- Improved traffic engineering in high-pedestrian areas can simplify the road crossing task.

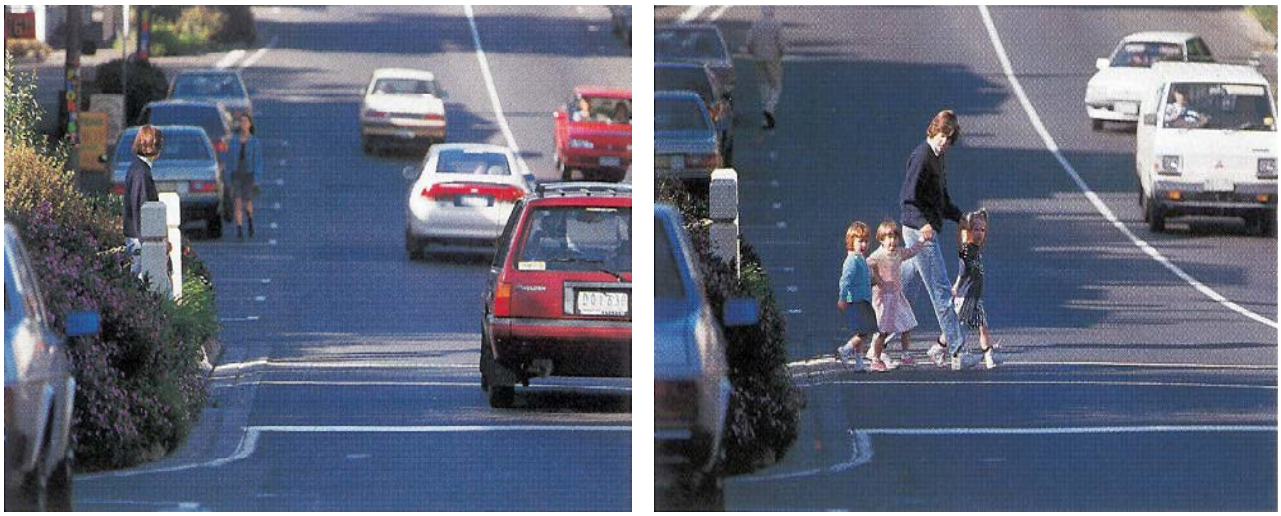
8.4 Designing for Pedestrians

About 14% of all road fatalities in Australia are pedestrians (ATSB 2008), while in New Zealand the proportion is 10% (Ministry of Transport New Zealand 2006).

In urban areas, pedestrians are key road users. Designs must provide for good visibility, for suitable crossing locations and for medians and refuges where these can be of benefit. As children are shorter than adults, they are harder to see and are more easily hidden by landscaping, parked cars and some devices (Figure 8.2). Older pedestrians can take longer to cross a road and can be less able to sense the presence or speed of traffic. Intoxicated pedestrians are a particular concern, especially after dark. Common hazards encountered by pedestrians on the road network (Bowman, Fruin and Zeger 1989) include:

- footpaths that constrain pedestrians movements because of obstructing (permanent and temporary) roadside furniture, e.g. advertising signs, goods on display, garden sprays, bins, poles, seats, etc.
- pedestrian facilities that are inaccessible or hazardous for use by people with disabilities
- inadequate provisions and safeguards in construction areas
- residential streets without footpaths (which seek to provide a ‘greener’ streetscape), that expose pedestrians to traffic
- inadequate pedestrian walk and/or clearance time for elderly pedestrians at traffic signals.

Figure 8.2: Young pedestrians may be hidden by landscaping



8.4.1 Disabled pedestrians

An Australian Bureau of Statistics survey (McLennan 1988) found that about 16% of the Australian population had some type of disability. The most common were diseases of the muscular-skeletal system, loss of hearing, circulatory diseases, and visual impairment. Some of the most common problems encountered by people with disabilities using the road network include:

- Traffic signal timings that do not allow adequate time for the disabled to cross safely.

- People with impaired vision experiencing difficulties using visual queues. As a result high levels of delineation are required between the road and pedestrian areas, generally in the form of physical guidance (e.g. kerbs, and tactile pavement markers).
- Visually impaired pedestrians can be harmed by obstructions in their path; sign posts and other street furniture can cause confusion and potential safety problems, particularly at signals or crossing points.
- People with hearing impairments may be unable to detect oncoming vehicles early enough and therefore have to rely more on seeing them in order to cross safely. A clear view from the side of the road becomes critical.
- Wheelchair users have difficulties using uneven, discontinuous, soft or loose surfaces. They need a ramp to change levels. To cross a road safely the kerb edge needs to be designed so that it can be easily and safely mounted, and not be of a type that may tip a wheelchair over.

8.5 Designing for Motorcyclists

Nearly 15% of all road fatalities in Australia are motorcyclists (ATSB 2008), while in New Zealand the proportion is 7.5% (Ministry of Transport New Zealand 2006).

Road features that are hazardous for motorcyclists include:

- changes in road texture or shape in braking areas
- loose material or changes in road surface texture or shape on curves or corners
- difference in level between the traffic lane and road shoulder
- lack of warning where there are road patches, or other unexpected changes in the condition of the road surface
- dissimilar skid resistance between linemarking and adjacent paved road surface
- poor skid resistance where braking or manoeuvring is required
- poor sight distance
- steel plates used to cover excavation work
- areas of strong wind where warning may be required
- roadside watering systems spraying or draining on the road
- crack sealant (i.e. bitumen used to seal cracks in pavement), slippery in nature, particularly when wet
- kerb colouring that blends with the road, particularly on islands and protrusions.

8.6 Road Design Features

8.6.1 Design Speed

The design speed adopted should be compatible with project objectives and be appropriate for the adjoining roadside activity and terrain. If drivers are in mountainous terrain, the road should continue to make them aware of it. For example, do not build long straights or very high-speed alignments on steep grades. In other cases, higher design speeds will be appropriate where property access is fully or partly controlled. At intersections, the design speed for turning traffic should be compatible with expected intersection activity.

8.6.2 Design Context

Safe designs for major and minor roads differ. Narrow sections or slow points may be suitable on minor roads to slow traffic and improve safety. However, on major roads, such squeeze points may well cause frustration and become crash blackspots. The purpose of a road should be clear to its road users and treatments should not give conflicting messages: an appropriate and credible road hierarchy is a necessary prerequisite for a safe road network.

8.6.3 Horizontal and Vertical Curves

Crash frequency increases at crests and in dips. Increasing the degree of horizontal curvature also tends to increase crash frequency. In attempting to achieve a co-ordination of alignments and terrain, it is possible that a crest may mask the flow of the horizontal curve. Avoid tight (minimum radius) horizontal curves in combination with crests or dips (Figure 8.3).

Figure 8.3: A summit vertical curve restricts the driver's view of the start of the horizontal curve and may produce a dangerous situation

In attempting to maintain intermediate sight distance, a design may adopt a vertical curve that avoids the marking of barrier lines. However, adequate safe overtaking opportunities may actually be reduced because of the excessive length of the vertical curve. Shorter vertical curves with a length of barrier line may be safer in some circumstances.

8.6.4 Intersections

Priority and layout

The layout and control arrangement at an intersection should be simple and obvious to approaching motorists. Straight priority is usually expected and modifications to this can require additional visual reinforcement. Even where priority is straight, some existing strong visual cues like fence lines or lines of trees on the minor legs can suggest the continuation of the road so strongly that the control sign and markings are not noticed by some motorists (Figure 8.4).

Figure 8.4: Visual cues such as lines of trees and driveway openings can suggest that a road continues straight when it actually takes a bend

Roundabouts are a form of intersection control with their own set of priority rules. It is essential that roundabouts look like roundabouts, but look different to other types of intersection island treatments. At roundabouts, the approach radius should be tighter than the exit radius as motorists tend to drive in lines as straight as possible: re-entrant curves on outer kerblines will not be trafficked and will collect debris.

Within intersections with simple priority, it is still possible to confuse motorists with complex island arrangements and hazard markers.

Visibility

Provide adequate visibility distances for emerging traffic; do not confuse visibility distances with warrants for Stop signs. Avoid creating obstructions by street furniture or landscaping. Provide adequate visibility to control features; on crests and curves, linemarking and other devices can be hidden yet they need to be visible for decision making. Use linemarking and signs to guide drivers safely into the correct position for their subsequent manoeuvres.

Avoid Y-junctions and intersections at acute angles, as these restrict forward and side visibility. Similarly, avoid intersections on the inside of curves, as buildings, fences and landscaping invariably encroach into sight lines, even where they are intentionally kept clear at the design or construction stage. Do not attempt to reduce speeds by relying on limited forward or side visibility.

Other issues at intersections

On left-hand curves in particular, start a splitter island (for example, on the approach to a roundabout) sufficiently far back that the island nose is to the right of the approach path and line of view, to prevent wrong-way movements into the oncoming traffic path.

Provide safe pedestrian and cyclist crossing points. Consider central refuges as they permit people to cross traffic from one direction at a time, which is a much easier task than judging gaps in both directions at once and safer than waiting on a centreline.

Use appropriate corner radii. Large radii allow excessive speeds and cause hazards for pedestrians. On the other hand, radii that are tighter than the turning path of a design vehicle at a low speed will result in these vehicles swinging out wide or hitting kerbs.

Avoid confusing intersections such as that shown in Figure 8.5.

Figure 8.5: Avoid confusing intersections

8.6.5 Cross-section

The relationship between cross-sectional elements and safety is affected by the volume of traffic and the character of the traffic.

Narrow lanes

There is a view that traffic management has often gone too far in narrowing the lanes of urban roads to create additional lanes. This is particularly important on horizontal curves where larger vehicles need extra width to track. The existing urban design standards do not provide for curve transitions and widening. These may be satisfactory when wide lanes are used but they are unsatisfactory when narrow lanes are adopted.

Shoulder widths

There is a safety benefit in providing wide shoulders throughout the length of the road. However, paved widths much greater than 2 m may encourage illegal overtaking and even a false sense of comfort leading to excessive speeds. It is best not to reduce widths or eliminate shoulders at culverts, bridges, overtaking lanes or intersections. On freeways, the paved shoulder is the only space available for broken-down vehicles. It should be wide enough for a stationary vehicle's doors to be opened clear of the traffic lanes.

Median widths

In rural areas, medians less than 3 m wide should be avoided. Where turning or crossing vehicles do not require a greater width, there is little safety advantage in medians greater than 20 m wide. In urban areas, pedestrians can use medians as narrow as 1.5 m, but a 2 m width is preferable where space permits.

8.6.6 Access Control

At each point on the road system where vehicles have access to adjacent land, there is the potential for conflict and crashes. Where service roads have been provided to separate through traffic from local traffic movements, the spacing of breaks should not be reduced to the minimum standard. The same is true with median breaks. Motorists need time to think between conflict points, particularly where traffic flows are heavy. The incremental degradation of access control as development occurs beside a road can have a major impact on the long-term safety of that road; routes with restricted access can have up to 60% fewer crashes (Brindle 1998).

8.6.7 Parked Vehicles

Vehicles parked on the carriageway affect safety in several ways:

- as physical obstructions that are run into or sideswiped
- as obstructions that cause sudden braking and nose-to-tail crashes
- as obstructions that deflect vehicles into adjacent vehicle paths
- as hazards to passing vehicles (including bicycles) from opening doors
- as obstructions that hide pedestrians
- as obstructions that block visibility at intersections and access points.

Parked vehicles are involved in about 10% of urban arterial road crashes and a higher proportion of local street crashes. Designs should ideally avoid or remove/relocate parking in traffic lanes. With isolated improvement schemes like intersection treatments, parking (even some distance from the site) can influence the operation and safety of the site. Check the influence of parking well beyond the limits of the design plan. Parking in side streets close to busy arterial roads can be a hazard to turning vehicles. Check the interaction of parked vehicles, turning vehicles and any queued emerging vehicles in these locations. Do not rely on parking control signs to eliminate parking in hazardous locations: enforcement will not always be available. Pedestrian fencing can be very effective in discouraging parking. The fencing should not itself create a hazard.

8.6.8 Trees

Survey information is often deficient on the precise location and size of trees within the road reserve. The designer, therefore, cannot be sure that the plans have established an adequate clear zone width or provided protection against vehicles hitting roadside trees. A small tree at the design stage may well become a roadside obstacle by the time the road is built and in operation. Photographs may help the designer appreciate these roadside features.

8.6.9 Signs

It is often tempting to use traffic signs instead of appropriate design in an attempt to solve a real or perceived problem. Before using a traffic sign:

- Demonstrate a need for the sign

  Use a sound traffic engineering assessment to determine the need. Check the warrants and appropriate uses in the standards or guidelines. If no standard sign exists, ask why. Is one needed for this situation?

- Ensure that the sign conveys a clear message to all road users under all conditions

  The ability to choose an effective and appropriate message and design an effective sign is an expert skill. Signs in standards and guidelines have been designed with this skill and should be chosen for standard situations. Otherwise, seek expert advice. Ensure sign messages are compatible with the messages of other devices like linemarking. Keep it simple. Locate it where the information is needed.

- Ensure that the sign or its supports are not a hazard

  Keep sign support structures away from the edge of the carriageway. Avoid or protect sign supports on the outside of curves and other vulnerable places. Ensure that signs or their supports do not obstruct visibility of other devices (signals, other signs, etc.), do not obstruct the view between conflicting road users or create a hazard for pedestrians or cyclists.

8.6.10 Merges

Adequate sight distance is required in advance of any merging area to allow drivers to appreciate and plan their merge. In addition, it is important to provide a length of mutual sight to allow the gap to be selected for the merging manoeuvre. Merges should be avoided just prior to the start of left-hand curves. They force the vehicle on the left-hand lane to veer to the right to merge and then be immediately faced with a movement to the left to negotiate the curve. Consider this aspect also when designing overtaking lanes.

8.6.11 Sight Distance

The effect of horizontal and vertical curves and the cross-section is generally closely examined during road design. However, sight distance can also be affected by trees, raised medians, guard fences, concrete barriers and the like. Further, sight distance to the end of a queue, rather than to the control point at the start of the queue, may need to be considered on approaches to busy intersections.

8.6.12 Other design issues

Loss of superelevation

The effective superelevation is reduced around horizontal curves on steep down grades. Crossfalls may need to be increased to partly compensate for this effect.

Concrete barriers

Concrete barriers are usually erected to be vertical. Although this does not create a problem on straights, it does mean that the angles of impact on horizontal curves can be different for each direction of travel, due to the superelevation.

Night visibility

The driving population is ageing. Older people generally have poorer eyesight, which makes reading letters on signs difficult and also makes their perception of widths as well as distances more difficult at night-time and at times of poor light conditions. Where minimum width lanes are used or there are islands to narrow the road, a high standard of street lighting and delineation should be used.

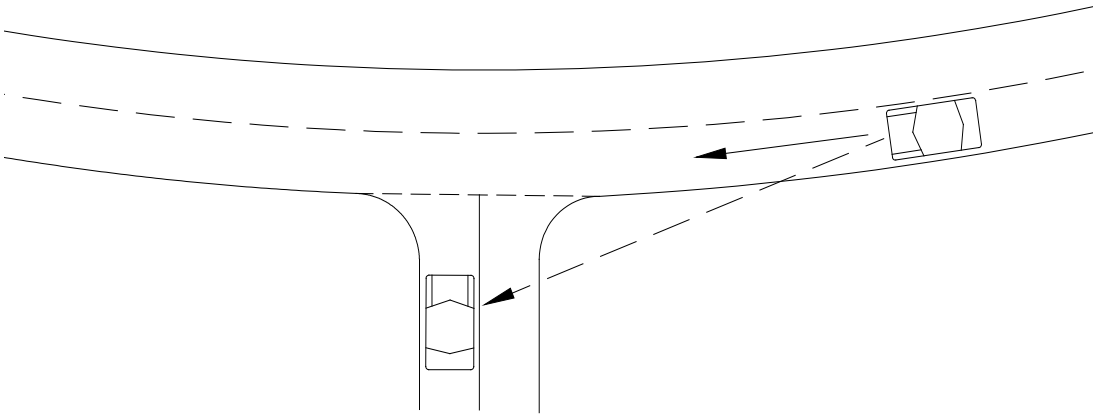
Visibility of road surfaces and linemarking is affected by rain. Where lines curve, even to the limited extent of deviating through a flared intersection treatment, supplementary delineation such as raised reflective pavement markers is usually necessary.

Further information on good design practice and safety experience with numerous road design elements can be found in Chapter 7 of Ogden (1994) and Chapters 8–14 of Ogden (1996).

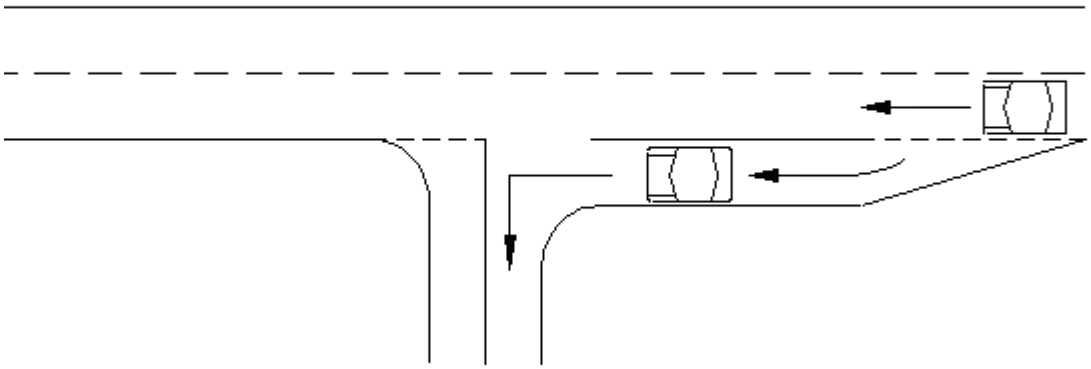
8.6.13 Practical example

Sometimes design elements which individually enhance safety can combine to cause safety problems, as the following example shows.

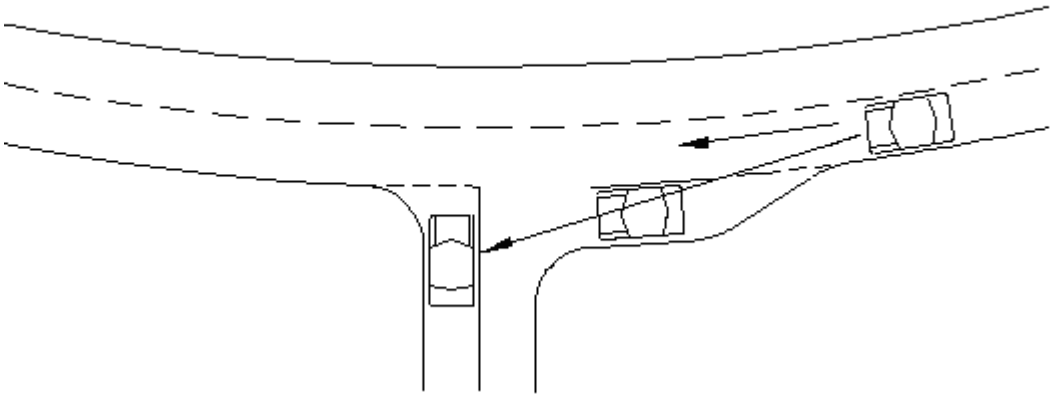
1. An intersection on the outside of a horizontal curve provides good horizontal sight distance from the side road.



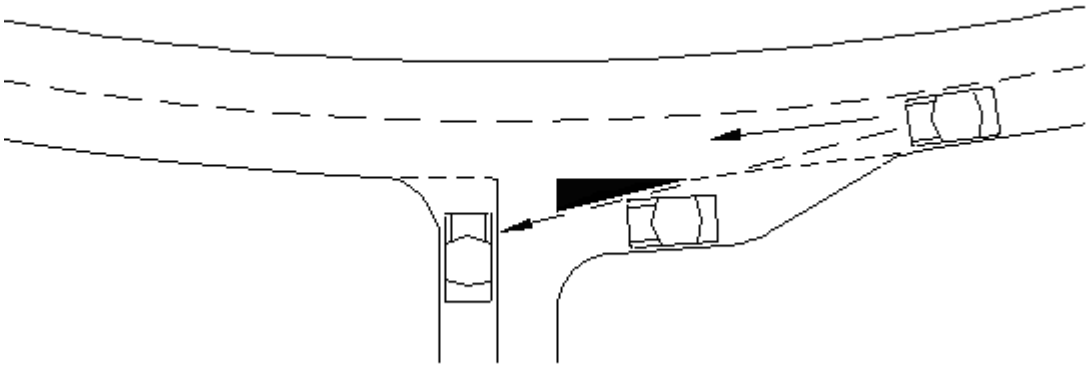
2. A deceleration lane allows vehicles to slow down clear of the through traffic lane, reducing the risk of nose-to-tail crashes.



3. But combining these two elements can result in a left-turning vehicle hiding a following vehicle, under some combinations of road and intersection alignment. Right-angle crashes may result.



4. Intersection diagrams should place the waiting vehicle in a position from which the driver can clearly see all the approaching vehicles.



9. Road Safety Audit Tools

9.1 Introduction

A number of tools are available to assist in conducting road safety audits. Austroads has funded the development of the Road Safety Audit Toolkit and, through funding of research, has supported the development of the Road Safety Risk Manager.

9.2 Road Safety Audit Toolkit

The Road Safety Audit Toolkit is an online program that assists practitioners and is based primarily on the checklists in this document (Section 11). It steps users through the Austroads road safety audit process (i.e. feasibility stage, preliminary design stage, detailed design stage, pre-opening stage, roadwork traffic scheme and road safety audit of existing roads), provides Australasian and jurisdiction specific references, and allows auditors to generate road safety audit reports. Figure 9.1 provides an example screen for conducting an audit.

Figure 9.1: Road Safety Audit Toolkit — example screen

The Road Safety Audit Toolkit is not a replacement for a road safety auditing course or an audit conducted by an experienced audit team. Rather, it is designed to assist in the undertaking of road safety audits. The software is free for road safety professionals (username and password required).

The system is designed to assist road safety auditors by prompting them with checklist questions and providing:

- a medium in which they can record the location and audit team details
- a medium in which auditors can record the findings of an audit in a structured manner
- relevant Australasian and jurisdiction specific reference publications and a searching function that allows auditors to interrogate references using key words to identify salient sections

- an export function that generates road safety audit reports.

Further information on the Road Safety Audit Toolkit and access to this can be found at: www.rsatoolkit.com.au.

9.3 Road Safety Risk Manager

The Road Safety Risk Manager (RSRM) provides authorities with a tool to manage, prioritise and track the status of road safety issues on their networks. Figure 9.2 shows the initial screen of the RSRM.

Figure 9.2: Road Safety Risk Manager software

The process allows an assessment of hazards for locations without a history of crashes or waiting for crashes to occur. The preferred treatments can be prioritised to develop a works program focussed on maximising the reduction in road trauma.

The software allows the assessment and comparison of some 70 different road safety treatments including issues such as the duplication of a highway, intersection upgrades, guardrail and other roadside treatments, signage and delineation. The flexibility of the tool also allows for the assessment of design options in addition to hazards in the existing road environment.

RSRM is most relevant to the road safety audit process in the prioritisation of road safety audit issues requiring treatment. The tool allows the optimisation of crash risk reduction from these treatments based on limited available budgets.

Further details can be found on the ARRB website (www.arrb.com.au), or in Part 7 of the Guide to Road Safety (Austroads 2006).

9.4 Austroads Road Safety Engineering Toolkit

To assist road safety practitioners identify solution options to road safety problems Austroads has developed a Road Safety Engineering Toolkit (Figure 9.3). It may be used by road safety auditors to identify safety deficiencies, and to also make recommendations when requested, as part of their audit report. The toolkit can be used to obtain information related to deficiencies commonly identified through the audit process.

Treatments options can be selected by identifying either a crash problem (such as head-on or run-off-road crashes) or by selecting a specific road safety deficiency (such as pavement issues or deficiencies at signalised intersections). Information is provided for a number of treatments on the situations where a treatment should or should not be used; the benefits of the treatment (including an indication of crash reduction); approximate costs and treatment life; alternative treatments to consider; and references for further information.

The toolkit can be accessed at www.engtoolkit.com.au.

Figure 9.3: Road Safety Engineering Toolkit

10. Notes on The Road Safety Audit Checklist

10.1 The Purpose of Checklists

Before assessing the client's documents and inspecting the site, the audit team members should acquaint themselves with the relevant checklists which are contained at the end of this document.

A successful audit is not achieved by ticking off a checklist (whether on paper or in a computerised 'expert system'): checklists are a means to an end, not an end in themselves.

Their purpose is to help the auditor identify any potential safety issues. They should be used in a way that best meets each auditor's needs. There is no single best way to identify safety issues and no single best way to use checklists. Many of the items in the checklists may not be relevant to the project being audited; some checklist items may appear repetitive. Before starting, decide which checklists to use and how to use them, for example:

- Some experienced road safety engineers and auditors only use the master checklists.
- Some auditors use other checklists, including checklists developed for specific types of traffic facilities.
- Less experienced auditors should use the checklists provided with these guidelines. In this case, before assessing the documents and inspecting the site consider editing the checklists to delete items which are repetitive or not relevant (for example, rural issues if the project is urban).

It is stressed that a road safety audit is not an audit of the design standards, though these will need to be referred to, and their proper use makes a good starting point with any design.

The checklists should not be appended to the audit report. The written report should contain sufficient explanation of its findings and recommendations[5], without any need to refer to notes on checklists.

Designers may also wish to use the checklists to help them identify potential safety problems in their designs and as a way of knowing the types of issues an auditor will address.

10.2 When to Use the Checklists

There are checklists for each of the following:

Design stage audits

1. Feasibility stage
2. Preliminary design stage
3. Detailed design stage
4. Pre-opening stage

Other types of audits

1. Roadwork traffic scheme
2. Existing roads

The checklists are for use during an audit when:

- Assessing the documentation. In particular, when the project drawings are being examined.

5 If requested by the client.

- Inspecting the site. At this point, it is important to visualise how the project will fit into the existing features.
- Writing the audit report, to re-check that the relevant issues have been addressed.

10.3 How to Use the Checklists

Determine which set of checklists is needed as an audit may cover more than one stage in the design process.

Use the master checklist to scan the topics for audit and to prompt any questions about additional topics which should be considered.

The detailed checklists can be downloaded from the Road Safety Audit Toolkit www.rsatoolkit.com.au or can be photocopied, so that the copy may be used as a set of field sheets. A copy of the relevant page of the master list may also be useful as a quick reference in the office or in the field. Some auditors mark on the master list any points they believe fail to meet safety requirements or require further checking. More details can be logged on the checklist pages, on plans or in a notebook.

The topics listed are intended to cover only the more common elements of design and practice; they are not exhaustive and auditors should use their own skills and judgement about the safety of any feature. If a listed topic is not apparently relevant to the project being audited, a broad view of the topic should be taken, to see if it prompts a relevant question. For example, sight lines may be obstructed by features not listed in the checklists, and perhaps only at particular times of day. An understanding of the general environment around the project will help auditors make the most of the checklists.

11. Checklists

11.1 Master Checklists – All Stages

CHECKLIST 1 – FEASIBILITY STAGE AUDIT

1.1 General topics

1. Scope of project; function; traffic mix
2. Type and degree of access to property and developments
3. Major generators of traffic
4. Staging requirements
5. Future works
6. Wider network effects

1.2 Design issues (general)

1. Route choice
2. Impact of continuity with the existing network
3. Broad design standards
4. Design speed
5. Design volume and traffic characteristics

1.3 Intersections

1. Number and type of intersections

1.4 Environmental constraints

1. Safety aspects

1.5 Any other matter

CHECKLIST 2 – PRELIMINARY DESIGN STAGE AUDIT

2.1 General topics

1. Changes since previous audit
2. Drainage
3. Climatic conditions
4. Landscaping
5. Services
6. Access to property and developments
7. Adjacent developments
8. Emergency vehicles and access
9. Future widening and/or realignments
10. Staging of the scheme
11. Staging of works
12. Maintenance

2.2 Design issues (general)

1. Design standards
2. Typical cross-sections
3. The effect of cross-sectional variation
4. Roadway layout
5. Shoulders and edge treatment
6. Effect of departures from standards or guidelines

2.3 Alignment details

1. Geometry of horizontal and vertical alignment
2. Visibility; sight distance
3. New/existing road interface
4. 'Readability' of the alignment by drivers

2.4 Intersections

1. Visibility to and at intersections
2. Layout, including the appropriateness of type
3. Readability by drivers

2.5 Special road users

1. Adjacent land
2. Pedestrians
3. Cyclists
4. Motorcyclists
5. Equestrians and stock
6. Freight
7. Public transport
8. Road maintenance vehicles

2.6 Signs and lighting

1. Lighting
2. Signs
3. Marking and delineation

2.7 Traffic management

1. Traffic flow and access restrictions
2. Overtaking and merges
3. Rest areas and stopping zones
4. Construction and operation

2.8 Additional questions to be considered for development proposals

1. Horizontal alignment
2. Vertical alignment
3. Parking provision
4. Servicing facilities
5. Signs and markings
6. Landscaping
7. Traffic management
8. Other

2.9 Any other matters

CHECKLIST 3 – DETAILED DESIGN STAGE AUDIT

3.1 General topics

1. Changes since previous audit
2. Drainage
3. Climatic conditions
4. Landscaping
5. Services
6. Access to property and developments
7. Emergencies, breakdowns, emergency and service vehicle access
8. Future widening and/or realignments
9. Staging of the scheme
10. Staging of the work
11. Adjacent developments
12. Stability of cut and fill
13. Skid resistance

3.2 Design issues (general)

1. Geometry of horizontal and vertical alignment
2. Typical cross-sections
3. Effect of cross-sectional variation
4. Roadway layout
5. Shoulders and edge treatment
6. Effect of departures from standards or guidelines
7. Visibility and sight distance
8. Environmental treatments

3.3 Alignment details

1. Visibility; sight distance
2. New/existing road interface
3. 'Readability' of the alignment by drivers
4. Detail of geometric design
5. Treatment at bridges and culverts

3.4 Intersections

1. Visibility to and visibility at Intersections
2. Layout
3. Readability by drivers
4. Detailed geometric design
5. Traffic signals
6. Roundabouts
7. Other intersections

3.5 Special road users

1. Adjacent land
2. Pedestrians
3. Cyclists
4. Motorcyclists
5. Equestrians and stock
6. Freight
7. Public transport
8. Road maintenance vehicles

3.6 Lighting, signs and delineation

1. Lighting
2. Signs
3. Marking and delineation

3.7 Physical objects

1. Median barriers
2. Poles and other obstructions
3. Crash barriers
4. Bridges, culverts and causeways/floodways

3.8 Development proposals: additional questions

1. Horizontal alignment
2. Vertical alignment
3. Parking provision
4. Servicing facilities
5. Signs and markings
6. Landscaping
7. Traffic management
8. Other

3.9 Any other matters

CHECKLIST 4 – PRE-OPENING STAGE AUDIT

4.1 General topics

1. Changes since previous audit; translation of design into practice
2. Drainage
3. Climatic conditions
4. Landscaping
5. Services
6. Access to property and developments
7. Emergency vehicles and access
8. Batter treatment
9. Shoulders and edge delineation
10. Signs and markings
11. Surface treatment; skid resistance
12. Contrast with markings
13. Roadside hazards
14. Natural features
15. All road users
16. Speed zoning

4.2 Alignment details

1. Visibility; sight distances
2. New/existing road interface
3. Readability by drivers
4. Bridges and culverts

4.3 Intersections

1. Visibility of intersection
2. Visibility at intersection
3. Readability by drivers
4. Traffic signals
5. Roundabouts and approach islands

4.4 Special road users

1. Adjacent land
2. Pedestrians
3. Cyclists
4. Motorcyclists
5. Equestrians

4.5 Lighting, signs and delineation

1. Lighting
2. Signs
3. Marking and delineation

4.6 Physical objects

1. Median barriers
2. Poles and other obstructions
3. Crash barriers

4.7 Operation

1. Operation
2. Traffic management
3. Temporary traffic control/management
4. Safety matters not already covered

CHECKLIST 5 – ROADWORK TRAFFIC SCHEME AUDIT

5.1 General items

1. Alignment
2. Turning radii and tapers
3. Traffic lane safety and visibility
4. Night-time safety
5. Maintenance
6. Access to property
7. Safety barriers
8. Inspections

5.2 Traffic management

1. Traffic controls
2. Speed management
3. Work site access

5.3 Signs and pavement markings

1. Signs
2. Day/night sign requirements
3. Traffic control
4. Delineation and reflective markers
5. Pavement marking
6. Detours

5.4 Traffic Signals

1. Temporary traffic signals
2. Location
3. Visibility
4. Signal display
5. Traffic movements

5.5 Pedestrians and cyclists

1. General
2. Elderly and disabled access
3. Cyclists

5.6 Road pavement

1. Pavement defects
2. Skid resistance
3. Ponding

CHECKLIST 6 – EXISTING ROADS: ROAD SAFETY AUDIT

6.1 Road alignment and cross-section

1. Visibility; sight distance
2. Design speed
3. Speed limit/speed zoning
4. Overtaking
5. Readability by drivers
6. Widths
7. Shoulders
8. Crossfalls
9. Batter slopes
10. Drains

6.2 Auxiliary lanes

1. Tapers
2. Shoulders
3. Signs and markings
4. Turning traffic

6.3 Intersections

1. Location
2. Visibility; sight distance
3. Controls and delineation
4. Layout
5. Miscellaneous

6.4 Signs and lighting

1. Lighting
2. General sign issues
3. Sign legibility
4. Sign supports

6.5 Markings and delineation

1. General issues
2. Centrelines, edgelines, lane lines
3. Guideposts and reflectors
4. Curve warning and delineation

6.6 Crash barriers and clear zones

1. Clear zones
2. Crash barriers
3. End treatments
4. Fences
5. Visibility of barriers and fences

6.7 Traffic signals

1. Operations
2. Visibility

6.8 Pedestrians and cyclists

1. General issues
2. Pedestrians
3. Cyclists
4. Public transport

6.9 Bridges and culverts

1. Design features
2. Crash barriers
3. Miscellaneous

6.10 Pavement

1. Pavement defects
2. Skid resistance
3. Ponding
4. Loose stones/material

6.11 Parking

1. General issues

6.12 Provision for heavy vehicles

1. Design issues
2. Pavements/shoulder quality

6.13 Floodways and causeways

1. Ponding, flooding
2. Safety of devices

6.14 Miscellaneous

1. Landscaping
2. Temporary works
3. Headlight glare
4. Roadside activities
5. Errant vehicles
6. Other safety issues
7. Rest areas
8. Animals

11.2 Detailed Checklists

CHECKLIST 1: FEASIBILITY STAGE AUDIT

Issue	Yes	No	Comment
1.1 General topics			
1.1.1 Scope of project; function; traffic mix			
What is the intended function of the scheme?			
Is the design consistent with the function of the road?			
Will the proposed scheme/redesign safely cater for: • cars? • motorcyclists? • Cyclists • pedestrians? • heavy vehicles? • buses?			
Is the expected mix of traffic adequately catered for?			
Will the proposed scheme be consistent with adjacent roads, land forms and traffic management?			
1.1.2 Type and degree of access to property and developments			
Is the degree of access control consistent with the road's function and with other sections of the road?			
Will sight distances be satisfactory: • at intersections? • at property accesses?			
Is the design speed (or the likely vehicle speeds) compatible with the number and type of intersections/property accesses present?			
Does the width of the right of way satisfy access needs?			
1.1.3 Major generators of traffic			
Are all major generators of traffic (including housing or shopping centres) far enough away to avoid unsafe influences on the form of the design?			
Have existing or alternative accesses been arranged to ensure existing suburbs/areas are not cut off by the development of the scheme/works?			
Are the accesses for significant traffic generators far enough away from intersections for safety?			
Is sight distance to and from accesses to significant traffic generators adequate?			
Will the proposed scheme be consistent with adjacent roads, land forms and traffic management?			
1.1.4 Staging requirements			
Will this design be implemented in one stage only?			

Issue	Yes	No	Comment
If the design is to be implemented in more than one stage, has safety been given a high priority • in transitions between stages? • in transitions to existing roads?			
Will the work avoid problems with safety standards elsewhere during construction?			
1.1.5 Future works			
Will the route be free of compromises in safety if there is to be: • future widening? • the addition of a complete second carriageway? • after realignments? • major geometric changes at intersections? • linear extensions of the scheme?			
1.1.6 Wider network effects			
Have all harmful safety effects of this scheme upon the surrounding road network been identified? Have they been adequately dealt with?			
1.2 Design issues (general)			
1.2.1 Route choice			
Are all aspects associated with the location of the route and/or its alignment safe?			
If the route follows existing roads what are the effects of this? (comment)			
If the route is in 'green fields' (undeveloped corridor), is the alignment safe? Could it be safer? (comment)			
Does the scheme fit in with the physical constraints of the landscape?			
Does the scheme take account of major network considerations?			
1.2.2 Impact of continuity with the existing network			
Are all sections/transitions where the proposed road scheme connects with the existing network free of potential problems?			
1.2.3 Broad design standards			
Have the appropriate design standards been used? (having regard to the scope of the project and its function in relation to the traffic mix)			
Does the geometric plan and profile meet design guidelines?			
Have the appropriate design vehicle and check vehicle been used?			

Issue	Yes	No	Comment
1.2.4 Design speed			
Has the appropriate design speed been selected with regard to: • horizontal and vertical alignment? • visibility? • merging? • weaving? • decelerating or accelerating at intersections?			
Is sight distance generally satisfactory: • at intersections? (if not, what implications?) • at entry and exit ramps? • at property entrances? • at emergency vehicle access points?			
Can any sudden change in the speed regime or posted speed limit be safely accommodated?			
Is the designated speed limit, if any, on the proposed road appropriate?			
Is the designated or intended speed limit consistent with the design speed?			
1.2.5 Design volume and traffic characteristics			
Is the design appropriate with regard to the design volume and traffic characteristics (including the effects of unusual proportions of heavy vehicles, cyclists and pedestrians, or side friction effects)?			
Will the scheme safely cope with unforeseen or large increases in traffic volume?			
Will the scheme safely cope with unforeseen changes in the traffic characteristics?			
1.3 Intersections			
1.3.1 Number and type of intersections			
Are all aspects of intersections (for example, spacing, type, layout, etc.) appropriate with respect to: • the broad concept of the project • the function of this road and intersecting roads • the traffic mix on this road and intersecting roads • types which are consistent within the scheme, • and consistent with adjacent sections?			
Is the frequency of intersections appropriate (neither too high nor too low): • for safe access? • to avoid impacts on the surrounding network? • for emergency vehicle access?			
Have all physical, visibility or traffic management constraints which would influence the choice or spacing of intersections been considered?			
Has the vertical and/or horizontal alignment been taken into account with regard to the style or spacing of intersections?			

Issue	Yes	No	Comment
Are all of the proposed intersections necessary or essential?			
Can any unnecessary intersections be removed? Can access safety be improved by changes on the surrounding road network?			
Will the angle of the intersecting roads and the sight lines be adequate for the safety of all road users?			
1.4 Environmental constraints			
1.4.1 Safety aspects			
Is the surrounding terrain free of physical or vegetation defects which could affect the safety of the scheme? (for example, heavy planting, forestry, deep cuttings, steep or rocky bluffs which constrain the design)			
Do the gradients, curves and general design approaches fit in with the likely weather or environmental aspects of the terrain? (for example, fog-prone areas)			
Has safety been considered in the location of environmental features? (for example, noise fences)			
Does the scheme deal adequately with potential animal conflicts? (for example, kangaroos, wombats, cattle, etc.)			
Will the scheme perform safely at night when it is wet, or there is fog?			
Are visual distractions (for example, scenic vistas) adequately dealt with? (for example, by providing areas for people to stop safely)			
Has the issue of unstable country been considered? (for example, mine subsidence)			
1.5 Any other matters			
1.5.1 Safety aspects not already dealt with			
Has the possibility of flooding been adequately dealt with?			
Have any railway level crossings been identified and are they treated adequately?			
Have other distractions (for example, low-flying aircraft, advertising, etc.) been adequately dealt with?			
Has the need for laybys or parking (for example, for tourist routes, trucks, picnic or rest areas) been considered?			
Has the potential of the location to attract roadside stalls been considered?			
Have all unusual or hazardous conditions associated with special events been considered?			
Have all classes of pedestrians that could be seriously affected by the proposal been catered for? (for example, school children, elderly, etc.)			
Have any safety or accident problems on the existing network been addressed? (not carried over to the new scheme)			
Has the issue of providing lighting for the design been considered?			

Issue	Yes	No	Comment
Has the need for drivers to stop been considered? (for example, generally, rest areas, truck parking, enforcement)			
Have all other matters which may have a bearing on safety been addressed?			

CHECKLIST 2: PRELIMINARY DESIGN STAGE AUDIT

Issue	Yes	No	Comment
2.1 General topics			
2.1.1 Changes since previous audit			
Do the conditions for which the scheme was originally designed still apply? (for example, no changes to the surrounding network, area activities or traffic mix)			
Has the general form of the project design remained unchanged since previous audit (if any)?			
2.1.2 Drainage			
Will the scheme drain adequately?			
Has the possibility of surface flooding been adequately addressed, including overflow from surrounding or intersecting drains and water courses?			
2.1.3 Climatic conditions			
Has consideration been given to weather records or local experience that may indicate a particular problem? (for example, snow, ice, wind, fog)			
2.1.4 Landscaping			
If any landscaping proposals are available, are they compatible with safety requirements? (for example, sight lines and hazards in clear zones)			
2.1.5 Services			
Does the design adequately deal with buried and overhead services? (especially in regard to overhead clearances, etc)			
Has the location of fixed objects or furniture associated with services been checked, including the position of poles?			
2.1.6 Access to property and developments			
Can all accesses be used safely? (entry and exit/merging)			
Is the design free of any downstream or upstream effects from points of access, particularly near intersections?			
Have rest areas and truck parking accesses been checked for adequate sight distance, etc.?			
2.1.7 Adjacent developments			
Does the design handle accesses to major adjacent generators of traffic and developments safely?			
Is the driver's perception of the road ahead free of misleading effects of any lighting or traffic signals on an adjacent road?			
2.1.8 Emergency vehicles and access			
Has provision been made for safe access and movements by emergency vehicles?			

Issue	Yes	No	Comment
Does the design and positioning of medians and vehicle barriers allow emergency vehicles to stop and turn without unnecessarily disrupting traffic?			
2.1.9 Future widening and/or realignments			
If the scheme is only a stage towards a wider or dual carriageway is the design adequate to impart this message to drivers? (is the reliance on signs minimal/appropriate, rather than excessive?)			
Is the transition between single and dual carriageway (either way) handled safely?			
2.1.10 Staging of the scheme			
If the scheme is to be staged or constructed at different times: • are the construction plans and program arranged to ensure maximum safety? • do the construction plans and program include specific safety measures, signing; adequate transitional geometry, etc. for any temporary arrangements?			
2.1.11 Staging of the works			
If the construction is to be split into several contracts, are they arranged safely?			
2.1.12 Maintenance			
Can maintenance vehicles be safely located?			
2.2 Design issues (general)			
2.2.1 Design standards			
Is the design speed and speed limit appropriate? (for example, consider the terrain, function of the road)			
Has the appropriate design vehicle and check vehicle been used?			
2.2.2 Typical cross-sections			
Are lane widths, shoulders, medians and other cross-section features adequate for the function of the road?			
Is the width of traffic lanes and carriageway suitable in relation to: • alignment? • traffic volume? • vehicle dimensions? • the speed environment? • combinations of speed and traffic volume?			
Are overtaking/climbing lanes provided if needed?			
Have adequate clear zones been achieved?			
2.2.3 The effect of cross-sectional variation			
Is the design free of undesirable variations in cross-section design?			

Issue	Yes	No	Comment
Are crossfalls safe? (particularly where sections of existing highway have been used or there have been compromises to accommodate accesses, etc.)			
Does the cross-section avoid unsafe compromises such as narrowings at bridge approaches or past physical features?			
2.2.4 Roadway layout			
Are all traffic management features designed to avoid creating unsafe conditions?			
Is the layout of road markings and reflective materials able to deal satisfactorily with changes in alignment? (particularly where the alignment may be substandard)			
2.2.5 Shoulders and edge treatment			
Are the following safety aspects of shoulder provision satisfactory: • provision of sealed or unsealed shoulders • width and treatment on embankments • crossfalls all of shoulders			
Are the shoulders likely to be safe if used by slow moving vehicles or cyclists?			
Are any rest areas and truck parking areas safely designed?			
2.2.6 Effect of departures from standards or guidelines			
Any approved departures from standards or guidelines: is safety maintained?			
Any hitherto undetected departures from standards: is safety maintained?			
2.3 Alignment details			
2.3.1 Geometry of horizontal and vertical alignment			
Do the horizontal and vertical design fit together correctly?			
Is the design free of visual cues that would cause a driver to misread the road characteristics? (for example, visual illusions, subliminal delineation such as lines of trees, poles, etc.)			
Does the alignment provide for speed consistency?			
2.3.2 Visibility; sight distance			
Are horizontal and vertical alignments consistent with the visibility requirements?			

Issue	Yes	No	Comment
Will the design be free of sight line obstructions due to safety fences or barriers? • boundary fences? • street furniture? • parking facilities? • signs? • landscaping? • bridge abutments? • parked vehicles in laybys or at the kerb? • queued traffic?			
Are railway crossings, bridges and other hazards all conspicuous?			
Is the design free of any other local features which may affect visibility?			
2.3.3 New/existing road interface			
Does the interface occur well away from any hazard? (for example, a crest, a bend, a roadside hazard or where poor visibility/distractions may occur)			
If carriageway standards differ, is the change effected safely?			
Is the transition where the road environment changes (for example, urban to rural; restricted to unrestricted; lit to unlit) done safely?			
Has the need for advance warning been considered?			
2.3.4 Readability of the alignment by drivers			
Will the general layout, function and broad features be recognised by drivers in sufficient time?			
Will approach speeds be suitable and can drivers correctly track through the scheme?			
2.4 Intersections			
2.4.1 Visibility to and at intersections			
Are horizontal and vertical alignments at the intersection or on the approaches to the intersection consistent with the visibility requirements?			
Will drivers be aware of the presence of the intersection? (especially on the minor road approach)			

Issue	Yes	No	Comment
Will the design be free of sight line obstructions due to: • safety fences or barriers? • boundary fences? • street furniture? • parking facilities? • signs? • landscaping? • bridge abutments?			
Are railway crossings, bridges and other hazards near intersections conspicuous?			
Will the design be free of any local features which adversely affect visibility?			
Will intersection sight lines be obstructed by permanent or temporary features such as parked vehicles in laybys, or by parked or queued traffic generally?			
2.4.2 Layout, includes its appropriateness			
Is the type of intersection selected (cross roads, T, roundabout, signalised, etc.) appropriate for the function of the two roads?			
Are the proposed controls (Give Way, Stop signals, etc.) appropriate for the particular intersection?			
Are junction sizes appropriate for all vehicle movements?			
Are the intersections free of any unusual features which could affect road safety?			
Are the lane widths and swept paths adequate for all vehicles?			
Is the design free of any upstream or downstream geometric features that could affect safety? (for example, merging of lanes)			
Are the approach speeds consistent with the intersection design?			
Where a roundabout is proposed: • have pedal cycle movements been considered? • have pedestrian movements been considered? • are details regarding the circulating carriageway sufficient?			
2.4.3 Readability by drivers			
Will the general type, function and broad features be perceived correctly by drivers?			
Are the approach speeds and likely positions of vehicles as they track through the scheme safe?			
Is the design free of sunrise or sunset problems that may create a hazard for motorists?			

Issue	Yes	No	Comment
2.5 Special road users			
2.5.1 Adjacent land			
Will the scheme be free of adverse effects from adjacent activity and intensity of land use? (if not, what special measures are needed?)			
2.5.2 Pedestrians			
Have pedestrian needs been satisfactorily considered?			
If footpaths are not specifically provided, is the road layout safe for use by pedestrians? (particularly at blind corners or on bridges)			
Are pedestrian subways or footbridges sited to provide maximum use? (i.e. Is the possibility of pedestrians crossing at grade in their vicinity minimised?)			
Has specific provision been made for pedestrian crossings, school crossings or pedestrian signals?			
Where present, are these facilities sited to provide maximum use with safety?			
Are pedestrian refuges/kerb extensions provided where needed?			
Has specific consideration been given to provision required for special groups? (for example, young, elderly, disabled, deaf or blind)			
2.5.3 Cyclists			
Have the needs of cyclists been satisfactorily considered, especially at intersections?			
Have cycle lanes been considered?			
Are all cycleways of standard or adequate design?			
Where a need for shared pedestrian/cycle facilities exists, have they been safely treated?			
Where cycleways terminate at intersections or adjacent to the carriageway, has the transition treatment been handled safely?			
Have any needs for special cycle facilities been satisfactorily considered? (for example, cycle signals)			
2.5.4 Motorcyclists			
Has the location of devices or objects that might destabilise a motorcycle been avoided on the road surface?			
Will warning or delineation be adequate for motorcyclists?			
Has barrier kerb been avoided in high-speed areas?			
In areas more likely to have motorcycles run off the road is the roadside forgiving or safely shielded?			

Issue	Yes	No	Comment
2.5.5 Equestrians and stock			
Have the needs of equestrians been considered, including the use of verges or shoulders and rules regarding the use of the carriageway?			
Can underpass facilities be used by equestrians/stock?			
2.5.6 Freight			
Have the needs of truck drivers been considered, including turning radii and lane widths?			
2.5.7 Public transport			
Has public transport been catered for?			
Have the needs of public transport users been considered?			
Have the manoeuvring needs of public transport vehicles been considered?			
Are bus stops well positioned for safety?			
2.5.8 Road maintenance vehicles			
Has provision been made for road maintenance vehicles to be used safely at the site?			
2.6 Signs and lighting			
2.6.1 Lighting			
Is this project to be lit? Will safety be maintained if the project is not lit?			
Is the design free of features that make illuminating sections of the road difficult? (for example, shadow from trees or over bridges)			
Has the question of sighting of lighting poles been considered as part of the general concept of the scheme?			
Are frangible or slip-base poles to be provided?			
Are any special needs created by ambient lighting? Will safety be maintained if special treatments are not provided?			
Have the safety consequences of vehicles striking lighting poles (of any type) been considered?			
2.6.2 Signs			
Are signs appropriate for their location?			
Are signs located where they can be seen and read in adequate time?			
Will signs be readily understood?			

Issue	Yes	No	Comment
Are signs located so that visibility to and from accesses and intersecting roads is maintained?			
Are signs appropriate to the driver's needs? (for example, destination signs, advisory speed signs, etc.)			
Have the safety consequences of vehicles striking sign posts been considered?			
Are signs located so that drivers' sight distance is maintained?			
Where signs are to be located in the clear zone, are they frangible or adequately shielded by a crash barrier?			
2.6.3 Marking and delineation			
Has the appropriate standard of delineation and marking been adopted?			
Are the proposed markings consistent with the works in the adjoining section of the route?			
Are the previous/adjacent markings to be upgraded? If not, will safety be maintained?			
2.7 Traffic management			
2.7.1 Traffic flow and access restrictions			
Can traffic volumes from the proposed scheme be safely accommodated on existing sections of road?			
Have parking provision and parking control been adequately considered?			
Can any turn bans be implemented without causing problems at adjacent intersections?			
Has the effect of access to future developments been considered?			
Is safety maintained for any traffic diverting to other roads? (for example, to avoid a traffic control device)			
2.7.2 Overtaking and merges			
Are overtaking sight distance and stopping distance adequate?			
Have suitable shoulder widths been provided at lane drop merges?			
Have standard signs and markings been provided for any lane drop?			
Has adequate sight distance been provided to any lane drop?			
Are shoulders wide enough opposite access points and intersections?			
2.7.3 Rest areas and stopping zones			

Issue	Yes	No	Comment
Are there sufficient roadside stopping areas, rest areas and truck parking areas?			
Are any entries and exits to rest areas or truck parking areas safe?			
2.7.4 Construction and operation			
If the scheme is to be constructed 'under traffic', can this be done so safely?			
Can the scheme be safely constructed?			
Have the maintenance requirements been adequately considered?			
Is safe access to and from the works available?			
2.8 Additional questions to be considered for development proposals			
2.8.1 Horizontal alignment			
Is visibility adequate for drivers and pedestrians at proposed accesses?			
Is adequate turning space provided for the volume and speed of traffic?			
Are curve radii and forward visibility satisfactory?			
Are sight and stopping distances adequate?			
2.8.2 Vertical alignment			
Are gradients satisfactory?			
Are sight and stopping distances adequate?			
2.8.3 Parking provision			
Is on-site parking adequate to avoid on-street parking and associated risks?			
Are parking areas conveniently located?			
Is adequate space provided in parking areas for circulation and intersection sight distance?			
2.8.4 Servicing facilities			
Are off-street loading/unloading areas adequate?			
Are turning facilities for large vehicles provided in safe locations?			
Is emergency vehicle access adequate?			
2.8.5 Signs and markings			
Have necessary traffic signs and road markings been provided as part of a development?			

Issue	Yes	No	Comment
Is priority clearly defined at all the intersection points within the car park and access routes?			
Will the signs and markings be clear in all conditions, including day/night, rain, fog, etc.?			
2.8.6 Landscaping			
Does landscaping maintain visibility at intersections, bends, accesses and pedestrian locations?			
Has tree planting been avoided where vehicles are likely to run off the road?			
2.8.7 Traffic management			
Have any adverse area-wide effects been addressed?			
Will the design keep travel speeds at the safe level?			
Are the number and location of accesses appropriate?			
Are the facilities for public transport services safely located?			
Are any bicycle facilities safely located in respect to vehicular movements?			
Are pedestrian facilities adequate and safely located?			
2.8.8 Other			
Has appropriate street lighting been provided?			
Are any roadside hazards appropriately dealt with?			
Has safe pedestrian access to the development been provided?			
2.9 Any other matter			
2.9.1 Safety aspects not already covered			
Have all unusual or hazardous conditions associated with special events been considered?			
Is the road able to safely handle oversize vehicles, or large vehicles like trucks, buses, emergency vehicles, road maintenance vehicles?			
If required, can the road be closed for special events in a safe manner?			
If applicable, are special requirements of scenic or tourist routes satisfied?			
Have all other matters which may have a bearing on safety been addressed?			

CHECKLIST 3: DETAILED DESIGN STAGE AUDIT

Issue	Yes	No	Comment
3.1 General topics			
3.1.1 Changes since previous audit			
Do the conditions for which the scheme was originally designed still apply? (i.e. no significant changes to the surrounding network or area to be served, or traffic mix)			
Has the design of the project remained unchanged since previous audit (if any)?			
3.1.2 Drainage			
Will the new road drain adequately?			
Are the road grades and crossfalls adequate for satisfactory drainage?			
Are flat spots avoided or adequately dealt with at start/end of superelevation?			
Has the possibility of surface flooding been adequately addressed, including overflow from surrounding or intersecting drains and water courses?			
Is gully pit spacing adequate to limit flooding?			
Is pit grate design safe for pedal cycles? (i.e. gaps not parallel with wheel tracks)			
Will footpaths drain adequately?			
3.1.3 Climatic conditions			
Has the design taken into account weather records or local experience which may indicate a particular problem? (for example, snow, ice, wind, fog)			
3.1.4 Landscaping			
Will drivers be able to see pedestrians (and vice versa) past or over the landscaping?			
Will intersection sight lines be maintained past or over the landscaping?			
Will safety be adequate with seasonal growth? (for example, no obscuring of signs, shading or light effects, slippery surface, etc.)			
Will roadside safety be adequate when trees or plantings mature (no roadside hazard)?			
Has 'frangible' vegetation been used in possible run-off road areas?			
3.1.5 Services			
Does the design adequately deal with buried and overhead services? (especially in regard to overhead clearances, etc.)			

Issue	Yes	No	Comment
Has the location of fixed objects/furniture associated with services been checked? (including any loss of visibility, position of poles, and clearance to overhead wires)			
3.1.6 Access to property and developments			
Can all accesses be used safely?			
Is the design free of any downstream or upstream effects from accesses, particularly near intersections?			
Do rest areas and truck parking area have adequate sight distance at access points?			
3.1.7 Emergencies, breakdowns, emergency and service vehicle access			
Has provision been made for safe access and movements by emergency vehicles?			
Does the design and positioning of medians and vehicle barriers allow emergency vehicles to stop and turn without unnecessarily disrupting traffic?			
Have broken-down vehicles or stopped emergency vehicles been adequately considered?			
Is provision for emergency telephones satisfactory?			
Are median breaks on divided carriageways safely located? (i.e. frequency, visibility)			
3.1.8 Future widening and/or realignments			
If the scheme is only a stage towards a wider or dual carriageway is the design adequate to impart this message to drivers? (is the reliance on signs minimal/appropriate, rather than excessive?)			
Is the transition between single and dual carriageway (either way) handled safely?			
3.1.9 Staging of the scheme			
If the scheme is to be staged or constructed at different times: • are the construction plans and program arranged to ensure maximum safety? • do the construction plans and program include specific safety measures, signing; adequate transitional geometry; etc. for any temporary arrangements?			
3.1.10 Staging of the work			
If the construction is to be split into several subprojects, is the order safe? (i.e. the stages are not constructed in an order that creates unsafe conditions)			
3.1.11 Adjacent developments			
Does the design handle accesses to major adjacent generators of traffic and developments safely?			
Is drivers' perception of the road ahead free of misleading effects of any lighting or traffic signals on an adjacent road?			

Issue	Yes	No	Comment
Has the need for screening against glare from lighting of adjacent property been adequately considered?			
3.1.12 Stability of cut and fill			
Is the stability of batters satisfactory? (for example, no potential for loose material to affect road users)			
3.1.13 Skid resistance			
Has the need for anti-skid surfacing been considered where braking or good road adhesion is most essential? (for example, on gradients, curves, approaches to intersections and signals)			
3.2 Design issues (general)			
3.2.1 Geometry of horizontal and vertical alignment			
Does the horizontal and vertical design fit together correctly?			
Is the vertical alignment consistent and appropriate throughout?			
Is the horizontal alignment consistent throughout?			
Is the alignment consistent with the function of the road?			
Is the design free of misleading visual cues? (for example, visual illusions, subliminal delineation like lines of poles)			
3.2.2 Typical cross-sections			
Are lane widths, shoulders, medians and other cross-section features adequate for the function of the road?			
Are the shoulder widths adequate for stationary vehicles and errant vehicles?			
Are median widths adequate for road furniture?			
Is superelevation consistent with the road environment?			
Is the width of traffic lanes and carriageways suitable in relation to: • alignment? • traffic volume? • vehicle dimensions? • the speed environment? • combinations of speed and traffic volume?			
Are the shoulder crossfalls safe for vehicles to traverse?			
Are batter slopes drivable for cars, trucks?			
Are side slopes under structures appropriate?			
Have adequate facilities been provided for pedestrians and cyclists?			

Issue	Yes	No	Comment
3.2.3 Effect of cross-sectional variation			
Is the design free of undesirable variations in cross-section design?			
Are crossfalls safe? (particularly where sections of existing highway have been used, there have been compromises to accommodate accesses, at narrowings at bridges, etc.)			
Are any curves with adverse crossfall within appropriate limits?			
Is superelevation provided and sufficient at all locations where required?			
3.2.4 Roadway layout			
Are all traffic management features designed so as to avoid creating unsafe conditions?			
Is the layout of road markings and reflective materials able to deal satisfactorily with changes in alignment? (particularly where the alignment may be substandard)			
Is there adequate provision for overtaking?			
Are overtaking lanes provided where required and safely commenced and ended?			
Are overtaking requirements satisfactory?			
Is the design free of sunrise/sunset problems?			
Have public transport requirements been adequately catered for?			
3.2.5 Shoulders and edge treatment			
Are the shoulders likely to be safe if used by slow moving vehicles or cyclists?			
Are the following safety aspects of shoulder provision satisfactory? • provision of sealed or unsealed shoulders • width and treatment on embankments • crossfall of shoulders			
3.2.6 Effect of departures from standards or guidelines			
Any approved departures from standards or guidelines: is safety maintained?			
Any hitherto undetected departures from standards: is safety maintained?			
3.2.7 Visibility and sight distance			
Are horizontal and vertical alignments consistent with visibility requirements?			
Has an appropriate design speed been selected for visibility requirements?			

Issue	Yes	No	Comment
3.2.8 Environmental treatments			
Has safety been considered in the location of environmental features? (for example, noise fences)			
3.3 Alignment details			
3.3.1 Visibility; sight distance			
Are horizontal and vertical alignments consistent with the visibility requirements?			
Is the design free of sight line obstructions due to safety fences or barriers? • boundary fences? • street furniture? • parking facilities? • signs? • landscaping? • bridge abutments? • parked vehicles in laybys or at the kerb? • queued traffic?			
Are railway crossings, bridges and other hazards all conspicuous?			
Is the design free of any other local features which may affect visibility?			
Is the design free of overhead obstructions (for example, road or rail overpasses, sign gantries, overhanging trees) which may limit sight distance at sag curves?			
Has a clear headroom or a high vehicle detour been provided where necessary?			
Is visibility adequate at: • any pedestrian, bicycle or cattle crossings? • access roads, driveways, on and off ramps, etc.?			
Has the minimum sight triangle been provided at: • entry and exit ramps? • gore areas? • intersections? • roundabouts? • other conflict points?			
3.3.2 New/existing road interface			
Have implications for safety at the interface been considered?			
Is the transition from old road to the new scheme satisfactory?			
If the existing road is of a lower standard than the new scheme, is there clear and unambiguous warning of the reduction in standard?			
Have the appropriate provisions for safety been made where sudden changes in speed are required?			
Is access or side friction handled safely?			

Issue	Yes	No	Comment
Does the interface occur well away from any hazard? (for example, a crest, a bend, a roadside hazard or where poor visibility/distractions may occur)			
If carriageway standards differ, is the change effected safely?			
Is the transition where the road environment changes (for example, urban to rural; restricted to unrestricted; lit to unlit) done safely?			
Has the need for advance warning been considered?			
3.3.3 Readability of the alignment by drivers			
Will the general layout, function and broad features be recognised by drivers in sufficient time?			
Will approach speeds be suitable and will drivers correctly track through the scheme?			
3.3.4 Detail of geometric design			
Are the design standards appropriate for all the requirements of the scheme?			
Is consistency of general standards and guidelines, such as lane widths and crossfalls, maintained?			
3.3.5 Treatment at bridges and culverts			
Is the geometric transition from the standard cross-section to that on the bridge handled safely?			
3.4 Intersections			
3.4.1 Visibility to and at intersections			
Are horizontal and vertical alignments at the intersection or on the approaches to the intersection consistent with the visibility requirements?			
Is the standard adopted for provision of visibility appropriate for the speed of traffic and for any unusual traffic mix?			
Will the design be free of sight line obstructions due to safety fences or barriers • boundary fences? • street furniture? • parking facilities? • signs? • landscaping? • bridge abutments? • parked vehicles in laybys and at the kerb? • queued traffic?			
Are railway crossings, bridges and other hazards all conspicuous?			
Is the design free of any other local features which may affect visibility?			

Issue	Yes	No	Comment
3.4.2 Layout			
Are intersections and accesses adequate for all vehicular movements?			
Have the appropriate design vehicle and check vehicle been used for turning dimensions?			
Are swept paths accommodated for all likely vehicle types? (has the appropriate design vehicle been used?)			
Are intersections free of any unusual features which could affect road safety?			
Are pedestrian fences provided where needed? (for example, to guide pedestrians or discourage parking)			
Has pavement anti-skid treatment been provided where needed?			
Have islands and signs been provided where required?			
Vehicles which may park at or close to the intersection: can they do this safely or does this activity need to be relocated?			
Are safety hazards due to parked vehicles avoided?			
3.4.3 Readability by drivers			
Will the existence of the intersection and its general layout, function and broad features be perceived correctly and in adequate time?			
Are the approach speeds and likely positions of vehicles tracking through the intersection safe?			
Is the design free of misleading elements?			
Is the design free of sunrise or sunset problems which may create a hazard for motorists?			
3.4.4 Detailed geometric design			
Can the layout safely handle unusual traffic mixes or circumstances?			
Does any median or any island safely account for: • vehicle alignments and paths? • future traffic signals? • pedestrian storage space and surface? • turning path clearance? • stopping sight distance to the nose? • mountability by errant vehicles?			
Is adequate vertical clearance to structures provided? (for example, powerlines, shop awnings)			

Issue	Yes	No	Comment
3.4.5 Traffic signals			
Is the signal phasing/sequence safe?			
Is adequate time provided for traffic movements and pedestrian movements?			
Will the signal lanterns be visible? (for example, not obstructed by trees, poles, signs or large vehicles)			
Are lanterns for other approach directions adequately shielded from view?			
Are high-intensity signals and/or target boards provided if likely to be affected by sunrise/sunset?			
Does the alignment (vertical and horizontal) provide satisfactory stopping sight distance to the intersection or back of queue?			
Are pedestrian facilities provided where they are required?			
Will approaching drivers be able to see pedestrians?			
Are partially or fully controlled turning phases provided where required?			
Are signal posts located where they are not an undue hazard?			
Are road markings for turning traffic satisfactory?			
Have adequate pedestrian phases been provided?			
3.4.6 Roundabouts			
Is adequate deflection provided to reduce approach speeds?			
If splitter islands are needed, are they adequate for sight distance, length, pedestrian storage, etc.?			
Is the central island prominent?			
Can the appropriate design vehicle and check vehicle be accommodated?			
Are the central island details satisfactory? (delineation, mountability, conspicuousness)			
Can pedestrians be seen by drivers in sufficient time?			
Can pedestrians determine whether vehicles are turning? (no obstructions to sight lines)			
Are direction markings in approach lanes provided where required?			
Is the lighting adequate?			
3.4.7 Other intersections			
Has the need for kerbed or painted islands and refuges been considered?			

Issue	Yes	No	Comment
Do intersections have adequate queue length/storage for turning movements (including in the centre of a staggered intersection)?			
3.5 Special road users			
3.5.1 Adjacent land			
Are all accesses to and from adjacent land/properties safe?			
Have the special needs of agriculture and stock movements been considered?			
3.5.2 Pedestrians			
Can pedestrians cross safely at: • intersections? • signalised and pedestrian crossings? • refuges? • kerb extensions? • bridges and culverts? • other locations?			
Is each crossing point satisfactory for: • visibility, for each direction? • use by the disabled? • use by the elderly? • use by children/schools?			
Is pedestrian fencing on reservations and medians provided where required for each crossing?			
Is fencing adequate on freeways?			
Are pedestrians deterred from crossing roads at unsafe locations?			
Are pedestrian related signs appropriate and adequate?			
Is width and gradient of pedestrian paths, crossings, etc. satisfactory?			
Is surfacing of pedestrian paths, crossings, etc. satisfactory?			
Have dropped kerbs been provided for each crossing?			
Have channels and gullies been avoided at each crossing?			
Is lighting satisfactory for each crossing?			
Are crossings sited to provide maximum use?			
Is avoidance of a crossing unlikely? (for example, by more direct but less safe alternative)			

Issue	Yes	No	Comment
3.5.3 Cyclists			
Have the needs of cyclists been considered: • at intersections (particularly roundabouts)? • especially on higher speed roads? • on cycle routes and crossings? • at freeway entry and exit ramps?			
Are shared cycleway/footway facilities (including subways and bridges) safe and adequately signed?			
3.5.4 Motorcyclists			
Has the location of devices or objects that might destabilise a motorcycle been avoided on the road surface?			
Is the roadside clear of obstructions where motorcyclists may lean into curves?			
Will warning or delineation be adequate for motorcyclists?			
Has barrier kerb been avoided in high-speed areas?			
In areas more likely to have motorcycles run off the road is the roadside forgiving or safely yielded?			
Are all unnecessary poles, posts and devices removed or appropriately shielded?			
Are drainage pits and culverts traversable by motorcycle?			
3.5.5 Equestrians and stock			
Have the needs of equestrians been considered, including the use of verges or shoulders and rules regarding the use of the carriageway?			
Can underpass facilities be used by equestrians/stock?			
3.5.6 Freight			
Have the needs of truck drivers been considered, including turning radii and lane widths?			
Have the needs of freight transport been considered, adequately signed and catered for?			
3.5.7 Public transport			
Have the needs for public transport been considered, adequately signed and catered for?			
Have the needs of public transport users been considered?			
Have the manoeuvring needs of public transport vehicles been considered?			
Are bus stops well positioned for safety?			
3.5.8 Road maintenance vehicles			
Have the needs of road maintenance vehicles been considered, adequately signed and catered for?			

Issue	Yes	No	Comment
Can maintenance vehicles be safely located?			
3.6 Lighting, signs and delineation			
3.6.1 Lighting			
Has lighting been adequately provided where required?			
Is the design free of features which interrupt illumination? (for example, trees or overbridges)			
Is the design free of lighting poles that would present a fixed roadside hazard?			
Are frangible or slip-base poles to be provided?			
Ambient lighting: if it creates special lighting needs, have these been satisfied?			
Is the lighting scheme free of confusing or misleading effects on signals or signs?			
Does the lighting adequately illuminate crossings, nearby paths, refuges, etc.?			
Are all gore areas adequately illuminated?			
Are all merge areas adequately illuminated?			
Is the scheme free of any lighting black patches?			
If there are locations with accident problems that are known to be amenable to treatment with improved lighting, has this lighting been provided?			
3.6.2 Signs			
Are signs appropriate for their location?			
Are signs located where they can be seen and read in adequate time?			
Will signs be readily understood?			
Are signs appropriate to the driver's needs? (for example, direction signs, advisory speed signs, etc.)			
Are signs located so that drivers' sight distance is maintained?			
Are signs located so that visibility is maintained: • to/from accesses and intersecting roads? • to/from pedestrians and important features on the road?			
Have the consequences of vehicles striking signposts been considered?			
Are sign supports out of the clear zone?			

Issue	Yes	No	Comment
If not, are they: • frangible? • shielded by barriers (e.g. guard fence, crash cushions)?			
Has an over-reliance on signs (in lieu of adequate geometric design) been avoided?			
Are signs on the new scheme consistent with those on the adjoining section of road (or will the previous signs need to be upgraded)?			
3.6.3 Marking and delineation			
Are markings (lines, arrows, etc.) consistent with standard markings?			
Have any locations where standard markings might be confusing or misread been identified and treated in a way which considers road users' likely responses?			
Are barrier lines (no overtaking) provided where required?			
Are raised retroreflective pavement markers (RRPMs) provided where necessary?			
Are curve warning signs, advisory speed plates or chevron alignment markers provided where required?			
Are markings on the new scheme consistent with those on the adjoining section of road (or will the previous markings need to be upgraded)?			
Are diagonal markings or chevrons painted where required?			
Will markings and delineation be visible at night-time?			
Will markings and delineation be visible in wet weather?			
Has the need for profiled (audible) line marking been considered?			
Have both high and low-beam cases been considered?			
Are guide posts of the frangible type?			
3.7 Physical objects			
3.7.1 Median barriers			
Have median barriers been considered and properly detailed?			
Have all design features that require special attention (for example, end treatments) been considered?			
3.7.2 Poles and other obstructions			
Are all poles located well away from moving traffic?			
Have frangible or breakaway poles been included where required?			
Are median widths adequate to accommodate lighting poles or trees?			

Issue	Yes	No	Comment
Is the position of traffic signal controllers and other service apparatus satisfactory?			
Is the roadside clear of any other obstructions that may create a safety hazard?			
Have all necessary measures been taken to remove, relocate or shield all hazards?			
Can roadside drains and channels be safely traversed by any vehicle that runs off the road?			
3.7.3 Crash barriers			
Are crash barriers provided where necessary and properly detailed? (for example, at embankments, structures, trees, poles, drainage channels, bridge piers, gore areas)			
Is the crash barrier safe? (i.e. unlikely to create a danger for road users including pedestrians, cyclists, motorcyclists, etc.)			
Are the end conditions of the crash barrier safe and satisfactory?			
Is the guard fence designed according to standards for: • end treatments? • anchorages? • post spacing? • block outs? • post depth? • rail overlap? • stiffening at rigid obstacles?			
Is all guard fence necessary? (i.e. what it shields is a greater hazard than the fence)			
Where pedestrians and cyclists travel behind guard fence, is the rear of the fence safe for them?			
3.7.4 Bridges, culverts and causeways/floodways			
Are bridge barriers and culvert end walls safe regarding: • visibility? • ease of recognition? • proximity to moving traffic? • the possibility of causing injury or damage? • collapsible or frangible ends? • signs and markings? • connection of crash barriers? • roadside hazard protection?			
Is the bridge railing at the correct level and strong enough?			
Is the shoulder width on the bridge the same as on the adjacent road lengths?			
Is safe provision made for non-vehicular traffic over structures? (for example, pedestrians, pedal cycles, horses/stock, etc)			
Are all culvert end walls (including driveway culverts) drivable or outside the clear zone?			

Issue	Yes	No	Comment
Have causeways/floodways etc. been given correct signing and adequate sight distance?			
3.8 Additional questions to be considered for development proposals			
3.8.1 Horizontal alignment			
Is visibility adequate for drivers and pedestrians at proposed accesses?			
Is adequate turning space provided for the volume and speed of traffic?			
Are curve radii and forward visibility satisfactory?			
Are sight and stopping distances adequate?			
3.8.2 Vertical alignment			
Are gradients satisfactory?			
Are sight and stopping distances adequate?			
3.8.3 Parking provision			
Is on-site parking adequate to avoid on-street parking and associated risks?			
Are parking areas conveniently located?			
Is adequate space provided in parking areas for circulation and intersection sight distance?			
3.8.4 Servicing facilities			
Are off-street loading/unloading areas adequate?			
Are turning facilities for large vehicles provided in safe locations?			
Is emergency vehicle access adequate?			
3.8.5 Signs and markings			
Have necessary traffic signs and road markings been provided as part of a development?			
Is priority clearly defined at all the intersection points within the car park and access routes?			
Will the signs and markings be clear in all conditions, including day/night, rain, fog, etc.?			
3.8.6 Landscaping			
Does landscaping maintain visibility at intersections, bends, accesses and pedestrian locations?			
Has tree planting been avoided where vehicles are likely to run off the road?			
3.8.7 Traffic management			
Have any adverse area-wide effects been addressed?			
Will the design keep travel speeds at a safe level?			
Are the number and location of accesses appropriate?			

Issue	Yes	No	Comment
Are the facilities for public transport services safely located?			
Are any bicycle facilities safely located in respect of vehicular movements?			
Are pedestrian facilities adequate and safely located?			
3.8.8 Other			
Has appropriate street lighting been provided?			
Are all roadside hazards appropriately dealt with?			
Has safe pedestrian access to the development been provided?			
3.9 Any other matter			
Safety aspects not already covered			
Is the road able to safely handle oversize vehicles, or large vehicles like trucks, buses, emergency vehicles, road maintenance vehicles?			
If required, can the road be closed for special events in a safe manner?			
If applicable, are special requirements of scenic or tourist routes satisfied?			
Have all unusual or hazardous conditions associated with special events been considered?			
Have all other matters which may have a bearing on safety been addressed?			

CHECKLIST 4: PRE-OPENING STAGE AUDIT

Issue	Yes	No	Comment
4.1 General topics			
4.1.1 Changes since previous audit; translation of design into practice			
General check: have any matters that have changed since a previous audit been executed safely?			
Has the translation of the design into practice been executed safely?			
4.1.2 Drainage			
Is the drainage of the road and surrounds adequate?			
4.1.3 Climatic conditions			
Are any facilities put in place to counter climatic problems effective?			
4.1.4 Landscaping			
Is the planting and species selection appropriate from a safety point of view?			
Is vegetation/landscaping 'frangible' in locations where vehicles may run off the road?			
Is visibility maintained past or over vegetation/landscaping (particularly for pedestrian safety)? Will this continue to be so once plants grow and mature?			
4.1.5 Services			
Are all boxes, pillars, posts and lighting columns located in safe positions?			
Are they of appropriate materials or design?			
4.1.6 Access to property and developments			
Are all accesses safe for their intended use?			
Are all accesses adequate, particularly in terms of design, location and visibility?			
4.1.7 Emergency vehicles and access			
Are the provisions for emergency vehicle access and stopping safe?			
4.1.8 Batter treatment			
Will the batter treatment prevent or limit debris falling on to the carriageway?			
4.1.9 Shoulders and edge delineation			
Are all delineators and reflectors correctly in place?			
4.1.10 Signs and markings			
Are all signs and pavement markings correctly in place?			
Will they remain visible at all times (day and night)?			

Issue	Yes	No	Comment
Are new markings consistent with existing markings? (check with adjacent road network)			
Have old signs and markings been removed?			
Have all potentially confusing circumstances been avoided or removed?			
4.1.11 Surface treatment; skid resistance			
Are all joints in surfacing free of excessive bleeding or low-skid resistance?			
Have all trafficked areas been checked for similar problems, including loose metal?			
4.1.12 Contrast with markings			
Do the installed road markings have sufficient contrast with the road surface and are they clear of debris?			
4.1.13 Roadside hazards			
Is the scheme free of newly installed or overlooked roadside hazards?			
4.1.14 Natural features			
Is the scheme free of natural features (for example, a bank, rock or major tree) that will be a roadside hazard or an obstruction to visibility?			
4.1.15 All road users			
Is safety adequate for: • pedestrian movements? (pedestrians of all ages) • bicycle/non-motorised vehicle movements? • truck and bus movements? • motorcycle movements? • car movements?			
4.1.16 Speed zoning			
Has the appropriate speed zone been selected?			
4.2 Alignment details			
4.2.1 Visibility; sight distances			
Are sight lines free of obstructions?			
4.2.2 New/existing road Interface			
Additional signs and/or markings: have they been considered and provided where required?			
4.2.3 Readability by drivers			
Is the form and function of the road and its traffic management easily recognised under likely operating conditions? (for example, under heavy traffic, minimal traffic or poor visibility conditions)			
Is the transition from old work to new work satisfactory? (i.e. no uncertainty or ambiguity at the transition)			

Issue	Yes	No	Comment
4.2.4 Bridges and culverts			
Are all markings and signs in place and conspicuous?			
4.3 Intersections			
4.3.1 Visibility of intersection			
Will drivers approaching the intersection be aware of its presence? (especially if required to give way)			
4.3.2 Visibility at intersection			
Are all visibility displays clear for the different driver eye heights of cars, trucks, bicycles, motorcycles, vehicles with restricted visibility?			
4.3.3 Readability by drivers			
Is the form and function of the intersection clear to drivers on all approaches? (check by driving)			
Are Give Way or Stop lines visible in time? Are there sufficient visual cues to prevent overshooting into the conflicting traffic?			
4.3.4 Traffic signals			
Is the alignment of lanterns and general correctness of installation satisfactory?			
Are all applicable lanterns visible from each approach lane at the appropriate distances?			
Are all traffic signals functioning properly and safely?			
Are all pedestrian signals functioning correctly and safely?			
4.3.5 Roundabouts and approach islands			
Are the roundabout and islands fully visible and recognisable from all approaches?			
Are all signs, markings and lighting correctly in place?			
4.4 Special road users			
4.4.1 Adjacent land			
Is fencing adequate, particularly on roads where pedestrians and animals are not allowed?			
4.4.2 Pedestrians			
Are all pedestrian facilities likely to operate safely regarding: • visibility? • signs? • surfacing? • fencing? • the operation of other hardware, including • lighting? • wheel chairs and prams? • visually impaired people?			
4.4.3 Cyclists			

Issue	Yes	No	Comment
Are all cycleways, lanes, etc. and facilities likely to operate safely regarding: • visibility? • signs? • surfacing? • fencing? • the operation of other hardware, including lighting?			
4.4.4 Motorcyclists			
Has the location of devices or objects that might destabilise a motorcycle been avoided on the road surface?			
Is the roadside clear of obstructions where motorcyclists may lean into curves?			
Will warning or delineation be adequate for motorcyclists?			
Has barrier kerb been avoided in high-speed areas?			
In areas more likely to have motorcycles run off the road is the roadside forgiving or safely shielded?			
Are all unnecessary poles, posts and devices removed or appropriately shielded?			
Are drainage pits and culverts traversable by motorcycle?			
4.4.5 Equestrians			
Are all relevant facilities likely to operate safely regarding: • visibility? • signs? • other special features?			
4.5 Lighting, signs and delineation			
4.5.1 Lighting			
Is all lighting operating and, from a safety point of view, is it effective?			
4.5.2 Signs			
Are the correct signs used and are they correctly placed?			
In daylight and darkness, are signs satisfactory regarding: • conspicuousness? • clarity of message? • readability/legibility at the required distance?			
Is sign retroreflectivity or illumination satisfactory?			
Are any variable message signs operating satisfactorily?			
Are all signs necessary?			
Can all signs be seen (i.e. not hidden or camouflaged by their background or adjacent distractions)?			

Issue	Yes	No	Comment
4.5.3 Marking and delineation			
Is all delineation and road marking placed correctly and fully visible?			
Are RRPMs fully visible with correct spacings, colour, etc.?			
Are all other delineation devices correctly installed (especially location, type and size)?			
Are guide posts adequate and properly spaced?			
Are guide post delineators operating adequately at night?			
Reflectors on crash barrier: are they the correct type, level and spacing and not misleading in alignment?			
Are all road markings clearly visible at all times to motorists and other road users?			
Is there continuity and uniformity of delineation and markings through the scheme and at transitions?			
4.6 Physical objects			
4.6.1 Median barriers			
Are all necessary median barriers in place and properly signed or delineated?			
Are barriers placed so that they do not restrict visibility or form a roadside hazard?			
4.6.2 Poles and other obstructions			
Are all poles and sign structure bases safely designed and appropriately located?			
Is the scheme free of any other poles or obstructions that may have been missed in other checks?			
Otherwise, are obstructions suitably shielded?			
4.6.3 Crash barriers			
Are all crash barriers in place and safely located (not a hazard in themselves)?			
Is the length of any guard fence adequate?			
Is the guard fence correctly installed, regarding: • end treatments? • anchorages? • post spacing? • block outs? • post depth? • rail overlap? • stiffening at rigid obstacles?			

Issue	Yes	No	Comment
4.7 Operation			
4.7.1 Operation			
Are all operating features working satisfactorily and can access be gained to them safely?			
4.7.2 Traffic management			
Do all traffic management devices function properly when observed from a moving vehicle?			
4.7.3 Temporary traffic control/management			
Have all temporary arrangements, signing, etc. been removed and replaced by final arrangements? (for example, signs, signals, lines, construction accesses and temporary barriers)			
4.7.4 Safety aspects not already covered			
Has the scheme been driven and walked to identify any potential problems not already dealt with?			
Have all other matters which may have a bearing on safety been addressed?			

CHECKLIST 5: ROADWORK TRAFFIC SCHEME AUDIT

Issue	Yes	No	Comment
5.1 General items			
5.1.1 Alignment			
Are the roadworks located safely with respect to horizontal and vertical alignment? If not, does works signing cater for this?			
Are the transitions from the existing road to the roadworks safe and clearly laid out?			
5.1.2 Turning radii and tapers			
Are turning radii and tapers constructed in accordance with guidelines?			
Are the tapers delineated by roadworks cones where necessary?			
Are the width of the lanes satisfactory for the traffic using the works area?			
Are the alignment of kerb, traffic islands and medians satisfactory?			
5.1.3 Traffic lane safety and visibility			
Is the work area clearly defined?			
Are the travel paths for both directions of traffic clearly defined? Is the work area appropriately separated from passing traffic?			
Are centre lines/lane lines/edge lines clear and unambiguous?			
Are sight and stopping distances adequate at works and at intersections and driveways?			
Are bus stops appropriately located with adequate clearance from the traffic lane for safety and visibility?			
Can passengers safely walk to and from bus stops?			
5.1.4 Night-time safety			
Is appropriate street lighting or other delineation provided at the roadworks to ensure that the site is safe at night? (Night-time inspection essential.)			
Is the works area safe for pedestrians and cyclists at night?			
5.1.5 Maintenance			
Can the road be maintained safely during construction (consider workers and the public)?			
Is the road surface likely to be free of gravel, mud or other debris?			
5.1.6 Access to property			
Do the roadworks safely accommodate property access?			

Issue	Yes	No	Comment
5.1.7 Safety barriers			
Are safety barriers used where required to separate works areas from public areas?			
Are safety barriers used where required to shield traffic from other hazards?			
Are the barriers of an approved type for the purpose and located and assembled correctly?			
Are safety barriers erected in a manner that: • does not make them a hazard to traffic? • does not obstruct visibility?			
5.1.8 Inspections			
Has the site been inspected day and night?			
5.2 Traffic management			
5.2.1 Traffic controls			
Are appropriate traffic management controls in place?			
Have the needs of cars, trucks, pedestrians, bicyclists, motorcyclists and bus users been considered?			
Is sight distance to traffic controllers adequate?			
Have parking and clearway matters been considered?			
Have the police and other emergency services been consulted?			
5.2.2 Speed management			
Are speed limit signs required for these works? If so, are they correctly applied?			
Are speed limit signs required to be maintained all day and at night?			
Are motorists informed of the need to slow down through the roadworks site?			
5.2.3 Work site access			
Are site entrances and exits safely located with adequate sight distance?			
Are traffic merges/exits/entries/turns properly delineated and controlled?			
Are adequate merge lengths provided?			
Are appropriate traffic controls in place where works traffic and public traffic interact?			

Issue	Yes	No	Comment
5.3 Signs and pavement markings			
5.3.1 Signs			
Are all necessary regulatory, warning and direction signs in place?			
Are they correctly placed, clean and conspicuous?			
Do they conform with AS 1724.3-1996 and other guidelines?			
If chevron alignment markers are installed, have the correct types been used?			
Have unnecessary signs been removed when works are not in progress? (for example, at night)			
Are traffic signs correctly located, with adequate lateral and vertical clearance?			
Are signs placed to not restrict sight distance, particularly for turning vehicles?			
5.3.2 Day/night sign requirements			
Are the correct signs used for each situation including at night where required, and is each sign necessary?			
5.3.3 Traffic control			
Are other traffic control devices according to standards and used correctly?			
Are flagmen or temporary traffic signals provided where required? (comment - where, when and how)			
5.3.4 Delineation and reflective markers			
Are traffic lanes clearly delineated?			
Have temporary reflective markers been installed?			
Where coloured reflective markers are used, have they been installed correctly?			
5.3.5 Pavement marking			
Are all necessary pavement markings installed in accordance with guidelines?			
Are vehicle paths through the works area clear to motorists?			
Are works areas clearly defined and clear of through traffic when flagmen are not used?			
Have any issues of site difficulties for motorcyclists (day or night) been addressed?			
5.3.6 Detours			
Do temporary detours allow heavy vehicles and buses to safely manoeuvre in their designated lane?			

Issue	Yes	No	Comment
5.4 Traffic signals			
5.4.1 Temporary traffic signals			
Are the temporary traffic signals clearly visible to approaching motorists?			
Are signs warning of temporary traffic signals adequate?			
Has the need for additional warning signs been considered?			
Will the ends of vehicle queues be visible to motorists so that they may stop safely?			
5.4.2 Location			
Are traffic signals operating correctly? Is the number and location of signal displays adequate?			
5.4.3 Visibility			
Have any visibility problems caused by the rising or setting sun been addressed?			
Do any site works or any construction equipment create visibility problems for traffic signals?			
5**.4.4 Signal display**			
Are signal displays shielded so they can be seen only by the motorists for whom they are intended?			
5.4.5 Traffic movements			
Are all movements, including pedestrians, catered for by the temporary traffic signals?			
5.5 Pedestrians and cyclists			
5.5.1 General			
Have the effects of the works areas on pedestrians and cyclists been considered?			
Are appropriate travel paths and crossing points provided for pedestrians and cyclists?			
Are pedestrians and cyclists adequately warned of obstructions and temporary works hazards on their traveled way?			
5.5.2 Elderly and disabled access			
Are there adequate safety access provisions for the elderly, disabled, children, wheel chairs and prams? (for example, holding rails, kerbs and median crossings, ramps)			
5.5.3 Cyclists			
Is the route available for bicycles continuous and free of squeeze points or gaps?			

Issue	Yes	No	Comment
5.6 Road pavement			
5.6.1 Pavement defects			
Is the pavement free of defects (for example, excessive roughness or rutting, potholes, loose material, etc.) that could result in safety problems like loss of steering control for: • car drivers? • cyclists? • motorcyclists? • heavy vehicle drivers?			
5.6.2 Skid resistance			
Does the pavement appear to have adequate skid resistance, especially on steep descents?			
5.6.3 Ponding			
Is the pavement free of areas where ponding or sheet flow of water may cause safety problems?			
5.6.4 Signal display			
Are signal displays shielded so they can be seen only by the motorists for whom they are intended?			
5.7 Any other matter			
Safety aspects not already covered			
Have all other matters which may have a bearing on safety been addressed?			

CHECKLIST 6: EXISTING ROADS: ROAD SAFETY AUDIT

Issue	Yes	No	Comment
6.1 Road alignment and cross-section			
6.1.1 Visibility; sight distance			
Is sight distance adequate for the speed of traffic using the route?			
Is adequate sight distance provided for intersections and crossings? (for example, pedestrian, cyclist, cattle, railway)			
Is adequate sight distance provided at all private driveways and property entrances?			
6.1.2 Design speed			
Is the horizontal and vertical alignment suitable for the (85th percentile) traffic speed?			
If not: • are warning signs installed? • are advisory speed signs installed?			
Are the posted advisory speeds for curves appropriate?			
6.1.3 Speed limit/speed zoning			
Is the speed limit compatible with the function, road geometry, land use and sight distance?			
6.1.4 Overtaking			
Are safe overtaking opportunities provided?			
6.1.5 Readability by drivers			
Is the road free of elements that may cause confusion? For example: • is alignment of the roadway clearly defined? • has disused pavement (if any) been removed or treated? • have old pavement markings been removed • properly? • do tree lines follow the road alignment? • does the line of street lights or the poles follow the road alignment?			
Is the road free of misleading curves or combinations of curves?			

Issue	Yes	No	Comment
6.1.6 Widths			
Are medians and islands of adequate width for the likely users?			
Are traffic lane and carriageway widths adequate for the traffic volume and mix?			
Are bridge widths adequate?			
6.1.7 Shoulders			
Are shoulders wide enough to allow drivers to regain control of errant vehicles?			
Are shoulders wide enough for broken-down or emergency vehicles to stop safely?			
Are shoulders sealed?			
Are shoulders traffickable for all vehicles and road users? (i.e. are shoulders in good condition)			
Is the transition from road to shoulder safe? (no drop-offs)			
6.1.8 Crossfalls			
Is appropriate superelevation provided on curves?			
Is any adverse crossfall safely managed (for cars, trucks, etc.)?			
Do crossfalls (carriageway and shoulder) provide adequate drainage?			
6.1.9 Batter slopes			
Are batter slopes traversable by cars and trucks that run off the road?			
6.1.10 Drains			
Are roadside drains and culvert end walls traversable?			
6.2 Auxiliary lanes			
6.2.1 Tapers			
Are starting and finishing tapers located and aligned correctly?			
Is there sufficient sight distance to the end of the auxiliary lane?			
6.2.2 Shoulders			
Are appropriate shoulder widths provided at merges?			
Have shoulder widths been maintained beside the auxiliary lane?			
6.2.3 Signs and markings			
Have all signs been installed in accordance with the appropriate guidelines?			
Are all signs conspicuous and clear?			

Issue	Yes	No	Comment
Does all linemarking conform with these guidelines?			
Is there advance warning of approaching auxiliary lanes?			
6.2.4 Turning traffic			
Have right turns from the through lane been avoided?			
Is there advance warning of turn lanes?			
6.3 Intersections			
6.3.1 Location			
Are all intersections located safely with respect to the horizontal and vertical alignment?			
Where intersections occur at the end of high-speed environments (for example, at approaches to towns), are there traffic control devices to alert drivers?			
6.3.2 Visibility; sight distance			
Is the presence of each intersection obvious to all road users?			
Is the sight distance appropriate for all movements and all road users?			
Is there stopping sight distance to the rear of any queue or slow-moving turning vehicles?			
Has the appropriate sight distance been provided for entering and leaving vehicles?			
6.3.3 Controls and delineation			
Are pavement markings and intersection control signs satisfactory?			
Are vehicle paths through intersections delineated satisfactorily?			
Are all lanes properly marked (including any arrows)?			
6.3.4 Layout			
Are all conflict points between vehicles safely managed?			
Is the intersection layout obvious to all road users?			
Is the alignment of kerbs obvious and appropriate?			
Is the alignment of traffic islands obvious and appropriate?			
Is the alignment of medians obvious and appropriate?			
Can all likely vehicle types be accommodated?			
Are merge tapers long enough?			
Is the intersection free of capacity problems that may produce safety problems?			
6.3.5 Miscellaneous			

Issue	Yes	No	Comment
Particularly at rural sites, are all intersections free of loose gravel?			
6.4 Signs and lighting			
6.4.1 Lighting			
Has lighting been adequately provided where required?			
Is the road free of features that interrupt illumination? (for example, trees or overbridges)			
Is the road free of lighting poles that are a fixed roadside hazard?			
Are frangible or slip-base poles provided?			
Ambient lighting: if it creates special lighting needs, have these been satisfied?			
Is the lighting scheme free of confusing or misleading effects on signals or signs?			
Is the scheme free of any lighting black patches?			
6.4.2 General signs issues			
Are all necessary regulatory, warning and direction signs in place? Are they conspicuous and clear?			
Are the correct signs used for each situation, and is each sign necessary?			
Are all signs effective for all likely conditions? (for example, day, night, rain, fog, rising or setting sun, oncoming headlights, poor lighting)			
If restrictions apply for any class of vehicle, are drivers adequately advised?			
If restrictions apply for any class of vehicle, are drivers advised of alternative routes?			
6.4.3 Sign legibility			
In daylight and darkness, are signs satisfactory regarding visibility and: • clarity of message? • readability/legibility at the required distance?			
Is sign retroreflectivity or illumination satisfactory?			
Are signs able to be seen without being hidden by their background or adjacent distractions?			
Is driver confusion due to too many signs avoided?			
6.4.4 Sign supports			
Are sign supports out of the clear zone?			

Issue	Yes	No	Comment
If not, are they: • frangible? • shielded by barriers (for example, guard fence, crash cushions)?			
6.5 Markings and delineation			
6.5.1 General issues			
Is the line marking and delineation: • appropriate for the function of the road? • consistent along the route? • likely to be effective under all expected conditions? (day, night, wet, dry, fog, rising and setting sun position, oncoming headlights, etc.)			
Is the pavement free of excessive markings? (for example, unnecessary turn arrows, unnecessary barrier lines, etc.)			
6.5.2 Centrelines, edgelines, lane lines			
Are centrelines, edgelines, lane lines provided? If not, do drivers have adequate guidance?			
Have RRPMs been installed where required?			
If RRPMs are installed, are they correctly placed, correct colours, in good condition?			
Are profiled (audible) edgelines provided where required?			
Is the linemarking in good condition?			
Is there sufficient contrast between linemarking and pavement colour?			
6.5.3 Guideposts and reflectors			
Are guideposts appropriately installed?			
Are delineators clearly visible?			
Are the correct colours used for the delineators?			
Are the delineators on guard fences, crash barriers and bridge railings consistent with those on guideposts?			
6.5.4 Curve warning and delineation			
Are curve warning signs and advisory speed signs installed where required?			
Are advisory speed signs consistent along the route?			
Are the signs correctly located in relation to the curve? (i.e. not too far in advance)			
Are the signs large enough?			
Are chevron alignment markers (CAMs) installed where required?			
Is the positioning of CAMs satisfactory to provide guidance around the curve?			
Are the CAMs the correct size?			

Issue	Yes	No	Comment
Are CAMs confined to curves? (not used to delineate islands, etc)			
6.6 Crash barriers and clear zones			
6.6.1 Clear zones			
Is the clear zone width traversable? (i.e. drivable)			
Is the clear zone width free of rigid fixtures? (if not, can all of these rigid fixtures be removed or shielded?)			
Are all power poles, trees, etc., at a safe distance from the traffic paths?			
Is the appropriate treatment or protection provided for any objects within the clear zone?			
6.6.2 Crash barriers			
Are crash barriers installed where necessary?			
Are crash barriers installed at all necessary locations in accordance with the relevant guidelines?			
Are the barrier systems suitable for the purpose?			
Are the crash barriers correctly installed?			
Is the length of crash barrier at each installation adequate?			
Is the guard fence attached correctly to bridge railings?			
Is there sufficient width between the barrier and the edge line to contain a broken-down vehicle?			
6.6.3 End treatments			
Are end treatments constructed correctly?			
Is there a safe run-off area behind breakaway terminals?			
6.6.4 Fences			
Are pedestrian fences frangible?			
Are vehicles safe from being speared by horizontal fence railings located within the clear zone?			
6.6.5 Visibility of barriers and fences			
Is there adequate delineation and visibility of crash barriers and fences at night?			
6.7 Traffic signals			
6.7.1 Operations			
Are traffic signals operating correctly?			
Are the number, location and type of signal displays appropriate for the traffic mix and traffic environment?			
Where necessary, are there provisions for visually impaired pedestrians? (for example, audio-tactile push buttons, tactile markings)			

Issue	Yes	No	Comment
Where necessary, are there provisions for elderly or disabled pedestrians? (for example, extended green or clearance phase)			
Is the controller located in a safe position? (i.e. where it is unlikely to be hit, but maintenance access is safe)			
Is the condition (especially skid resistance) of the road surface on the approaches satisfactory?			
6.7.2 Visibility			
Are traffic signals clearly visible to approaching motorists?			
Is there adequate stopping sight distance to the ends of possible vehicle queues?			
Have any visibility problems that could be caused by the rising or setting sun been addressed?			
Are signal displays shielded so that they can be seen only by the motorists for whom they are intended?			
Where signal displays are not visible from an adequate distance, are signal warning signs and/or flashing lights installed?			
Where signals are mounted high for visibility over crests, is there adequate stopping sight distance to the ends of traffic queues?			
Is the primary signal free from obstructions on the nearside footway to approaching drivers? (trees, light poles, signs, bus stops, etc.)			
6.8 Pedestrians and cyclists			
6.8.1 General issues			
Are there appropriate travel paths and crossing points for pedestrians and cyclists?			
Is a safety fence installed where necessary to guide pedestrians and cyclists to crossings or overpasses?			
Is a safety barrier installed where necessary to separate vehicle, pedestrian and cyclist flows?			
Are pedestrian and bicycle facilities suitable for night use?			
6.8.2 Pedestrians			
Is there adequate separation distance between vehicular traffic and pedestrians on footways?			
Is there an adequate number of pedestrian crossings along the route?			
At crossing points is fencing oriented so pedestrians face oncoming traffic?			
Is there adequate provision for the elderly, the disabled, children, wheelchairs and baby carriages? (for example, holding rails, kerb and median crossings, ramps)			

Issue	Yes	No	Comment
Are adequate hand rails provided where necessary? (for example, on bridges, ramps)			
Is signing about pedestrians near schools adequate and effective?			
Is signing about pedestrians near any hospital adequate and effective?			
Is the distance from the stop line to a cross walk sufficient for truck drivers to see pedestrians?			
6.8.3 Cyclists			
Is the pavement width adequate for the number of cyclists using the route?			
Is the bicycle route continuous? (i.e. free of squeeze points or gaps)			
Are drainage pit grates bicycle safe?			
6.8.4 Public transport			
Are bus stops safely located with adequate visibility and clearance to the traffic lane?			
Are bus stops in rural areas signposted in advance?			
Are shelters and seats located safely to ensure that sight lines are not impeded? Is clearance to the road adequate?			
Is the height and shape of the kerb at bus stops suitable for pedestrians and bus drivers?			
6.9 Bridges and culverts			
6.9.1 Design features			
Are bridges and culverts the full formation width?			
Are bridge and culvert carriageway widths consistent with approach conditions?			
Is the approach alignment compatible with the 85th percentile travel speed?			
Have warning signs been erected if either of the above two conditions (i.e. width and speed) are not met?			
6.9.2 Crash barriers			
Are there suitable traffic barriers on bridges and culverts and their approaches to protect errant vehicles?			
Is the connection between barrier and bridge safe?			
Is the bridge free of kerbing that would reduce the effectiveness of barriers or rails?			
6.9.3 Miscellaneous			
Are pedestrian facilities on the bridge appropriate and safe?			
Is fishing from the bridge prohibited? If not, has provision been made for safe fishing?			

Issue	Yes	No	Comment
Does delineation continue over the bridge?			
6.10 Pavement			
6.10.1 Pavement defects			
Is the condition of the pavement edges satisfactory?			
Is the transition from pavement to shoulder free of dangerous edge drop offs?			
Is the pavement free of defects (for example, excessive roughness or rutting, potholes, loose material, etc.) that could result in safety problems (for example, loss of steering control)?			
6.10.2 Skid resistance			
Does the pavement appear to have adequate skid resistance, particularly on curves, steep grades and approaches to intersections?			
Has skid resistance testing been carried out where necessary?			
6.10.3 Ponding			
Is the pavement free of areas where ponding or sheet flow of water could contribute to safety problems?			
6.10.4 Loose stones/material			
Is the pavement free of loose stones and other material?			
6.11 Parking			
6.11.1 General issues			
Are the provisions for, or restrictions on, parking satisfactory in relation to traffic safety?			
Is the frequency of parking turnover compatible with the safety of the route?			
Is there sufficient parking for delivery vehicles so that safety problems due to double parking do not occur?			
Are parking manoeuvres along the route possible without causing safety problems? (for example, angle parking)			
Is the sight distance at intersections and along the route, unaffected by parked vehicles?			
6.12 Provision for heavy vehicles			
6.12.1 Design issues			
Are overtaking opportunities available for heavy vehicles where volumes are high?			
Does the route generally cater for the size of vehicle likely to use it?			

Issue	Yes	No	Comment
Is there adequate manoeuvring room for large vehicles along the route, at intersections, roundabouts, etc.?			
Is access to rest areas and truck parking areas adequate for the size of vehicle expected? (consider acceleration, deceleration, shoulder widths, etc.)			
6.12.2 Pavement/shoulder quality			
Are shoulders sealed at bends to provide additional pavement for long vehicles?			
Is the pavement width adequate for heavy vehicles?			
In general, is the pavement quality sufficient for the safe travel of heavy and oversized vehicles?			
On truck routes, are reflective devices appropriate for truck drivers' eye heights?			
6.13 Floodways and causeways			
6.13.1 Ponding, flooding			
Are all sections of the route free from ponding or flow across the road during wet weather?			
If there is ponding or flow across the road during wet weather, is there appropriate signposting?			
Are floodways and causeways correctly signposted?			
6.13.2 Safety of devices			
Are all culverts or drainage structures located outside the clear roadside recovery area?			
If not, are they shielded from the possibility of vehicle collision?			
6.14 Miscellaneous			
6.14.1 Landscaping			
Is landscaping in accordance with guidelines? (for example, clearances, sight distance)			
Will existing clearances and sight distances be maintained following future plant growth?			
Does the landscaping at roundabouts avoid visibility problems?			

Issue	Yes	No	Comment
6.14.2 Temporary works			
Are all locations free of construction or maintenance equipment that is no longer required?			
Are all locations free of signs or temporary traffic control devices that are no longer required?			
6.14.3 Headlight glare			
Have any problems that could be caused by headlight glare been addressed? (for example, a two-way service road close to main traffic lanes, the use of glare fencing or screening)			
6.14.4 Roadside activities			
Are the road boundaries free of any activities that are likely to distract drivers?			
Are all advertising signs installed so that they do not constitute a hazard?			
6.14.5 Errant vehicles			
Is the roadside furniture on the verges and footways free of damage from errant vehicles that could indicate a possible problem, hazard or conflict at the site?			
6.14.6 Other safety issues			
Is the embankment stability safe?			
Is the route free of unsafe overhanging branches?			
Is the route free of visibility obstructions caused by long grass?			
Are any high-wind areas safely dealt with?			
If back-to-back median kerbing is used is it: • adequately delineated? • obvious where it starts? • obvious at intersections? • unlikely to be a hazard to pedestrians?			
6.14.7 Rest areas			
Is the location of rest areas and truck parking areas along the route appropriate?			
Is there adequate sight distance to the exit and entry points from rest areas and truck parking areas at all times of the day?			

Issue	Yes	No	Comment
6.14.8 Animals			
Is the route free from large numbers of animals? (for example, cattle, sheep, kangaroos, koalas, wombats, etc.)			
If not, is it protected by animal-proof fencing?			
6.14.9 Safety aspects for heavy vehicles not already covered			
Have all other matters which may have a bearing on safety for heavy vehicles been addressed?			

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