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Chapter 3

Road Planning and Design Fundamentals

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Chapter 3 Amendments – December 2005

Revision Register

Issue/ Rev No.	Reference Section	Description of Revision	Authorised by	Date
1	-	First Issue	Steering Committee	Oct 2000
2	Section 3.4.2	Modified. New section added.	Steering Committee	Aug 2001
	New	References.		
	New	Relationship to Other Chapters.		
3	All	New Chapter.	Steering Committee	Aug 2004
4	All	Some headings, figures and tables renumbered. References in text amended to reflect the renumbering.	Steering Committee	Dec 2005
	Various sections	Term “standard” changed to design criteria, design parameter or design value where appropriate. Term “desired speed” introduced for the term “speed environment” (the two are largely analogous). Terms “Normal Design Domain” and “Extended Design Domain” (EDD) introduced where appropriate. Some minor amendments to various sections.		
	Section 3.2.1	“Community consultation” removed and replaced with “community engagement”. Text, related figures and references corrected to reflect new Main Roads community engagement publications.		

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Issue/ Rev No.	Reference Section	Description of Revision	Authorised by	Date
4	Sections 3.2.5, 3.2.5.1, 3.2.5.2, 3.2.5.3, 3.2.5.4, 3.2.5.5 and 3.2.5.6 (new)	New section “Other design issues” included. Text relating to design factors previously dispersed in other sections moved into this Section. This includes “Road geometry” (Section 3.2.5.1), “Pavements” (Section 3.2.5.2), “Intersections and interchanges” (Section 3.2.5.3), “Roadside furniture” (Section 3.2.5.4), “Public Utility plant (PUP) (Section 3.2.5.5)” and “Drainage” (Section 3.2.5.6).	Steering Committee	Dec 2005
	Section 3.3.2.2, 3.3.2.3, 3.3.2.4, 3.3.2.5, 3.3.2.6 and 3.3.2.7 (old)	Sections deleted and content moved to new Section 3.2.5 (see above).		
	Section 3.3.2 (new)	New content/new section titled “Design for road safety”.		
	Section 3.4.1.3	Dot points amended to include additional references.		
	References	Additional references added and others corrected.		

Chapter 3
Road Planning and Design Fundamentals

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3.1 Objectives

The objective of this chapter is to provide planners and designers with sufficient information on the fundamentals underpinning the planning and design of roads to allow them to understand the context of their projects and the bases for decisions taken. It brings together the issues to be considered and discusses, in a general sense, environmental considerations, transport planning principles, engineering considerations, public consultation, whole of life issues and crime prevention. It does not deal with the details of the planning and design process, which is described in the Pre-construction Processes Manual (Main Roads, 2005).

The structure of this Chapter is framed around the outcomes required by Roads Connecting Queenslanders (RCQ - Main Roads, 2002), namely:

- safer communities;
- industry competitiveness and growth;
- liveable communities; and
- environmental conservation.

These outcomes required are addressed in terms of the requisite outputs of Main Roads which are:

- safer roads;
- efficient and effective transport;
- fair access and amenity; and
- environmental management.

This Chapter also provides general information on some of the principles to be adopted in each of the areas, and then provides guidance on the application of these principles. (It is not a comprehensive reference on many of the areas covered but serves to highlight to designers and planners the breadth of the aspects that must be considered in planning and design. Designers and planners should consult the references given in this Chapter as well as other relevant references for detailed or specific information not covered in this Chapter.)

Some elements of the planning and design process do not fit neatly into Main Roads' RCQ outputs and a separate section on overarching issues is included to cover these matters (Section 3.2). These overarching issues tend to be ones that apply to more than one of the outputs or are relevant to a wide spectrum of the planning and design considerations.

While the chapter discusses issues separately by necessity, the total process is an integrated one in which each of the issues can impinge on the others with varying degrees of impact. The planning and design process must recognise this interaction between the issues and approach the project in a holistic way, considering all of the issues together (i.e. produce a context sensitive design, refer to Chapter 2).

Roads are a facilitator of human, social and economic activity. The planning and design process must deliver a product that is suitable for its intended use with an acceptable environmental impact. It must also accommodate the appropriate needs of all users within the boundaries of the transport corridor. Further, providing road infrastructure can achieve other societal objectives, as prescribed by Government from time to time, and the planning and design process should also consider these objectives.

When undertaking a particular project, the requirements of the investment strategies, link strategies and the Strategic Framework for Road System Asset Management (Main Roads, 2003) must be incorporated. These will be determined in the early phases of the project and must be carried through in the detailed design to ensure the integrity of the project.

Planners and designers should:

- consult widely to determine the aspirations of stakeholders and potential issues;
- adopt a holistic approach to the planning and design arriving at an appropriate balance between all of the competing factors (refer to Chapter 2);
- visit the project site before completing the planning and the design processes to ensure that all of the proposed design elements are practical for the site.
- visit the project site after construction to gain feedback on the success or otherwise of the adopted design; and
- ensure that the adopted values for all design elements are appropriate for the:
    - purpose of the road;
    - function of the road
    - type of road; and
    - the outcomes expected from the project.

3.2 Overarching issues

3.2.1 Community engagement

The management and administration, which includes planning and design, of the road system is a community driven one and an important element at every stage of the process is community engagement and consultation with stakeholders.

"Stakeholders are those individuals, groups and organisations who are likely to be affected by and/or have an interest in Main Roads' decisions and actions. These include communities, industry, businesses and government." (Main Roads, 2005)

Stakeholders therefore include, but are not limited to, affected and adjoining landowners, relevant statutory authorities (e.g. Local Government, other Government Departments, Public Utility Plant [PUP] Authorities), industry bodies and users of the facility. The identification and involvement of stakeholders throughout all phases will help to ensure that all issues and needs are identified and considered and will lead to outcomes with a high degree of support and ownership (Figure 3.1).

Community engagement and consultation, including public consultation, are therefore an essential part of all planning and design activities. To get the best results, it is necessary to start with a "clean sheet" and develop the project as the input from the consultation process unfolds (Figure 3.2). If this is not done, the consultation process will suffer from a perception that Main Roads has made up its mind and is in the process of selling the proposal (rather than listening and consulting). Figure 3.2 also shows that the ability to make changes (e.g. through community engagement) reduces as a project progresses through each phase; early engagement of the community is therefore important. Figure 3.3 outlines the community engagement process.

The "clean sheet" approach is particularly applicable to route location proposals and "green field" sites. Some modification to the process could be justified when the proposal is to upgrade an existing facility (e.g. a restoration project). The initial community engagement and consultation will require information on the need for the upgrade and the general concept behind it. This will allow the stakeholders to understand the intent of the project and to provide more informed input. However, it is desirable that alternative proposals for the project be generated after the initial input so that they can be developed in the knowledge of the range of community concerns. The second part of community engagement and consultation will then have more specific proposals to consider and this can result in additional issues arising. This approach retains the essential elements of the "clean sheet" approach and avoids settling on preferred alternatives too early in the process.

3.2.1.1 Further information

To support policy implementation and community engagement practice, community engagement programs should be undertaken in accordance with the following documents (Main Roads, 2005):

- Community engagement policy, principles, standards and guidelines – this publication contains Main Roads' policy statement, standards and guidelines linked to the Queensland Government's principles for community engagement.
- Community engagement planner - this publication contains a practical step-by-step planner to be used when engaging communities.
- Community engagement toolbox - this publication contains tools that can be used when informing, consulting and actively engaging communities.
- Community engagement resource guide - this publication contains practical "how to" information such as community profiling, managing expectations, risk, engaging target groups, holding a meeting, questionnaires and evaluation.

For detailed information regarding community engagement, planners and designers should refer to the above publications. Some useful definitions are included below.

Further guidance for specific communities is provided by the following publications (Department of Aboriginal and Torres Strait Islander Policy and Development, 1998):

- Protocols for Consultation and Negotiation with Aboriginal People; and
- Mina Mir Lo Ailan Mun: Proper Communication with Torres Strait Islander Peoples.

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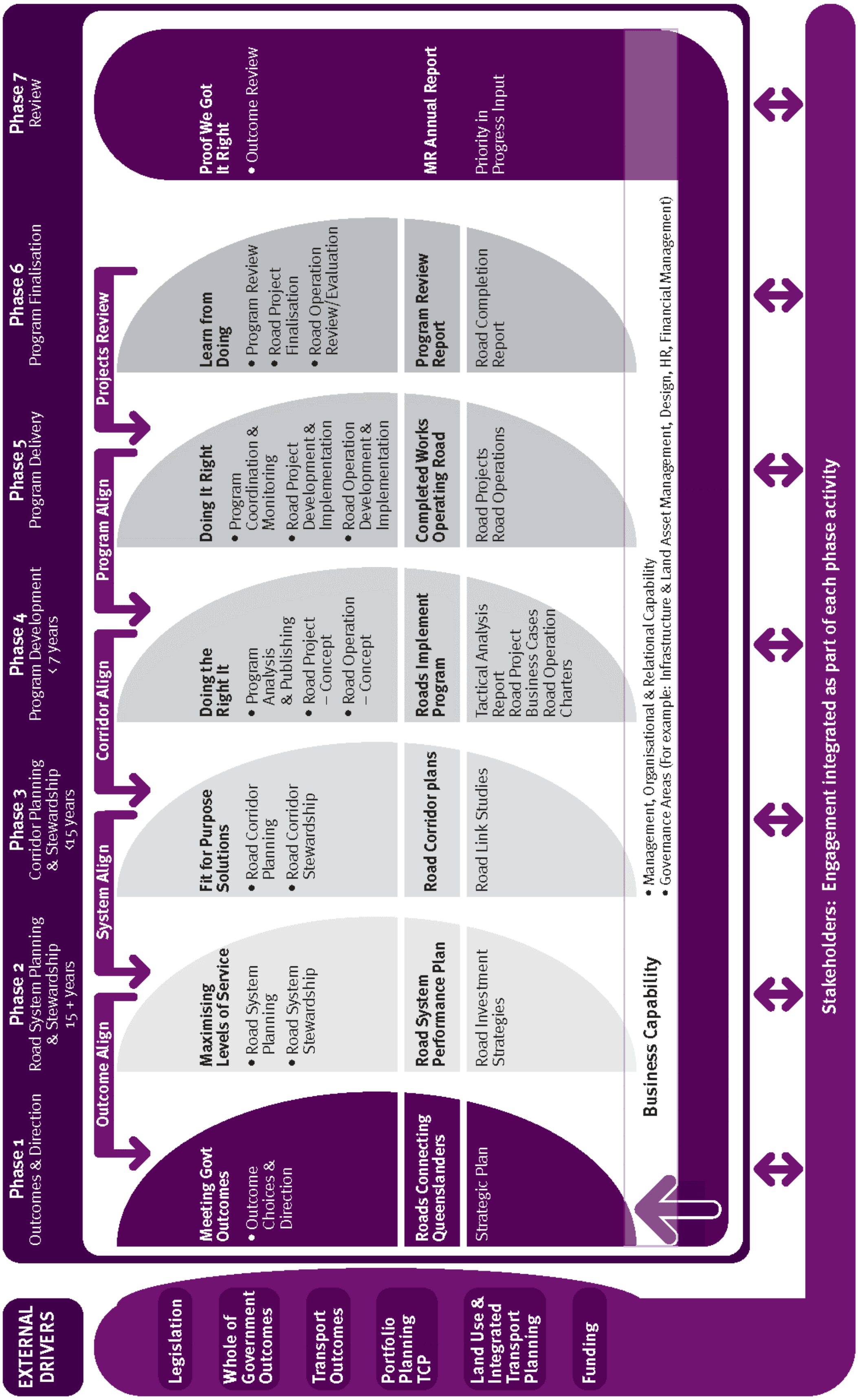

Figure 3.1 Consultation - the Road System Manager perspective (Main Roads, 2005)

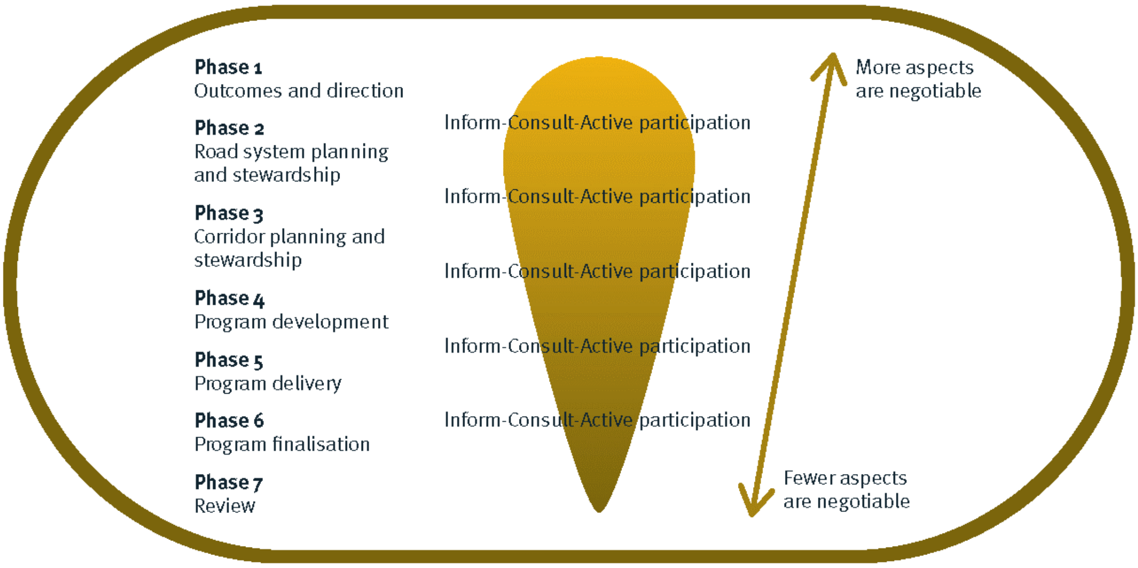

Figure 3.2 Community engagement across the Road System Manager phases (Main Roads, 2005)

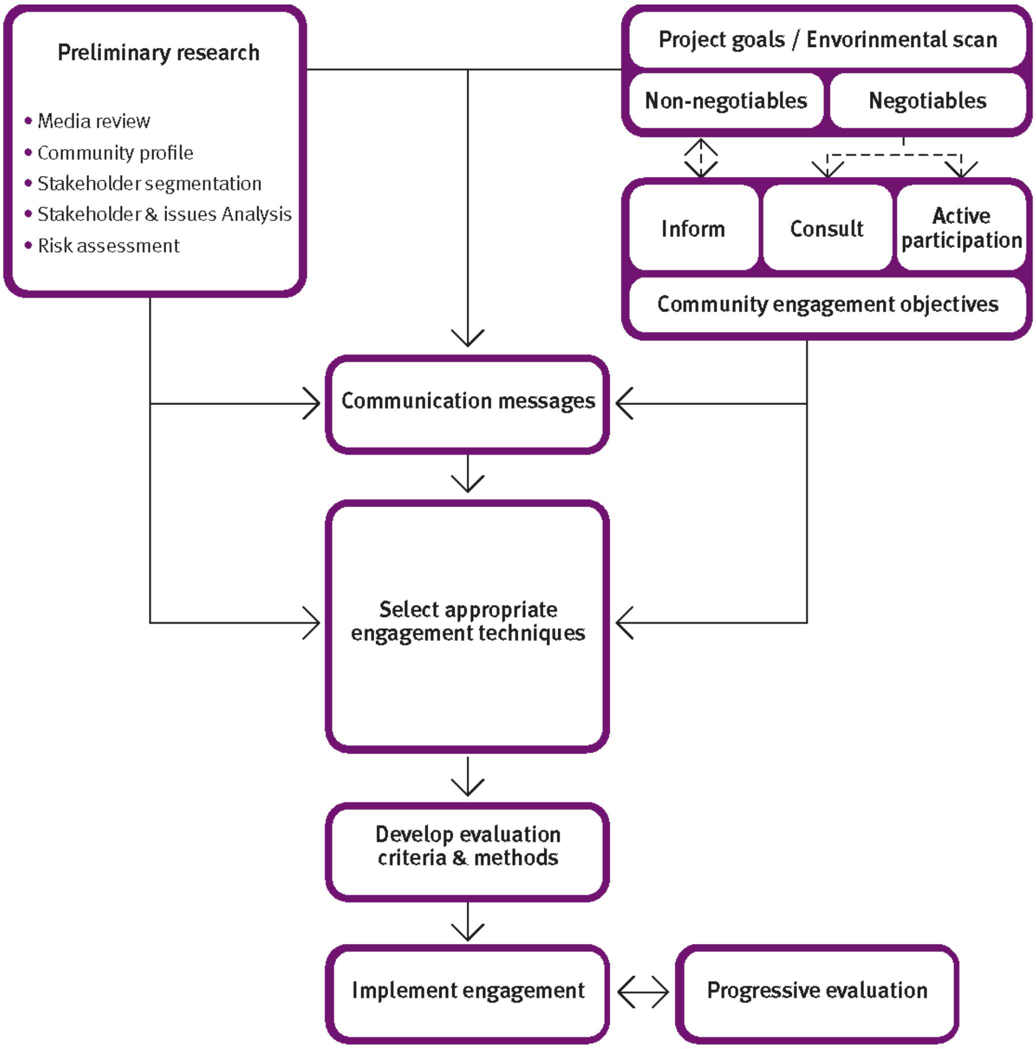

Figure 3.3 The overall community engagement process (Main Roads, 2005)

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Community engagement is:

"…one of the many ways that communities and individuals connect and interact with government in developing and implementing policies, programs and services. It involves a wide range of government-community interactions, ranging from information to consultation and active participation. Engagement can be formal or informal, direct or indirect" (Main Roads, 2005).

Consultation is:

"… a two-way relationship where the views of individuals and communities are sought on policies, programs, services and projects that affect them directly or in which they may have a significant interest" (Main Roads, 2005).

Further:

"Consultation can occur at various points and can be used to help frame an issue, identify or assess options and evaluate existing policies, programs, services or projects. Issues can be specific or quite general. Consultation includes face-to-face meetings, advisory committees, focus groups, online consultation, public meetings, petitions, polls and surveys.

Consultation can be used to work with communities on road projects and road operations, to discuss the impacts of existing policies and programs and to seek solutions to community issues.

Consultation alerts staff to community issues such as the impacts of project timing on small businesses" (Main Roads, 2005).

Information is:

"…a one-way relationship in which information is disseminated to communities and individuals. It covers both passive access to information by individuals via a range of avenues such as the telephone, publications and websites and active measures by government, to disseminate information to individuals through education and awareness activities. While this is not public involvement, information and communication technologies enable government to move beyond one-way information sharing to an information exchange with individuals" (Main Roads, 2005).

Active participation is:

"Active participation recognises and acknowledges a role for individuals and communities in shaping policy dialogue and proposing policy, program, service and project options" (Main Roads, 2005).

Further:

"It is achieved through a range of deliberative processes, including steering committees, search conferences, policy roundtables, citizen juries and formal and informal partnerships. Active participation processes enable individuals and communities to raise their own issues with government and can also encourage or enable participants to take responsibility for their contribution to solutions.

Active participation actively involves and empowers people in Main Roads decision process. It can be used as part of community visioning of transport plans and future road-system planning. However, some decisions cannot be changed (such as political decisions, legal and legislative conditions or the location and extent of a road project). In these instances, active participation should not be used as expectations may be raised that cannot be met" (Main Roads, 2005).

3.2.2 Local Government involvement

All proposals will impact on the responsibilities of Local Government in some way. Consultation with the relevant Local Government/s at all stages of the process is therefore essential. Agreement must be reached on the details of the project and in particular, any requirements for changes to Local Government infrastructure or for Local Government input into the project.

Development of proposals will have to consider the implications of the alliance between the Department and Local Government (Main Roads, 2000) respecting the protocols of that alliance, and taking the needs of the whole road system into account when deciding on the best options. Integration with the land use planning undertaken by Local Government is an essential part of the planning process (viz. the Integrated Transport Planning Framework for Queensland: A Guide for Transport Planning, Queensland Government, 2003). (Refer also to the Integrated Development Assessment System Manual, Main Roads).

It is also necessary to reach agreement on the cost sharing arrangements if applicable. The "Agreement between the Local Government Association of Queensland Inc. and Department of Main Roads for Cost Sharing based on Responsibilities within State Controlled Roads" (Main Roads, 2000) sets out this agreement. It must be applied in discussions with the relevant Local Government/s on these matters. Project Managers should ensure that adequate warning is given to Local Governments to fund their share of the works. Local Governments normally need costs confirmed at least one financial year in advance of the commencement of construction. Where adequate time can not be provided, an alternative arrangement for payment might need to be negotiated.

3.2.3 Whole of Government approach

Main Roads is committed to working across the whole of government to deliver integrated outcomes to Queenslanders. In many cases it will mean that the objectives and policies of other departments will have to be considered in the planning decisions taken. Consultation with those departments is essential to ensure that planners and designers consider all factors in the planning process.

In particular, the various State Planning Policies (SPPs – Queensland Government, 1992 to 2005), and their associated guidelines, could have an impact on decisions for projects and must be implemented where applicable. These include:

- SPP 1/92 "Development and conservation of agricultural land."
    - Guideline 1 for SPP 1/92: "The identification of good quality agricultural land."
    - Guideline 2 for SPP 1/92: "Separating agricultural land and residential land uses."
- SPP 1/02 "Development in the vicinity of certain airports and aviation facilities."
    - Guideline for SPP 1/02: "Development in the vicinity of certain airports and aviation facilities."

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- SPP 2/02 "Planning and managing development involving acid sulphate soils."
  - o Guideline for SPP 2/02: "Planning and managing development involving acid sulphate soils."
- SPP 1/03 "Mitigating the adverse impacts of flood, bushfire and landslide."
  - o Guideline for SPP1/03: "Mitigating the adverse impacts of flood, bushfire and landslide."

(Note: At the time of publication a "Draft SPP Protection of Extractive Resources" also existed.)

At the time of publication copies of State Planning Polices policies could be found under the Integrated Planning Act area of the Department of Local Government and Planning website (refer to References section).

In addition the State Coastal Management Plan (Queensland Environmental Protection Agency, 2002), and relevant regional coastal management plans, may affect projects. At the time of publication details of these plans could be found on the Environmental Protection Agency website (refer to References section).

3.2.4 Major structures

Chapter 22 discusses the requirements of major structures (i.e. bridges, retaining walls and tunnels) and their impact on road and project development. It provides guidance on the potential structures to be used and how the choice of the type of structure can affect the cost of the project.

Factors to be considered in the design of structures include:

- whether screening is required (refer to the "Reduction of Risk from Objects Thrown From Overpass Structures onto Roads" Policy - Main Roads, 2004);
- the required flood immunity for bridges (defined in the Road Drainage Design Manual [RDDM - Main Roads, 2001]);
- the type of structure required (e.g. bridge or tunnel) and their form (refer to Chapter 22);
- cross section requirements (discussed in Chapter 7, supplemented by Chapter 22);
- the bridges required for interchanges (discussed in Chapters 16 and 22);
- provision for enforcement (e.g. speed cameras on overhead bridges); and
- requirements for PUP noting that:
  - o requirements should be determined early in the planning process;
  - o PUP inside closed cells of bridges or tunnels can pose a serious hazard, for example:
    - water and sewer lines can leak so proper drainage is required; and
    - gas mains should not be placed inside closed cells because of the risk of explosion;
  - o high-pressure gas mains present a serious explosive hazard if ruptured and should not be placed on or near bridges or in tunnels without incorporating and taking special precautions;
  - o high voltage electrical cables may have a significant heat output and may require ventilation;

- o PUP Authorities may have restrictions on the location of their PUP with respect to other PUP;
- o electrical cable ducting for street lighting is to be provided on bridges where required for present or future lighting; and
- o PUP may be provided for:
  - in the footway/bikeway;
  - via suspension from the side of prestressed units; or
  - under the deck in girder bridges as permitted by the PUP Authority.

3.2.5 Other design issues

The following sections discuss some of the issues planners and designers should consider in the planning and design process. Technical details of these issues are covered in other parts of this Manual or in other manuals and publications (refer to References section in each chapter). These are identified where appropriate.

3.2.5.1 Road geometry

The road geometry has to be designed in accordance with the requirements set out in this Manual for the design criteria set by the Investment and Link Strategies. Additional considerations include:

- school zones which have their own speed limits (refer to the Manual of Uniform Traffic Control Devices [MUTCD] – Main Roads, 2003);
- high rainfall areas where special attention to pavement surfacing is required, particularly where alignments are winding, steep or heavily trafficked;
- aquaplaning which should be minimised in planning and design to reduce the effect of the combination of superelevation and grade on depth of water (refer to the RDDM [Main Roads, 2001]);
- areas of fog which require good delineation;
- runaway vehicle facilities (refer to Chapter 15); and
- roadside hazards, in particular the presence of potential hazards (refer to Chapter 8).

Roadside hazards should be removed where possible or protected with a safety barrier where warranted (refer to Chapter 8.)

3.2.5.2 Pavements

Pavements can be the most expensive part of a project and considerable attention to the design of the pavement is required at the options analysis, business case and preliminary design phases (i.e. Program Development Phases and Program Delivery) to obtain a reasonable estimate of the cost of the works. The type of pavement affects the cross section and both need to be designed in conjunction with each other.

Groundwater water can adversely affect the useful life, and maintenance requirements, of pavements. Groundwater water can also be critical to adjacent rural properties and care is required that the road construction does not cut off this supply. Appropriate treatments and subsurface drainage requirements must be determined and incorporated into the design, even in dry areas.

Details of the approach to pavement design can be found in the Pavement Design Manual (Main Roads, 2004). For special

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pavements (e.g. heavy-duty motorway pavements), specialist advice should be obtained. Similarly, details of the approach to pavement rehabilitation design can be found in the Pavement Rehabilitation Manual (Queensland Transport, 1992). For special treatments (e.g. foamed bitumen stabilisation) specialist advice should be obtained.

Further discussion on pavements is contained in Section 3.4.6.2.

3.2.5.3 Intersections and interchanges

Details of intersection and roundabout requirements are included in Chapters 13 and 14, respectively. Chapter 16 deals with interchanges and motorways.

3.2.5.4 Roadside furniture

Elements of roadside furniture to be considered and dealt with include:

- Signs (refer to the Manual of Uniform Traffic Control Devices [MUTCD - Main Roads, 2003] the Traffic and Road Use Management [TRUM] Manual [Main Roads, 2003] and the Traffic Control Sign Design Manual [Main Roads, 2000]);
- Existing advertising signage including that associated with Service Centres (refer to the Guide to the Management of Roadside Advertising [Main Roads, 2002] and the contract with the Service Centre Operator);
- Pavement markings (refer to the MUTCD [Main Roads, 2003] the TRUM Manual [Main Roads, 2003] and the Guide to Pavement Markings [Main Roads, 2000]);
- Lighting, including route and intersection lighting (refer to Chapters 8 and 17);
- Traffic signals (refer to Chapters 8 and 18);
- Noise barriers (refer to Chapter 8 and the Road Traffic Noise Management: Code of Practice [Main Roads, 2000]);
- Road edge guide posts (refer to Chapter 8);
- Help telephones (refer to Chapter 8 and the TRUM Manual [Main Roads, 2003]);
- Safety barriers (refer to Chapter 8);
- Fencing (refer to Chapter 8);
- Crime Prevention through Environmental Design (CPTED) principles (refer to Section 3.3.4); and
- Other roadside furniture (refer to Chapter 8).

The Standard Drawings Manual (Main Roads, 2004) also contains information on many items of road furniture.

Design considerations relevant to noise barriers are provided in the Road Traffic Noise Management: Code of Practice (Main Roads, 2000 - also refer to Section 3.5.4.3).

Some further discussion on roadside furniture is contained in Section 3.4.6.2.

3.2.5.5 Public Utility Plant (PUP)

Alterations and/or relocations of PUP, also known by the term “services”, can be one of the most expensive components of a road construction project. The location and size of all PUP must be determined early in the process to allow appropriate adjustments in the proposals to minimise the costs involved. The relevant PUP authorities must be consulted to obtain accurate information in addition to what can be ascertained from ground survey. Future proposals for the upgrading of any PUP installations should also be determined. PUP includes, but is not limited to:

- Telecommunications:
  - telephone exchanges;
  - high bandwidth communication conduits – fibre optic cables, co-axial cables;
  - low bandwidth communications - local connections;
  - cables;
  - satellite communication facilities; and
  - high bandwidth communication towers.
- Water:
  - large reticulation systems;
  - pressure mains;
  - water towers, storage tanks; and
  - pump stations.
- Wastewater and sewerage:
  - pump stations;
  - large mains; and
  - pressure mains.
- Electricity:
  - towers;
  - high voltage overhead lines;
  - substations;
  - power pole mounted transformers; and
  - underground cables.
- Gas:
  - gas mains.
- Oil pipelines.

PUP also includes associated ancillaries (e.g. pits, manholes, valves, etc).

A detailed assessment of PUP relocation requirements must be undertaken at business case stage; it should also be considered, perhaps in less detail, at the options analysis stage. It is necessary to determine the extent of the work and to assess whether early relocation might be advantageous to facilitate the construction process. The various PUP authorities should be advised early in the business case stage of the proposals so that any affected PUP can be identified.

Where possible, relocation of PUP should be minimised by judicious adjustment to the design. Minor changes to the design can often be made without compromising the standard of the design and major savings can consequently be achieved.

If stage construction is involved, PUP should be placed in its final location, clear of the final works, if possible.

Chapter 7 provides guidance on the clearances required for (overhead and underground) PUP as well as desired locations for PUP in the road reserve.

The presence, relocation or protection of PUP must also be considered and taken into account for temporary works constructed or used to facilitate construction (e.g. construction of a temporary side track, use of a detour by high vehicles, etc).

Further discussion on PUP is contained in Section 3.4.6.5.

3.2.5.6 Drainage

Drainage of pavement surfaces has a significant impact on safety. In particular, aquaplaning or partial aquaplaning can occur when the conditions are conducive to it and the design of the geometry of the road must take this into account. The phenomenon of aquaplaning is discussed in detail in the RDDM (Main Roads, 2001).

Care is required in the combination of geometric elements that can lead to increasing the depth of water on the pavement surface. Specifically, the combination of vertical grade, horizontal curvature and superelevation can create situations where the water falling on the surface stays on the surface, gaining depth as it flows across the pavement from side to side.

Water flowing across the surface can be a hazard (e.g. aquaplaning may result) if:

- it deposits material on the road surface (e.g. gravel, sand);
- a driver enters the flowing water at too high a speed; and/or
- the water is too deep for safe navigation by vehicles (e.g. from overland flow onto the road).

Material deposited on the road by water flowing across it can be a hazard, particularly where the side friction demand is high. It will also be particularly hazardous to vulnerable road users, such as motorcyclists.

Where possible overland flows should be controlled (e.g. through the use of catch banks/drains and culverts) to avoid potential problems and to minimise hazards to users.

Care is required to ensure that the surface of the water over a floodway is visible for sufficient distance before a floodway, allowing a driver sufficient time to stop or slow down before entering the water. Appropriate signing (e.g. flood depth indicators), and good visibility to it, is essential.

For more detail on these issues, refer to Chapter 12, and the RDDM (Main Roads, 2001).

Further discussion on drainage is contained in Section 3.6.5.3.

3.3 Safer roads

3.3.1 General principles

Safer roads are to support safer communities, which means investing in a safer road network by setting design criteria, design values and interventions that achieve the best impact for the whole road system, through:

- improving road network safety using a risk management approach;
- designing for safer travel for all road users;
- providing safer access to the road system for cyclists and pedestrians;
- ensuring worksite safety; and
- co-ordinating with other government agencies in partnership.

Network considerations are discussed in Chapter 1 and the basis for selecting design criteria, design values and interventions is discussed in Chapters 2 and 4.

3.3.2 Designing for road safety

3.3.2.1 Introduction

There is an implicit contract of trust between the travelling public and the agency providing and managing the road network on which they travel. By extension, this trust is also between the road user and the road designer. The essence of the trust is that road users may rightly expect the agency and its employees to use the best available knowledge in order to decide how much safety to build into the roads they produce. Not using such knowledge amounts to a breach of trust (Hauer, 1999).

The aim of those developing policies (e.g. policy makers, strategic planners), link strategies and investment strategies, as well as all road designers, must therefore be to provide the safest road possible within the constraints of cost, operating efficiency and environmental impact, etc. All road design is therefore a compromise between a range of factors (refer to Chapter 2).

To be able to produce the best result, there must be a clear understanding of what is meant by road safety and how the decisions of the policy maker and the designer affect the safety of the road in question.

This section of the Manual addresses the question of safety, what it means and how policy makers, strategic planners, designers, etc need to act to achieve the appropriate level of safety in their designs.

In this Chapter, the term used will be "crashes" rather than "accidents" to accord with the standard terminology used in the recording and analysis of road trauma in Australia.

3.3.2.2 Road safety – what is it?

Definitions

A dictionary definition of safety includes the statements (The Macquarie Library Pty Ltd, 1997):

- the state of being safe;
- freedom from injury or danger;
- the quality of insuring against hurt, injury, danger, or risk;
- a contrivance or device to prevent injury or avert danger; and
- the action of keeping safe.

There is no entirely safe road since crashes will occur. We only derive some meaning for "safety" by measuring the number of crashes, deaths and/or injuries, and comparing the rate of their occurrence on the roads in question in the system (however the rate is measured – refer to Section 3.3.2.3) with what is acceptable and achievable and with performance on similar roads in other jurisdictions (e.g. international experience).

Hauer (1999) notes that the safety of a road is measured by the frequency and severity of crashes occurring on it, and that road safety is therefore a matter of degree. He also notes that since crashes occur on all roads in use, it is inappropriate to say of any road that it is safe. However, it is correct to say that roads can be built to a nominal level of safety.

Safety concepts

Road safety is therefore a relative term referring to the difference in performance between roads when the crash rate (refer to Section 3.3.2.3) is measured. Thus a safer road will have a relatively lower crash rate than a less safe road. This does not mean that the number of crashes or deaths will be less on this "safer" road than on other "less safe" roads when the "safer" road is a very highly trafficked road such as a motorway. While well designed motorways are built to a high design standard (refer to definition of standard in Chapter 2) and can be considered among the safest roads built, the very high traffic volumes mean that the number of crashes and deaths will probably be larger than a rural road carrying a

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relatively small volume of traffic, even if that rural road has a much higher crash rate.

What constitutes "safety" must be more closely examined. How does an agency or a designer determine whether one road is "safer" than another? Traditionally, design has relied on developing elements of the road by an objective analysis of the particular situation using the laws of physics and measures of the factors being input into those laws (e.g. eye height, object height, deceleration rate) applied using an objective assessment of human behaviour in that situation (refer to the discussion pertaining to design criteria based on objective safety in Chapter 2).

But do design criteria determined in this way provide an assurance of safety? To assess this, a useful approach is suggested by Hauer (1999) who proposes a clear distinction between two kinds of safety to analyse situations, namely:

- substantive safety is the measured or expected crash frequency and severity;
- nominal safety is produced by a design that complies with design criteria, warrants and guidelines, and sanctioned design procedures.

Substantive safety is a matter of degree. A road in use cannot be safe, only safer or less so. What level of substantive safety is appropriate is therefore governed by considering what level of safety is attainable with the resources available. In contrast, a road can be nominally safe, meaning that it conforms to design criteria, warrants and guidelines, and sanctioned design procedures. Whether a road that is nominally safe is always (or even usually) substantively safer than a road that is not nominally safe cannot be said definitively (from Hauer 1999).

Ideally, there should be sufficient information on the effect of changes in design elements on the level of safety to allow an objective assessment of "substantive" safety. In this ideal case it would be unnecessary to consider "nominal" safety. This level of information is not currently available for many design criteria but the following four aspects of nominal safety still have value (Hauer, 1999):

- Designs must enable road users to behave legally. This can be attained by nominal safety.
- Designs should not create situations with which a significant minority of road users has difficulties. This too can be secured by making roads nominally safe.
- Nominal safety is useful protection against claims of professional and legal liability.
- Resorting to nominal safety may be a temporary necessity when crash frequency and severity consequences are unknown. In such cases, a statement about the absence of crash-based information is needed.

It is the case that the nominal safety models are based on logical analysis and are intuitively sound. They have in general stood the test of time with modifications implemented when actual crash rates have indicated that change was necessary. They also provide a framework on which substantive safety analysis can be based. Most researchers have found difficulty in obtaining robust relationships between road geometry and crash rates.

The crash history of a road should be observed and regularly assessed over time as part of the assessment of the safety of a road.

3.3.2.3 Measuring road safety

Information on road crashes, deaths and injuries is collected world wide in a range of formats including:

- total number of crashes;
- total number of deaths;
- motor vehicle crashes per 100 million kilometres;
- motor vehicle deaths per 100 million kilometres;
- fatality rates per 10,000 licensed motor vehicles;
- fatality rates per 100,000 population;
- road accident costs (e.g. total cost, percentage of Gross National Product) and;
- costs per crash type (e.g. fatal, major injury, minor injury, property damage only).

Further analysis of crashes includes determination of:

- crash rate by gender;
- proportion of children under 15;
- proportion of pedestrians among fatalities; and
- crash rate by type of road facility.

For the purposes of determining the effect of road design elements on the crash rate, it is necessary to include the exposure of drivers to potential crashes. That is, the measure must relate to the overall usage of the road; the rate of crashes per 100 million vehicle kilometres of travel (vkt) is the most commonly used measure. The other measures described above have uses for other purposes but do not usually provide the type of information required to judge the appropriateness or otherwise of design elements.

Researchers have studied road crashes with a view to determining the relationship between the crash rate and the features of the road including the various geometric elements. This research has not always been conclusive but some useful relationships for some geometric elements have been found such as for roundabouts (Arndt, 1994), intersections (Arndt, 2004), shoulder widths (Armour and McLean, 1983) and cross section elements (McLean, 1996). However, there are many elements of design where there has been no successful development of a specific relationship between changes in the element and the crash rate although some general trends have been demonstrated (refer to Chapter 2.)

3.3.2.4 Road crashes

Crashes occur when some part or parts of the road system fail. The road system is a complex, dynamic and fundamentally unstable system, the use of which has devastating consequences for many (Fuller et al, 2002). The road system is made up of three components – the human, the vehicle and the environment (including the road itself) in which they operate.

PIARC (2003) states that an accident (sic) is a disruption of the balance among the three components of the human-environment-vehicle system leading to the following principles:

- each accident is the result of a succession of events occurring under precise circumstances;

- each event can be related to one or more of the components of the road safety system;
- an adverse conjunction of events is the explanatory cause of the malfunction; and
- each event is largely determined by preceding events and their circumstances.

A crash can therefore occur when sufficient factors are in alignment and create the conditions for it. For example, a driver's inattention combined with an unexpected change in direction on a narrow formation leading to his/her vehicle being on the wrong side of the road at the same time as a vehicle is coming in the other direction are all the ingredients for an inevitable serious crash. Removing the unexpected change in direction on a narrow formation may avert the crash.

3.3.2.5 Role of the designer

Designers must recognise the complexity of the system of which the road is one element and account for the human requirements as far as is reasonable. Consideration of the human user is paramount and the impact of human capability and behaviour must always be accounted for in any design.

Road users can only adapt so far to the system, therefore the system should be designed to be user friendly (Dewar et al, 2002). Making the road easy to "read" is an important part of this consideration and acceptance of this leads to the "self-explaining" road concept. If this concept is followed for an entire road link it will have that characteristic so important to improving the level of safety – consistency (refer to Chapter 2).

Consistency in design (of a road link) aims to produce consistent expectations in drivers' and so provide them with confidence that what they see ahead gives an appropriate message so they can anticipate and act with a high degree of confidence. It therefore allows the driver to develop virtually automatic responses to various situations, reducing the driver workload (i.e. freeing up the mental processes that would be consumed in deciding the actions required for an inconsistent feature for other important decisions).

An alternative approach, with similar intent is the "inherently safer road system" reported by Jagtman (2004) based on the following objectives:

- prevent crashes from happening in the first place as far as possible; and
- minimise the severity of the limited crashes that remain.

These objectives are underpinned by safety principles such as:

- functional use of the road network by preventing unintended use of the roads;
- homogenous use by preventing large differences in vehicle speed, mass and direction;
- predictable use thus preventing uncertainties amongst road users, by enhancing the predictability of route choices and the behaviour of road users; and
- the forgiving roadside environment concept (refer to Chapter 8).

Designers must recognise that drivers are not perfect and will make mistakes. Designers must therefore use error prevention and mitigation strategies to account for this. For example, drivers will occasionally leave the road and the designer must therefore try to warn the driver (e.g. audible line marking), keep the car occupants safe (e.g. provide a forgiving roadside environment with flat batters that are free of hazards), protect hazards (safety barrier), locate hazards outside clear zones if possible or mitigate the effect of leaving the road (install breakaway poles, install crash cushions, provide hazard free clear zones). In addition, the roadside must be made as safe as possible, the overall result being a forgiving roadside. (Refer to Chapter 8 for a description of the forgiving roadside concept.)

Designers must:

- understand the road system and the interaction between the parts of the system;
- understand the relation between design elements and crash rate;
- ensure that the combination of elements is appropriate to the circumstances;
- design with the user in mind (including the needs of both the older and younger population of drivers, motorcyclists pedestrians and cyclists);
- reduce or eliminate uncertainty or the unexpected for drivers; and
- take a holistic approach to design (i.e. produce a context sensitive design – refer to Chapter 2).

Since the only way of judging the level of safety is by the crash rate, it is necessary to know what the effect of changing a design element will be. This information is not available for all of the design elements but there is information available for:

- roundabouts (refer to Chapter 14 and Arndt, 1994); and
- intersections (refer to Chapter 13 and Arndt, 2004)

Although definitive relationships are not available some guidance is available on:

- cross sections (McLean, 1996); and
- shoulders (Armour and McLean, 1983).

Designers should never forget that the design is for the user, not the gratification of the designer. Users are complex beings and are an integral element of the system. All of the designs must recognise the frailty of the human being and, as far as possible, provide for this frailty. Eliminating uncertainty is one large step towards this objective.

A holistic approach involves taking an overall perspective and realising that road design is a compromise between the ideal and what is reasonable in terms of cost, safety and environmental impacts; the aim should be to produce a context sensitive design (refer to Chapter 2).

3.3.2.6 Guidance for designers

The application of safety design principles is an integral part of the development of the design criteria set out in the various chapters of this Manual. Assumptions made, and the principles adopted, are set out in the individual chapters and all designers should be familiar with those details.

The design philosophy to be used is described in detail in Chapter 2 and should be read in conjunction with this section.

Details of human factors are discussed in Chapter 5 and the principles set out in that chapter are an essential input into designing for safer operation.

Chapter 5 also deals with design vehicles and designers should be familiar with the

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requirements of the appropriate design vehicles, another essential component of the road system. Providing the appropriate dimensions for the vehicles using the system is integral to a safer design solution.

Further insights into the safety aspects of design are included in virtually all Chapters of this Manual.

3.3.2.7 Application of standards

How design criteria are applied is one of the most important aspects to design. The design philosophy set out in Chapter 2 makes clear that design cannot be merely the application of numbers from a set of prescribed design criteria. To do so implies that an adequate level of safety will be achieved if all of the elements meet at least the minimum criteria/values given in design publications.

This is clearly not the case. Consistent adherence to lower bound criteria/values only is not desirable and it may be more cost effective to adopt higher or lower design criteria/values. It also may not allow for future development of the road as more and different usage occurs.

When applied to a combination of features, lower bound design criteria may create operational and safety problems.

"The challenge to the designer is to achieve the highest level of safety within the physical and financial constraints of a project. The challenge requires the designer to go beyond the minimum levels of design to find the desirable level for each project" (AASHTO, 1997).

The crucial element is the appropriate combination of design criteria for each road element, which requires judgement and experience to be applied by the designer. Wherever possible, this judgement and experience should be based on objective assessment of the potential crash rate, particularly compared with other sections of the road link being designed.

Proper combination of design criteria can be used to mitigate a potentially less safe situation. For example, it might be necessary to compensate for adopting a lower bound value of one element by being more generous with an associated element. This is illustrated by the requirement for a wider carriageway when the radius of a vertical crest curve is less than desirable (refer to Chapters 4, 9 and 12). (This extra width allows drivers to manoeuvre.)

Other examples of appropriate combination of design criteria are included in the various chapters. A major issue for the combination of design criteria is that of combination of vertical and horizontal alignment, the subject of Chapter 10.

Designers should carefully consider the safety aspects of design as enunciated in this Manual when using the design criteria set out in this Manual.

3.3.2.8 Other sources of information

The references listed at the end of this Chapter provide much more detail than it is possible to cover in this section. The complexities of the human factors to be considered are detailed well in the two major publications cited (i.e. Fuller et al, 2002 and Dewar et al, 2002).

AASHTO's (1997) Highway Safety Design and Operations Guide provides useful advice on all aspects of design elements.

3.3.3 Worksite safety

Worksite safety falls into two categories:

- safety of the workforce undertaking the construction; and
- safety of road users (e.g. the general public, pedestrians, cyclists and motorists).

3.3.3.1 Safety of workers

Designs should ensure that the site is readily accessible by construction personnel and equipment, and that this can occur safely in the presence of other traffic. The worksite should be separated from the general traffic as far as possible and the workers protected from the passing traffic with appropriate delineation (and barriers if warranted). Details of temporary and permanent barriers are included in Chapter 8. Signage and reduced speed limits for road works may also be necessary; reference should be made to the MUTCD (Main Roads, 2003).

While the protection of workers is the responsibility of the construction contractor, it is necessary to ensure that the design adopted will allow appropriate protective measures to be used. It should also ensure that safe access arrangements are feasible and economical.

3.3.3.2 Safety of road users

Proper allowance for the safe movement of traffic, pedestrians and cyclists through both the worksite and the completed project must be designed into the project. The sequencing of the works during construction should allow for the:

- efficient and safe traffic movement through the worksite at all stages of the construction; and
- easy and safe pedestrian and cycle movement through and/or around the site providing protection for these users from the construction activity and from the passing traffic.

For projects delivered using the more traditional scheme delivery process (i.e. design, then tender and then construct) the scheme documents are not required to specify the sequencing of the construction process; that responsibility falls to the construction contractor. However, the scheme documents must specify the parameters or limits within which the construction contractor must operate.

Issues to be addressed include the following:

- Maintenance of access to property and business – this does not only include direct access to adjacent property but must consider the wider effect on customer access to established businesses.
- Pedestrian and cyclist movements – special pathways and protective devices could be required to ensure adequate and safe pedestrian and cyclist movement through the site. All pedestrian treatments must consider the needs of people with disabilities.
- Traffic movements – considerable attention must be given to the safety of traffic movement and the management of traffic through the project. This might include:
    - o reduced speed limits;
    - o lane closure/s;
    - o traffic diversion (via another route, i.e. detours); and
    - o construction of side tracks, paved and/or sealed, or other temporary roadways.

- Requirement for safety barrier and barrier terminals when required or as is appropriate.
- Bus routes – maintenance of bus stops and service to the public is essential.

Important data for these considerations includes pedestrian and cycle movements, traffic volume, level of service, percentage of heavy vehicles, traffic speeds, and intersection capacity and delay. This data will allow a proper analysis of the operation of the traffic through the site. Signage and reduced speed limits for road works may also be necessary; reference should be made to the MUTCD (Main Roads, 2003). Designs of temporary sidetracks, etc and analyses should take reduced speeds, if they will be used, into account. Chapter 4 discusses criteria for temporary roads.

3.3.4 Crime Prevention Through Environmental Design (CPTED)

Crime Prevention through Environmental Design (CPTED) is an important consideration in reducing the incidence of crime near or adjacent to roads. Detailed discussion with Police and Community groups is required to ensure that appropriate measures are taken.

The basic premise of CPTED is that proper design and effective use of the built environment can produce behavioural effects that will lead to a reduction in the incidence and fear of crime, and lead to an increase in the quality of life. These behavioural effects can be accomplished by reducing the propensity of the physical environment to support criminal behaviour (Crowe, 2000).

There are three overlapping strategies used in CPTED. They are:

- natural access control;
- natural surveillance; and
- territorial reinforcement.

Every design will encompass a mixture of all three of the concepts in a way appropriate to the particular requirements of the site in question. The essential component of the design should be an emphasis on naturalness - designing and constructing the things that must be included better. Some examples of actions that have been used are:

- provision of a clear border definition of controlled space;
- provision of a clearly marked transitional zones that indicate movement from public to semi-public to private space;
- a relocation of gathering areas to locations of natural surveillance and access control;
- re-designation of the use of space to provide natural barriers to conflicting activities;
- improved scheduling of space to allow for effective use and appropriate “critical intensity”;
- a re-design or re-vamp of space to increase the perception and reality of natural surveillance;
- improving communications to overcome distance and isolation;
- avoidance of creating areas of potential entrapment - areas should have several clearly marked entrances/exits that are clearly lit; and
- careful selection, location and design of road furniture, including noise barriers and fences.

3.3.4.1 Natural access control

Natural access control is a concept directed at decreasing crime opportunity. This can be achieved through organised means such as guards, or by natural means. Natural access control can be enhanced by:

- using clear delineation between public and private areas (e.g. kerbs, landscaping);
- providing a hierarchy of elements to define public and private space;
- defining walkways clearly;
- ensuring that pathways are well lit with a clear view of the destination;
- using landscaping as a natural barrier (but designed so that it is not at the expense of natural surveillance);
- creating common areas used by a range of people; and
- ensuring that plants and other objects do not obscure views of any of the areas of concern.

3.3.4.2 Natural surveillance

Natural surveillance comes from ensuring that all publicly accessible areas are under observation by the adjacent residents and businesses. This is intended to keep intruders under observation, thereby creating a perception of risk for potential offenders. Surveillance can be organised-direct (e.g. police patrol), mechanical (e.g. lighting, surveillance cameras) or natural (e.g. windows, glass walls). Some actions that are available to assist in natural surveillance are:

- ensuring that all publicly accessible areas can be observed and that it is clear that the area can be observed;
- using "see-through" fencing or walls (if fencing or a wall is required at all) to ensure external visibility of the area;
- ensuring that plants and foliage are trimmed and maintained to prevent obstruction of visibility;
- ensuring that entrances are located so that they are easily observed;
- providing the ability to see into a space before entering it;
- providing mixed use activities to encourage regular use of the surrounding space; and
- provide appropriate lighting to the areas of concern.

3.3.4.3 Territorial reinforcement

This strategy relies on the concept of "ownership" of the areas involved. The natural access control and surveillance strategies tend to reinforce this concept and create a sense of "territoriality". This tends to promote responsiveness by users in protecting their "territory" (more awareness, reporting and reacting) and at the same time, promote a perception of greater risk for offenders (Crowe, 2000).

Some strategies to achieve this are to:

- make the space clearly belong to someone or group;
- define the intended use clearly;
- ensure that the physical design matches the intended use; and
- provide the means for normal users to naturally control activities, control access and provide surveillance.

Territorial Reinforcement can be regarded as an "umbrella" strategy encompassing all three of the elements of CPTED, even though each has distinct operational differences.

3.3.4.4 Specific cases

Parking areas

CPTED measures for parking areas that may be considered include:

- avoiding obstructions to sight lines and avoiding potential entrapment spots by;
  - o eliminating dense bushes, solid fences or advertisements that obscure the view;
  - o eliminating unnecessary buildings or sheds (i.e. hiding places);
  - o maximising sight lines from the entrances/exits to the various parts of the area; and
  - o using low fences and low growing shrubs as the boundaries of the area.
- enhancing natural surveillance by:
  - o locating the area to take advantage of buildings with windows overlooking the area;
  - o taking advantage of adjacent or nearby business premises or houses so that the occupants can see the area;
  - o maintaining landscaping to prevent it obscuring the view of the area; and
  - o using "see-through" fences rather than solid walls as boundaries.
- providing lighting such as:
  - o providing lighting such that a person can see into the back seat of a vehicle before entering it;
  - o ensuring that lighting is uniform to avoid deep shadows; and
  - o designing to provide more fixtures with lower wattage to obtain better uniformity (and the lighting level should enable a person with normal vision to identify a face from a distance of 15m).

Pedestrian underpasses

CPTED measures for pedestrian underpasses that may be considered include:

- maximising sight lines and avoiding entrapment spots:
  - o locating entrances/exits where they can be viewed by the maximum number of people;
  - o designing routes to and from the underpasses so they are free of sharp turns;
  - o designing underpasses so the full length of the is visible from each end with no changes in level or direction;
  - o designing entrances/exits so they are at the same level as the streets being served; and
  - o designing landscaping near entrances/exits such that hiding places and/or the creation of shadows is avoided.
- providing lighting by:
  - o ensuring all approaches and the length of the underpass are well lit (i.e. the lighting level sufficient to identify a face at a distance of 15m) and maximising its effectiveness and performance by:
    - - using fittings that are vandal proof (to protect against breakage);

  - designing the fittings such as to manipulation is prevented; and
  - using a wall colour that increases the efficiency of the lighting (e.g. white or other light colour).

- enhancing natural surveillance by:
  - o incorporating, if possible, street level activities with the entrances/exits;
  - o encouraging surveillance opportunities from adjacent streets and nearby buildings; and
  - o avoiding any hidden spaces or potential hiding places.

Cycling routes

CPTED measures for cycling routes that may be considered include:

- for isolated routes:
  - o designing to have frequent, clearly marked exits to areas of high pedestrian and car traffic if possible;
  - o ensuring sight lines provide visibility along and adjacent to the route; and
  - o avoiding the creation of entrapment areas.
- consider providing lighting and in so doing note that:
  - o lighting isolated sections of a bikeway in an urban area is desirable;
  - o where the bikeway is through a recreational area not otherwise lit, it may be impracticable to provide lighting and in these cases signs should be provided at the entrances to inform cyclists that no lighting is provided;
  - o if the bikeway coincides with a walkway, lighting should be provided unless it leads into an unlit park or recreational area; and
  - o providing lighting in a recreational area may give a false sense of security to potential users and a false impression that the path is well used at night time.

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Walkways

CPTED measures for walkways that may be considered include:

- maximising sight lines and avoiding potential entrapment spots by:
  - o avoiding elements such as sharp corners, inset areas along buildings or walls, tall fences, earth berms or overgrown shrubbery (as these may restrict visibility and provide potential for entrapment); and
  - o modifying elements to ensure there are good pedestrian sight lines and surveillance from adjacent properties.
- consider providing lighting, and in so doing note that:
  - o on street walkways should be lit by the normal street lighting;
  - o on well-travelled walkways, lighting at the pedestrian level should be provided;
  - o lighting of a consistent level should be provided (to allow for a pedestrian to be able to identify a person 15m away);
  - o fittings should be vandal resistant; and
  - o providing lighting in a recreational area may give a false sense of

security to potential users and a false impression that the path is well used at night time.

Bus shelters

CPTED measures for bus shelters that may be considered include:

- maximising surveillance:
  - design of nearby land uses should provide natural surveillance, especially at night and at weekends;
  - the bus stop should be located so as to be highly visible for potential passengers and the casual observer; and
  - plantings should not interrupt the visibility of the site or provide hiding places (e.g. use high branching trees - no branches less than 2.4m above the pedestrian surface and/or low growing plants below knee height; maintain/trim vegetation).
- Considering the provision of lighting and if included:
  - provide high standards of lighting at the stop as well as on the approach routes; and
  - restrict landscaping to the type described above.
- avoiding entrapment areas by:
  - providing multiple entrance/exit routes that enable passengers to bypass potentially unsafe situations;
  - limited walls/fencing immediately adjacent to the stop to a height of 1.2m; and
  - locating the stop to avoid areas of inappropriate land uses that create social or safety problems (or the perception of them).

Bridge overpasses

The "Reduction of Risk from Objects Thrown From Overpass Structures onto Roads" Policy (Main Roads, 2004), details a practical risk assessment methodology to address the issue of objects being thrown from pedestrian overpass structures onto roads and the resulting serious potential danger to motorists. During the planning and design phases this element of CPTED should be built into the project.

3.4 Transport efficiency and effectiveness

3.4.1 Land use and transport planning

3.4.1.1 General principles

Land use and transport demand are inextricably linked; one will always influence the other. Therefore, they must not be considered separately and an integrated planning approach is necessary.

A major premise of transport and land use planning is that an appropriate balance between the various modes of transport be achieved. A system that relies too heavily on the use of the private car for trips will not serve the long term needs of the urban community.

Land use planning has a key role in providing for an integrated transport strategy. Forward planning of the location, scale, density, design and mix of land uses can help reduce the need to travel, reduce the length of journeys and make it safer and easier for people to walk, cycle or use public transport. Decreases in forms of urban pollution can be achieved through better land use development and better design of transport systems. (The transport sector is one of the largest sources of greenhouse gas emissions in Australia and private transport is the largest urban land use related source of emissions - refer to Section 3.6.4.)

The "Integrated Transport Planning Framework for Queensland – A Guide for Transport Planning" (Queensland Government, 2003) sets out the desired outcomes, directions, principles and planning steps to provide hands-on advice for integrated transport planning across urban, rural and remote locations in Queensland. It also provides an overview of existing legislation, plans and policies as well as a checklist of planning steps. All planners should apply the requirements of this publication when undertaking their projects. Designers should also be aware of these requirements.

Some of the specific elements that should be considered in the transport planning process are described in the references that follow.

"Shaping Up: A guide to the better practice and integration of transport, land use and urban design techniques" (Queensland Transport, 1999) is an outstanding guide to developing urban areas to reduce car dependence, principally through "shaping" (i.e. moulding, designing) places to better support public transport, cycling and walking. It includes clearly illustrated guidelines for:

- public transport stops;
- cycling;
- walking;
- interchanges between transport modes;
- residential areas;
- transport corridors; and
- business activity centres.

This document lists "best practice" initiatives in each section, illustrated by a series of hypothetical case studies. There is an emphasis on safety (e.g. use of knee-height landscaping, provision of multiple routes so pedestrians can by-pass unsafe areas) and passive surveillance (refer to Section 3.3.4) as well as discussion of issues including density, gradients, connectivity, traffic calming, footpaths and cycle paths. Public transport stops are discussed, with emphasis placed on the importance of complementary facilities (e.g. telephones, drinking fountains, post boxes), while the importance of minimising transfer distances and avoiding level changes at interchanges between modes is also emphasised.

The Australian Model Code Of Residential Development (AMCORD, Commonwealth Department of Housing and Regional Development, 1995) is a National manual for residential design in Australia. It features comprehensive design guidelines on:

- neighbourhood design;
- integrated movement networks including pedestrian and cycling facilities; and
- the location and design of;
  - bus stops;
  - street lighting;
  - landscaping; and
  - roadside furniture.

Access, safety/security and attractiveness are consistent themes in AMCORD. It is supplemented with Planning Practice Notes on:

- neighbourhood design;

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- responsive urban design (that is safe, stimulating and sustainable);
- transport, accessibility and the local environment;
- streetscape and neighbourhood character; and
- guidelines for crime prevention including bus shelters, pedestrian and cycling routes (also refer to Section 3.3.4).

Planning SA (South Australian Government, 2000) touches on most of the detailed elements of the urban fabric that can influence people in making real choices in selecting their travel mode. It sets out general urban design principles and then looks in turn at the specific needs of the pedestrian (refer Section 3.5.6) and the cyclist (refer Section 3.5.6) as well as the facilitation of public transport (refer Section 3.4.4). The issues addressed in Planning SA provide a convenient checklist of the issues to be considered.

3.4.1.2 Legislative framework

The Integrated Planning Act (IPA - refer to Chapter 1) includes the need to co-ordinate, integrate and streamline development assessment processes, and to provide for an improved whole of government approach to land use and infrastructure planning.

The objective of the Act is to seek to achieve ecological sustainability through:

- coordinated and integrated planning at the local, regional and State levels;
- managing the process by which development occurs; and
- managing the effects of development on the environment (including managing the use of premises).

This can be achieved through a number of mechanisms including:

- the Integrated Development Assessment System (IDAS), which improves the speed and quality of development assessment by creating a single integrated development assessment system for State and Local Government approval processes;
- integrated planning to provide a basis for the co-ordination of local, regional and state planning objectives and criteria into Local Government planning schemes;
- infrastructure provision to ensure State and Local Government capital works spending and infrastructure provision are co-ordinated with land use planning decisions and reflected in the planning scheme;
- clear principles for funding essential infrastructure in new communities; and
- recognition of regional planning forums and regional planning outcomes through a statutory framework.

The role of state agencies in both forward planning and development assessment is expanding. As the Act puts greater emphasis on the formulation of planning schemes, state agencies will express their objectives and criteria for future programs, strategies, funding etc as they are relevant to the local areas.

It is necessary for Main Roads to determine a program of projects, policies, financial provisions and performance measures for road infrastructure under its own legislation. Under the integrated planning system this information may be transposed into Local Government planning schemes to ensure effective service delivery and to minimise potential conflicts between land use and transport planning objectives at the earliest opportunity.

In addition to the involvement of state agencies at the concept phase, input into the development assessment process is also be required under the integrated planning system.

Identifying the current and future land use in an area is an essential prerequisite for the assessment of the travel patterns and traffic demand on any future or current facility. The source of this information is the Local Government for the area, together with any Regional Plans prepared by Government and/or Regional Organisations of Councils (ROCs).

Local Government planning schemes contain provisions that provide the strategic vision and goals to guide development for at least a 10 to 15 year period. It is expected that they will be reviewed at least once within this time.

The planning scheme preparation or review process provides state agencies with the ideal opportunity to input into the process in a proactive rather than reactive manner. This will help to ensure that the needs of State-controlled road corridors can be safeguarded and protected.

The process also provides the opportunity to identify future or changing land use patterns that are an important determinant of the need for particular infrastructure within an area.

Planning schemes reflect community planning policy and land use management. They are the key instruments against which the assessment of the majority of development applications is made.

When key State or Federal legislation is involved, authority may be vested in the responsible State or Federal agency or minister.

Reflecting the needs and criteria in planning for and maintaining State controlled road corridors in the planning scheme is, however, good practice.

The IPA also includes “designated land for community infrastructure” as another means of integrating land use policy and infrastructure provision. “Community infrastructure” is defined in a Schedule of the IPA and this includes State controlled roads. State controlled roads can be identified on Local Government planning schemes as an overlay to the scheme. The purpose of this community infrastructure designation is to:

- achieve integration of infrastructure planning and land use planning;
- provide infrastructure more efficiently and cost effectively; and
- give governments and other stakeholders greater clarity and certainty about intended future directions for development and land use.

3.4.1.3 Demography

The future demography of the area will be intimately bound up with the land uses of that area. Estimates of future population and its distribution depend on the assumptions made regarding land uses.

The primary source of demographic predictions is the Queensland Department of Local Government and Planning, Planning Information and Forecasting Unit. They provide a high, medium and low series of population forecasts for each shire together with age composition and other data. This takes into account many issues including land supply, IPA schemes, committed infrastructure and proposed industrial development. Their initial source of information includes the census.

Shire prediction should normally be in accord with these forecasts. When doing assessments the three rates (high, medium and low) should be considered or evaluated to manage the risk of over investing.

In the absence of more formal demographic predictions, data obtainable from Local Government sources to assist predictions of rate of growth of population may include:

- historical growth rate data (including building approval figures);
- planning investigations such as:
    - South East Queensland Regional Plan 2005-2026 (Queensland Office of Urban Management and Queensland Department of Local Government, Planning, Sport and Recreation, 2005);
    - The South East Queensland Infrastructure Program and Plan (SEQIPP - Queensland Office of Urban Management and Queensland Department of Local Government, Planning, Sport and Recreation, 2005);
    - Far North Queensland Regional Plan (Queensland Department of Communication and Information, Local Government, Planning and Sport, 2000);
    - Cairns Integrated Transport Study – Draft Technical Report (Queensland Transport and Eppell Olsen and Partners, 2003);
    - Gulf Savannah Integrated Regional Transport Plan (Queensland Transport, 2000);
    - Townsville Port Access Impact Assessment Study (Maunsell, 2000);
    - Townsville Thuringowa Integrated Regional Transport Plan (TTIRTP – Queensland Transport, Main Roads, Townsville City Council and Thuringowa City Council, 2001);
    - Townsville Thuringowa strategy plan: framework for managing growth and development (Queensland Department of Communication and Information, Local Government, Planning and Sport, Thuringowa City Council and Townsville City Council, 2000);
    - Capricornia Integrated Regional Transport Plan 2004-2030 (Queensland Transport, 2004);
    - Gladstone Integrated Regional Transport Plan 2001-2030 (Queensland Transport, 2001);
    - Mackay Area Integrated Transport Plan 2002-2025 (Queensland Transport, 2002);
    - Border Integrated Transport Plan – Draft for Consultation 2004 (Queensland Transport, 2004);
    - Eastern Downs Integrated Transport Plan (Queensland Transport, 2003);
    - Gowrie to Grandchester Rail Corridor Study (Queensland Transport, 2005);
    - Wide Bay Integrated Transport Plan 2002-2020 (Queensland Transport, 2002);
    - South East Queensland Infrastructure Plan and Program

2005-2026 (SEQIPP – Office of Urban Management, 2005);

- o South East Queensland Regional Plan 2005-2026 (Office of Urban Management and Department of Local Government, Planning, Sport and Recreation, 2005);
- o Integrated Regional Transport Plan for South East Queensland (Queensland Government, 1997);
- o South-East Queensland travel survey (Queensland Transport, 2005);
- o Petrie to Kippa-Ring Transport Corridor Study (GHD, 2003);
- o The Gold Coast Light Rail Feasibility Study (APD et al, 2004 APD partnership, Parsons Brinckerhoff, Steer Davies Gleave, KPMG, Queensland Transport and Gold Coast City Council);
- o Robina to Tugun Rail Impact Assessment Study (Parsons Brinckerhoff, 2005);
- o Caboolture to Landsborough Rail Upgrade Study (Arup, 2005); and
- o Caboolture to Maroochydore Corridor Study (Arup, 2001).

- the dynamics of land supply in surrounding areas (i.e. an assessment of housing competition);
- information on the land development industry; and
- input from community consultation.

Other sources of information for demographic study may include the Queensland Department of Tourism, Fair Trading and Wine Industry Development, Queensland Department of State Development, Trade and Innovation and the Australian Bureau of Statistics. The Applied Population Research Unit based at the University of Queensland is also an authority in this field.

3.4.2 Travel demand and demand management

Traffic demand and management may be influenced by public transportation facilitation (Section 3.4.4).

3.4.2.1 Travel demand

Future travel demand is a function of land use, demography and available choices of travel mode. Determining this includes estimating both the scale of demand for each travel mode and their associated patterns that will lead to identifying the future design flows (e.g. private vehicle, cyclists, public transport) in a particular corridor.

Identifying the future travel demand is important for:

- planning the location of the future road system;
- identifying the width and design criteria of any particular corridor;
- establishing the intended function/s that a corridor fulfils; and
- determining future estimates of travel in a particular road corridor which will depend upon the:
    - o growth and type of development in the catchment of the corridor;
    - o growth in traffic including through traffic; and
    - o future trends in travel mode selection.

For rural areas, the issue of freight movements is particularly significant in terms of the level of demand and the physical and design attributes the corridor will require.

Increased use of public transport, walking and cycling is an objective expressed in all of the ITRPs' targets which are aimed at increasing the usage of sustainable transport, and is encouraged in Shaping Up (Queensland Transport, 1999). Objectives include:

- higher use of sustainable transport by increasing the proportion of trips made by public transport, walking and cycling, and share rides;
- restraining the growth of peak period travel demand by reducing the predominance of single occupant vehicle travel, eliminating unnecessary trips and distributing the traffic patterns on the network to reflect the appropriate function and achieve efficiency across the existing transport system;
- providing sufficient road capacity by planning to meet moderated traffic demand and accommodate the growth of the regions' urban areas;
- co-ordinating transport and land use planning by supporting more compact, better designed urban development that supports public transport and allows people to walk and cycle more;
- ensuring social justice by a more integrated transport system that shares the costs and benefits of transport equitably across the region;
- maintaining environmental quality by better traffic planning and improved approaches to providing transport infrastructure;
- providing appropriate road and traffic management, local area traffic management and street closures; and
- providing for freight and the requirements of commercial vehicles.

(In identifying the future demand for travel in a particular corridor, special consideration may have to be given to different classes of traffic such as High Occupancy Vehicles [HOVs], B-doubles and road trains and public transport vehicles. The proportion of Heavy Goods Vehicles [HGVs] may also be important.)

In support of integrated planning and the sustainable transport objectives of the strategies emerging from IRTPs, and similar plans, corridors will have to make provision for the range of travel modes required and the infrastructure required to support each of them.

3.4.2.2 Travel demand management

Several of the objectives of the IRTPs involve the management of travel demand by encouraging the use of modes of transport other than single occupant use of private cars (e.g. walking, cycling and public transport).

One strategy seeks to address the problem of congested road space by reducing the number of vehicles (e.g. single occupant private cars) required to accomplish the transport task, thereby improving the level of service to all road users and obtaining the best use of the existing infrastructure (refer Section 3.6.4). Part of this strategy is to encourage greater occupancy of private cars (and trucks), use of other types of vehicles (e.g. motorcycles and bicycles) and greater use of public transport. Collectively, private vehicles with multiple passengers and road bound public transport vehicles are referred to as HOVs. Providing special facilities to give HOVs (and other eligible vehicles which may include motorcycles and bicycles, refer Section 3.4.4.1) a level of priority higher than single occupant cars and trucks is one way to achieve the desired outcome (by encouraging the desired behaviour). If sufficient time savings can be obtained, then it will be attractive for people to use HOVs.

Planning activities must take account of the potential for HOV facilities and use them appropriately to cater for the traffic demand and to determine the type and size of roadway required. Requirements for these facilities are discussed in Section 3.4.4.1.

It is beyond the scope of this Manual to address the range of other measures that can be taken to manage travel demand (e.g. the use of a parking policy).

3.4.3 Traffic forecasting

The planning and design of a new road in a corridor depends on having accurate forecasts of the traffic expected to use it throughout its design life. It is also important that an accurate estimate of the traffic generating characteristics of a new development is known so that its impact can be gauged and the development properly assessed. In general, planning is based on the traffic expected in 20 years from the opening of the facility but it might be necessary to obtain predictions for a series of years to determine the potential for staging of the required works. Heavy-duty pavements are often designed using a design life of 40 years meaning an estimate of the traffic use over that period is required. (Refer to the Pavement Design Manual [Main Roads, 2004] and the Pavement Rehabilitation Manual [Queensland Transport, 1992] for a detailed discussion related to pavement design, including pavement design traffic).

The accurate forecasting of a traffic volume in 20 years, or other specified times in the future, might require specialist skills and special studies to be undertaken. Some of the contributing factors have been discussed in other sections. Another approach is to extrapolate historical traffic data and modify these figures for the traffic generated by specific developments (factored for growth over the planning period).

Traffic generated by specific developments can be estimated from industry norms determined from experience. Appendix 3A provides summary information on trip generation rates for a range of land uses (and cites references to which planners and designers should turn for detailed information).

Predicted traffic volumes on (i.e. along and across) the road in question is the basis for many aspects of the design and can influence the overall impact of the road on all of the factors being considered. This applies to the environmental impact as well as the effect on the range of engineering parameters adopted for the design. The traffic parameters to be used are discussed in Chapter 5.

3.4.4 Public transport facilitation

3.4.4.1 Transit lanes

In Queensland, special lanes to accommodate HOVs, and other eligible vehicles, are known as “transit lanes”. This section sets out the objectives of transit lanes and the factors to be considered in

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their planning and implementation. For a comprehensive treatment of this subject, refer to the "Brisbane HOV Arterial Roads Study Report" (PPK et al, 2000) and publications by the Transportation Research Board (1998) and Fuhs (1990). Although the PPK study focuses on Brisbane, it provides basic principles that apply throughout Queensland.

Objectives of transit lanes

In addition to the basic requirements such as designing for personal safety, cost-effectiveness, and design criteria (including provisions for cycling), which are part of any roadway or transit project, the following objectives are appropriate for transit lanes:

- Increase the attractiveness of HOVs and other eligible vehicle types by improving their operational efficiency and reliability.
- Induce a behavioural shift towards HOVs, and other eligible vehicle types, by providing travel time savings and more reliable trip times for these vehicles.
- Increase the person movement capacity of road links by increasing the average number of persons carried per vehicle.
- Implement HOV priority measures such that community-wide net benefits outweigh any net disadvantages.

The key issue in setting out transit lane objectives is the relationship between the transit lane objectives and those of the rest of the transport system. To arbitrarily apply measures which meet the above transit lane objectives could disadvantage non-transit lane users in some cases to such a degree that the net impact on person movement would be negative. For example, converting a busy general-purpose lane to an under-used transit lane, for instance, might result in a total person-hour time increase. Another example is where a proposed HOV facility might meet technical warrants yet be unacceptable to the adjacent community. Further, the conversion of a parking lane to a HOV lane may make it difficult or unsafe for cyclists using it.

There will be quantitative and qualitative aspects to assess both the benefits and detrimental aspects of transit lane implementation. The acceptability of some proposals will obviously be case-specific or community-specific. There will be situations where the needs of through freight movement are very significant in which case a HOV may not be appropriate (as freight vehicles are not HOVs and so permitted in transit lanes) and other locations where the views of the surrounding community are strongly for or against HOV priority and still other cases where a balance between all the road users' needs can be readily achieved. There are environmental impacts and policy issues to be considered as well. For instance, it might be feasible to widen a transit lane to cater for cyclists on a key cycling route, thus improving the potential for increasing cycling.

All of these benefits and disadvantages need to be considered over time, and there will be situations where short-term impacts may need to be endured in order to influence long-term trend lines.

Despite the best planning intentions, the reality is that no HOV project should be implemented if it causes unacceptable disruption to the rest of the system. Such a project could irreparably harm the overall ability to implement other projects that together would contribute to achieving overall transport objectives.

HOV spot treatments such as by queue jumps at ramp metering and other traffic signals can provide large benefits for low cost. These spot improvements may be part of a wider HOV system or may be isolated in specific locations where such a facility will provide significant benefits. Planners and designers of individual projects should be alert to the possibility of including such spot treatment to achieve these benefits at little additional cost.

Key planning issues

Based on Brisbane and international experience, the most significant issues likely to be faced by a HOV network or its individual components are:

- Vehicle eligibility by type - what type of vehicle constitutes an eligible HOV? That is, will the HOV facility be a bus lane or a transit lane?
- Vehicle eligibility by occupancy (for transit lanes only) - how many occupants are required in/on each eligible vehicle?
- Hours of operation – peak period, all day or 24-hour?
- Usage criteria and warrants - when is a priority lane justified, under-used, or congested?
- Network consistency and integration - under what conditions should adjoining transit lanes use the same rules or does it make a difference?
- Compliance monitoring and enforcement - what level of violation is tolerable and what can be done to keep it that way?
- HOV lane implementation - when is lane conversion rather than lane addition the right answer?
- Cycling and buses - can cyclists and buses co-exist in shared HOV lane? If so, how?

Each project will have to consider these issues and provide a facility that best suits the environment (physical and political) that prevails in the area under consideration.

Vehicle eligibility by type

General-purpose lanes are generally open to any type of vehicle at any time. However large commercial vehicles that do not have as of right access (e.g. B-doubles, type 2 road trains) can only use general-purpose lanes under permit. A priority facility requires limiting or restricting usage to only a specific type or types of (i.e. eligible) vehicle(s).

The current Traffic Regulations (as per the Transport Operations [Road Use Management] Act) allow:

- the following vehicles in bus lanes:
  - buses;
  - taxis/limousines;
  - emergency vehicles;
  - bicycles;
  - any vehicles turning within 100m of an intersection; and
  - vehicles accessing adjacent properties.
- the following vehicles in transit lanes:
  - motor vehicles with a specified minimum number of occupants;
  - buses (omnibuses);
  - taxis/limousines;

- motorcycles;
- emergency vehicles;
- bicycles;
- any vehicles turning within 100m of an intersection; and
- vehicles accessing adjacent properties.

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Buses, taxis, motorcycles, bicycles and emergency vehicles are allowed in a transit lane regardless of occupancy.

Transit lane warrants

For planning purposes, guidelines are needed to establish the minimum and maximum vehicle volumes for an effective transit lane:

- The minimum criteria should reflect the tenet that the transit lanes should carry at least as many people as the adjacent general-purpose lane. Note that this person volume can be carried by any combination of buses and carpools, with car-pool figures varying depending on whether the lane is a T2 (i.e. two person occupancy) or T3 (i.e. three person occupancy) facility.
- The maximum criteria are based on the premise that the lane should, at all times, operate without congestion. Basic lane capacity depends on the road type, the proportion of green time available and whether buses stop in the lane (and the duration of the stop) or use bus bays. Capacity can be calculated using the procedures of the Highway Capacity Manual (TRB, 2000).

These factors have been combined in Figure 3.6, Figure 3.7 and Figure 3.8 (Appendix 3C) as ready references. These figures illustrate the target envelope for the combined bus/car-pool volumes in transit lanes for three types of roads:

- a signalised urban street with a capacity of 650v/h/lane;
- a signalised suburban arterial with a capacity of 800v/h/lane; and
- a high standard suburban arterial with a capacity of 900v/h/lane.

Furthermore, there must be public acceptance that the usage of the lane is sufficient. If the public perceives that the lane is underused, then it will be difficult to maintain the integrity of the lane and violations of the usage of the lane by ineligible vehicles will be significant.

PPK et al (2000) set out these conditions in some detail; planners and designers should refer to this reference for guidance.

Evaluation

Evaluation of any proposals for transit lanes should be based on agreed criteria using suitable weighting of the factors selected for the evaluation criteria (PPK et al, 2000). Table 3.1 sets out appropriate evaluation criteria with some guidance on the measures to be used and the weighting to be applied.

Support programs

Support programs are the group of measures that can be taken outside the road right-of-way to encourage, promote and market HOV use. These programs are part of the travel demand strategy and are focused on changing the habits of the person making the trip.

Table 3.1 Evaluation criteria for transit lanes (based on PPK et al, 2000)

Criteria	Measures	*Weighting (%)
HOV Travel Time Savings	• Annual person-hours of travel time savings (net, i.e. benefits to HOVs less disadvantages to vehicle other than HOVs).	15
Person Throughput	• Anticipated persons carried under conditions of existing/predicted demand, with and without priority treatment. • Impact of treatment on generating modal shift. • Person carrying capacity of HOV lane relative to that of the adjacent general-purpose lane.	5
Bus Operations	• Suitability of bus operating pattern (express/all-stop/turns). • Ability to provide bus stops/bays to allow unimpeded through movement.	10
Cost- effectiveness	• Total capital cost. • Annual operating cost. • Net value of travel time savings (net of time disadvantages to vehicles other than HOVs) calculated over a ten year life.	15
Traffic Operations	• Intersection level of service with and without priority treatment, for HOV and general traffic. • Ability to accommodate HOV turn demand.	10
Safety and Bicycles	• Existing accident figures for route/site. • Impact of treatment on accident potential. • Compatibility with bicycle operation. • Pedestrian safety.	10
Network Impact	• Consistency with adjacent HOV facilities. • Continuity of treatment in corridor. • Relationship with trunk bus routes. • Linkage with support facilities (e.g. park and ride, bus interchanges).	5
Enforceability	• Ability to detect violation. • Ability to intercept/penalise violators. • Minimum threshold volumes to avoid the empty lane syndrome.	10
Context	• Positive and negative impacts on adjacent business. • On-street parking. • Impact on adjacent residential areas (cut through traffic). • Co-ordination with other projects. • Physical feasibility.	15
HOV Travel Time Reliability	• The degree to which variations in traffic conditions affect the operation of the treatment. • Off-peak operating conditions.	10
*The weightings shown in this table are a guide and may be varied to suit a particular project. Refer to PPK et al (2000) for a detailed discussion.		

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These measures will fall under one of the following three functional groupings:

- Group 1 - Convenience/ encouragement which includes:
    - employer incentives;
    - ride-match program;
    - vanpool program;
    - guaranteed ride home;
    - marketing; and
    - information.
- Group 2 – Parking which includes:
    - park and ride car park;
    - carpool car park;
    - preferential parking spaces; and
    - preferential parking rates;
- Group 3 – Policies and social issues.

It is beyond the scope of this Manual to deal with these measures in detail. PPK et al (2000) contains a detailed discussion of these issues.

Specific treatments

Details of specific HOV treatments are given in Chapter 7.

3.4.4.2 Passenger transport modes

The information on bus routes given in this section is based on Shaping Up (Queensland Transport, 1999). Refer to Shaping Up for any additional information required above what is given in this section. Planning SA (South Australian Government, 2000) touches on most of the detailed elements of the urban fabric that can influence people in making real choices in selecting their travel mode. It sets out general urban design principles and then looks in turn at the specific needs of the pedestrian, the cyclist and the transit passenger (refer also to Section 3.5.6).

In any community, there is a demand for "public" transport to and between work, shopping, education and leisure activities, and in residential areas.

The level and nature of demand for these transport services are determined by such factors as density of development, spatial distribution of activities and the socio-economic characteristics of an area as well as the demographics of the area's population. The extent to which public transport can meet the potential demand is influenced not only by these factors, but also by the road layout, hierarchy and geometry in the service area and the quality of the amenities provided.

Local and international research indicates that passengers desire the following amenities in order of priority (South Australian Government, 2000):

- shelter;
- seating;
- information;
- an attractive and clean environment;
- security;
- accessibility;
- directional signage;
- convenient transfer between modes;
- direct pedestrian access to their destination; and
- reassurance.

The role that public transport should perform on various classes of road is as discussed below.

Safety

Safety for transit passengers centres mainly on the ability to wait in a public place without fear of assault or harassment. This is most acute at night and is exacerbated by isolation. In addition to personal safety, passengers who access public transport by car or bicycle require a secure place to park their vehicle. Personal safety can be enhanced by:

- providing good lighting at stops, stations and interchanges;
- encouraging activity at and around stops, stations and interchanges to improve passive surveillance;
- locating interchanges between modes of transport within centres to improve security and convenience for transit passengers;
- providing shelters that allow direct views to and from the street;
- providing video surveillance, help phones and distress alarms at stops, stations and interchanges between modes of transport, and on vehicles to contribute to a more secure environment and one that feels secure;
- providing taxi ranks at key stops, stations and interchanges;
- providing well-lit commuter parks and well-lit pedestrian walkways that are used to access public transport;
- avoiding the provision of underpasses; and
- CPTED (refer to Section 3.3.4).

Convenience

Convenience for transit passengers is largely related to information and certainty about obvious and direct paths, and about frequency and timing of services. Reassurance for passengers involves providing route and travel information at stops, stations and interchanges between modes of transport, working towards providing "real time" information about routes and travel, providing a clock in waiting areas, and providing clear directional signage to, from and within stations, stops and interchanges.

Convenience also covers providing direct and comfortable access for passengers transferring between different modes or vehicles, providing access for elderly people and those with disabilities or those pushing prams, providing for bicycle carriage on buses and trains and providing storage for bicycles at stations.

Pleasure

Pleasure for transit passengers can include time for reading and conversation and freedom from the stress that sometimes accompanies driving.

Comfort

Comfort includes weather protection, comfortable seating while waiting, directional signage to toilets and other facilities, a clean and attractive waiting environment free of graffiti, phones, rubbish bins, and other services like a news stand and a café.

Public art

Public art can enhance the experience while waiting for a bus or train. Experience indicates that public art may also reduce the incidence of graffiti

Trains

In major urban areas, trains often provide a major public transport service. It is important that good quality access to railway stations for all modes (walking,

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cycling, buses, motorcycles and private car) is provided where required. Facilities could include:

- pedestrian and cyclist underpasses or overpasses;
- on-road and/or off-road pedestrian and cycle facilities;
- bus priority measures;
- "kiss and ride" facilities;
- motorcycle parking;
- bike storage facilities; and
- bus stops.

Buses

In rural areas well removed from urban communities, the major public transport requirement is for school buses. Providing access to the road system for this service is usually the dominant public transport issue. However, some long distance services require some level of access and these must also be considered (refer to Chapter 20 for details of some bus stop requirements).

Land use planning and bus routing

The general philosophy of land use planning for efficient bus transport is that which best combines:

- providing direct routes between major activity centres (such as retail centres, industrial estates, commercial centres, large schools, and significant leisure centres) and the patronage source (i.e. the residential areas);
- providing appropriate density of residential developments along such routes which should be within a "convenient" walking distance to bus stops;
- providing appropriate and convenient pedestrian facilities that give access to all bus stop locations while also being accessible for people with disabilities;
- locating lesser activity centres (e.g. smaller schools, local shops, commercial centres, post offices and public buildings) on, or very close to, the routes between the major activity centres;
- placing residential centres such that residents have a choice of major activity centres, in either direction on the bus route/s;
- implementing progressive co-ordinated development of land parcels which enable new or extension bus service to be implemented efficiently, or which "fill-in" gaps in existing route catchments; and
- ensuring opportunities for inter-modal trips by providing safe and convenient cycling access to bus interchanges.

Bus routing and road planning options

Ease of bus movements between the various road types must be considered in the design of the road layout, intersection layout and intersection control.

In particular, buses should not be expected to cross, or make uncontrolled right turns onto, highly trafficked arterial roads through a "Stop" or "Give Way" control. Channelisation, roundabout or traffic signal control should be introduced on bus routes to assist bus access to the arterial system. Alternatively bus priority measures should be implemented. Wherever possible in such circumstances, T-junctions rather than four way intersections should be used as these significantly improve safety and accessibility.

At any location where significant bus delays are expected, introducing some form of bus priority should be considered (refer to Section 3.4.4.1).

High volume arterial roads (typically found in the high population urban areas)

Arterial roads are very suitable for trunk express or limited-stop bus services. As volumes of traffic and congestion increase on high volume arterial roads, provision of HOV lanes may be appropriate to support public transport objectives and maintain reliability for bus operations. Wherever bus stops occur, passengers should be isolated as far as practicable from the arterial road traffic by providing stopping areas clear of the main carriageway (preferably on service roads) and pedestrian access facilities segregated from the arterial road vehicles (via grade separation desirably, or pedestrian signals as a minimum).

Lower volume arterial roads (typically found in lower population urban areas, small cities and rural towns), sub-arterial and collector roads

Principal pedestrian access to, facilities for, and routes of, major bus services are best suited to sub-arterial and collector roads. At bus stops, passengers should be isolated as far as practicable from the road traffic by providing a bus pull off area clear of the main carriageway.

Local roads

Local roads should be restricted to residential traffic only and are not suitable for use as bus routes.

Major developments and bus access

Where a large commercial development, such as a shopping centre, office park, college or hospital is planned for an area away from the central city area, the needs of, and demands on, public transport should be carefully assessed. Particular factors to be considered include the following:

- Bus access/egress and stop facilities should not be intermixed with normal car parking or affected by private vehicle queues.
- Bus route diversions off the sub-arterial or collector roads through the centre should be as short as possible, in both distance and time.
- Bus stop facilities should be as close as possible to the pedestrian access facilities for the centre.
- Colleges and hospitals should be located convenient to major transport routes (but not adjacent to arterial roads) and have good pedestrian access between the public transport stops and the facility. A shelter and even covered walkways (for very high volume routes) are desirable. Note that these facilities can be significant generators of traffic with different requirements from the through traffic on arterial roads. Noise is an issue for these facilities if they are located too close to an arterial road.
- Intermodal transport: People can walk, cycle or use other vehicles (e.g. car, motorcycle to get to public transport. Appropriate facilities are required for all modes and user types to support intermodal trips.

Consultation with Local Government and other stakeholders regarding the above points is essential.

3.4.5 Staged construction

3.4.5.1 Principles

The potential for developing a project in stages has to be determined in the Concept Phase. Appropriate staging will require a

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detailed analysis of the traffic impacts of the staging and the likely life of the stages proposed.

Proper attention must be given to the design to ensure that future construction of the next stages can be achieved without undue disruption to the road users and the adjacent property owners. This can affect various aspects of the design and can have a significant effect on the detail of the design adopted. Some features affected include the:

- width of medians;
- location of carriageway in the road reserve;
- length of overpass bridges;
- grading of the carriageway to facilitate future grade separation;
- location and spacing of intersections and interchanges;
- location of property accesses;
- provision for pedestrians and cyclists;
- provision of transit lanes;
- thickness, configuration and type of the pavement;
- clearance to overpass structures; and
- extent of works to facilitate temporary connections and their removal.

Whole of life considerations would indicate that current works should provide for the future stages to be implemented with minimal effect on the current works. In addition, they should make for ease of construction of the future works. Hence, a pavement could be extended to provide a clean joining point for a future extension to the carriageway clear of the traffic using the first stage.

Other examples include:

- providing space for piers for a future overpass;
- designing for a future overpass rather than an underpass;
- allowing space for future widening into the median;
- allowing for duplication of a single carriageway in the same right of way;
- providing a longer bridge for a future loop or additional lanes under the structure (e.g. duplication, widening);
- building bridge abutments and piers (i.e. substructures) wide enough for future deck widening (which might be particularly relevant in some environmentally sensitive areas);
- providing for spoil to be placed on the alignment of a future carriageway;
- providing space for PUP clear of the current and future carriageways;
- locating new PUP and relocating existing PUP so that it does not have to be relocated for future stages of the road development;
- minimising the temporary works required for future stages; and
- allocating corridor space to future on-road or off-road cycling facilities.

Methods of achieving these results are discussed in other parts of this Manual.

3.4.5.2 Construction sequencing and traffic diversion during construction

Sequencing of the construction process is different from the staging of a project and requires a different approach. Construction sequencing is the set of activities required to ensure that the project can be constructed economically while minimising disruption. In contrast, staging of a project defines the works to be carried out over an extended time frame to achieve some "ultimate" goal for the standard of the road.

During planning and design (i.e. concept and development phases) planners and designers must:

- Ensure that the project can be constructed in an economical manner and that residents, business, traffic and pedestrians are not unduly disrupted in the process. This might require changes to the planning and design, and some additional works to ensure that a satisfactory and safe outcome is achieved (refer to Section 3.3.3).
- Examine the sequencing of the works to determine the feasibility of the project and to determine the temporary works required to manage the construction process. Depending on the circumstances it might be appropriate to document the construction sequence.

There is support for both including and not including construction sequencing and temporary works in contract documents (e.g. on plans). Each project should be treated on its own merits. When there are many ways to sequence a project, the "rules" for managing traffic and other impacts are usually more appropriate than expending design time documenting a sequence. Conversely safety, ministerial commitment, the outcome of public consultation, or other essential constraints, might require a particular construction sequence that is not the most economical if those requirements were not there. In any case, the documents should allow contractors to devise a sequence appropriate to their methods provided all of the requirements are met.

Closely allied to sequencing is the number of construction contracts required to implement each stage of the project. To manage risk, traffic or cash flow, it might be advantageous to have separate contracts for specific aspects of the project. Preloading (to encourage early settlement), over-bridges, interchanges, specialist or proprietary works, some environmental management devices, PUP alterations and landscaping are some of the aspects where it may be appropriate to have separate contracts. Refer to Volume 1 of the Main Roads Project Delivery System (MRPDS - Main Roads, 2005) for further details on selecting the appropriate delivery method.

3.4.6 Life cycle costs

3.4.6.1 General

When developing options and deciding between them, both the initial capital cost of the facility and the ongoing cost of operations and maintenance must be considered. Decisions on the form of the design, the materials used and the staging of the works can have an impact on the whole of life costs of a project. Adopting a cheap solution for the initial construction will not necessarily produce the minimum whole of life cost.

3.4.6.2 Materials

Selection of the materials to use for pavements, bridges, safety barriers and noise barriers can have a marked effect on both the initial cost and the long-term costs (i.e. whole of life cost) of a project.

__Pavements__

The choice of pavement materials and type of pavement/s is one that generally requires a choice between a low initial cost with high recurring costs of maintenance and rehabilitation, or a high initial cost with low ongoing costs. The whole of life costs of such choices can be estimated and a decision can be made based on economic grounds. In some cases, the volume of traffic will be a determining factor (e.g. type of surfacing) but **availability of material is often a crucial issue** and may dictate the pavement design.

(Note: Section 3.2.5.2 also contains a general discussion about pavements.)

Bridges

Concrete (e.g. reinforced, pre-tensioned, post-tensioned) is the current material of choice for long-term low maintenance costs (assuming that the concrete is manufactured and constructed correctly with durable materials). Steel structures require ongoing maintenance (e.g. painting) that may negate any initial cost advantage they may have. In arid western areas, maintenance needs are significantly less and galvanized steel girders may represent an economical solution because the savings in transportation costs of girders to site may more than adequately offset any maintenance costs. Further considerations are the availability of suitable maintenance personnel and specialised maintenance equipment, and the accessibility of the structure (both getting to the structure as well as accessing elements of the structure itself).

Safety barriers

The choice of the type of safety barrier involves considerations other than the material type since the circumstances prevailing might not allow all types to be used (refer to Chapter 8). However, if different types are suitable, the cost of replacement and ongoing maintenance is a consideration. Concrete safety barriers have the highest capital cost but also the lowest ongoing costs since they are not usually damaged in a collision and there is little other maintenance required. They may also remain fully functional immediately after impact.

The type of surface under a barrier can also influence maintenance costs. Semi-rigid safety barrier placed above/through a sealed pavement requires negligible vegetation clearance maintenance work around the posts compared to a safety barrier placed on embankment or unsealed pavement.

Safety barriers may also require end treatments (where warranted). End treatments are normally expensive to repair and experience has shown that they may become obsolete as the vehicle fleet changes, or due to future research and development.

It should be noted that safety barriers are not the only solution; they should be "engineered out" where possible. For example, a flatter batter may deliver lower cost whole of life outcomes than a safety barrier and can also deliver greater safety benefits. (Refer to Chapter 8 for discussion about the forgiving roadside concept.)

Noise barriers

The lowest capital cost noise barriers are usually made of treated timber or earthworks. However, timber noise barriers are susceptible to damage by fire – a risk that should be assessed. Other materials are also available and other constraints or conditions may require their use (e.g. the provisions of transparent barriers or textured concrete barriers for aesthetic reasons). Whatever the case, the whole of life costs of each option can be calculated to help an appropriate decision to be reached.

Where space is available, an earth mound can provide distinct advantages as generally they have a higher aesthetic value to adjacent property owners and the travelling public. In addition, they can offer safety benefits, are low maintenance, fire proof, can be landscaped and obviate the graffiti problem. Earth mounds are particularly suitable in rural areas as they are more in character with rural settings than wall type structures.

3.4.6.3 Maintenance needs

The ongoing maintenance costs of the various features of a design must be considered in the decision making process. In addition the design must provide adequate access for maintenance activities. The maintenance requirements of the following are some aspects that must be considered when planning or designing a road:

- pavements (refer to Sections 3.2.5.2 and 3.4.6.2);
    - o pavement edges (e.g. seal shoulders to reduce maintenance requirements);
    - o outer wheel path pavement deformation (e.g. sealing shoulders reduces deformation and hence maintenance requirements if the thickness of pavement is adequate);
    - o flush seal pavements – require reseal every seven years on average;
- batter slopes (e.g. steeper slopes require expensive boom mowing while flatter slopes can be slashed);
- line marking (as different materials have different durability);
- debris removal from drainage inlets and outlets (which affects size and type of opening, use of grates, hydraulic design);
- surface drainage features (such as use of natural materials, concrete lining, channel shapes, use of bicycle safe grates);
- bridges (refer to Section 3.4.6.2);
- noise barriers (refer to Section 3.4.6.2);
- materials requiring painting (note that galvanized products remain unpainted);
- safety barriers (refer to Section 3.4.6.2);
- landscaping elements (refer to Section 3.4.6.4); and
- safe access for maintenance personnel and vehicles.

3.4.6.4 Landscaping

The whole of life costs of landscaping is heavily dependent on the type of treatments adopted and the standard of appearance desired. Refer to the Road Landscape Manual (Main Roads, 2004) for further information.

Issues to be considered include:

- the growth habit of trees and shrubs (e.g. know the expected size of trees and shrubs at maturity) and the location of these with respect to the clear zone;
- the impact of root growth (as they may intrude into drainage lines, cause heaving of pavements and footpaths);
- watering costs; and
- maintenance costs (e.g. costs of mowing, pruning and weed control).

The "Roadside Landscaping Policy" (Main Roads, 1994) should also be referenced.

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3.4.6.5 Public Utility Plant (PUP)

The objective should be to reduce the need for future road openings for PUP to zero. This is an unlikely possibility but the fewer road openings, the lower the long term costs for the road. To minimise the number of road openings, careful attention to the location of the PUP in the first instance is essential. In addition, providing sufficient space in the area allocated to the individual services, and installing enough ducts to provide for future expansion will reduce the need for future openings (refer to Sections 3.2.5.5 and 3.4.5.1).

3.4.6.6 Rehabilitation

Various components of the road require periodic rehabilitation to maximise the service life of the component. In particular, road pavements and surfacings other than concrete require rehabilitation at (regular) intervals; the length of these intervals depend on the type of pavement and surfacing. The design should recognise this and make provision so that these processes can be carried out with as little disruption as possible.

Increased clearances to overhead structures should be provided to allow (future) overlays to be done without breaching (i.e. reducing clearance below minimum value) the requirements for that structure. (Refer also to Chapter 7.) In addition, where allowance is made for future overlays, the width of the carriageway and formation must also be adjusted so that this can be accommodated (i.e. provide extra width now so adequate width remains after a future overlay).

3.4.6.7 Road user costs

Road user costs represent a significant part of the whole of life costs of a road. Benefit cost analyses account for these costs, which are affected by:

- road roughness;
- grades;
- length of travel;
- accident rates; and
- delay.

In addition to the immediate impact of particular features of the design, planners and designers have to take account of the rate of change in that feature with time and usage. In particular, road roughness increases with time and usage, the rate of increase depending on the type of pavement, its durability and the characteristics of the traffic.

Delay also may change with time as traffic volumes and congestion increase. Potential flooding delay remains constant for the road as long as the road levels remain constant.

3.4.7 Design vehicles

Appropriate design vehicles must be used for the planning and design of all roads. Chapter 5 sets out the approach to deciding on the vehicle to be used, and provides guidance on how to accommodate the occasional larger vehicle. When selecting the design vehicle and check vehicle consideration must be given to the likely vehicles that may use the road in the future (e.g. due to changes in permitted vehicles).

On many of the roads in the State, the appropriate vehicle will be a Freight Efficient Vehicle (FEV) or other Multi-Combination Vehicle (MCV), the form of which depends on the location and the link strategy. For example, road trains would be appropriate for many of the inland roads; B-Doubles should be accommodated on nearly all parts of the state declared road system.

In some cases, the appropriate vehicle should be a FEV, regardless of the current vehicles permitted on the road in question. This will allow the appropriate geometry for future use to be accommodated with very little, if any, expense in the first instance. Retrofitting the road for the larger vehicles in the future could be expensive.

3.5 Fair access and amenity

3.5.1 General principles

RCQ (Main Roads, 2002) sets out the principles of fair access and amenity. It means investing in roads for community quality of life, including access, employment, cultural heritage and amenity through:

- providing fair access across Queensland;
- undertaking roads programs that contribute to employment objectives;
- respecting culture and conserving cultural heritage;
- integrating roads into the community; and
- considering the aims of other government agencies in partnership with them.

The planning and design process must recognise these principles and apply them to all projects. The principles relevant to the planning and design process are captured in the following sections. Since consultation is a feature of many aspects of the planning and design process, that aspect is discussed in Section 3.2.

3.5.2 Fair access

The hierarchy of roads adopted by Main Roads for administering the road system provides the means by which fair access is achieved in Queensland (refer to Chapter 1). This hierarchy allocates a reasonable share of the use of the road to traffic travelling long distances and “local” property access traffic depending on the demand in an area. Research has proven that the accident rate increases as the number of property access points increases. This means it is appropriate to restrict property access in some cases in favour of the through traffic to provide safe movement of the major demand.

It is also necessary to provide fair access to pedestrians and cyclists to provide safe and convenient movement for this part of the road user population (refer Section 3.5.6).

3.5.3 Cultural heritage

Cultural heritage (both Indigenous and European) issues must be identified and their impact must be considered in the planning and design process. For guidance on all matters related to indigenous cultural heritage reference must be made to the Indigenous Cultural Heritage Policy and Guidelines Manual (Main Roads, 2004). Guidance for all other cultural heritage matters is provided in the Cultural Heritage Manual (Main Roads, 1998). (The parts of the Cultural Heritage Manual that deal with indigenous cultural heritage have been superseded by the Indigenous Cultural Heritage Policy and Guidelines Manual, however the remaining parts are still current.)

All native title issues must be identified and appropriate actions taken in planning of a project. The required notifications should be prepared and submitted at the same time as land resumption requests are made to minimise delays in obtaining right-of-way.

3.5.3.1 Aboriginal Cultural Heritage Act 2003 and the Torres Strait Islander Cultural Heritage Act 2003

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Indigenous Cultural Heritage Policy and Guidelines Manual (Main Roads, 2004) includes policy, guidelines and procedures which enable Main Roads to meet its statutory "duty of care" not to harm indigenous cultural heritage. These acts:

- are administered by the Queensland Department of Natural Resources, Mines and Energy;
- obligate all persons to fulfil a duty of care when undertaking actions that may impact on indigenous cultural heritage values; and
- defines the cultural heritage "duty of care" as: "*A person who carries out an activity must take all reasonable and practicable measures to ensure the activity does not harm indigenous cultural heritage*".

3.5.4 Community amenity

3.5.4.1 Property impacts

A range of issues concerned with impact on property and land acquisition can affect the planning and design of a road project including:

- Native title – this is a significant consideration and should be dealt with early in the process. Consultation with the appropriate indigenous communities is an essential component of the approach to be taken (Queensland Department of Families, Youth and Community Care 1997a, 1997b).
- Heritage listings – advice from the Queensland Environmental Protection Agency must be sought where there is any possibility of an impact on a heritage listed site.
- Vegetation protection orders (by-laws) and Green Areas – Local Governments could have tree preservation orders and/or rare tree listings and these could have a significant effect on the planning and design of the project.
- Acquisition costs – the Property Services Branch of Main Roads can provide the appropriate advice (injurious affection can be a significant cost).
- Types of property – communities have concerns for the residents of low cost housing being able to relocate, and for local producers being able to re-establish.
- Impact on property – loss of bore water supply, impact on dams, impact on income producing properties that can be critical to marginal operations.
- Number of people affected – this might be more important than the number of properties.
- Property values – there are often concerns that the value of property will be adversely affected by the project because of:
  - o increased traffic volumes and noise;
  - o restricted or controlled property access;
  - o reduced personal privacy due to loss of entertainment and recreation area;

- reduced flexibility in building modifications (e.g. future dwelling extensions prevented); and
- reduced amenity (e.g. loss of neighbourhood parks).

- Severance of farming properties – this might require accommodation works to provide for:
  - animal and machinery access (e.g. cattle creeps);
  - relocation of farm infrastructure;
  - maintenance of access to irrigation, dams, bores, streams, etc;
  - restoration of fencing (including dingo and rabbit fences where applicable); and
  - construction or relocation of grids.
- Mining leases – consultation with the Queensland Department of Natural Resources and Mines is required.
- Quarry leases – consultation with the relevant Local Government/s is required.
- Town plans – respect for the town plan and its objective is essential. Consultation with the relevant Local Government/s can assist in locating a new road to reinforce the objectives of the plan rather than be in conflict with it (refer to Section 3.4.1).

Land required for the project should be considered during the concept and development phases. Any land for environmental amelioration must also be identified at this stage. Final requirements should be determined at the preliminary design stage and resumption plans prepared in accordance with the Drafting and Design Presentation Standards (Main Roads, 2002).

The extent of land required should be determined from the clearance requirements defined in Chapter 7. Such land might be required for such things as noise mounds, sedimentation ponds, gross filter traps and buffer zones as well as space for maintenance activities. Where future development of the road will require property in addition to that required for the current project (e.g. staging), it is desirable to determine these future requirements in the first stage so it can be acquired at the same time, and so that multiple resumptions on the same property are avoided (i.e. resume once but in so doing allow for future requirements). This will avoid undue disruption to property owners in the future and provide a secure basis for future planning by Main Roads. It also minimises the risk of unnecessary relocation of PUP (refer to Sections 3.2.5.5, 3.4.5.1 and 3.4.6.5).

3.5.4.2 Effect on adjacent landholders

Planning must address the potential impact on adjacent landholders in addition to the effects on that property actually required for the project. Issues that must be considered include:

- Property values – properties not required for acquisition can be affected by the options in different ways and this might be an issue in deciding between alternatives. Costs of amelioration works could also be a consideration.
- Community severance – might require special consideration of pedestrian and cyclist facilities, together with provisions for local traffic movements.
- Local Government and State owned land – the future use of adjacent land owned by government authorities might

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have a significant effect on the development of the road proposal. Considerations could include:

- o access requirements (might need to incorporate additional lanes, channelisation or traffic signals);
- o service roads;
- o contributions by others to the infrastructure; and
- o special needs for education, police, hospitals, day care centres, libraries, etc.

- Emergency Services – the project might adversely affect the level of service that can be provided by the various emergency services (e.g. ambulance, fire brigade and police) and access requirements should be considered. For example, traffic signals might be required to allow rapid access from a station to the road for the fire brigade.
- Educational institutions – the requirements for pedestrians, cyclists, drop off zones, parking and public transport must be considered.
- Airport (aerodrome) clearances – projects in the vicinity of airports must comply with the State Planning Policy SPP 1/02 Development in the Vicinity of Certain Airports and Aviation Facilities and its guideline. They also must consider the effect of structures and poles on the obstacle limitation surfaces around the airport (aerodrome). (Refer to the Civil Aviation Safety Authority's website [www.casa.gov.au] for further details.) Further, road lighting in the vicinity of the airport (Aerodrome) might be confusing or distracting for pilots at night and special provisions may be required to obviate this effect (refer to Chapter 17).
- Airport (aerodrome) extensions – projects adjacent to airports require consultation with the airport (aerodrome) authorities with respect to future airport (aerodrome) developments (e.g. future runway extensions).
- Ports (clearance heights and shipping manoeuvre clearances).
- Other Institutions such as the following should also be considered:
  - o war memorials;
  - o hospitals;
  - o retirement villages; and
  - o vibration sensitive facilities or industries.

3.5.4.3 Noise and noise barriers

Properties subjected to an increase in noise level beyond the defined limits (refer to the Road Traffic Noise Management Code of Practice - Main Roads, 2000) could require protection by some form of noise amelioration device. This is generally accomplished with noise barriers.

The Road Traffic Noise Management Code of Practice (Main Roads, 2000) provides guidance on the design considerations relevant to noise barriers. Key points follow:

- Ensure that the design and location of noise barriers takes account of sight lines.
- Provide sufficient access for maintenance crews behind noise barriers when the barriers are not located on the property boundary, or

when located near other road furniture (e.g. safety barriers).

- Set back noise barriers a sufficient distance to allow the designed deflection of a safety barrier to occur without impacting the noise barrier. required to allow for deflection (refer to Chapters 7 and 8 for the lateral clearances required). In some cases, a noise barrier may be incorporated as an integral part of the design of a rigid safety barrier. Designs must be consistent with the requirements of Chapter 8.
- Ensure that the noise barriers do not hinder drainage.
- Provide materials that are suitable for the location (e.g. consider the risk of fire to a timber noise barrier in a rural environment).
- Ensure that the length noise barriers overlap is double the distance between the two noise barriers.
- Ensure that noise barriers comply with CPTED principles (e.g. do not prevent natural surveillance from occurring, refer to Section 3.3.4).
- Earth mounds could be a more suitable solution, particularly in more rural areas.

3.5.5 On-road amenity – development and retention of views

It is desirable that any point of interest near the road be able to be viewed by users of the road. This has positive effects on the aesthetics of the road from the driver's perspective, but it also has beneficial effects in maintaining driver interest and in reducing driver fatigue. Tourism can also benefit if an area's natural beauty is readily visible. Points of interest include areas of high scenic value and include natural and man-made features.

Natural features include:

- hinterlands;
- mountain ranges;
- the ocean; and
- other bodies of water (e.g. lakes or rivers).

Manmade features include:

- city skyline profiles; and
- landmarks.

Where possible, the alignment should capture attractive scenic views and use appropriate features as "aiming points" on the route, as shown in Figure 3.4. The alignment should provide a varying perspective of such features to provide variety for the driver (and so reduce monotony) and to provide an awareness of progress at a reasonable speed (which avoids "velocitisation" of the driver - refer to Chapter 10).

Figure 3.4 This alignment captures views and orientates the driver

Ideally, the view of the feature should change at a rate that provides the driver with an appreciation of the speed of travel. At the least, the rate of change must provide the driver with confirmation that adequate progress is being achieved in a reasonable time.

To achieve this, the road has to be aligned such that the point of interest falls within the driver's field of vision when looking straight ahead. The feature must then remain within this field (including peripheral vision) while changing position within it to provide the appreciation of movement and progress. If the view falls outside the driver's normal field of vision, he/she will be encouraged to look away from the road and be distracted from the driving task (i.e. their eyes will follow the point of interest rather than the road). Further, features located remote from the field of vision will not provide the sense of movement and progress desired. During the design of the vertical alignment, the planner or designer should, as far as is practicable, ensure that views are not largely obscured by the presence of cuttings and their batters, noise barriers or other roadside furniture.

When positioning road, rail or pedestrian overpasses, any adverse effects on views should be avoided if possible. The same applies with respect to the location of landscape planting and roadside furniture. Roadside furniture that potentially affects views includes:

- signs with multiple supports;
- gantry signs;
- noise barriers;
- safety barriers (particularly concrete barriers);
- headlight anti-glare screens; and
- advertising signage (Figure 3.5).

Excluding noise barriers, these items of roadside furniture can normally be built into the road landscape without diminishing the value of distant and close views. The benchmark to determine the impact of a structure on a view is that the structure should not dominate, distract or diminish the ability to appreciate the view. The Road Landscape Manual (Main Roads, 2004) addresses some of the issues regarding aesthetics for roads.

Figure 3.5 Advertising signage can adversely affect views

It is particularly important that views on existing roads be maintained. At locations where a panoramic view ahead is framed by the sides of a cutting, it is important that the presence of roadside furniture does not obscure this view.

On high volume roads through urban and rural residential areas, residents might like dense roadside vegetation to eliminate headlight glare and reduce the visual impact. In these situations, the desires of the local residents must be balanced against the need to provide views from the road and a forgiving roadside environment.

3.5.6 Pedestrians and cyclists

Transportation corridors provide a medium for all modes of transport. In urban environments, cyclists and pedestrians form a growing proportion of transport corridor users. The IRTPs and many Local Governments are actively encouraging increased walking and cycling. Therefore, high quality, convenient, connected, safe and attractive routes for cycling and walking need to be incorporated into road designs at the concept phase to encourage use of these modes and to ensure the safety of these 'at-risk road users'.

Pedestrian issues (South Australian Government, 2000) include:

- safety - avoiding conflicts with cars and providing safe crossings;
- convenience – obvious or direct paths, continuity and permeability;
- pleasure - vibrant and varied surroundings;
- protection from the weather;
- comfort - wider footpaths, good paving, places to wait and sit, opportunities for people-watching;
- security - good lighting, active frontages, pedestrian routes not separated from roads; and
- interest - building frontages (for window shopping), landmarks, attention to detail in the paving surface and texture, art in public places, unfolding views.

The needs of cyclists (South Australian Government, 2000) include:

- safety - safety is again about avoiding conflict with cars through clearly marked lanes, lowering/calming the speed of adjacent traffic, providing high kerbs to prohibit cars from parking on the footpath, safe crossings; and
- convenience - speed maintenance, connectivity, clearance, smooth surfaces, appropriate vegetation, secure storage at the end of the trip and changing/shower facilities.

CPTED (refer Section 3.5) also influences the design of facilities for pedestrians and cyclists.

Mixing cyclists and pedestrians is increasingly common and raises safety issues. Hybrids (e.g. skateboards and roller blades) are also common in some areas and introduce additional considerations of paving, kerb edges and street furniture. Planning SA notes in passing:

"*bike racks and lockers, though convenient … are not benign in the urban landscape and should be designed and positioned with the same care as other street furniture*" *(South Australian Government, 2000).*

The needs of pedestrians and cyclists must be incorporated into the concept phase and included in the relevant elements of the road design. Chapter 5 describes the basic parameters for assessing these requirements. Special features will often be required to accommodate their needs.

In some cases, an overall strategy is in place to provide a network of cycle ways and pathways and these strategies form the basis of the decisions required for the facilities to be included. Planners and designers should ascertain the strategies in place for the area in question and incorporate the necessary features into the project. Main Roads has developed a "Cycling on State controlled Roads" policy (Main Roads, 2004) - designers and planners must comply with it.

Providing for pedestrians and cyclists is a major function of Local Government. It is therefore necessary to ensure that Main Roads proposals are compatible with the Local Government's responsibilities, and vice versa. This could involve sharing costs between the Local Government and Main Roads, both for construction and for

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maintenance. The responsibilities and cost sharing arrangements are set out in the "Agreement between the Local Government Association of Queensland Inc. and Department of Main Roads for Cost Sharing based on Responsibilities within State Controlled Roads (Main Roads, 2000)".

The following issues should be addressed in the concept phase.

Cyclists

Cycling facilities or cycle friendly designs (e.g. provision of wider road shoulders) must be considered on State Controlled Roads in accordance with the "Cycling on Sate Controlled Roads" policy (Main Roads, 2004). Provision for cycling increases the safety of all road users and avoids the impedance created by having cycling in the general use traffic lanes. Planners and designers need to consult with the Local Government to ensure that installation of the cycling facility conforms to the regional and local authority cycle network plans. If no such plans are in place, consultation with the local authority staff, local representative user groups (e.g. Bicycle User Groups [BUGs]) and local cyclists will be necessary. Refer to Chapter 5, the Guide to Traffic Engineering Practice (GTEP) Part 14 (Austroads, 1999) and the MUTCD (Main Roads, 2003) for guidance on provision of cycling facilities. Queensland Transport has also published a number of cycle notes that may be useful (Queensland Transport, 2005). However, for State Controlled Roads the order or precedence is:

1. Chapter 5 and the MUTCD (Main Roads, 2003).
2. The GTEP Part 14 (Austroads, 1999).
3. The Queensland Transport Cycle Notes.

When providing a cycling facility, consider whether an on-road or off-road facility is required. Off-road facilities provide the highest separation from motorised traffic for this at-risk road user group, but could increase land resumption requirements and also increase the cost; these issues must be taken into account. In rural areas it might be more feasible to provide for the highest degree of separation via off-road paths because the cost of the construction may be less than the cost of widening the road pavement (as extra land would rarely be required in these cases). The most appropriate type of cycling facility will depend on speed and volume of traffic, surrounding land uses and the types of user expected on the facility.

Potential bicycle/motor-vehicle conflict points may require special treatment. Special intersection treatments such as advanced stop lines, storage bays, bike lanes or bike crossing signals, might be required and the cost included in the project costing. The planning and design process should pay particular attention to cycle trip generators (e.g. schools and shopping centres) and "pinch points" (e.g. channelised intersections). Any need for the use of grade-separated structures (e.g. at interchanges) should be identified in the concept phase.

Pedestrians

Provision for pedestrians will be required on all Sate Controlled Roads in built up areas except those such as motorways where separate provision will need to be built into the project. Note however that the cost of providing a footpath is normally borne by the relevant local government. The concept phase should include consultation with the Local Government and community groups to confirm the requirements for pedestrians (refer also to Chapter 5).

If a footpath is required its width must be determined; Chapters 5 and 7 provide guidance. The width necessary for the installation of PUP must be taken into account. Footpath width will affect the land acquisition requirements.

Potential pedestrian/motor-vehicle conflict points may require treatment. Special intersection treatments could be needed and the costs to the project of providing the necessary facilities must be taken into account (refer to the GTEP Part 13 - Austroads, 1995).

Note that all pedestrian facilities provided must be in accordance with design criteria for people with disabilities.

Combined pedestrian and cycling (i.e. shared) facilities

It is important to note that Chapter 5 and the GTEP Part 14 (Austroads, 1999) outline design requirements for shared pedestrian/cycling facilities, which are also designed using design criteria that are suitable for people with disabilities. Shared facilities are often a safe, cost effective solution in outer urban and rural residential areas.

3.5.7 Roadside amenities

3.5.7.1 Service centres

Service Centres are major facilities provided by private enterprise on major roads with full access control. Acquisition of land and provision of infrastructure for Service Centres is the responsibility of the private developer. The requirements for Service Centres are described in Chapter 20. Main Roads' Service Centre policies should also be consulted and adhered to (Main Roads, 1997, 1998 and 2002).

3.5.7.2 Rest areas

Rest areas are established, located and designed in accordance with Main Roads' "Provision of Roadside Amenities" policy (Main Roads, 2003). They are off road stopping places providing at least safe parking, shade, picnic tables, benches and rubbish bins. Toilets, water and barbecue facilities with fuel and lighting may be provided in accordance with the "Provision of Roadside Amenities" policy (Main Roads, 2003). Access to the rest area must be properly designed with attention to the required acceleration and deceleration lanes and turning facilities (refer to Chapters 13 and 20).

3.5.8 Special works

Special works include:

- Cattle creeps which might be required where a new road severs a rural property. They are usually placed where the vertical alignment affords the opportunity but it could be necessary to adjust the design to accommodate the crossing to make it convenient for the property owner to use.
- Fauna crossings, which are discussed in Section 3.6.6.
- Grids which are installed to control cattle, sheep, etc. If the AADT exceed 700s, grids are not suitable and the road should be fenced to ensure adequate safety for the traffic.
- Open level rail crossings (refer to Chapter 21).

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3.5.9 Stock routes

Stock Routes are managed by the Queensland Department of Natural Resources and Mines from a central office in Brisbane. Where Limited Access declarations could impact on a Stock Route, the Queensland Department of Natural Resources and Mines must be consulted before finalising the plans.

Proposals are to be forwarded to the central office for stock management in the Queensland Department of Natural Resources, Mines and Energy in the first instance and the central office will coordinate with the local officers.

Main Roads has also published polices related to "stock-on-hoof" (Main Roads, 1998 and 2005)

3.5.10 Development assessment

With respect to development assessment, applications will be referred to Main Roads when State matters of roads and transport infrastructure are at issue, triggered by legislative provisions, scheme provisions or threshold guidelines.

Benchmark development sequencing is also provided for under legislation. This is a mechanism to encourage the most cost efficient delivery of infrastructure to new co-ordinated and sequential development. Identifying development sequences in planning schemes will act as an incentive to encourage development within the planned sequence, and allow recovery of costs for bringing forward development that is "out-of-sequence". The methodology for determining "bring forward" costs is outlined in the Guidelines for Assessment of Road Impacts of Development Proposals (Main Roads, 2001).

Main Roads is a referral agency for IDAS, which requires that developments be referred to Main Roads for assessment when certain conditions are met. The referral triggers and thresholds are described in the Integrated Development Assessment System Manual (Main Roads).

Applications are referred to Main Roads to ensure that sufficient road and transport infrastructure is provided in relation to the development thereby maintaining a satisfactory level of safety and service to all road users. Main Roads has published the Guidelines for Assessment of Road Impacts of Development Proposals (Main Roads, 1999) to assist developers provide the required information and to provide guidance to Main Roads Officers in assessing proposals.

To assist in determining the traffic impact of these developments, possible generation rates are included in Appendix 3A of this Chapter. Planners (and designers) should use actual generation rates for similar trip generators that are measured locally if such information is available and robust.

3.6 Environmental management

3.6.1 Main Roads' commitment

Main Roads provides a commitment to the protection of the environment in its "Environmental Management Policy and Strategy 2002-2007" (Main Roads, 2002) and RCQ (Main Roads, 2002). The commitment is for Main Roads to undertake infrastructure planning and development in accordance with the whole of government approach to Ecologically Sustainable Development (ESD).

ESD refers to a concept of identifying the ecological, economic and social aspects of a proposal and ensuring that it:

"... improves the total quality of life, both now and in the future, in a way that maintains the processes on which life depends" (UNESCO).

ESD may be defined as using, conserving and enhancing the community's resources so that the ecological processes on which life depends are maintained, and the total quality of life, now and in the future, can be increased (Australian National Strategy for ESD – Commonwealth of Australia, 1992). It is not a balance; it refers to the need to advance each ecological, economic or social objective without loss of value in any one of them.

To achieve the objectives of ESD and environmental principles, environmentally sensitive decisions are to be employed throughout the concept and development phases of a road project. These principles are then to be carried through to construction and maintenance activities (e.g. implementation phase). The four guiding principles of ESD follow:

- Improve well-being – to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations.
- Ensure intergenerational equity – to provide for equity within and between generations.
- Protect biodiversity – to protect faunal and floral diversity.
- Maintain ecological processes – to maintain essential ecological processes and life-support systems.

For Main Roads to achieve the Government's objectives concerning ESD, a road project must at the very least advance one of the above principles and not adversely impact the others (Austroads, 1995). Main Roads already uses many tools for assessing ESD in the concept, development and implementation phases of projects. Principal tools that can be used within the project charter are outlined in Appendix 3B of this Chapter.

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3.6.2 Scope

Environmental considerations cannot be addressed in isolation of other road and transport planning or design practices. The Environmental Protection Act (Queensland Government, 1994) places responsibility on all Queenslanders to meet a general environmental duty. This means that Main Roads (and its contractors) must not carry out any activity that causes, or is likely to cause, environmental harm unless the responsible party has taken all reasonable and practicable measures to prevent or minimise the potential for harm to occur. Therefore, all activities undertaken by and on behalf of Main Roads should consider environmental impacts and incorporate environmental treatments where required. With this in mind, appropriate environmental issues have been incorporated within all relevant chapters of this Manual.

This chapter only provides guidelines of some key environmental issues to assist the planning and design of State Controlled Roads. These issues should not be considered in isolation; they should be dealt with in conjunction with all the other issues that need to be considered.

Further detailed environmental information relevant to the planning and design of road projects can be obtained from the following publications (and Chapter 1):

- Pre-construction Processes Manual (Main Roads, 2005);
- The Road Project Environmental Management Processes Manual (Main Roads, 2004);
- The Road Landscape Manual (Main Roads, 2004);
- Roads in the Wet Tropics Manual (Main Roads, 1997);
- Cultural Heritage Manual (Main Roads, 1998);
- Environmental Legislation Register (Main Roads, 2004);
- Road Traffic Noise Management: Code of Practice (Main Roads, 2000);
- Fauna Sensitive Road Design (Main Roads, 2000);
- RDDM (Main Roads, 2001);
- Main Road's Roadside Conservation Policy (Main Roads, 1994);
- Main Road's Roadside Landscaping Policy (Main Roads, 1994);
- Main Road's Pest Management Policy (Main Roads, 2003);
- Main Road's Interim Clearing Within Road Boundaries Policy (Main Roads, 2005);
- the Interim MRS11.51 Environmental Management Specification (Main Roads, 2004);
- Main Road's Red Imported Fire Ant Policy and Strategy (Main Roads, 2002);
- Main Road's Environmental Management Policy and Strategy 2002-2007 (Main Roads, 2002); and
- Austroads' Environmental Risk Assessment (Austroads, 2001).

However the above list is not exhaustive and specialist advice should be sought.

3.6.3 Environmental assessment

Chapter 1 summarises the planning processes for road projects, which are detailed in the Pre-construction Processes Manual (Main Roads, 2005). These also demonstrate the integration of environmental documentation into the road project phases.

Appropriate actions/decisions in the early part of the concept phase of road projects have the greatest potential to minimise environmental harm. This is achieved through identifying and avoiding areas that contain significant environmental values or where unmanageable environmental limitations occur (e.g. landslip prone areas, potential acid sulphate soils).

During the early part of the concept phase, constraints mapping or environmental risk assessments should be undertaken to establish the presence or absence of significant environmental constraints. Commonwealth legislation, (i.e. Environment Protection and Biodiversity Conservation Act), also has a significant impact on the planning of our roads with regard to avoiding significant impacts on matters of national environmental significance (refer Chapter 1 for details). **An environmental specialist should establish the environmental issues relevant to the road project so that all environmental constraints are identified and considered.**

Key areas for consideration include the following (refer also to the following notes as indicated):

- World Heritage properties[1,2].
- Wetlands (e.g. Ramsar[1,2] and otherwise significant wetlands).
- Protected areas (e.g. National Parks and Nature Reserves[2]).
- Fish habitat reserves[2].
- Endangered bio-regional ecosystems[2].
- Areas that are known to support internationally, nationally, state, regionally and/or locally significant flora and fauna species and communities (as per the Environment Protection and Biodiversity Conservation Act and the Nature Conservation Act)[2,3].
- Sites of indigenous and non-indigenous cultural heritage significance[3].
- High risk soil types (e.g. acid sulphate, sodic and toxic soils)[3].
- Contaminated sites.
- Areas which provide connectivity of habitats for plant and animal species[3].
- Good quality agricultural land[3].
- Mineral reserves[3].
- Noise and vibration sensitive receptors[3].
- Declared areas (e.g. irrigation, groundwater recharge, approved property plans)[3]. Local Governments generally hold information regarding approved property plans and these plans might identify conservation areas on freehold or leasehold lands.
- Environmentally sensitive areas where existing Memoranda of Understanding (MOUs) apply – planners must establish whether such MOUs exist and consider their requirements.

Notes to above dot points:

1. The location and extent of these areas can be identified from the Environment Australia web site (the website at the time of publication was www.environment.gov.au).
2. The location and extent of these areas can be identified from the Road Corridor Environmental Assessment Main Roads Intranet page on ARMIS Online. This requires interrogation of relevant databases and field assessments as part of the process. Officers of external organisations should contact the relevant Main Roads District to obtain this information.
3. This requires interrogation of relevant databases and field assessments that are undertaken as part of the environmental assessment process. Officers of external organisations should contact the relevant Main Roads District to obtain this information.

When deciding the appropriate location of road corridors, the need for early consideration of any areas with key environmental values and limitations cannot be overemphasised.

Planners, including strategic planners, and designers should:

- Visit the site preferably, in the company of an environmental specialist, during the concept and development phases to ensure that all of the proposed environmental elements are practical for the site.
- Ensure environmental assessment documentation has been provided with

the design brief. If it has not been, seek instruction with regard to the environmental considerations of the project.

- Ensure environmental constraints (e.g. "no-go" areas, cultural heritage sites) and opportunities (e.g. suitable sites for stockpiles, construction compounds) are defined on design drawings or in contract documentation (an environmental specialist can assist).

The Road Project Environmental Processes Manual (Main Roads, 2004) describes the assessment and reporting requirements and these are summarised in the Pre-construction Processes Manual (Main Roads, 2005).

3.6.4 Greenhouse strategy

(Refer to "Promoting Best Practice in Transport and Land Use Planning" publication [Queensland Transport et al, 2002] for detailed information; this section is based extensively on that document.)

The National Greenhouse Strategy (Commonwealth of Australia, 1998) is the primary mechanism through which Australia's international commitments will be met.

The Australian Government developed a National Greenhouse Response Strategy as a means of meeting Australia's international obligations under the Framework Convention on Climate Change and as a basis for examining greenhouse issues. However, this strategy was subsequently extended to form the National Greenhouse Strategy (Commonwealth of Australia, 1998). The National Greenhouse Strategy (Commonwealth of Australia, 1998) provides details of existing actions and measures to be implemented by stakeholders as a way of meeting Australia's international commitments.

The Mission Statement for the National Greenhouse Strategy is:

"Australia will actively contribute to the global effort to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system and within a time frame sufficient to:

- *allow ecosystems to adapt naturally to climate change;*
- *ensure that food production is not threatened; and*
- *enable economic development to proceed in a "sustainable way."*

As part of the overall strategy being implemented by the Australian Government, Queensland Transport, together with Austroads and the Australian Greenhouse Office, produced, in 2002, a document called "Promoting Best Practice in Transport and Land Use Planning". This is an extensive resource of information available to assist in minimising greenhouse gas emissions when undertaking planning and design for transport infrastructure.

The reduction of greenhouse gas emissions from the transport sector will contribute to the achievement of additional environmental, economic and social objectives. These include:

- reduced business costs through decreased traffic congestion;
- improved urban air quality; and
- greater public transport accessibility for members of the community through more efficient use of infrastructure and land.

Land use planning has a key role in providing for an integrated transport strategy (refer also to Section 3.4.1). Forward planning of the location, scale, density, design and mix of land uses can help reduce the need to travel, reduce the length of journeys and make it safer and easier for people to walk, cycle or use public transport. Decreases in forms of urban pollution can be achieved through better land use development and better design of transport systems.

The transport sector is one of the largest sources of greenhouse gas emissions in Australia and private transport is the largest urban land use related source of emissions. The characteristics of urban form significantly influence greenhouse gas emissions from the transport sector. In Australia in 1998, transport was the second largest contributor of emissions from the energy sector. In terms of total net emissions, transport comprised 16% of Australian emissions.

Reducing greenhouse gas emissions in the transport sector relies heavily on encouraging environmentally friendly forms of transport such as walking, cycling and using public transport. Planners, including strategic planners (and designers) should be alert to the need to provide for these forms of transport in convenient and attractive ways when developing their plans. A range of sources of information to assist in the planning process is available and reference to them can be found in Queensland Transport et al (2002).

However, the largest effects on emissions are related to the broader planning aspects as described in Sections 3.4.1, 3.4.2 and 3.4.4.

3.6.5 Engineering design

3.6.5.1 Introduction

Planners and designers, in seeking to develop a context sensitive design (refer to Chapter 2), should take a holistic approach to the design and consider all of the elements as a whole, taking account of how they interact with and affect each other. In some cases, the solution will only come from an iterative approach that tries various solutions and assesses them against the required criteria until the most effective answer emerges (e.g. options analysis).

The following sections discuss some of the major road planning and design issues that impinge on environmental values. Other elements can also have an effect (e.g. alignment) and these effects must be accommodated where they occur. The elements discussed in the following sections have a direct and enduring effect on the environment.

3.6.5.2 Cross section

Chapter 7 discusses cross section design, and the particular requirements of the wet tropics. The significant issues, other than batter slopes, relate to the total width of cross section and the extent of clearing required. The issues with respect to batter slopes are worthy of further discussion in the Section.

Detailed discussion of the engineering requirements of batter slopes is given in Chapter 7 and that chapter should be read in conjunction with Main Roads' Specifications and the comments in this section, which are directed to the environmental sustainability of batter slope design.

When designing batter slopes, planners and designers should review the geotechnical data with regard to soil types (for soil "erosivity" and "dispersiveness") in addition to assessing the stability of cut and fill batters. Guidelines to assist in the design of batter slopes follow:

- Direct overland flow away from the batter face using catch banks and/or catch drains. Be aware that catch-banks/drains can create concentrated flow and therefore also cause an erosion problem. As such, armouring of the catch drain and outlet, or reducing flow velocities through the use of diversion drains (or level spreaders), may be required.
- Flatten the slope of (cut and fill) batters wherever possible. In addition to reducing erosion potential, flatter batters provide safety benefits and often remove the need for a safety barrier. Flatter batters can also significantly reduce mowing maintenance costs if a tractor and rear mounted slasher can be used instead of a side boom mower.
- Flatter batters assist in the establishment of landscaping and reduce erosion of topsoil. Grass will usually grow on flatter batters in areas where grass would otherwise find it difficult to grow.
- Where required, batter protection treatments (e.g. rock mulching, shotcrete, grouted rock, erosion control blankets) should extend at least 1m beyond the slope crest and the toe of the slope.
- Surface roughening to a depth of 30mm to 50mm should be provided on stable batters because it provides greater opportunity for the establishment of vegetation. Roughening is not suitable in dispersive soils unless carried out in conjunction with the application of a surface cover. Roughening should be done along the contour or at an angle to a grade that reduces velocities before discharge.
- Benching should not occur in dispersive soils. If benching is required in dispersive soils, consult an environmental specialist for advice regarding suitable erosion control treatments.
- Consider soil types in addition to the cut or fill height and land acquisition boundaries when determining the slope of a batter (refer to Table 3.2 for guidelines).
- Stormwater from the road must be managed and controlled to avoid erosion of batters. Dykes and batter drains provide one method of control of this run-off (refer Chapter 7 and the RDDM [Main Roads, 2001]).

3.6.5.3 Drainage

(Note: Section 3.2.5.6 also contains a general discussion about drainage.)

The design of drainage for the road should fit in with any strategic or master drainage schemes of the relevant Local Government where possible. Planners and designers can obtain the details of these schemes and the existing drainage networks from the relevant Local Government and from previous departmental schemes and documents (e.g. plans).

In addition, major drainage structures might require the approval of the Queensland Department of Natural Resources and Mines.

Table 3.2 Guidelines for selecting batter slope based on soil types

Material	Slope Type	Height	Slope
Stable material/rock	Cut	<1m >1m	≤1on3. ≤≤1 on 1.5.
	Fill	<1m >1m	≤1 on 4 ≤1 on 2
Soils with high erosion potential(e.g. sodic subsoils)	Cut	Any	1 on 2 with surface treatment and diversion drains above the slope.
	Fill	-	Materials should not be used for fill slopes without treatment or covering with non-dispersive material.
Sandy soils (lacking cohesion)	Cut	<2m >2m	≤1 on 4. ≤ 1 on 3.
	Fill	-	1 on 4 to 1 on 6.

1. Where benching is required, geotechnical input is required to determine location of bench and whether inward or outwards drainage is required. Generally, drainage should be inward unless slopes to be affected are treated.
2. Diversion drains may need to be lined to prevent dispersion of underlying materials. If upstream catchment is small, drainage can be sheeted over the face of the slope provided erosion control treatment has been applied to the slope.
3. Benching should not be used in soils with high erosion potential.
4. Refer also to Chapter 7.

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During the concept phase and in particular, the development phase, it will be necessary to undertake a more detailed examination of the requirements of major drainage structures when:

- cultural heritage issues arise;
- native title issues arise;
- the size and shape of the structure affects the land acquisition required;
- environmental impacts might be significant;
- the vertical distance from the base of the drainage path to the bottom of the pavement is critical;
- the height of the upstream head might cause flooding problems; and
- the proposed drainage structure (or drainage works) might conflict with PUP or other structures thereby affecting the structure's size, shape and location.

The overall effect of the structure on the cost and/or land requirements will determine the extent of design required at the various phases of the project. This could require a detailed hydrological or hydraulic analysis to be undertaken; if a complex hydrological or hydraulic analysis is required, specialists should undertake it. (Refer also to the RDDM [Main Roads, 2001]). Discussion of some specific issues follows.

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Major drainage structures

A major drainage structure is one where the cost of the structure has a significant effect on the total cost of the project and includes structures over rivers or creeks. Planners and designers will need to assess the approximate structure sizes early in the concept phase (e.g. proposal and/or options analysis) to avoid misleading conclusions about the cost of the project.

In some rural schemes that lack major drainage structures, the costs of drainage works structures might only be a very small part of the overall cost. In this case, very few calculations will be required to determine the drainage requirements and cost. However, in some cases in urban situations, the costs of drainage works/structures are a substantial part of the overall cost and planning of the drainage system will need to be more exact at earlier stages of the process.

Preliminary design for major drainage structures includes obtaining topographic maps or contour plans of the catchment areas surrounding the alignment to determine major drainage paths. Approximate flows may be determined as described in the RDDM (Main Roads, 2001). Future upstream development should be considered in the calculation of the drainage flows. Any possible drainage reserves or easements that are required should also be considered. (Refer also to the RDDM [Main Roads, 2001]).

Chapter 22 provides guidelines on bridge design and discusses potential environmental effects. Planners and designers should refer to Chapter 22 and the RDDM for guidance (Main Roads, 2001). Specialist advice should also be sought.

Cross drainage

In the early stages of a planning project, an approximate waterway area for cross drainage structures should be calculated to provide an estimate of the extent of work required. The RDDM (Main Roads, 2001) describes approximate methods. A preliminary assessment of the type and size of culvert can be determined from this information together with the preliminary vertical alignment and natural surface. Any possible adverse effects of the resultant upstream headwater level should be considered. If it is suspected that tail water levels might have a dominant effect (i.e. in low-lying flat areas), then preliminary design calculations assuming outlet control and a tail water level should be considered.

If a floodway is to be considered on a Auslink National Network Road Link the Commonwealth Government should be consulted to ascertain its requirements, if any, should be reflected in the relevant Link Strategy. For all other roads, the flood immunity requirements are defined in the Link Strategies for that road.

In addition to flood immunity requirements, the impact of a flood larger than the "design" flood on the road and on adjacent properties must also be considered.

Methods of floodway design are contained in the RDDM (Main Roads, 2001). Likewise erosion and sediment control is discussed in detail in the RDDM (Main Roads, 2001).

Longitudinal drainage

The location of the outlets of longitudinal drains can affect the quantity of water to be carried in some of the culverts and therefore can have a major bearing on culvert sizes and lengths. In some cases, the boundaries of the catchments might be affected by the distribution of the water from the longitudinal drainage system – this should be avoided. The water level at the outlet is also a major consideration. Refer to the RDDM (Main Roads, 2001) for design methods.

Consideration of the environmental issues for longitudinal drainage is important to reduce erosion risk and the resulting sediment laden water and maintenance costs. Key issues include:

- Limit the use of "V" drains, particularly in erosive soils. Parabolic or flat-bottomed drains should be used in preference. The latter may still require armouring but in these circumstances a combination of armouring and vegetation treatments are more likely to succeed.
- Limit flow velocities for longitudinal drainage for different soil types. (Refer to the RDDM [Main Roads, 2001] also provides guidance on acceptable flow velocities.) Flow velocities may be slowed through the use of roughening techniques (e.g. embedded rock, turfing), check dams and/or vegetation. Where check dams are installed, designers need to ensure that the design and location will not cause a hazard to errant vehicles. Limiting flow velocities is preferred over maintaining high flow velocities and providing armoured structures (e.g. by paved channel to energy dissipaters). In addition, an increase in the number of diversion drains (or turnouts, level spreaders) from the longitudinal drainage should be considered. Notwithstanding the above, median longitudinal drainage will usually have a concrete lined invert to assist maintenance and reduce the risk of errant vehicles rolling after hitting ruts caused by tractor mowing of the median invert.
- Consider collecting road run-off from bridge scuppers and discharging run-off into a sediment basin, gross pollutant trap or other relevant first flush containment device. This is particularly important where the run-off would otherwise be directed into a pond or the base flow channel, and/or if upstream of a sensitive environment (e.g. wetland, fish habitat reserve).
- Design the transition between longitudinal drains (e.g. table drains) and a cross-drainage culvert to avoid slopes in the drain with high potential for scour. Specific erosion protection, and/or particular attention to the design of the drainage structures will be required.

Refer to the RDDM (Main Roads, 2001) for further details.

Complex hydraulic analysis

Where the major drainage structure is on a waterway that requires precise analysis, specialist advice should be sought about the flood immunity required, and the type and size of structure required. Complex hydrological and hydraulic analysis is generally required on the following waterway types:

- waterways in/from large catchments;
- waterways in/from complex catchments (e.g. multi stream systems peaking at different times during the design flood);
- waterways with unsteady flows;
- flood plains;
- waterways downstream from dams, weirs and reservoirs;
- waterways with tidal flow; and

- waterways with significant local storage.

Minor drainage structures

There is generally no requirement to undertake any design calculations for minor drainage systems in the early concept phases. In the early concept phases:

- A nominal cost is usually sufficient to allow for minor drainage systems.
- Cross drainage culverts can be located by visual inspection of topographic maps or contour plans.
- For minor longitudinal drainage in urban areas, pits may be placed at a nominal spacing along the roadway and a nominal number of pits may be allowed for at each intersection.

The detailed drainage design requires that the designer consider a range of factors in addition to the normal engineering requirements for the design. These include both environmental and the requirements of various federal, state and local government agencies. Such factors should be reconsidered to ensure that the requirements are the same as determined during the concept phase. Environmental considerations are further considered in following sections.

3.6.5.4 Geotechnical and geological conditions

Geotechnical and geological conditions for any particular option can have a significant influence on its feasibility and cost. In extreme cases, natural hazards may preclude some options altogether while the presence of land slips, swamps, rock outcrops and the nature and depth of foundations of structures will influence the feasibility of some options.

As these conditions occur below the ground surface, some level of geotechnical investigation will normally be required during the options analysis (in the concept phase) to allow preliminary geotechnical models to be developed for use in the assessment of the options.

The level of investigation will vary from a simple collation of existing data confirmed by visual assessment, to some level of sampling, testing and analysis. A competent engineering geologist and geotechnical engineer should undertake such investigations. The geological and geotechnical models can be progressively developed as planners and designers proceed through the concept and development phases. As the project proceeds, geological and geotechnical investigations should focus on the critical geotechnical aspects of the selected option. This progressive development of the geological and geotechnical model will also facilitate the development of appropriate design parameters for design as well as identifying any constraints on the construction process.

Ground conditions that have a significant influence on the feasibility of any particular option include:

- Conditions of natural slopes including evidence of potential land instability, erosion, nature of materials and groundwater seepage.
- Occurrence and direction of slope of hard rock in cuts and the impact on excavation techniques and slope stability (and hence resumptions), stabilisation measures and drainage requirements.
- Presence of soft and swampy ground under embankments and implications

for settlement, stability, need for ground improvements, construction programming and investigation requirements and timing.

- Subgrade soil conditions that will influence pavement design and drainage.
- Presence of acid sulphate soils.
- Presence of sodic soils.
- Usability of excavated materials and implication on the earthworks balance, disposal of unsuitable material and selective winning and usage of suitable materials.
- Presence of underground openings (e.g. caves, old mine workings, etc.) causing potential short and long-term subsidence problems for both road and structures.
- Presence of PUP, adjacent structures (e.g. embankments, retaining walls, and bridges) and/or need to construct under traffic restricting, any of which may affect the range of alternatives.
- Presence of problem materials such as expansive soil/s, spoiled fill, refuse, contaminated land and other unsuitable material requiring specific improvement techniques or removal and replacement.

3.6.6 Fauna

Road designs that accommodate fauna passage are of increasing community interest. Planners and designers should provide special attention to fauna passage along (especially where the road reserve is the only fauna path remaining) and across the road reserve at fauna corridors (especially permanent and semi-permanent watercourses). The Fauna Sensitive Road Design Manual (Main Roads, 2000) provides details on such designs. The following should be considered:

- Accommodation of fish passage (if an identified requirement in the Review of Environmental Factors), use an arch or bridge in preference to a culvert. The RDDM (Main Roads, 2001) provides a detailed description and methods of design for accommodating fish passage.
- Accommodation of terrestrial fauna movement. Refer to the Fauna Sensitive Road Design Manual (Main Roads, 2000) as a guide for minimum culvert/underpass heights (e.g. desirable minimum culvert cell height for terrestrial passage).
- Concrete safety barriers and noise barrier fencing do not allow passage of terrestrial fauna across the road. Therefore, designers should consider alternatives to concrete safety barriers such as guardrail or wire rope. Noise mounds can be an alternative to noise barrier fencing. In designs where concrete safety barrier and/or noise barrier fencing is used, a combination of wildlife exclusion fencing and the provision of appropriately sized and located underpasses or culverts should be included (refer to the Fauna Sensitive Road Design Manual [Main Roads, 2000] for details).
- Where appropriately sized and located underpasses or culverts cannot be provided, an environmental specialist should be consulted to determine whether wildlife exclusion fencing should be used (in most instances it would not be recommended).

Refer also to the RDDM (Main Roads, 2001) for discussion of culvert treatments.

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References

AASHTO (1997): *Highway Safety Design and Operations Guide*.

APD partnership, Parsons Brinckerhoff, Steer Davies Gleave, KPMG, Queensland Department of Transport and Gold Coast City Council (2004): *The Gold Coast Light Rail Feasibility Study*.

Armour, M. and J. R. McLean (1983): *The Effect of Shoulder Width and Type on Rural Traffic Safety and Operations,* Australian Road Research Board.

Arndt, O. (1994): *Relationship between Roundabout Geometry and Accident Rates*, Masters Thesis submitted to the Queensland University of Technology.

Arndt, O. (2004): *Relationship between Unsignalised Intersection Geometry and Accident Rates – Final Results,* Queensland Department of Main Roads Technology Transfer Forum 2004.

Arup (2001): *Caboolture to Maroochydore Corridor Study*.

Arup (2005): *Caboolture to Landsborough Rail Upgrade Study* (the internet website current at the time of publishing was: http://www.arup.com.au/clrs/index.php).

Austroads (1995): *Strategy for Ecologically Sustainable Development*.

Austroads (1995): *Guide to Traffic Engineering Practice – Part 13 Pedestrians*.

Austroads (1999): *Guide to Traffic Engineering Practice – Part 14 Bicycles*.

Austroads (2000): *Ecologically Sustainable Development: Toolbox, Part A – Guidance Package; Part B – Case Studies*.

Australian Standards (2000): *AP-R166/00: Ecologically Sustainable Development "Toolbox"*.

Austroads (2001): *Environmental Risk Assessment*.

Bornhorst, Ward, Veitch: *Guidelines to Planning and Design for Bus Public Transport in Regional Conurbations*.

Commonwealth Department of Housing and Regional Development (1995) *AMCORD: A National Resource Document For Residential Development*, AGPS, ACT.

Commonwealth of Australia (1998): *National Greenhouse Strategy* (the internet website current at the time of publishing was: http://www.greenhouse.gov.au/government/ngs/ngs.html)

Commonwealth of Australia (1999): *Environment Protection and Biodiversity Conservation Act.*

Commonwealth of Australia (1992): *Australian National Strategy for ESD.*

Crowe, T. D (1991 or 2000): *Crime Prevention through Environmental Design – Applications of Architectural Design and Space Management.*

City of Edmonton (1995): *Design Guide for a Safer City - Planning and Development Department*.

Dewar, R. E. and Olsen, P. L. (2002): *Human Factors in Traffic Safety.*

Fuhs, C. A. (1990): *High Occupancy Vehicle Facilities – Current Planning, Operation, and Design Practices – Parsons Brinkerhoff Monograph 5.*

Fuller, R and Jorge A. Santos (2002): *Human factors for Highway Engineers.*

GHD (2003): *Petrie to Kippa-Ring Transport Corridor Study*.

Hauer, Ezra (1999): *Safety in Geometric Design Standards.*

Institute of Transportation Engineers (ITE) (2003): *Trip Generation*.

Jagtman, H. M. (2004): *Road Safety by Design* (Eburon Delft)

McLean, J. R. (1996): *Review of accidents and rural cross section elements including roadsides – ARR 297*, ARRB Transport Research Ltd

Mark Doonar & Associates (1998): *Building Better Bus Shelters - for Queensland Transport*.

Maunsell (2000): *Townsville Port Access Impact Assessment Study*.

Parsons Brinckerhoff (2005): *Robina to Tugun Rail Impact Assessment Study* (the internet website current at the time of publishing was: http://www.pb.com.au/robina/).

PIARC (2003): *Road Safety Manual*.

PPK et al (2000): *Brisbane HOV Arterial Roads Study – Final Report* (Prepared for Queensland Department of Main Roads, Queensland Transport and Brisbane City Council).

Queensland Department of Communication and Information, Local Government, Planning and Sport (2000): *Far North Queensland Regional Plan*.

Queensland Department of Communication and Information, Local Government, Planning and Sport, Thuringowa City Council and Townsville City Council, (2000): *Townsville Thuringowa strategy plan: framework for managing growth and development*.

Queensland Department of Aboriginal and Torres Strait Islander Policy and Development (1998): *Protocols for Consultation and Negotiation with Aboriginal People*.

Queensland Department of Aboriginal and Torres Strait Islander Policy and Development (1998): *Mina Mir Lo Ailan Mun: Proper Communications with Torres Strait Islander People*.

Queensland Department of Transport and Eppell Olsen and Partners (2003): *Cairns Integrated Transport Study – Draft Technical Report*.

Queensland Department of Transport, Queensland Department of Main Roads, Townsville City Council and Thuringowa City Council (2001): *Townsville Thuringowa Integrated Regional Transport Plan*.

Queensland Department of Main Roads (1994): *Roadside Conservation Policy*.

Queensland Department of Main Roads (1994): *Roadside Landscaping Policy*.

Queensland Department of Main Roads (1997): *Roads in the Wet Tropics Manual*.

Queensland Department of Main Roads (1997): *Service Centre Strategy - No 2/98 Pacific Highway (Logan River - Tugun).*

Queensland Department of Main Roads (1997): *Service Centre Strategy - No. 1/97 Bruce Highway (Pine River -Gympie).*

Queensland Department of Main Roads (1997): *Service Centre Strategy - No. 2/97 Gateway Motorway (South-East Freeway-Bruce Highway).*

Queensland Department of Main Roads (1998): *Cultural Heritage Manual*.

3

Queensland Department of Main Roads (1998): *Land Use Development and State Controlled Roads*.

Queensland Department of Main Roads (1998): *Service Centre Policy*.

Queensland Department of Main Roads (1998): *Service Centre Strategy - No 1/98 Cunningham Highway (Ipswich Motorway) - Warrego Highway*.

Queensland Department of Main Roads (1998): *Stock on Hoof on State-controlled Roads - Guidelines*. (Note this policy was under review at the time of publishing this Chapter.)

Queensland Department of Main Roads (1999): *Cost Benefit Analysis Manual for Road Infrastructure Investment*.

Queensland Department of Main Roads (2000): *Guidelines for Assessment of Road Impacts of Development Proposals*.

Queensland Department of Main Roads (2000): *Road Traffic Noise Management: Code of Practice*.

Queensland Department of Main Roads (2000): *Fauna Sensitive Road Design*.

Queensland Department of Main Roads (2000): *Agreement between the Local Government Association of Queensland Inc. and Department of Main Roads for Cost Sharing based on Responsibilities within State Controlled Roads*.

Queensland Department of Main Roads (2000): *Traffic Control Sign Design Manual*.

Queensland Department of Main Roads (2001): *Guidelines for Assessment of Road Impacts of Development Proposals*.

Queensland Department of Main Roads (2001): *Screening of Overpass Structures Policy*.

Queensland Department of Main Roads (2001): *Road Drainage Design Manual*.

Queensland Department of Main Roads (2002): *Access Policy for Roadside Service Centre Facilities on Limited access Roads*.

Queensland Department of Main Roads (2002): *Drafting Design and Presentation Standards.*

Queensland Department of Main Roads (2002): *Environmental Management Policy and Strategy*.

Queensland Department of Main Roads (2002): *Guide to the Management of Roadside Advertising*.

Queensland Department of Main Roads (2002): *Red Imported Fire Ant Policy and Strategy*.

Queensland Department of Main Roads (2002): *Roads Connecting Queenslanders.*

Queensland Department of Main Roads (2002): *Traffic and Road Use Management Manual*.

Queensland Department of Main Roads, (2003): *Manual of Uniform Traffic Control Devices*.

Queensland Department of Main Roads (2003): *Pest Management Policy*.

Queensland Department of Main Roads (2003): *Policy for the Provision of Roadside Amenities*.

Queensland Department of Main Roads (2003): *Strategic Framework for Asset Management* (now called Road System Manager).

Queensland Department of Main Roads (2004): *Indigenous Cultural Heritage Policy and Guidelines Manual*.

Queensland Department of Main Roads (2004): *Environmental Legislation Register*.

Queensland Department of Main Roads (2004): *MRS11.51 Environmental Management Specification (Interim).*

Queensland Department of Main Roads (2004): *Policy for Cycling on State Controlled Roads*.

Queensland Department of Main Roads (2004): *Road Landscape Manual*.

Queensland Department of Main Roads (2004): *Reduction of Risk from Objects Thrown From Overpass Structures onto Roads*.

Queensland Department of Main Roads (2004): *Road Project Environmental Management Processes Manual*.

Queensland Department of Main Roads (2004): *Pavement Design Manual*.

Queensland Department of Main Roads (2004): *Standard Drawings Roads Manual*.

Queensland Departments of Main Roads and Transport (2005): *Community Engagement Planner*.

Queensland Department of Main Roads (2005): *Community Engagement – Resource Guide*.

Queensland Departments of Main Roads and Transport (2005): *Community Engagement Resource Guide.*

Queensland Departments of Main Roads and Transport (2005): *Community Engagement Toolbox.*

Queensland Department of Main Roads (2005): *Pre-construction Processes Manual*.

Queensland Department of Main Roads (2005): *Interim Clearing Within Road Boundaries Policy*.

Queensland Department of Main Roads (2005): *Interim Policy - Stock on hoof on State-controlled roads - Straying - advice*.

Queensland Department of Main Roads (2005): *Main Roads Project Delivery System, Volume 1*.

Queensland Department of Main Roads: *Integrated Development Assessment System Manual*.

Queensland Department of Transport (1992): *Pavement Rehabilitation Manual*.

Queensland Department of Transport (1995): *Draft Transport Assessment Guide*.

Queensland Department of Transport (1999): *Shaping Up: A guide to the better practice and integration of transport, land use and urban design techniques - 2nd edition*, Government of Queensland, Brisbane.

Queensland Department of Transport (2000): *Gulf Savannah Integrated Regional Transport Plan*.

Queensland Department of Transport (2001): *Gladstone Integrated Regional Transport Plan 2001-2030*.

Queensland Department of Transport (2002): *Wide Bay Integrated Transport Plan 2002-2020*.

Queensland Department of Transport (2002): *Mackay Area Integrated Transport Plan 2002-2025*.

Queensland Department of Transport (2003): *Eastern Downs Integrated Transport Plan*.

3

3

Queensland Department of Transport (2004): *Capricornia Integrated Regional Transport Plan 2004-2030*.

Queensland Department of Transport (2004): *Border Integrated Transport Plan – Draft for Consultation 2004*.

Queensland Department of Transport (2005): *Gowrie to Grandchester Rail Corridor Study* (the internet website current at the time of publishing was: http://www.transport.qld.gov.au/qt/tpSite.nsf/index/GGRCS).

Queensland Department of Transport (2005): *South-East Queensland travel survey* (the internet website current at the time of publishing was: http://www.transport.qld.gov.au/qt/tpSite.nsf/index/SEQTS).

Queensland Department of Transport (2005): *Technical information - cycle notes* (the internet website current at the time of publishing was: http://www.transport.qld.gov.au/qt/LTASinfo.nsf/index/cycling_notes).

Queensland Department of Transport, Austroads and the Australian Greenhouse Office (2002): *National greenhouse strategy measure 5.3: promoting best practice in transport and land use planning: resources. Guidelines, concepts and resources to enable institutions, practitioners and the community to reduce greenhouse gas emissions associated with transport and land use planning interactions.*

Queensland Environmental Protection Agency (2002): *State Coastal Management Plan*. (The internet website current at the time of publishing was: http://www.epa.qld.gov.au/environmental_management/coast_and_oceans/coastal_management/state_coastal_management_plan/)

Queensland Government (1994): *Environmental Protection Act.*

Queensland Government (1992): State Planning Policy (SPP) *1/92 Development and conservation of agricultural land.* (The internet website current at the time of publishing was: http://www.ipa.qld.gov.au/codes/codespolicies.asp)

Queensland Government (1992): *Guideline 1 for State Planning Policy (SPP) 1/92 - The identification of good quality agricultural land.* (The internet website current at the time of publishing was: http://www.ipa.qld.gov.au/codes/codespolicies.asp)

Queensland Government (1992): *Guideline 2 for State Planning Policy (SPP) 1/92 - Separating agricultural land and residential land uses.* (The internet website current at the time of publishing was: http://www.ipa.qld.gov.au/codes/codespolicies.asp)

Queensland Government (2002): *State Planning Policy (SPP) 1/02 - Development in the vicinity of certain airports and aviation facilities.* (The internet website current at the time of publishing was: http://www.ipa.qld.gov.au/codes/codespolicies.asp)

Queensland Government (2002): *Guideline for State Planning Policy (SPP) 1/02 - Development in the vicinity of certain airports and aviation facilities.* (The internet website current at the time of publishing was: http://www.ipa.qld.gov.au/codes/codespolicies.asp)

Queensland Government (2002): *State Planning Policy (SPP) 2/02 - Planning and managing development involving acid sulphate soils*. (The internet website current at the time of publishing was: http://www.ipa.qld.gov.au/codes/codespolicies.asp)

Queensland Government (2002): *Guideline for State Planning Policy (SPP) 2/02 - Planning and managing development involving acid sulphate soils*. (The internet website current at the time of publishing was: http://www.ipa.qld.gov.au/codes/codespolicies.asp)

Queensland Government (2003): *State Planning Policy (SPP) 1/03 - Mitigating the adverse impacts of flood, bushfire and landslide*. (The internet website current at the time of publishing was: http://www.ipa.qld.gov.au/codes/codespolicies.asp)

Queensland Government (2003): *Guideline for State Planning Policy (SPP) 1/03 - Mitigating the adverse impacts of flood, bushfire and landslide*. (The internet website current at the time of publishing was: http://www.ipa.qld.gov.au/codes/codespolicies.asp)

Queensland Government (2004): *Draft State Planning Policy (SPP) - Protection of Extractive Resources*. (The internet website current at the time of publishing was: http://www.ipa.qld.gov.au/codes/codespolicies.asp)

Queensland Government (2003): *Integrated Transport Planning Framework for Queensland – A Guide for Transport Planning* (Queensland Transport, Department of Main Roads, Department of Local Government and Planning in association with Local Government Association of Queensland).

Queensland Office of Urban Management (2005): *South East Queensland Infrastructure Plan and Program 2005-2026* (SEQIPP).

Queensland Office of Urban Management and Queensland Department of Local Government, Planning, Sport and Recreation (2005): *South East Queensland Regional Plan 2005-2026*.

Roads and Traffic Authority (RTA New South Wales - 2002): *Guide to Traffic Generating Developments, Issue 2.2*.

South Australian Government (2000): *Planning SA - Transport Choice and Urban Design: Design Issues for Accessible Neighbourhoods*, Department of Transport, Urban Planning and the Arts, South Australia, Adelaide.

Straker, A. (1998): *Management of Roads as Biolinks and Habitat Zones in Australia*, Presented at the International Conference on Wildlife Ecology and Transportation, Florida.

The Macquarie Library Pty Ltd (1997): *The Macquarie Dictionary*, third edition.

Transportation Research Board (TRB) (1998): *NCHRP Report 414 – HOV Systems Manual*.

Transportation Research Board (TRB) (2000): *Highway Capacity Manual*.

United States Department of Transportation, Federal Highway Administration (1997): *Flexibility in Highway Design*, FHWA-PD-97-062 HEP-30/7-97(10M) E.

Relationship to other Chapters

This Chapter relates to all Chapters of this Manual. It relies on Chapters 1 and 2 for overall context and particularly relevant Chapters include:

- Chapter 7;
- Chapter 8;
- Chapters 10, 11 and 12;
- Chapters 13, 14 and 16;
- Chapter 20; and
- Chapter 22.

3

Appendix 3A Trip generation rates

The Transport Assessment Guide draft document (Queensland Transport, 1995) provides a summary of average basic traffic generation rates for development in urban areas.

It should be noted that the most reliable source of trip generation data is survey data from the actual development or a similar one in a similar location (in close proximity).

Appendix 3A provides only basic trip generation rates for some land uses to assist people who may not have traffic engineering training. It should be recognised that by simplifying the rates, site specific variations cannot be taken into account. In all instances, it is desirable to use recent, local data. For detailed information further reference should be made to:

- **The Roads and Traffic Authority's (RTA's) Guide to Traffic Generating Developments (which is available from the Main Roads Central Library or which can be purchased from the RTA); and**
- **the Guidelines for Assessment of Road Impacts of Development Proposals (for details see below).**

The proportion of development traffic that impacts on State Controlled Roads has to be assessed for each development. The methodology for the assessment of developments that impact on State Controlled Roads is provided in the Guidelines for Assessment of Road Impacts of Development Proposals (Main Roads, 2000). While the guidelines are not mandatory, they provide a basis for the dealings between developers and Main Roads. This publication is freely available on the Main Roads website (www.mainroads.qld.gov.au).

Trip generation rates for other land uses are available from a number of sources, including:

- the Guide to Traffic Generating Developments (RTA, 2002); and
- Trip Generation (USA Institute of Transportation Engineers, 2003).

Note:

- "Peak Rate" refers to the trips in the peak hour, which varies between different regions and roads.
- "Trip" is defined as a one way vehicular movement from one point to another and excludes the return trip.

Child care centres

Traffic generation rates for childcare centres should be based on the licensed maximum enrolments allowed on any one day.

Of the three types of child care centres commonly found in urban areas, pre-school facilities have, on average, higher traffic generation than long day care centres which in turn have higher generation rates than before school/after school care.

Peak times commonly coincide with the trip to/from work, however they can also vary with operating hours of the centre. Some adjustments to these peak hours may be necessary where the centre is remote from the general place of work.

The rates in Table 3.3 are based on childcare centres in urban locations. A reduction of up to 20% may be applicable in areas remote from commercial centres.

Table 3.3 Traffic generation data – child care centres

Description	Peak Rate (per unit)	Daily Rate	Unit	Source*
Pre-school	1.4	N/A	Child	RTA
Long Day Care	0.8	N/A	Child	RTA
Before/After School Care	0.65	N/A	Child	RTA
Notes: * RTA – Roads and Traffic Authority, NSW.				

Commercial premises

Commercial premises generally refer to offices with little or no manufacturing or retail facilities. The nature of a business and the proximity of its premises to the Central Business District (CBD) affect the traffic generation of it.

A survey by the RTA found that computer and technology driven businesses have the highest employee densities and high visitor trips. Management, legal and accountancy type offices have average employee densities while customer orientated offices such as banks have the lowest employee densities but higher visitor trips.

To assess a proposed development, the likely future tenant mix needs to be determined, keeping in mind that it may change in the future.

Office intensity is usually measured in terms of floor area with Gross Floor Area (GFA) being the typical unit of measurement.

Peak times for the majority of offices coincide with the roadway peak hours. Mode split and car occupancy are to be considered when assessing commercial premises. The RTA data (Table 3.4) is based on sites with a mean peak hour mode split for cars of 0.62 and a mean peak hour car occupancy of 1.19 (52% car drivers). Employee density also affects generation rates, with the RTA data based on 4.75 employees per 100m^2 GFA. A site specific analysis may indicate different figures should be used.

Table 3.4 Traffic generation data – commercial premises

Description Source*	Peak Rate (per Unit)	Daily Rate	Unit	Source*
All	2	10	100m^2 GFA	RTA
Notes: * RTA – Roads and Traffic Authority, NSW				

Dwellings

Residential buildings are usually treated under three categories:

- detached dwellings (e.g. traditional house on block);
- medium density dwellings (e.g. town houses); and
- high density dwellings (e.g. apartment buildings).

There is a trend to smaller residential lots giving higher density development, coupled with increased HOV usage, in developments remote from the inner metropolitan areas.

Other factors that affect traditional traffic generation rates are the size of developments, with those beyond about 200 lots tending to have trip attractors (e.g. schools, shops) contained within the development.

For medium to high density dwellings, the smaller units (up to 2 bedrooms) are more likely to have a lower vehicle generation rate, and vice versa for larger units and townhouses (three or more bedrooms).

The rates for high density dwellings (in the CBD), do no include vehicle generation rates for commercial purposes, which should be considered separately.

Peak times commonly coincide with the road peak.

Table 3.5 provides some guidance for dwellings.

Table 3.5 Traffic generation rates – residential dwellings

Description	Peak rate /unit	Daily rate	Unit	Source*
Detached	0.85	9	Dwelling	RTA
	0.8	6-10	Dwelling	QT
	N/A	9.6	Dwelling	AMCORD
	N/A	10	Dwelling	Qld Streets
Medium Density		4-6.5	Dwelling	RTA
	N/A	5.9	Dwelling	AMCORD
	N/A	6	Dwelling	Qld Streets
High Density	0.4	3-6	Dwelling	QT
	0.29	N/A	Dwelling	RTA
	N/A	4.2	Dwelling	AMCORD

Notes:

*Abbreviations are as follows:

RTA – Roads and Traffic Authority, NSW

QT – Queensland Transport

AMCORD – Australian Model Code for Residential Development

Qld Streets – Institution of Engineers Australia publication on standards and guidelines for streets

Fast food outlets

Fast food outlets can be classified as one of the following groups, with reasonable generation consistency within these groups:

- McDonalds or Hungry Jacks;
- KFC or Red Rooster;
- Pizza shops; or
- Miscellaneous smaller urban take-away shops.

The RTA found that traffic generated by the larger outlets is extremely variable and cannot be accurately related to floor area. Further, there is very little data available for estimating traffic generated by the smaller urban outlets.

Factors which should be considered when evaluating the generation capability of fast food outlets in urban areas includes the proximity of other outlets, hours of business (e.g. sites open for breakfast will generate more daily traffic than vehicles open from lunch to dinner), the duration of stay of patrons, the waiting time for foodstuffs, the presence of a drive through facility and the demographics of the residential catchment.

A summary of available generation data is shown in Table 3.6. **This data should only be used where market research information is unavailable.** In cases where access configuration is an important factor, significant sensitivity testing should be included in any analysis. Queue space for drive through facilities is also important as is the provision of cycle and pedestrian access to the site (separated from drive through entrances and exits).

Table 3.6 Traffic generation rates – fast food outlets

Description	Peak rate /unit	Daily rate	Unit	Source*
McDonalds, Hungry Jacks	180	N/A	Vehicles	RTA
KFC, Red Rooster	100	N/A	Vehicles	RTA
Pizza shops and other small outlets	12	N/A	100m² GFA	QT

Notes:
*Abbreviations are as follows:
RTA – Roads and Traffic Authority, NSW
QT – Queensland Transport

Industrial

Industrial sites vary significantly in type from light industry/retail to heavy industry. They can include showrooms, warehouses, factories, production plants, and bulk storage facilities. The diversity in this type of facility requires caution to be exercised when applying generation rates.

The key factors affecting peak traffic generation of industrial sites are employee density, travel mode, peak period travel distribution, location and style of facility (e.g. labour intensive versus machinery intensive).

The most important of these is employee density. However, this figure is often difficult to determine prior to development of an industrial precinct. Previously developed rates have therefore been based on floor area. As a guide, GFA is typically about 45% of site area for industrial uses, as considerable space has to be devoted to parking, servicing and manoeuvring.

When considering entire industrial areas, the site peak often coincides with the adjacent major road peak. Isolated facilities may have different site peak times to road peak times and locations need to be reviewed in a site-specific basis.

A summary of some of the available traffic generation data for industrial land uses is shown in Table 3.7.

Table 3.7 Traffic generation data – industrial uses

Description	Peak rate /unit	Daily rate	Unit	Source*
Factories	1	5	100m² GFA	RTA
	N/A	4-5	100m² GFA	QT
Warehouses	0.5	4	100m² GFA	RTA
Light Industrial	0.9	9	100m² GFA	QT

Notes:
Factories are sites where articles are manufactured.
For warehouses, generation rates can vary depending on the type of goods being stored. Also, if the warehouse has a retail component, the daily generation rate may be higher.
The light industrial category is considered to encompass sites with established uses such as storehouses, light fabrication, building supplies and showrooms.
*Abbreviations are as follows:
RTA – Roads and Traffic Authority, NSW
QT – Queensland Transport

Service stations

The recent trend in service station developments has been to include convenience stores in the same facility. As a Brisbane survey (date of survey unknown) has shown only 50% of the users of the shared facilities stop for refuelling only;

30% only stop for goods only and 20% stop for refuelling and goods.

Factors affecting peak hour generation rates that need to be considered are the proximity of other service stations and convenience stores, hours of business, the volume of passing traffic and ease of access into the facility.

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In most urban localities, peak usage of service station facilities coincides with the road peak with the largest generation occurring during the afternoon peak period.

A summary of some of the available traffic generation data for service stations is shown in Table 3.8. This data should only be used for service stations in urban locations. Service stations/service centres/road-houses located on major rural highways are expected to develop significantly different generation rates and patterns. These will require a site specific analysis.

Table 3.8 Traffic generation rates - service stations

Description	Peak rate /unit	Daily rate	Unit	Source*
With Convenience Store	66	N/A	100m² GFA	RTA
Urban - All	70	700	100m² GFA	QT
Notes: *Abbreviations are as follows: RTA – Roads and Traffic Authority, NSW QT – Queensland Transport				

Shopping centres

The traffic generated by shopping centres is most influenced by the proximity of other centres and hence the size of the urban catchment. On site facilities such as cinemas, restaurants, etc can also have a significant impact on generation rates.

Refer to the Guide to Traffic Generating Developments (RTA, 2002), and Appendix F of the Guidelines for Assessment of Road Impacts of Development Proposals (Main Roads, 2001) for information regarding shopping centres.

Other land uses

Table 3.9 provides a summary of some of the available traffic generation data for a variety of other land uses.

Modifying factors

Traffic generation rates may be affected by the provision of good quality pedestrian access and appropriate cycling facilities (on and/or off-road). This is particularly so around:

- schools;
- recreational facilities, and
- shopping areas.

The extent of any reduction in traffic generation rates will have to be consistent with the circumstances prevailing at the site, and the potential for change in mode in the future.

Table 3.9 Traffic generation data – other land uses

Land use	Type range	Peak rate	Daily rate	Unit	Peak time/comment	Source*
Amusement Centre	All	10	N/A	100m² GFA	-	ITE
Bank	All	20	N/A	100m² GFA	-	QT
Car Repair	Tyres/brakes	6	N/A	100m² GFA	-	QT
Car tyre Retail	All	1	10	100m² GFA	-	RTA
Caravan Park	Urban	0.4	4	Occupied site	-	QT
Caravan Park	Rural	0.8	8	Occupied site	-	QT
Fitness Centres	Metropolitan-regional centre	3	20	100m² GFA	6-7pm weekdays	RTA
	Metropolitan-sub regional area	9	45	100m² GFA	6-7pm weekdays	RTA
	All	10	80	100m² GFA	-	QT
Hotel	All	100-200	N/A	Vehicles	-	QT
Medical Centres	All	13	N/A	100m² GFA	-	QT
Medical Centres	All	N/A	30-70	Doctor	-	QT
Motel	All	0.4	3	Unit	Assume 100% occupancy rates	RTA
Motel	All	0.4	4	Occupied Unit	-	QT
Motor Showrooms	All	0.7	N/A	100m² GFA	N/A	RTA
Restaurants	All	5	60	100m² GFA	Total daily trips can be greater if lunch is served.	RTA
Restaurants	All	5	N/A	100m² GFA	-	QT
Retirement/ Ages homes	Aged/Disabled	0.1-0.2	1-2	Dwelling	Rates of resident funded facilities are generally greater than subsidized facilities as indicated by the higher end of the range	RTA
Schools	State Primary	0.2	N/A	Student	-	QT
Schools	State Secondary	0.12	N/A	Student	-	QT
Schools	Private	0.1	N/A	Student	-	QT
Squash Courts	All	3	N/A	Court	Evening peak rates	RTA
Squash Courts	2 courts	17	N/A	Court	-	QT
Squash Courts	4 courts	13.5	N/A	Court	-	QT
Squash Courts	6 courts	10.5	N/A	Court	-	QT
Squash Courts	8 courts	8.8	N/A	Court	-	QT

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Land use	Type range	Peak rate	Daily rate	Unit	Peak time/comment	Source*
Swimming Pools	All	4.95	N/A	100m² site area	-	RTA,QT
Tennis Courts	All	4	45	Court	-	RTA
Tennis Courts	All	4	N/A	Court	-	QT
Truck Terminals	Road Transport	1	5	100m² GFA	-	RTA
Truck Terminals	Truck Stop	1.3-3.3	13	100m² GFA	-	QT
Video Stores	Friday	22.8	N/A	100m² GFA	4-6pm peak time	RTA
Video Stores	Saturday	49.9	N/A	100m² GFA	5-8pm peak time	RTA

Notes:

*Abbreviations are as follows:

ITE - Institute of Transportation Engineers (ITE). ITE data is from Trip Generation ((ITE, 2003) which is based on empirical data from trip generation studies conducted in the USA by public agencies, developers and consulting firms).

RTA – Roads and Traffic Authority, NSW

QT – Queensland Transport

Appendix 3B Ecologically sustainable development assessment

Table 3.10 outlines the applicable Ecologically Sustainable Development (ESD) process and tools relating to the phases of a project. The use of **some** of these tools is summarised in the following pages of this Appendix. **Planners and designers should refer to Austroads ESD toolbox (Austroads, 2000) for a complete list, and detailed explanation of, ESD and the ESD tools.**

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Table 3.10 ESD tools and applicability to network/corridors and phases (Austroads, 2000)

Tool/process[3]	Phases applicable to:			
	Concept	Development	Implementation	Operation
Network/corridor strategy	Major[1]	Major[1]	-	-
REF (concept)	Major[1]	-	-	-
REF (planning)	-	Major[1]	-	-
Impact assessment study	Major[1]	Major[1]	-	-
Environmental design report	-	Major[1]		
Environmental management systems	Lesser[2]	Major[1]	Major[1]	Major[1]
Environmental management plan (maintenance)	-	-	-	Major[1]
Environmental management plan (planning)	Major[1]	Major[1]	-	-
Environmental management plan (construction)	-	-	- Major[1]	-
Strategic environment assessment	Major[1]	Major[1]	Lesser[2]	Lesser[2]
Cumulative impact assessment	Major[1]	Major[1]	Lesser[2]	Lesser[2]
Life cycle assessment	-	Major[1]	Lesser[2]	Lesser[2]
Environmental risk assessment	Major[1]	Major[1]	Lesser[2]	Major[1]
Sustainability Assessment (MCA)	Major[1]	Major[1]	Major[1]	Major[1]

Notes:

1. Major consideration during this phase.
2. Lesser consideration during this phase.
3. Not all tools or processes are described in this Appendix. Refer to Austroads ESD toolbox (Austroads, 2000) for a complete list, and detailed explanation of, ESD and the ESD tools.

3

Strategic Environmental Assessment (SEA)

Table 3.11 Summary of SEA

Strategic Environmental Assessment (SEA)	SEA is an important tool for the 'integration' principle of ESD			
Intent and area of application	Useful at the early stages of project development. Often applied to strategy and network formulation. Spatial extent is usually focussed on corridor, network, regional or larger areas.			
Strengths	A broad analytical framework for examining tradeoffs between social, economic and environmental concerns.			
Weaknesses	No standard methodology exits. Can be data intensive and time consuming			
Level of Difficulty	High			
Applicability	SEA is best suited to the early stages of the decision making process. SEA may be applied in a number of areas including multi-modal and inter-modal proposals including evaluation of alternative scenarios including road-rail interchanges, waterway options (inland waterways and sea ports), networks of airports, major route selection, and integrated transport and land use planning.			
	Concept Phase	Development Phase	Implementation Phase	Operation Phase
	✓	✓	-	-

Example: Roadsides as biolinks

In this example the 'integration' principle is demonstrated by examining roads in their broader social, environmental and economic context. In addition to their transport role, roads are considered as an opportunity to provide 'biolinks' for fauna habitat and movement.

SEA is often focussed on corridor wide issues rather than localised project specific issues. An example of how SEA may be used is seen in a Victorian project called the Big to Little Desert Biolink Corridor Management Plan (Straker, 1998). This project is located in the Wimmera in the North-West of Victoria.

The project is designed to revegetate key parts of the network of roads in the 5,000 square kilometre gap between the Little Desert and the Big Desert Wilderness National Parks. While the area retains less than 5% of its original vegetation cover, it is still rich in species diversity. Furthermore, much of this diversity is located within the road corridor.

This revegetation of the existing road network would create a large corridor network or 'biolink' and is an example of a strategic interpretation of the use of roads.

Qualitative ESD assessment

Table 3.12 Summary of qualitative ESD assessment

Qualitative ESD Assessment	The use of qualitative ESD assessment is recommended as an initial review tool to provide a rapid coverage of key project aspects from an ESD perspective. The approach is also useful for graphical presentation of the relative performance of project options. Qualitative ESD Assessment may be used to aid the decision making process at the early stage of a development proposal.			
Intent and area of application	Quick assessment of compatibility with the objectives and principles of ESD.			
Strengths	Transport planners, environmental planners and strategy and network analysts would use this approach without reference to detailed technical issues. When combined with graphical presentation can be a very valuable communication technique.			
Weaknesses	Limitations relate to subjective nature of some of the assessments. There is no standard set criteria with which performance can be assessed.			
Level of Difficulty	Low to Medium			
Applicability	Can be applied before and after project implementation.			
	Concept Phase	Development Phase	Implementation Phase	Operation Phase
	✓	✓	✓	✓

Example: Environmental Effects Statement (EES) for the Scoresby transport corridor

A graphical display of performance measures is useful as a communication and management tool. Such a display could be based on a Multi-Criteria Analysis (MCA) approach using a range of selected performance measures.

The Scoresby Transport Corridor EES adopted three main themes for assessment.

They are:

- Prosperity – focuses on economic development that enhances the capacity to meet the essential needs of the community and the welfare of future generations.
- Liveability – focuses on human health, environmental amenity and needs for well being and quality of life. In particular, the transport related aspects include safety, accessibility, amenity (e.g. noise, visual amenity) and equity in terms of transport choice.
- Sustainability – focuses on the natural environment. In particular the key issues relate to energy use, greenhouse gas emissions, water quality, ecosystem processes and biodiversity.

This approach can be used to assess different implementation options using a display that rates how well each option satisfies the prosperity, liveability and sustainability objectives.

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Risk assessment

Table 3.13 Summary of risk assessment.

<table>
<tr><td>Risk Assessment</td><td colspan="4">Risk assessment is a key approach to implementing the precautionary principle. Risk assessment also contributes towards other principles of ESD. For example, inter-generational equity can be considered by using a risk exposure approach that examines, for instance, the distribution of environmental exposures (e.g. noise or accident exposure).</td></tr>
<tr><td>Intent and area of application</td><td colspan="4">Implementation of the precautionary principle. Useful at the early stages of project development. Risk Assessment is a critical technique for examining the need for a project. Risk Assessment is a key ESD tool. It is particularly important for implementing the precautionary principle.</td></tr>
<tr><td>Strengths</td><td colspan="4">Risk assessment is a discipline with mature methodologies. Can be used for a wide variety of risk assessments including assessment of transport risk, safety risk, societal or health risk, environmental risk and ecological risk.</td></tr>
<tr><td>Weaknesses</td><td colspan="4">Limitations relate to difficulties with quantifying consequences and risk exposure.</td></tr>
<tr><td>Level of Difficulty</td><td colspan="4">Moderate to high. The level of difficulty varies with the scope. Qualitative risk assessment can be made much easier than quantitative risk assessment. The level of time and resources required is also a function of the level of detail required.</td></tr>
<tr><td rowspan="3">Applicability</td><td colspan="4">Typical applications include route selection and comparative risk assessment by transport mode for a given transport task.</td></tr>
<tr><td>Concept Phase</td><td>Development Phase</td><td>Implementation Phase</td><td>Operation Phase</td></tr>
<tr><td>✓</td><td>✓</td><td>✓</td><td>-</td></tr>
</table>

Example: Acid sulphate soils.

Acid sulphate soils are often found in lowland coastal areas, mangrove areas, and in soils not more than 5m above high tide level in marine and estuarine areas.

Potential acid sulphate soils have high concentrations of dissolved sulphates and sulphur containing compounds. Exposure of these soils to oxygen following excavation works can result in the formation of sulphuric acid with a corresponding risk of damage to water quality and aquatic ecosystems. In addition, the acidification of the soil can also impact vegetation growth.

These issues of risk exposure are best identified and managed at the concept phase rather than later at the development or implementation phases. This also avoids potentially large cleanup costs.

Tasks that are part of the concept and development phases, such as route selection, will play a key role in avoiding such water quality issues. Linked with geotechnical investigations the extent of acid sulphate soils can be determined, and routes planned to avoid these areas.

Analysis can produce a probability distribution map of the site that indicates the probability (from low to high) of encountering acid sulphate soils within the corridor at different depths below the ground surface.

Appropriate management responses to limit the disturbance of these soils should be included the preparation of an Acid

Sulphate Soils Management Plan (Queensland Government, 2002).

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Cumulative Impact Assessment (CIA)

Table 3.14 Summary of CIA

<table>
<tr><td>Cumulative Impact Assessment (CIA)</td><td colspan="4">CIA techniques assist the implementation of the 'precautionary principle' of ESD.</td></tr>
<tr><td>Intent and area of application</td><td colspan="4">CIA is used in planning, policy development and environmental assessment. Since the approach explicitly considers interactions between different activities as well as interactions across time, it is well suited as an ESD assessment tool for transport infrastructure projects. CIA is a useful tool for examining impacts that arise at different times and in different places. These include global impacts of greenhouse gas emissions and regional impacts relating to large water bodies or air sheds.</td></tr>
<tr><td>Strengths</td><td colspan="4">CIA provides for 'cumulative thinking'. It allows project suitability and need satisfaction to be compared with other projects and community needs.</td></tr>
<tr><td>Weaknesses</td><td colspan="4">-</td></tr>
<tr><td>Level of Difficulty</td><td colspan="4">Moderate to High</td></tr>
<tr><td rowspan="3">Applicability</td><td colspan="4">Typical applications include route selection and comparative risk assessment by transport mode for a given transport task.</td></tr>
<tr><td>Concept Phase</td><td>Development Phase</td><td>Implementation Phase</td><td>Operation Phase</td></tr>
<tr><td>✓</td><td>✓</td><td></td><td></td></tr>
</table>

Example: road runoff and wetland sediments

Constructed wetlands are used for a range of purposes including urban stormwater management, road runoff, creation of habitat and for recreation and visual amenity. One of the key operation and maintenance issues is the management of sediment and the bioaccumulation of toxic materials.

Wetlands used for road drainage purposes are likely to accumulate heavy metals and toxic materials over time. This can occur through heavy metal binding to soils, sediment and particulate matter. Pollutants may come from the first flush from road surfaces or through pesticides used on adjacent land. In addition, there may be bioaccumulation within the wetland ecosystem that can lead to damage to flora and fauna. This will be an issue if the wetland ecosystem is used for habitat enhancement in addition to stormwater management.

A wetlands maintenance program should include the need for sediment removal to ensure efficient hydraulic function as well as prevent the release of pollutants over time. If removal was not undertaken then the heavy metals within sediments could accumulate in coastal zones and other receiving waterways. The disposal of removed sediment may need to consider the legislative requirements for contaminated waste disposal.

In general the long-term implication of the accumulation of heavy metals in wetland sediment has not been well studied. These issues illustrate the need to use CIA as a tool for road planning, design and operation.

Appendix 3C Transit lane capacity

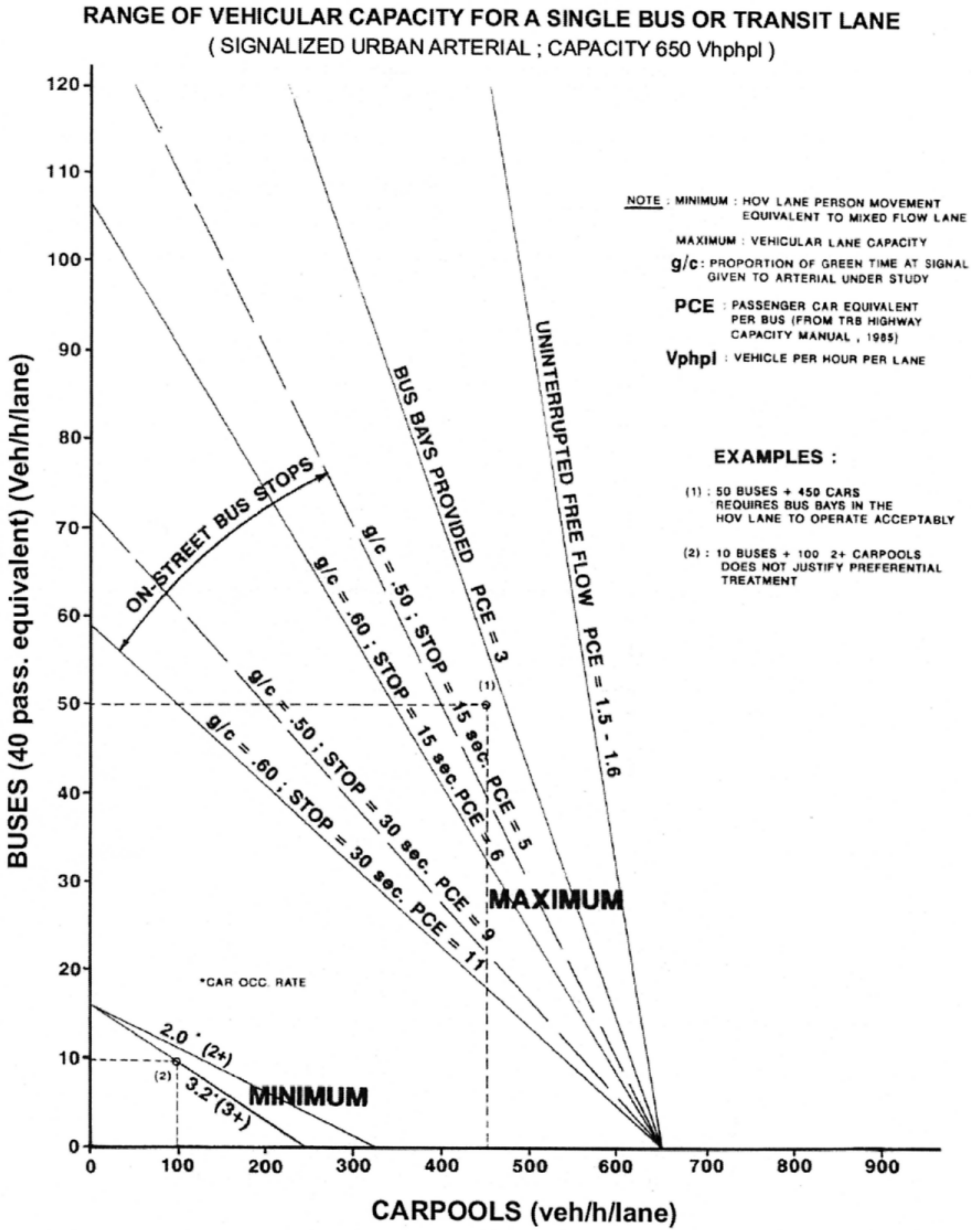

Figure 3.6 HOV lane capacity for a signalised urban street with a capacity of 650v/h/lane (PPK et al, 2000)

3

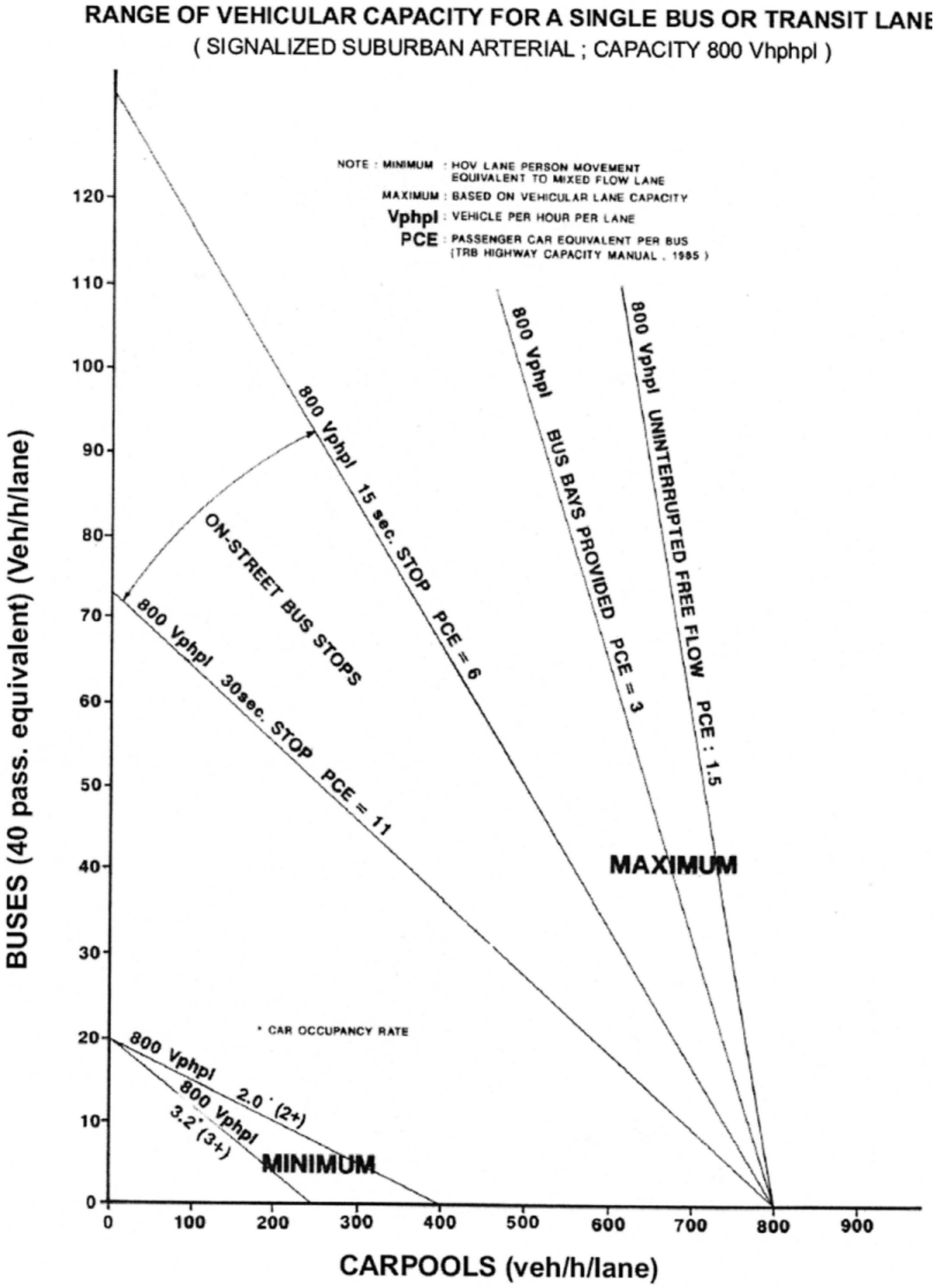

Figure 3.7 HOV lane capacity for a signalised suburban arterial with a capacity of 800v/h/lane (PPK et al, 2000)

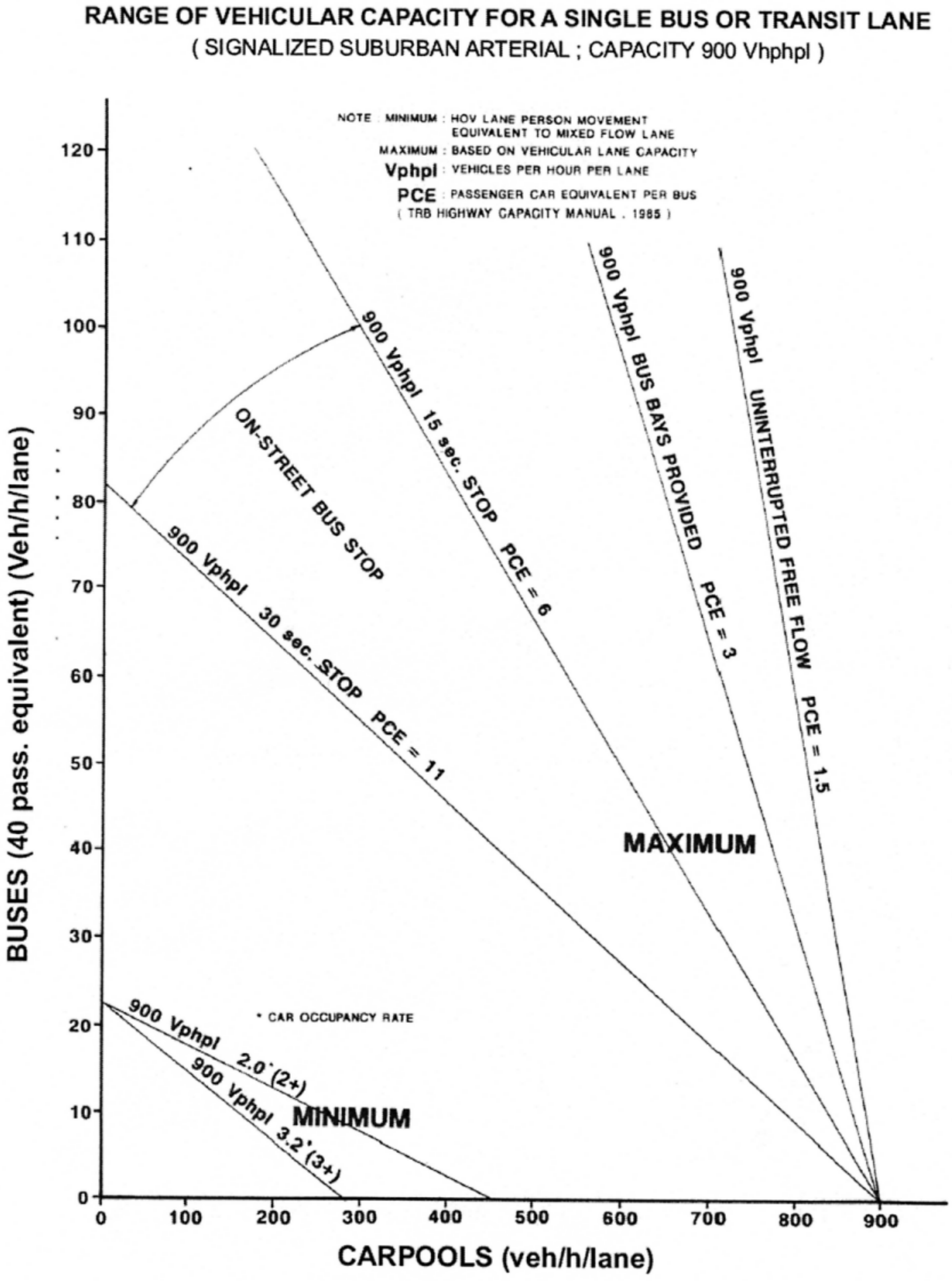

Figure 3.8 HOV lane capacity for a high standard suburban arterial with a capacity of 900v/h/lane (PPK et al, 2000)