CRASHES ON THE APPROACHES TO PROVINCIAL CITIES

by

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CRASHES ON THE APPROACHES TO PROVINCIAL CITIES

Abstract:
The study was undertaken to identify the characteristics of road crashes occurring on feeder roads on the outskirts of provincial cities. These roads generally traverse a road environment that is partially developed, extending from the commencement of a typical urban environment to one which is totally rural in nature.

The study investigated both mass accident and site conditions data in order to identify those facets of the road environment that contributed to the occurrence of road crashes.

The report establishes the uniqueness of roads which have only partial abutting development and prescribes measures that are designed to improve safety along their length. The main deficiencies and issues identified related to, the failure of the road design to respond to the demands of increased roadside development, the need to review road design policy and practices for major arterial roads in partially developed environments, and the importance of safety auditing and improved road design planning for roads within the transitional urban/rural areas.

Measures recommended in the report that are designed to improve safety on feeder roads on the outskirts of provincial cities include the provision of turning and acceleration/deceleration lanes, increased curve delineation, improvements in shoulder sealing practices and better utility pole placement/protection.

Key Words:
Arterial rural roads, road design, road environment, partial development, road safety, crashes, accidents, intermediate/transitional zone, feeder roads, speed limits/zones, provincial/rural cities.

Disclaimer:
This report is disseminated in the interests of information exchange. The views expressed are those of the author, and not necessarily those of Monash University.
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EXECUTIVE SUMMARY

Previous road strategies in Victoria have focused their attentions on arterial roads within an urban environment, or on the major state routes that had a wider national interest.

In December 1990, VIC ROADS released the report, 'VIC ROADS 2000', which sought to develop a rural arterial road strategy plan designed to take Victoria into the next century. This study complemented the previous long term arterial road strategy plans developed for this State.

The 'VIC ROAD 2000' study investigated the major issues confronting rural arterial roads, namely, road safety, access and mobility, asset preservation, environmental sensitivity and economic development, and developed strategy plans for each.

Emanating from the strategy related to road safety were a number of recommendations designed to reduce road trauma. One of these proposals was to improve safety on the approaches to provincial centres.

As a consequence, Monash University Accident Research Centre (MUARC) was commissioned to undertake a detailed investigation of crashes on the outskirts of major provincial cities in order that appropriate road safety improvement measures may be formulated.

The study entailed, the investigation of mass accident and site conditions data, the identification of accident causal factors, and the development of new or better targeted accident countermeasures.

Key Findings

The major findings of this study were that within a partially developed urban/rural road environment:

* the characteristics of road crashes experienced differed markedly from those occurring in either urban or rural road environments, and in general, the changes in the nature of crashes that prevailed along the feeder roads had occurred within the relatively short length of the transition zone.

* casualties per vehicle kilometres travelled per year, and casualties per kilometre per year are substantially greater in the partially developed transitional zones compared to rural zones. In the first instance, 45 cas/100 mill-km/yr compared to 27 cas/100 mill-km/yr, and in the second, 1.3 cas/km/yr compared to 0.4 cas/km/yr.

* the severity of casualty crashes, and the proportions of head-on and out-of-control crashes increased as the distance out from provincial city increased. This increase commenced as the transition zone was entered.
as the level of roadside development increased, the proportion of cross-traffic, right-turn-against and pedestrian types of casualty crashes increased.
intersection casualty accidents increased.
casualty accidents occurring during rainy/snowy conditions increased.
casualty crashes involving semi-trailers increased.
night-time casualty crashes decreased.

as a proportion of total casualty crashes, rear-end casualty accidents peaked within the transitional zone, as did the proportion of casualty accidents occurring during the dusk/dawn period.

road design features had failed to respond to the demands of increased roadside development, particularly as they related to the interaction of locally generated traffic, and non-local through motorists travelling at more uniformly high vehicle speeds. The most pronounced deficiencies of the road design within a transitional environment related to, insufficient curve delineation, turning lanes not provided, the absence of acceleration/deceleration lanes, inadequate shoulder seals and poles located in hazardous locations.

Major Outcomes

The key findings of this study provide the basis for the implementation of measures and procedures designed to improve safety on roads in partially developed areas.

The most significant outcome is the identification of better targeted accident countermeasures or pro-active treatments for roads within a partially developed roadside environment. Described in section 10 of this report, the treatments are generally at a relatively low implementation or road maintenance cost.

In summary, the major outcomes of the study were that:

* it has identified those road design elements that had failed to respond to the conflicts experienced by motorist in partially developed outer urban areas, and has recommended appropriate measures designed to improve the safety on roads in this environment (i.e., protected turning lanes, acceleration/deceleration lanes, improved shoulder sealing practices, increased curve delineation, and better pole placement/protection.).
* it will enable a more accurate evaluation of candidate road safety projects within transition zones to be undertaken.
* it has highlight the need to review road design standards and practices for arterial roads in partially developed areas, particularly as they relate to curve delineation, shoulder sealing, and the provision of turning lanes and acceleration/deceleration lanes.
* it has highlighted the importance of safety auditing, and future road design planning procedures for roads in urban/rural transition zones.
1.0 INTRODUCTION

1.1 Background

Of Victoria's total arterial road network, 80% is located in rural areas. Rural arterial roads which comprise approximately 18,000 km of roadway, are also estimated to carry 90% of all freight and tourist movements in Victoria.

Previous road strategies studies in Victoria have centred on arterial roads in Melbourne's Metropolitan areas, (METRAS - Metropolitan Arterial Road Access Study, and Shaping Melbourne's Future, both released during 1987), and on major designated interstate roads (NATROV - National Roads Strategy of Victoria). These previous studies were designed to develop an arterial road network for those environments that would take Victoria into the next century.

In order to complete and complement the functional objectives of these previous studies VIC ROADS, with input from relevant state and local authorities, and interested organisations, undertook the VIC ROADS 2000 study. The prime objective of this study was to develop an arterial road strategy for this State. The issues investigated which formed the basis of the development of the future strategy comprised the following:

* Road Safety
* Access and Mobility
* Asset Preservation
* Environmental Sensitivity
* Economical Development

The study examined rural areas on a VIC ROADS regional basis, i.e. South Western, Western, Northern, North Eastern and Eastern Regions.

The road safety component of the VIC ROADS 2000 study recommended a wide range of road safety initiatives, one of which related to the improvement of safety on the approaches to provincial centres.

Other road safety recommendations which formed the Road Safety Strategy of VIC ROADS 2000 related to, the continuation of the Accident Black Spot Program and implementation of pro-active treatments, and to the targeting of road safety initiatives designed for:

* out-of-control crashes
* heavy vehicle safety
* railway level crossings
* driver fatigue
* local road safety programs through community involvement
* consistent application across the state of road design standards and practices
* 'Safe Routes to School Program'
Preliminary investigations of the VIC ROADS study that related to improving safety on the outskirts of provincial cities, revealed that a substantial number of crashes were occurring on arterial roads on the immediate outskirts of, and radiating from major centres such as, Geelong, Ballarat, Bendigo, Shepparton, Traralgon and Bairnsdale.

In order to investigate the road crashes on the outskirts of the provincial cities in greater detail, VIC ROADS commissioned Monash University Accident Research Centre (MUARC) to undertake this project. The study has been undertaken as part of the Centre's baseline research program funded jointly by:

- Australian Road and Research Board (ARRB)
- Ministry for Police and Emergency Services
- Royal Automobile Club of Victoria (RACV)
- Transport Accident Commission (TAC)
- VIC ROADS

1.2 Scope of the Study

The major rural arterial roads to be investigated are those routes radiating from the provincial centres highlighted in the VIC ROADS study, i.e., Geelong, Ballarat, Bendigo, Shepparton, Traralgon and Bairnsdale.

While similar trends in road crashes were also identified on a number of arterial roads that approached the outer metropolitan areas of Melbourne, their investigation has been excluded from the scope of the study. However, it will be desirable to investigate this aspect at a latter date, in order to ascertain the validity of applying the findings and recommendations of this report, as they relate to major provincial or rural cities, to the main feeder roads entering Melbourne's outer metropolitan area.

A further aspect of this study is that it will be confined primarily to the examination of the feeder roads on the outskirts of the provincial centres, and not seek to investigate the accident experience on roads in either the typical urban or rural environments. It is considered that investigations and programs previously and currently undertaken address these aspects of road safety. This study will seek to investigate the nature of road crashes in a road environment not considered previously as a separate entity.

Reference to crashes on the approaches to provincial centres is also defined as the location of accidents on the feeder road radiating from city centres. It is not intended to describe the direction of travel of the vehicles involved in the casualty crashes.
1.3 Study Proposal and Objectives

The purpose of this study is to research and investigate in detail the crashes that prevail on feeder roads on the immediate outskirts to major provincial cities.

The feeder roads will essentially traverse a road environment that is partially developed, extending from the commencement of a typical urban road into one that is rural in nature.

The study will primarily seek to identify the characteristics of the road crashes on the feeder roads, and to subsequently formulate measures designed to address them. This will entail the detailed examination of both mass accident data, and aggregated prevailing site conditions data for the feeder roads under consideration.

In each case, the examination of both mass crash data and site investigation information, the objective will be to endeavour to identify the factors that have contributed to the crashes occurring that are amenable to correction.

1.4 Project Advisory Committee

In order to provide a mechanism by which VIC ROADS was kept informed of its progress, and were provided with the opportunity to provide input into its development, an advisory committee was established.

The committee comprised the following:

- John Cunningham (VIC ROADS - Manager, Road and Environment Safety Branch, Road Safety Division)
- Alex Evans/John Liddell (VIC ROADS - Operations Manager, Western Region)
- Charles Pashula (VIC ROADS - Metro North-West, Western Regional)
- John Sliogeris (VIC ROADS - Senior Professional Officer, Road and Environment Safety Branch, Road Safety Division)
- Michael Tziotis (Senior Research Fellow, MUARC)
- Peter Vulcan (Director, MUARC)

Committee meetings were convened to coincide with the completion of project milestones. Liaison between committee members was also conducted at an informal level between advisory committee meetings, particularly between VIC ROADS Road Safety representatives and MUARC.
2.0 BACKGROUND RESEARCH

2.1 Previous Studies

An examination of previous studies related to this topic, primarily conducted in Australia, revealed that little had been done to examine traffic crashes specifically occurring on a transitional urban/rural road environment.

The most relevant recent study was conducted by Queensland’s Road Safety Division during 1991. The study examined current trends in road safety in that state, and as part of the study investigated the general trends in road crashes according to speed limits. The most significant findings of the report were that:

- 3.5% of road crashes in the 70/80 km/h speed zones were fatalities, compared to 1.2% in the 60 km/h, and 5.4% in the 90/100 km/h speed zones.

- Heavy vehicles were over-involved in crashes when compared to other vehicle classes in the 70/80 km/h speed zone.

- Single vehicle crashes in the 70/80 km/h speed zone were similar to the state average.

- Compared to crashes occurring in the 60 km/h zone, accidents increased in the 70/80 km/h zones where roads were wet, or where changes in both the vertical and horizontal alignments prevailed.

This report considered that in the 70/80 km/h speed zoned areas, the potential exists to improve safety through the implementation of road engineering measures. This strategy differs from that suggested within the 60 km/h zone (traffic management measures and increased enforcement practices), and the 90/100 km/h zones (increased enforcement and engineering treatments such as improved linemarking works).

Speed zoning practices in Queensland are that:

- 80 km/h limits apply as an intermediate zone or at the entrance to country towns.

- 70 & 90 km/h limits are speed limits which are not encouraged and are only infrequently used.

- 100 km/h limit applies as a general rural speed limit.
The report concluded that in order to address the crashes in the 70/80 km/h speed zones through road improvements, detailed investigation of the characteristics of crashes in this road environment will be required. This will consequently provide the basis for application of appropriate site specific and general pro-active treatments to be implemented.

Another previous study that makes reference to crashes in a transitional road environment is the 'In Depth Study of Rural Road Crashes in South Australia, December 1988', conducted by the Road Accident Research Unit South Australia.

The in-depth study investigated crashes on roads that had a prevailing speed zone of 80 km/h or greater, the study's definition of a rural crash. It should be noted however, that 80 km/h speed zones in South Australia are applied as intermediate zones to provincial cities, or where there is some lower level of abutting development.

The study investigated in depth 60 casualty crashes, of which 13 occurred (7 in the wet and 6 in the dry) the 80 km/h speed zone. In view of the over-representation of wet weather crashes and the small number of crashes examined in this zone, it is not considered possible to draw general conclusions regarding road crashes in the type of partially developed road environment under investigation.

2.2 Liaison with Other State Road Authorities

In order to determine the most recent experience related to road crashes in the urban/rural transitional road environment under investigation, discussions were conducted with senior managers dealing with road and road safety issues from each of the other Australian states.

The feedback provided indicated that no additional investigations have been carried out to study crashes on roads in partially developed environments.

3.0 STUDY METHOD

3.1 Introduction

The study sought to:

(i) identify predominating accident types on the main feeder roads radiating from selected major provincial cities.

(ii) identify the factors that contributed to the crashes occurring.
(iii) develop appropriate countermeasures for the predominating accident types.

(iv) identify road or road environment features that may potentially contribute to the occurrence of a road crash, or which could increase the severity of road accidents.

The collection of crash and site data is confined to a maximum 20 km radius from the provincial cities, the distance out from cities specified in VIC ROADS Road Safety Group’s ‘Facts Document, Part 4, Road Environment-Significant Groups and Factors’, in its appraisal of the worst sections of roads in terms of crashes out from rural cities. Information from this facts document is also covered by the VIC ROADS 2000 study report.

As preliminary phase to this project, the piloting of the processes involved was undertaken. A nearby candidate major rural city was selected to trial the following tasks:

* the collection and processing of mass accident data collection for the major feeder roads to the provincial city.

* the inspection and investigation of the feeder roads, with specific attention being paid to crash sites along them.

* the determination of accident contributing factors and/or potentially accident contributing factors.

* the formulation of appropriate accident countermeasures.

In order to also examine the potential sourcing of VIC ROADS geographic information systems GIS, and to determine the opportunities that the GIS may provide for this study, a pilot of its application was also undertaken.

3.2 Site Selection

The selection of the major provincial cities whose feeder roads were chosen for detailed investigation was based on, those rural cities that had experienced a high casualty accident frequency per kilometre, as identified in the VIC ROADS 2000 study.

Listed on the following pages are the 14 major provincial centres and the main feeder roads selected for detailed investigation. The location of these provincial cities within Victoria are shown on Map 1.
(i) GEELONG
  Princes Hwy (East & West)
  Midland Hwy
  Torquay Rd
  Bellarine Hwy
  Hamilton Hwy

(ii) WARRNAMBOOL
  Princes Hwy (East & West)

(iii) BALLARAT
  Western Hwy (East & West)
  Glenelg Hwy
  Sunraysia Hwy
  Midland Hwy (North & South)

(iv) HORSHAM
  Western Hwy (East & West)
  Henty (Hwy)

(v) BENDIGO
  Calder Hwy (North-West & South-East)
  McIvor Hwy
  Midland Hwy (North)
  Loddon Valley Hwy

(vi) MILDURA
  Calder Hwy (South & North-West)
  Sturt Hwy

(vii) SHEPPARTON
  Midland Hwy (East & West)
  Goulburn Valley Hwy (North & South)

(viii) WANGARATTA
  Hume Hwy (North & South)

(ix) WODONGA
  Murray Valley Hwy

(x) MORWELL
  Princes Hwy (East & West)

(xi) TRARALGON
  Princes Hwy (East & West)

(xii) SALE
  Princes Hwy (East & West)
4.0 DATA COLLECTION

4.1 Mass Accident Data

In order to detect trends that may prevail on the feeder road on the approaches to major rural cities, accident data aggregated for all of the selected segments of roadway was obtained from VIC ROADS accident data base.

The mass accident data collected (1986 to 1991 inclusive), examined the following characteristics of road accidents:

* frequencies of different types of crashes (DCA's- Definitions for Classifying Accidents), on feeder roads to cities.

* the locations at which the crashes occurred:
  - at intersections/mid-blocks,
  - the speed zone in which the crashes occurred in.
* the accident frequencies by:
  - light conditions (ie, day/night/dusk/dawn),
  - weather conditions (ie, clear/raining/snowing/foggy/dusty),
  - road condition (ie, wet/dry),
  - time of day and day of week,
  - vehicle type (ie, car, rigid/articulated truck, motorcyclist,buses),
  - cyclist and pedestrians.

* severity of crashes according to differing road environments.

### 4.2 Site Conditions Data

An important facet of this study has been the inspection of those feeder roads which had experienced a high casualty accident rate. The site inspections carried out enabled the gathering of environmental road data that prevailed during the period in which crashes occurred. This information subsequently assisted in the development of the road environment profile at the time specific or predominating crash types occurred.

The identification of recurring road design elements that prevail at predominating accident types will provide the opportunity to review these aspects of the road environment.

To assist in the gathering of site data a safety check list was used. Based on the presently used safety audit form developed by VIC ROADS, the form considered all of the relevant road environment elements and sought to determine whether each had either contributed to the occurrence of a crash, or could potentially contribute to a crash occurring.

As detailed in the form used (Appendix A), the road characteristics examined included:

- alignment
- roadside hazards
- unprotected bridge end posts
- pedestrian and cyclist facilities
- parking and access
- road pavement
- signing and delineation
- guard fencing
- fencing
- traffic signals
- street lighting

The inspections were generally undertaken jointly by the author and regional VIC ROADS officers. This provided a number of benefits to the study and also to the future safety of each region. Regional officers while providing important background and local knowledge related to the road segments under investigation, were also provided with the opportunity to identify adverse features of the road that were potentially accident causing, some of which could be readily treated (eg., edgeline maintenance, trimming of vegetation obscuring signs, etc.)
The sections of feeder road for which accident data was collected commenced at the beginning of the transitional 75 km/h zone from the urban 60 km/h zone, through to the point in the 100 km/h speed zone where the road environment become exclusively rural in nature.

4.3 Traffic Volume Data

Traffic volume data was sought to enable the computation of casualty crash rates according to a changing road environment. The primary source of traffic volume information was VIC ROADS.

The purpose in obtaining this data was to establish traffic volumes for the feeder roads in urban, semi-urban and rural road environment categories, and determine accident rates for each of these environments.

While it was attempted to gather this data for all of the candidate roads, it was not available for a number of the road sections.

Listed below are available Average Annual Daily Traffic (AADT's) volumes for the feeder roads under investigation in this study.

<table>
<thead>
<tr>
<th>Location</th>
<th>Estimated AADT ( '00)</th>
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<tbody>
<tr>
<td></td>
<td>Urban</td>
</tr>
<tr>
<td>(i) Geelong</td>
<td></td>
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<tr>
<td>Princes Hwy (east)</td>
<td>370</td>
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<tr>
<td>Princes Hwy (west)</td>
<td>260</td>
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<tr>
<td>Midland Hwy</td>
<td>105</td>
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<tr>
<td>Torquay Rd</td>
<td>192</td>
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<tr>
<td>Bellarine Hwy</td>
<td>158</td>
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<tr>
<td>Hamilton Hwy</td>
<td>75</td>
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<tr>
<td>(ii) Warrnambool</td>
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<tr>
<td>Princes Hwy (east)</td>
<td>52</td>
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<tr>
<td>Princes Hwy (west)</td>
<td>52</td>
</tr>
<tr>
<td>(iii) Ballarat</td>
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<tr>
<td>Western Hwy (east)</td>
<td>94</td>
</tr>
<tr>
<td>Western Hwy (west)</td>
<td>85</td>
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<tr>
<td>Glenelg Hwy</td>
<td>-</td>
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<td>Sunraysia Hwy</td>
<td>226</td>
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<td>Midland Hwy (north)</td>
<td>108</td>
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<td>Midland Hwy (south)</td>
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<td>Road</td>
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<tr>
<td>Bendigo</td>
<td>Calder Hwy (north-west)</td>
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<td></td>
<td>Calder Hwy (south-east)</td>
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<td>McIvor Hwy</td>
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<td></td>
<td>Midland Hwy (north)</td>
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<td>Loddon Valley Hwy</td>
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<td>Mildura</td>
<td>Calder Hwy (south)</td>
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<td></td>
<td>Calder Hwy (north-west)</td>
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<td>Sturt Hwy</td>
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<td>Wangaratta</td>
<td>Hume Hwy (north)</td>
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<td>Ovens Hwy</td>
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<td>Wodonga</td>
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<td>Lakes Entrance</td>
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<td></td>
<td>Princes Hwy (west)</td>
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</tbody>
</table>

### 4.4 Casualty Crashes by Distance Travelled

(casualty crashes per 100 million vehicle kilometre travelled per annum)

Based on traffic volume and casualty crash data obtained, average casualty crashes by distance travelled were computed for both the transitional urban/rural road environment (ie, 75/80/90 km/h speed zoned segments), and the rural road environment (ie, zoned at 100 km/h).
It should also be noted that traffic volume data was based on a 1986 traffic volume inventory on estimated typical average weekday traffic volumes. It is considered that for the purpose of this study these volumes do not vary discernibly from average annual daily traffic volumes (AADT's), and therefore may be used as estimated AADT's.

The number of the casualty crashes per distance travelled sharply increases when the road environment progresses from one that is rural in nature, to a partial or transitional environmental zone (ie, 27 to 45 casualty crashes, per 100 million vehicle kilometre travelled per annum respectively).

4.5 Pilot Study - Feeder Roads to Ballarat

Prior to the detailed investigation of all of the candidate feeder roads, the study method was fully piloted for the major arterial roads leading to the provincial city of Ballarat.

Further to the piloting of the study method, the preliminary investigation sought to determine at an early stage whether the accident experience in the transitional urban/rural environment had unique characteristics, and also how accident countermeasure development could be undertaken.

The major conclusions from this pilot were that:

(i) detailed accident analysis was only necessary from the commencement of the intermediate 75 km/h speed zone to a location within the 100 km/h zone where the road environment is typically rural.

(ii) the trial highlighted the importance of establishing a safety check to identify both the accident causation factors and the elements of the road environment which have the potential to contribute to an accident.

(iii) the site inspection with VIC ROADS regional officers was important. Meeting with these officers and visiting the site with them provided important background knowledge of each road. It also provided the regions with the opportunity to identify aspects of the road environment that may be hazardous and could generally be readily treated at a relatively low cost.

(iv) the pilot study confirmed that the transitional road environment was a contributing factor to the occurrence of road crashes. The key finding from this preliminary study was that within the partially developed road environment, where motorists slowed to turn off the major road or when they entered the feeder road from the minor roads (and driveways), which serviced the outer partially developed areas, the mix between fast and slow moving traffic was significant, creating the potential for crashes.
The findings of this report will also have particular significance to VIC ROADS' Western Region, the region responsible for Ballarat. It is considered that the detail related to accidents and remedial treatment identified may assist in the development of future road safety programs for Ballarat and the Western Region. Copies of the pilot study report are available from MUARC.

4.6 Application of Geographic Information Systems (GIS) as an Aid to Site Investigations

The purpose of this investigation was to examine the potential of using VIC ROADS' GIS system to expedite accurately the collection of accident and site data, and draw the two together for this study.

GIS is a group of computer based systems that provides a linkage between mass data information, and digitised maps. For this study, GIS was used to provide outputs that related the frequency and types of crashes, together with their characteristics onto route locations maps. A major feature of GIS is that various aspects of the road network are able to be overlayed on the digitised maps. From VIC ROADS' Road Network Data Base (RNDB), road inventory data is able to be depicted onto the digitised road network maps (eg. speed zones of roads, and gradients and radii of curvature of roads).

Another potential feature of GIS is that it may provide a link between road crash characteristics and road environment features when consideration is being given to aggregating mass data. For example, when examining all of the major feeder roads to the 14 provincial centres in this study, summaries may be provided to draw relationships between aggregated aspects of road crash information and road environment characteristics, such as run-off the road accidents and curves on a road of a particular radius in the transitional 75/80 km/h speed zoned carriageways.

In view of the limited data available presently on GIS the trial was confined to its application on only one of the feeder roads under consideration. The major arterial selected was the McIvor Hwy leading to Bendigo.

Results of the trial, which entailed validation of the information provided, revealed that GIS had the potential to provide the types of outputs required. The location of crashes, and summaries of the characteristics of these crashes was able to be accurately produced in mapped/graphical form. Information related to the features of the road (eg. road width, vertical and horizontal alignments) was also provided and considered to be of acceptable accuracy. It should be noted however, that the information contained in the road feature data base had not been updated for the past 2-3 years for the whole of the state. Consequently, prior to processing aggregated crash data and relating it to road design characteristics, an update of the road feature data base would have been required.
When considering prevailing speed zone data for differing road segments using GIS, the information appeared to be particularly outdated. This inaccuracy was most pronounced along the transitional speed zone.

The general conclusion of the application of GIS as a tool for the investigation of crashes on the approaches to provincial centres was that it had the potential to provide the desired outputs. However in order to do so it would require a substantial resource commitment from the GIS team within VIC ROADS and ample lead time (in the order of 6 months), to finalise an accurate road inventory data base for the roads under investigation. Hence it was not used for the main study.

Copies of the detailed GIS trial report may also be made available from MUARC.

5.0 ANALYSIS OF MASS DATA

5.1 Introduction

The characteristics of road crashes were examined according to differing scenarios, namely by:

(i) per kilometre out from the outer urban fringe development of the provincial city, irrespective of small townships or hamlets that may exist along the length of the feeder road being studied.

(ii) per kilometre out from the outer fringe development of the provincial cities, however in this case, those roads that had small townships or hamlets along their length, being excluded.

(iii) speed zone of the roads (ie. 60 km/h - urban roads, 75/80/90 km/h -roads with some level of abutting development, and 100/110 km - rural roads), as a reflection of differing road environments.

5.2 Road Segment Investigations

Crash data was collected initially along 20 kilometre segments of carriageway, extending out from the centres of the cities. These sections of feeder roads contained on average an intrusion into the pure urban road environment of approximately 2.6 kilometres. The transitional urban/rural road environment was typically 2.2 kilometres long. The remaining road segments prevailed through a total rural road environment.
The aggregated crash data examined focused on those portions of the feeder roads just commencing within the urban road environment (as defined by the regulatory 60 km/h speed zone), through the transitional urban rural road environment, to the totally rural road environment.

Consequently, in the analysis, accident data was deleted from those road segments located within an urban environment where crashes were not considered to have been influenced by semi-rural or rural driving. The zone of influence was considered to occur approximately 1.5 km within the 60 km/h urban road environment from the commencement of transitional 75 km/h speed zone.

The lengths of the road segments along which the crash data was collected and aggregated was, where possible, made common at 15 kilometres. The exception to this was in one of the two speed zone scenarios, where in order to maximise the data base, all crash information was used out from the intruded 60 km/h zone to the 20 kilometre study radius.

The road segment investigations sought to examine the trends of differing facets of road accidents per kilometre, as the distance from the city outskirts was progressively increased out by one kilometre to a maximum of 15 kilometres.

Preliminary investigation of crash summary data also revealed that as the distance out from the cities increased, the km location of mid-block crashes became in some instances an average or approximate point. A consequence of moving away from developed, or developing areas, is that in a number of cases the lengths of mid-block portions of feeder roads exceed 1 km. Crashes that may have occurred over several kilometres when extracted in summary form, identify the location of the mid-block crashes as occurring at the one spot, the mid-point of the intersections along which the road segment prevails.

As an example, Princes Hwy between Avalon Road and Shell Parade (approaching Geelong from Melbourne), experienced 26 casualty crashes. This portion of the Princes Hwy extends between approximately 58 km and 62.5 km from Melbourne, however, when considered in accident summary, the kilometrage assigned to these link crashes is 60.1 km, mid-way along the mid-block. This may result in some distortion of crashes occurring per km when the distance out from cities reaches a point where mid-block lengths extend beyond 1 km. Examination of crash data and site conditions information suggest that such a situation would generally prevail well into the rural regions (ie, 12 or more kilometres out from the cities).
5.3 Speed Zone Investigations

As well as examining the trends of accident crash factors per kilometre out from provincial centres, mass accident data was examined according to the speed zone that prevailed at the time of the crash. It is assumed that the speed zone is a de facto measure of the nature and level of development of the road environment.

5.3.1 Speed Zoning Practices

Traditionally when establishing speed zones a number of factors are taken into consideration to determine the most appropriate speed limit value. The major criteria included:

* road environment
  - road classification, divided/undivided, lane widths and number of lanes
  - road condition, shoulder width and type
  - vertical and horizontal alignments
  - existence of footpaths

* type and level of abutting development
  - number and densities of different types of dwellings (i.e. houses, schools, shops, hospitals)
  - type and level of the varying traffic generated from the abutting land (i.e. cars, pedestrians, trucks, bicycles)

* prevailing vehicle speeds
  - 85th percentile speed, average speed
  - spread or range of speeds

* adjacent speed zones

* accident history

* environmental considerations
  - vertical/horizontal alignments
  - road geometry and condition
  - number of intersections

* the computation of a speed zone index (a method by which a number of environmental features are quantified) as an indicator for the most appropriate speed limit.
more recently, the application of V LIMITS, an expert system developed by ARRB for VIC ROADS as part of Victoria's 'Speed Management Strategy, March 1987'. This system enables a more consistent determination of the most appropriate speed limit to be derived.

5.3.2 Speed Limit Values

The major speed zones values that were applicable on Victorian roads during the period under investigation of this study, were defined as follows:

(i) 60 km/h - This speed zone is used to reinforce the speed limit of a built-up area. It is used as the maximum safe operating speed, reflecting the nature of both the elements of the road design and abutting roadside developments in urban areas.

(ii) 75 km/h - As a speed zone in an urban area, it reflects a high standard divided arterial with side carriageways. More recently however, these zone have been applied on arterials without service roads.

- In rural areas the 75 km/h speed limit is applied as a buffer or intermediate speed zone, grading the speed zone from a higher value down to 60 km/h. The zone is also applied on lengths of carriageway where roadside development is of insufficient density to warrant a 60 km/h limit. The desirable minimum length of these zones is 0.5 km (absolute minimum, 0.3 km).

80 km/h - More recently these speed zone values were applied as replacement values for the previously zoned 75 km/h, in order that Victoria conform with other Australian state practices of operating 80 km/h speed limits.

- This speed zone had previously been used exclusively where small developments prevailed. The level of development in these areas is substantially less than for urban areas.
5.3.3 Speed Zone Lengths and Changes

In order to compute as accurately as possible the total lengths of the segments under investigation within the three major categories, 60 km/h (adjacent to the 75 km/h zone), 75/80/90 km/h (speed zones that generally indicate some level of roadside development), and the 100 km/h zone, a speed zone inventory was undertaken. The inventory also sought to determine the timing of any speed zone changes in order to determine the casualty rate per kilometre per year, for each of the three speed zone categories.

As part of Victoria's Speed Management Strategy, March 1987, VIC ROADS (previously Road Traffic Authority), designated specialist officers to undertake in the field, a review of speed limits in order that speed zoning practices recommended by the report were consistently applied across the State. The field inspections and the recommended speed zone alterations were commenced and completed during 1989/90. During this period with the occasional exception, speed zone changes were deferred pending the outcome of the field inspections.

As part of the background investigations, all summaries of the field data completed by the specialist team were sought and obtained. Further, each of VIC ROADS regions was requested to provide current speed limit boundaries for the subject feeder roads.

In order to obtain historical speed zone data from 1986 (commencement of the accident period investigated), to 1988 (just prior to the commencement of the field work), a search of archived files was undertaken together with the retrieval of relevant files not archived but retained within some VIC ROADS departments.
From the investigation of the available data, it is estimated that during the period under investigation (1986 - 1991 inclusive) for the feeder roads being examined, the 60 km/h zones increased by approximately 0.01%, the 75/80/90 by 2.5%, while the 100 km/h speed zone decreased by .01%.

In kilometre terms these rates convert to:

* 60 km/h zone has increased in the order of 0.19 km/year  
  (total zone length is approximately 116 km)

* 75/80/90 km/h zone has increased by about 0.38 km/year  
  (total zone length is approximately 92 km)

* 100/110 km/h zone has decreased by about 0.83 km/year  
  (total zone length is approximately 497 km)

It is considered that these variations are small, and that they will not detract from the comparison that have been derived between casualty crashes occurring per kilometre per year within the varying speed zones.

5.3.4 Speed Zone Corrections

An examination of accident summaries revealed that a substantial number of them, as entered from the police accident forms, incorrectly reported the prevailing speed limit. For example, a crash occurring in a rural area, known to be zoned 100 km/h, but recorded as occurring in a 60 km/h speed zone.

All crash data was examined to identify these discrepancies, their true speed zones were determined, and the mass accident data base was subsequently corrected.

A further aspect considered was the effect of crashes at provincial cities that were substantially larger than the typical provincial cities under investigation (ie Geelong and Ballarat).

Examination of the mass crash data for the feeder roads to these larger centres revealed that the roads experienced a distribution of crashes out from the city centre similar to the remaining feeder roads under investigation.
6.0 RESULTS AND CONCLUSIONS OF MASS DATA ANALYSIS

A summary of key results is presented in this section, while a more detailed analysis of results is prepared in section 7.0 of this report.

The most significant findings from the mass data analysis were that,

(i) casualty crashes rates significantly increase as cities were neared from a point at which environmental development had commenced. (Sections 7.1.2 & 7.2.2)

(ii) changes in dominant crash types, and the characteristics of their occurrence generally occur within the relatively short length of the transitional/partially developed zone.

(iii) nearing provincial cities from rural areas, or from roads zoned 100 km/h, through transitional speed zones/partially developed areas, the proportion of,
  * cross-traffic, right-turn-against and pedestrian crashes increased markedly.
  * rear-end crashes peaked within the transitional speed zone/partially developed road environment. (Sections 7.1.4 & 7.2.4)

(iv) moving out from provincial cities, from the 60 km/h urban areas, through the transitional speed zone/partially developed areas the proportion of,
  * head-on and out-of-control increased significantly through the transitional zone/partially developed areas, and then plateaued. (Sections 7.1.4 & 7.2.4)
  * the severity of casualty crashes increased substantially. (Sections 7.1.3 & 7.2.3)

(v) other findings of the characteristics of casualty crashes on major routes nearing provincial cities were that the proportion of,
  * intersection crashes increased substantially through the transitional zone/partially developed areas.
  * dusk/dawn crashes peaked within the transitional zone/partially developed areas.
  * night-time crashes fell to their minimum value entering the urban zone.
  * crashes occurring during rainy/snowing conditions increased markedly through the transitional zone.
  * crashes involving semi-trailers decreased as the urban areas are entered. (Sections 7.1.5 & 7.2.5)
7.0 DETAILED RESULTS OF MASS DATA ANALYSIS

7.1 Characteristics of Casualty Crashes by Distance Out (per km) from the Outskirts of Provincial Cities

7.1.1 Introduction

The investigation of the characteristic of casualty crashes by the distance out from provincial cities, has enabled the determination of the approximate locations along the feeder roads at which changes in the characteristics of casualty crashes occur.

Examination of data in this manner also determines the rates of changes of the characteristics of the crashes by distance out from provincial cities, and provides a link between these changes and the roadside development, as the distance out from cities is increased.

Preliminary examination of the provincial cities under investigation revealed that in a number of instances small townships prevailed along small segments within the larger lengths of major feeder roads under investigation.

Consequently, to determine the effect these small townships/hamlets may have on the trends of the characteristics of the mass data, as the major rural centres are approached, the mass data was analysed in two ways:

(i) aggregated crash data for 15, one kilometre segments on the approaches to the rural centres, irrespective of any intermittent development, and
(ii) aggregated crash data for 15, one kilometre segments on the approaches to the rural centres, where no intermittent development occurred on the radiating roads.

Comparison of the two sets of data failed to detect any discernable differences between the variations of crash characteristics, per kilometre as the cities are approached. Consequently, the latter data has not been included in this working paper, although it will be available on request.

It should also be noted that when examining the trends in the characteristics of crashes per kilometre, radially from the city, approximately the first 1.7 km of carriageway lies within a total urban 60 km/h road environment, while about the next 2.2 km of road prevail through a transitional 75 km/h speed zone. The remaining portion of the 15 km length of feeder road generally lies within a rural 100 km/h speed zone environment.
7.1.2 Frequency of Casualty Crashes

Figure 1 below reveals that on the approach to major rural cities the frequency of casualty crashes commence to increase about 7 km out from the cities. Approaching cities from this point realises a progressive rise in the rate at which casualty crashes are occurring. This region generally corresponds to an environment that is partially developed. There is then a large increase in each of the inner two, 1 kilometre sections, which include in part the 60 km/h urban speed zone environment.

![Figure 1 - Casualty Crashes per year by kilometre out from Provincial Cities Studied](image)

7.1.3 Severity of Casualty Crashes

Examination of the three classes of severity crashes, fatals, serious injury and other injury, per kilometre out from the cities, as shown in figure 2, provided the following conclusions:

* the proportion of casualty crashes that were fatals increased sharply going away from the city from at about 4 km. Within the first 2 km 2.3% of casualty crashes were fatal accidents, this rose to 3.2% along the 3rd km, and then to 6.8% along the 4th km, which was a typical value per kilometre when travelling further away from the city centres.
the proportion of casualty crashes that resulted in a serious injury commenced to increase from about 3 to 5 km out from the cities outskirts. The rate of increase was from approximately 26% to 32%.

when considering the proportion of crashes that resulted in either a fatality or a serious injury, a gradual increase was evident from about 3 to 4 km moving out from the city. The proportion rose from about 27% to about 41%, and plateau at the 7 km mark with a value of about 43% (of casualty crashes resulting in either a fatality or a serious injury).

Figure 2 - Severity of Casualty Crashes
7.1.4 Predominant Types of Casualty Crashes

Examination of the mass crash data, shown in figures 3.1a & b and 3.2a & b provide the following major findings:

* approaching the cities, the frequency of cross-traffic accidents occur at a uniform rate until about the 3 to 4 km segments, the portion of road that prevails through the transitional speed zone. Within this region the rate increases sharply, from about 1.7 cas/km/yr to 6.8 cas/km/yr. The rate continues to increase to a maximum of 22.5 cas/km/yr. The proportion of cross-traffic accidents per kilometre increase at a similar point at which the frequency begins to increase, rising from about 7% to 14%, and ultimately 18% of casualty accidents occurring per kilometre being of the cross-traffic type.

* on the approach to cities the number and proportion of right-turn-against type crashes increase significantly 4 to 5 km out from provincial centres. The number of these types of crashes increase from about 1.3 cas/km/yr to 20 cas/km/yr, while the proportion of these types of casualty crashes increase from about 6% to 16%.

* approaching cities a gradual increase in pedestrian accidents is experienced about 8 km out from the city outskirts, with a dramatic increase commencing to occur about 3 km out from the city (ie, 1.3 to 2.8 to 11.8 cas/km/yr). When considering pedestrian accidents as a proportion of crashes per kilometre, the rate of increase is not as severe. At about the 3&8 km segments it commences to increase noticeably (2% to 6%, and 5% to 9.8% respectively).
Figure 3.1(a) - Frequency of Predominant Types of Casualty Crashes

Figure 3.1(b) - Proportion of Casualty Crashes
* approaching the cities at about 6 km segment the frequency of **rear-end type crashes** increases substantially (3.2 to 10.5 to 19 cases/km/yr), while when considered as a proportion of crashes, it peaks at approximately 3 km out from the cities to about 22.3%. Either side of this segment the proportion of rear end casualty crashes gradually decreased.

* the frequency of **head-on accidents** commences to increase at about the 6 km segment (1.0 to 2.3 cases/km/yr), as the cities are approached, after which their frequency of occurrence plateaus nearing the cities. However, as a proportion of all casualty crashes, head-ons increase going away from cities. Travelling away from the cities the proportion of head-on crashes increase noticeably from the 4 to 5 km point (i.e., 2.8% of all casualty crashes to 6.6%), and then plateaus.

* the frequency of **out-of-control type crashes** began to increase significantly as the cities were approached along the 6 km section (i.e., 5.7 to 10.6 cases/km/yr) and the 1 km section (i.e., 10.6 to 15.8 cases/km/yr). When considering out-of-control crashes as a percentage of all crashes for each kilometre, the proportion increased as the distance from the cities also increased. This increase rose most sharply along the 4 km segment out from the cities rising from 13.8% to 26.1%. The rate of increase from this road segment occurred more gradually out to the 15 km section, rising from 26.1% to 45.8%.

![Figure 3.2(a) - Frequency of Predominant Types of Casualty Crashes](image)
7.1.5 Other Major Features of Casualty Crashes

In order to examine the nature of the crashes radiating from provincial cities more fully, mass accident data was aggregated according to a number of additional features of casualty crashes, by kilometre, as the city is approached.

This analysis attempts to identify more comprehensively the trends in the characteristics of casualty crashes that may occur as the distances from provincial centres is increased.

The characteristics of casualty crashes investigated related to:
* the type of location where the crashes occurred, i.e., at intersections or mid-block locations.
* the light conditions that prevailed.
* whether the roads were wet or dry.
* the prevailing weather conditions.
* the types of vehicle involved or whether pedestrians were involved.
* the times of the day crashes occurred.
* the days of week crashes occurred.
* the variation of casualty crashes over recent years.
(i) Casualty Crashes by Type of Location

Examination of casualty crashes by their locations (figure 4), revealed that intersection crashes occurred substantially more often than mid-block crashes within the first 2 kms out from the cities, (about 70% occurred at intersections compared to 30% within mid-blocks), the next 3 km's saw the change over from where intersection casualty crashes as a proportion became less than for mid-blocks. This difference steadily increased as the distance from the cities was increased. The 4 km segment was the section at which both intersection and mid-block casualty crashes occurred in about the same proportion, 50%.

Figure 4 - Location of Casualty Crashes
(ii) Casualty Crashes by Light Conditions

The trends detected, as shown in figure 5, indicate that at about 4 to 5 km travelling away from the cities, the proportion of night time casualty crashes increase from about 22% to about 31%. The rate beyond the 5 km mark plateaus.

Dusk/dawn casualty crashes as a percentage of total crashes also show a gradual rate of increase as the distance from the city is increased. The rate of increase commences along the 1st km (3.4% casualty crashes occurring during dusk/dawn), through to the 6 km segment (7.9%). Beyond this distance the proportion appears to revert to the lower percentage value of about 3.4%.

Day time casualty crashes as a proportion of total crashes peak close to the city centre, at about 75%, and then reduce from 4 to 5 km to a plateau of about 63%.

Figure 5 - The Light Conditions under which Casualty Conditions Prevailed.
(iii) Casualty Crashes on Wet or Dry Roads

The trend in this facet of crashes although evident (figure 6), is very gradual. The proportion of casualty crashes on dry roads at the 1st km increases almost linearly along the 15 km study length (ie, 78% to about 85%). For wet road crashes, the proportion decreases in reverse proportion to dry road crashes as the distance from the cities is increased (ie, 21% to about 16%).

![Figure 6 - Wet or Dry Road Casualty Crashes](image)

(iv) Casualty Crashes by Weather Conditions

The significant findings from the examination of the weather conditions factor (illustrated in figure 7) are that:

* there is no clear relationship between the proportion of casualty crashes occurring during clear weather conditions and distances out from the cities (approximately 85%),

* the proportion of casualty crashes occurring in raining/snowing conditions rises as cities are approached at a the 4 to 5 km mark, increasing from about 8% to 14%,
(v) Casualty Crashes by Vehicle Type

The large majority of casualty crashes involve cars (figure 8a), about 80% with no apparent trend as the 15 km study length is travelled. The pattern regarding rigid trucks and buses is equally inconclusive, where their relative proportion is in the order of 3% and 1% respectively. However, when considering semi-trailers a trend does appear to have emerged. The proportion of casualty crashes in which a semi-trailer was involved steadily increases from the 1st km (1.4%) to the 5th km (5.9%), after which it appears to have flattened out. This may be a reflection of the relative exposure.

Casualty crashes involving bicyclists commence to occur at about 11 km out from the cities (figure 8b), suggesting the limit at which roadside development may have commenced. The rate of increase of such crashes as the cities are approached however is small, until about the 3 to 4 km mark where the proportional value increases from about 2% to 4%. Again this is likely to reflect the relative exposure.

With regard to motorcycle casualty crashes (figure 8b), the only general comment that may be derived from the data is that, as cities are approached, from about the 8 to 9 km segments, the proportion of such crashes increase only slightly (estimated to increase from 4.5% to 5.5%).
Figure 8(a) - Types of Vehicles involved in Casualty Crashes

Figure 8(b) - Types of Vehicles involved in Casualty Crashes
(vi) Casualty Crashes by Time of Day

Table 1 summarises the frequency of casualty crashes, and their proportion of occurrence according to different times of the day.

Nearing provincial cities between 6.00 am and 10.00 pm, two marked increases in the proportions of casualty crashes are experienced, one occurring along the 4 to 6 km segments and the other along the 2km section.

During the period 10.00 pm to mid-night, only one point of significant increase was detected, and this occurred along the 2 km section. For the period mid-night and 6.00 am, the number of casualty crashes were too few to draw any conclusions.

For other periods of the day, the number of casualty crashes are insufficient to enable the identification of trends in the proportions of casualty crashes occurring along feeder roads as provincial cities are approached.
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<td>TOTAL</td>
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</tr>
<tr>
<td>Casualty Per Year</td>
<td>9.5</td>
<td>12.8</td>
<td>10.8</td>
<td>35</td>
<td>47</td>
<td>24.3</td>
<td>51.2</td>
<td>66.8</td>
<td>83.5</td>
<td>50.7</td>
<td>34.7</td>
<td>30.2</td>
<td>23.8</td>
</tr>
</tbody>
</table>

Table 1 - Casualty Crashes by Time of Day
(vii) Casualty Crashes by Day of Week

Nearing provincial cities during each of the days of the week, as indicated in table 2 a significant increase in the proportion of casualty crashes is observed along three distinct road segments. The first occurring along the 5 to 6 km section, the second between the 3 to 4 km segment, and the final sharp increase along the 1 to 2 km road segment. This increase however is less pronounced on Saturdays.

<table>
<thead>
<tr>
<th>Km Interval</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Sat</th>
<th>Sun</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>27.8%</td>
<td>22.5%</td>
<td>26.9%</td>
<td>29.1%</td>
<td>23.7%</td>
<td>26.0%</td>
<td>23.8%</td>
</tr>
<tr>
<td>2</td>
<td>18.7%</td>
<td>21.1%</td>
<td>17.3%</td>
<td>17.4%</td>
<td>17.9%</td>
<td>13.4%</td>
<td>11.8%</td>
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<tr>
<td>3</td>
<td>13.8%</td>
<td>11.2%</td>
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<td>5.2%</td>
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<td>4.7%</td>
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<td>7</td>
<td>4.4%</td>
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</tr>
</tbody>
</table>

| Casuality Per Year | 60.5 | 63.8 | 64.5 | 75.7 | 86.5 | 68.5 | 60.8 |

Table 2 - Casualty Crashes by Day of the Week
(viii) Casualty Crashes by Year

No clear trends are able to be determined (Figures 9a & b).

Figure 9(a) - Casualty Crashes from 1986 to 1991 inclusive (1 Km to 10 Km)

Figure 9(b) - Casualty Crashes from 1986 to 1991 inclusive (8 Km to 15 Km)
7.2 Characteristics of Casualty Crashes by Speed Zone on the Outskirts of Provincial Cities

7.2.1 Introduction

Disaggregating mass crash data according to prevailing speed zones provides the opportunity to examine the characteristics, and trends of casualty crashes according to the nature of road environment, as defined by speed zoning practices (i.e., 60 km/h- urban, 75/80/90 km/h- partial roadside development, and 100 km/h-rural).

The data examined all casualty crashes from just within the 60 km/h urban speed zone (same start point as was used in the segment analysis of mass crash data) to a maximum distance out from the cities of 20 km.

The exercise was repeated using the same data set as was used in the analysis of crashes per km, as cities were approached from a radius of 15 km.

The crash rates proved to be almost identical, consequently the reporting of accidents by speed zone focuses on the larger data base (i.e. out to a maximum 20 km radius), although summaries of the characteristics of crashes using the same data base as used in the 15 km segments are available.

7.2.2 Casualty Crash Per Kilometre Per Year

Calculation of the number of casualty accidents per kilometre per year on the feeder roads according to the prevailing speed zones revealed that, as cities are approached from rural areas, as indicated by the 100 km/h speed zones, through the transitional/part-developed 75/80/90 km/h speed zone, a dramatic increase in the rate of casualty crashes is experienced. The rate rises from 0.4 cas/km/yr (100/110 km/h speed limit), to 1.3 cas/km/yr (75/80/90 km/h speed limit). There is a further large rise 3.4 cas/km/yr in the 60 km/h zone.

Examination of crash data on a sub set of feeder roads was undertaken to determine how the crash rate related with the continuation of travel through to the city centre and the out again. The investigation revealed that crash frequencies generally peaked mid-city, after which they reduced, following a normal distribution curve pattern.
7.2.3 Severity of Casualty Crashes

From table 3 the proportion of casualty crashes resulting in either a fatality or a serious injury increases markedly as the road environment changed from urban to semi-developed/transitional to rural (i.e., 27.1%-urban, 32.8%-transitional and 45.9%-rural). Fatal crashes increase as a proportion of total casualty crashes from 1.8%-urban to 5.0%-transitional to 8.2%-rural zone, while for serious injury casualty crashes the increase occurs from 25.3%-urban to 27.8%-transitional to 37.7%-rural.

<table>
<thead>
<tr>
<th>SEVERITY</th>
<th>60 km/h</th>
<th>75,80,90 km/h</th>
<th>100,110 km/h</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatals/yr</td>
<td>4.5</td>
<td>5.8</td>
<td>15.7</td>
<td>26.0</td>
</tr>
<tr>
<td>Serious Inj/yr</td>
<td>63.2</td>
<td>32.7</td>
<td>71.7</td>
<td>167.5</td>
</tr>
<tr>
<td>Other Inj/yr</td>
<td>182.3</td>
<td>79.0</td>
<td>103.0</td>
<td>364.3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>250.0</td>
<td>117.5</td>
<td>190.3</td>
<td>557.8</td>
</tr>
</tbody>
</table>

Table 3 - Severity of Casualty Crashes

7.2.4 Predominant Types of Casualty Crashes

The major findings from this analysis, as shown in figure 10, were that:

* **cross-traffic crashes** as a proportion of total crashes progressively increased approaching urban development, through the transitional zone, from the rural areas (i.e., 5.4%-rural, 8.5%-transitional and 17.7%-urban).

* **right-turn-against crashes** similarly increased approaching cities from rural areas. However the rate of the proportional increase of this type of crash between urban and transitional areas is not as pronounced (i.e., 4.1%-rural, 12.6%-transitional and 14.5%-urban).

* **pedestrian accidents** follow a similar path, their proportion rises steeply between the rural zone to the transitional zone, with only a relatively small rise with the urban zone (i.e., 1.8%-rural, 6.7%-transitional and 7.3%-urban).

* **rear-end type crashes** follow a different trend, they increase as a proportion of total crashes up to the transitional zone from both the rural zone, and the urban 60 km/h zone (i.e., 11.7%-rural, 24.3%-transitional and 18.1%-urban).
*head-on crashes* as a proportion of crashes increase as the distance out from the cities also increases (i.e., 1.9%-urban zone, 3.8%-transitional and 8.6%-rural).

*out-of-control types of crashes* also increase as the distance out from the cities is increased. However in this case the proportion of these types of crashes increase dramatically when entering the rural driving environment from the urban-transitional speed zones (i.e., 12.5%-urban, 18.6%-transitional and 44.5%-rural).

![Figure 10 - Predominant Types of Casualty Crashes](image)

7.2.5 Other Major Features of Casualty Crashes

(i) Casualty Crashes by Location

The primary feature of this aspect of casualty crashes (figure 11), is that in urban 60 km/h areas about 72% occur at intersections, compared to 52% in the transitional zone and 28% in the rural areas. Conversely in rural areas 75% of casualty crashes occur within mid-block locations, compared to 48% in transitional zones and 28% in the urban area.
(ii) Casualty Crashes by Light Conditions

The major findings of this analysis as depicted in figure 12 are that:

* the proportion of dusk/dawn casualty crashes peak within the transitional speed zone/partly developed areas at 6.4%, while in the urban zone it reduces to 4.0% and for the rural zone to 5.2%.

* the proportion of night-time casualty crashes increases sharply from the urban (22.1%) / transitional (23.1%) speed zones, and the rural zones (32.3%).
(iii) Casualty Crashes on Wet or Dry Roads

The most significant finding of this aspect of casualty crashes (figure 13), is that the proportion of casualty crashes occurring in wet conditions increase as cities are approached from the rural 100 km/h speed zone, through the transitional or partly developed zone to the urban areas (ie., 15.8%-rural, 20.1%-transitional and 22%-urban).
(iv) Casualty Crashes by Weather Conditions

The most significant trends in this facet of road crashes shown in figure 14 were that:

* the proportion of casualty crashes occurring during raining/snowing conditions gradually increased as urban areas were approached (i.e., 8.8%- rural, 12.3%-transitional and 14.2%-urban).

* moving away from urban areas, the proportion of casualty crashes occurring in both foggy and dusty/windy conditions gradually increased. In foggy conditions increasing from 0.3%-urban to 1.6%-transitional to 2.2%-rural, while under dusty wind conditions the proportions increased from 0.3%-urban to 0.7%-transitional to 1.7%-rural.

(v) Casualty Crashes by Vehicle Type

The major trends identified in this assessment as shown in figure 15, were that:

* the proportion of casualty crashes involving semi-trailers increased travelling out from the cities (i.e., 1.7%-urban, 4.0%-transitional and 6.0%-rural).

* the proportion of casualty crashes involving a rigid truck peaked within the transition/partly developed zone (i.e., 1.9%-urban, 3.3%-transitional and 2.5%-rural).
as a proportion, casualty crashes involving cyclists increased as developing urban areas were approached from rural areas (i.e., 1.1%-rural, 2.1%-transitional and 6.1%-urban).

Figure 15 - Casualty Crashes by Vehicle Type

(vi) Casualty Crashes by Time of Day

The most significant features of this analysis, shown in figure 16 are that:

* from 8 pm to 8 am the proportion of casualty crashes occurring gradually increase as the distance the from the urban areas also increases.

* from 8 am to 8pm however the reverse is generally true, that is, as cities are approached the proportion of casualty crashes that occur during this time span increase.

* the peak am and pm periods for the occurrence of casualty crashes for each of environmental categories considered were:
  - for the am, 11.1%-urban, 10.6%-transitional, both between 8.00 am and 10 am, and 8.2%-rural between 6.00 am and 8.00 am.
  - for the pm, 18.9%-urban, 18.0%-transitional and 14.5%-rural occurring between 4.00 pm and 6.00 pm.
(vii) Casualty Crashes By Day of Week

The major finding from this analysis (figure 17), is that the proportion of casualty crashes occurring in the rural areas on Saturdays (17.8%) and Sundays (15.8%) is greater than for both the urban (Sat-13.3% and Sun-10.9%), and transitional (Sat-12.5% and Sun-12.1%) zones. This pattern reverses from Monday to Thursday while on the Fridays the proportional values for each of the environments is similar at about 17.6%.
(viii) Casualty Crashes by Year

The main finding from this variable (figure 18), is that the rate of reduction in casualty crashes since 1989 was mostly experienced within the rural zone, when compared to the other two speed zone categories being examined.

![Figure 18 - Casualty Crashes by Year](image-url)
8.0 SITE INVESTIGATIONS

8.1 Introduction

The inspection of sites to collect road environment conditions data was undertaken between November 1991 and April 1992. While the objectives of the inspections were to identify accident and potential accident contributing factors, conclusions in some instances should be treated with caution. In some instances elements of the road environment observed may be different from those that prevailed at the time of a crash.

For example, road characteristics may have altered because of,

* road maintenance and resurfacing,
* maintenance of linemarkings (lane and centrelines, edgelines painted islands and pavement arrows),
* the replacement of raised reflective pavement markers (RRPM's) damaged or dislodged.
* maintenance of the road shoulder
* the replacement of damaged or missing posts or signs.

A further aspect of the site investigations data is that it does not endeavour to determine the degree to which each of the road environment factors may have contributed to the occurrence of a crash. Consequently the percentage values bracketed with each of the accident contributing factors is only intended to indicate that the factor was considered to have to a varying degree contributed to a crash, and to provide a basis for determining the most prevalent factors within the transitional and rural speed zone categories.

It should also be noted that the length of the rural 100 km/h zone inspected was generally greater than the lower speed zoned urban/rural road segments. Consequently a number of road characteristics had a greater potential to have either contributed or to potentially contribute to a crash, and therefore resulted in a higher percentage value.

8.2 Data Collection

For each of the candidate routes, site information was collected by the completion of the 'Accident Contributing Factors and Safety Check' form (Appendix A), for differing segments of carriageway.

For each of the feeder roads under investigation, two sections of roadway were inspected in detail using the form referred to above. The first section examined the portion of road that commenced just within the 60 km/h speed zone from the 75 km/h zone, through to the commencement of the 100 km/h zone, while the second section began at this location, and extended into the 100 km/h zone to a point where the road environment was typically rural.
In addition to the collection of detailed road environment data, photographs of each of the segments were taken. This aspect of the inspections assisted in the identification or collection of important or relevant site data that may not have been initially evident.

The collection of site data was aggregated and examined in a number of ways, namely by:

(i) identifying and ranking as a percentage, road environment factors considered to have contributed to casualty crashes occurring in both the transitional/partially developed 75/80/90 km/h speed zones, and the predominantly rural 100 km/h zone.

(ii) identification and ranking as a percentage, road environment factors considered to have the potential to contribute to a crash for the two road environments described in part (i) above.

(iii) comparison with, and between the major accident contributing factors, and potentially contributing factors for the intermediate and rural speed zones.

While collection and examination of data related to elements of the road environment that may potentially contribute to accidents is considered of secondary importance, investigation of this data may provide a better understanding of potential accident contributing factors, and how they relate to the incidence of accidents and accident types.

8.3 Nature of Abutting Developments

Site investigations identified a variable road environment according to the rural city or its region. Generally, the environment was a mixture of sparse residential development, commercial premises and smaller rural properties. As the distance out from the country cities increased, rural properties increased in size dominating the roadscape.

Summarised below are the provincial cities investigated, and nature of the outskirts development.

<table>
<thead>
<tr>
<th>Rural City</th>
<th>Outer Fringe Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Geelong</td>
<td>* Residential/Rural</td>
</tr>
<tr>
<td>* Princes Hwy (west)</td>
<td>* Residential/ Commercial/Rural</td>
</tr>
<tr>
<td>* Princes Hwy (east)/Midland Hwy/Torquay Rd/Bellarine Hwy</td>
<td></td>
</tr>
<tr>
<td>* Hamilton Hwy</td>
<td>Commercial/Rural</td>
</tr>
</tbody>
</table>
(ii) Warrnambool
   * Princes Hwy (east)
   * Princes Hwy (west)
   Residential/Commercial/Rural
   Residential/Rural

(iii) Ballarat
   * Glenelg Hwy
   * remaining roads
   Residential/Commercial/Rural
   Residential/Rural

(iv) Horsham
   * Western Hwy
   * Henty Hwy
   Residential/Commercial/Rural
   Residential/Rural

(v) Bendigo
   * all roads
   Residential/Rural

(vi) Mildura
   * all roads
   Residential/Commercial/Rural (vineyards)

(vii) Shepparton
   * all roads
   Residential/Rural

(viii) Wangaratta
   * all roads
   Residential/Rural

(ix) Wodonga
   * all roads
   Residential/Rural

(x) Morwell
   * all roads
   Residential/Rural

(xi) Traralgon
   * all roads
   Commercial/Rural

(xii) Sale
   * all roads
   Residential/Commercial/Rural

(xiii) Bairnsdale
   * Princes Hwy (east)
   * Princes Hwy (west)
   Residential/Commercial/Rural
   Residential/Rural

(xiv) Lakes Entrance
   * all roads
   Residential/Rural

A characteristic of the commercial premises was that the vehicles accessing the properties were also of the commercial type (ie., rigid/articulated trucks and vans). Such vehicles, particularly when loaded are a potential contributing factor to crashes when interacting with other traffic on the relatively high speed transitional zones.
8.4 Results and Key Findings of Site Investigations

Following the processing of the site conditions data, various road environment factors were examined to determine whether or not they had contributed to, or had the potential to contribute to road crashes.

In several cases factors were similar, had common features or overlapped in nature, ie.:

(i) roadside hazards—poles, non-frangible poles and unprotected poles were combined and described as, hazardous poles,
(ii) partial and unsealed shoulders were considered as inadequate shoulder seals, and
(iii) unsatisfactory entry to carriageway from, minor roads, private driveways, service roads and public facilities.

Listed below are the key findings and conclusions of this investigation. The percentage values in the brackets denotes the proportion of road segments studied for both the intermediate and rural speed zones that had experienced a road crash in which the highlighted facet of the road environment was considered to some degree to have either contributed to, or had the potential to contribute to a crash.

(i) the major accident contributing factors identified in the **transitional speed zone** according to their relative importance were:
   - poor curve delineation (39.5%),
   - traffic islands not provided, in particular protected right turn lanes (32.9%),
   - unprotected/hazardous poles (32.6%) and trees (32.6%),
   - unsealed (18.6%) and inadequate shoulder sealing (14.0%),
   - unsatisfactory entry to carriageway (ie. from minor road, service roads, private driveways and public facilities) (30.3%),
   - edgelines not provided (11.6%), or poorly maintained (9.3%). (Appendices B1)

(ii) when considering the road elements that have the potential to contribute to road crashes in the **transitional zone**, the following elements in order of importance were identified:
   - unprotected or hazardous poles (93%) and trees (83.7%),
   - street lighting not provided (90.7%),
   - lack of cyclist/pedestrian facilities (76.7%),
   - unprotected culverts (72.1%),
   - poor curve delineation (65.1%),
   - traffic islands not provided (62.8%)/unsatisfactory entry onto the main carriageway (55.8%),
   - guard fencing not provided (72.1%). (Appendices B1)
(iii) the major accident contributing factors identified in the 100 km/h rural speed zone were, in descending order of prominence:
- partially sealed (39.5%) and unsealed (37.2%) shoulders,
- poor curve delineation (53.5%),
- trees in hazardous locations or unprotected (48.8%),
- poor sight distance for overtaking (39.5%),
- guard fencing not provided (39.5%),
- sight distance poor at intersections (27.9%) and other access points (27.9%). (Appendices B2)

(iv) the following road design elements in the rural road environment have been identified as having a high potential to contribute to road crashes:
- partially sealed shoulders (55.8%) and unsealed shoulders (44.2%),
- unprotected or hazardous trees (90.7%), poles (65.1%)/culverts (62.8%),
- guard fencing not provided (76.7%),
- steep batter slopes/embankments (72.1%),
- poor curve delineation (69.8%),
- traffic islands not provide (55.8%)/unsatisfactory entry onto the main carriageway (58.1%). (Appendices B2)

8.5 Discussion

In addition to identifying those accident contributing factors, and potential contributing factors most frequently prevalent in the transitional and rural zones (detailed in section 8.3 above), further conclusions may be derived.

Examination of the site data also revealed that the order of factors contributing to crashes in a transitional speed zone vary significantly to those in a rural zone. Those factors that emerged at a higher order in the transitional zone compared to those within a rural zone included:

* poor or inadequate curve delineation,
* the lack of traffic islands (ie, protected right turn lanes),
* unprotected/hazardous poles,
* edgelines poorly maintained or not provided,
* unsatisfactory entry to carriageway.

While those factors with higher prominence in the rural zone were:

* inadequate shoulder sealing or unsealed shoulders,
* unprotected or hazardous trees,
* poor sight distance for overtaking. (Appendix B3)
When examining and comparing the order of both crash contributing and potentially contributing factors, a number of conclusions can be drawn. These conclusions were that:

- within the transition zone a correlation is established between the predominance of road factors identified as contributing to crashes, and factors that potentially may contribute to crashes. Such factors include, poor curve delineation, traffic islands not provided (ie. protected right turn), unsealed or inadequately sealed shoulders, poor sight distance at intersections, unsatisfactory entry to carriageway and road side hazards-trees.

- while the lack of, or inadequate street lighting offers a high potential to contribute to road crashes in both speed zone environments, it is only implicated in a relatively low number of crashes.

- in general, there are a lack of pedestrian/cyclist facilities in the two speed environments investigated, resulting in a high potential to contribute to an accident. In view of the low exposure of pedestrians/cyclists on feeder roads in these environments, the number of pedestrian/cyclist accidents, particularly in the transitional zone are considered to be significant. (Appendices B1&2)

9.0 Major Accident and Potential Accident Contributing Factors

Detailed in this section are examples of road design elements identified in section 8.0 of this report which are considered to have either contributed to, or have the potential to contribute to occurrence of a crash.

9.1 Curve Delineation

Photographs A and B in appendix C 1 depict a typical approach to a curve on a feeder road within an intermediate speed zone on outskirts of a major provincial city. Although the curve is delineated with guide posts and raised reflective pavement markers, out of control off the bend types of crashes have continued to prevail (ie., 2 serious injury and 2 non-injury crashes accidents during the 6 year period of this study, 1986 to 1991 inclusive). The site also features a relatively steep embankment, a factor which may potentially cause an out of control vehicle to roll over and thereby increase the severity of the crash.

A similar example of an inadequately delineated curve at a location where a steep embankment prevails is shown in photographs C and D of C1.
Non-delineated or inadequately delineated curves such as this are a common feature within the transitional and rural road environment. The delineation at such sites would be greatly enhanced with the installation of chevron alignment markers, wider edgelines, advisory speed signs, and in order to prevent vehicles losing control down steep embankments as depicted in photographs C and D of C1, guard fencing needs to be installed.

9.2 Turn Lanes and Acceleration / Deceleration Lanes

A feature of the road environment in the outskirts of the provincial cities was that at many intersecting roads motorists were not provided with a right turn lane to decelerate or stop in prior to turning off the feeder road onto the minor road. While traffic flow criteria dictate the circumstances under which turn lanes are provided in rural areas, it is considered that a review of this practice should be undertaken within the transitional zone where large discrepancies in vehicle speeds prevail due to motorists entering and exiting the feeder roads.

The feature of partial roadside development that results in the mixing of local traffic with non-local through arterial traffic also highlights the need to provide acceleration and deceleration lanes, thereby reducing the level and severity of conflict between local motorists entering/exiting the major road and the through feeder road traffic.

Examination of accidents at these locations reveals a substantial number may have been avoided if the road design provided protected right turn lanes and acceleration/deceleration lanes. In 33% of the routes examined in the transitional road environment, it was considered that the absence of such lanes contributed in varying degrees to the occurrence of crashes. The crashes that resulted were of the rear-end, out-of-control, head-on and side-swipe type of collisions.

Photographs A and B of appendix C 2 provide two examples where the lack of these facilities are considered to have contributed to, or have the potential to contribute to crashes. In photograph A, it should be noted that edgelines are not present, a factor that compounds the absence of turn and merge lane facilities as a contributing factor to road crashes.

9.3 Unprotected Poles/Trees

While generally poles and trees were set several metres back from the road shoulders a substantial number were located within 9 metres. Joubert reported to a NSW’s Joint Parliamentary Committee on Road Safety on 2-lane Country Roads (1987), that approximately 80% of roadside object collisions occurred within this distance. Appendix C3 provides two examples (photographs A and B) where poles are a contributing and potentially contributing factor in the occurrence of a crash.
9.4 Inadequate or Poorly Maintained Shoulders and Edgelines

The photographs provided in appendix C4 show instances where shoulders and or edgelines are considered to be inadequate or poorly maintained. They are either not provided (photograph A of C4), inadequate (photograph B of C4) particularly when considering the road environment (ie steep embankments), or poorly maintained (photographs C and D of C4).

Photograph A of C4 also provides an example where a concealed driveway on the left side of the road heightens the potential for a crash ie., a slow moving vehicle entering the feeder road from the driveway and interacting with a unexpected faster moving vehicle.

Photograph C of C4 provides an example of a shoulder that is poorly maintained while photograph D of C4 an example of depicts poorly maintained edgelineing.

9.5 Guard Fencing

In a number of cases guard fencing was found to be inadequate. Often the opportunity was not taken to extend only marginally the erection of fencing to better protect from roadside hazards. Photographs A and B of appendix C5 provide two such examples.

By marginally extending the guard fencing shown in photograph A of C5, or by joining together two sections of guard fencing that are close to each other, as depicted in photograph B of C5, two potential sources of accidents may be removed. In the first case it would provide protection from a pole located in a hazardous location, while in the latter case it will prevent totally the possibility of a vehicle crashing down a steep embankment. In the second case the portion of guard fence missing was observed to be on the outer portion of a curve.

9.6 Culverts

Appendix C6 photographs (A and B) provide a typical example of an unprotected culvert in the partially developed road environment being studied. A feature of this site is the presence of other crash contributing factors such as inadequate or poorly maintained shoulders, and a steep embankment.

9.7 Poor Sight Distance

A frequent aspect of the road environment studied, particularly in the partially developed transitional zone was access to the main road which was affected by poor sight distance. The adverse sight distances were due to the vertical and horizontal alignments of the road, or other road environment characteristic that caused vehicles to be obscured (eg, trees, shrubs).
Photographs A and B in appendix C7 reveal a driveway access located on a moderate curve at a slight grade. The sight distance is further effected by a cut batter. In this particular example it is evident that a vehicle had swerved off the major road, possibly to avoid the rear of a vehicle slowing or stopped as it entered or exited the driveway to the right of the photograph. The consequences of this conflict are depicted in photograph B of C7, where a vehicle had skidded off the road to the left and into a tree.

10.0 REMEDIAL / PRO-ACTIVE ROAD SAFETY TREATMENTS

10.1 Introduction

For each of the major road factors identified as having either contributed to, or which have the potential to contribute to a crash within a transitional urban/rural road environment, a number of measures may be undertaken to reduce the degree to which they contribute to the occurrence of a collision, or to reduce the severity of the a crash.

These relatively short transitional segments provide an opportunity to implement low cost measures targeted at elements of the road environment that have been implicated to varying degrees in the incidence and severity of crashes.

It should also be noted that the selection of treatments, or the formulation of a program of works should take account of the finding from this study that the severity of road crashes within a transitional urban/rural road environment, while being less than that within a rural environment is significantly greater than within an urban environment.

Based on the level of severity detected in each of the road environments, urban, urban/rural and rural, and the current costing of crashes used by VIC ROADS in the economic evaluation of road safety treatments and programs, the cost of a casualty crash in a transitional urban/rural road environment is estimated to be approximately $70,000. This value is derived from the costing of road crashes of both urban crashes ($57,000), and rural crashes ($90,000), as detailed in VIC ROADS, 'Guidelines for the Selection of Projects Under the Road Conditions Sub-Program'.

This document is used by VIC ROADS regions as an aid to the economic evaluation, and the formulation of their future road safety program (ie, Black Spot, Mass Action and Railway Level Crossings Projects).

Detailed in the following pages are recommended measures designed to ameliorate the road features that were identified by this study as major accident contributing factors.
10.2 Curve Delineation

While curves were generally defined with post mounted delineators, in 39% of the routes examined it was considered that the curve was not adequately delineated and this may have contributed to a crash, and in 65% of the routes investigated it was considered that inadequate curve delineation may potentially contribute to an accident.

The superelevation and surface of the road at the curves were considered to be generally adequate. Consequently, it is recommended that the measures to be considered on curves should focus on improving the conspicuity and severity of the curve. Such measures include:

* the erection of chevron hazard boards,
* advisory curve, and if appropriate speed signs,
* the use of wider edgelines around curves,
* guard railing on curves where steep embankments/batter slopes, or where roadside hazards are located,
* installation of additional raised reflective pavement markers along the centreline of the curve,
* the regular maintenance of all linemarkings, (ie., centreline and edgelines) through the curve.

10.3 Turn Lanes and Acceleration / Deceleration Lanes

A characteristic of traffic flow patterns and vehicle speeds in the transitional road environment, is that substantial variability may occur as a result of the mixture of locally generated traffic, and non-local through traffic. The interaction and conflicts between the two categories of traffic prevail on a road environment that is generally experiencing high vehicle speeds. Examination of the crashes occurring on these roads, and investigation of the characteristics of the road segments reveal that the road design fail to adequately respond to the conflicts that are generated in this environment. For example, a large proportion of intersections do not provide adequate separation of left or right turning traffic from the fast moving through traffic, or enable traffic entering the fast moving stream on the major arterial to do so at a speed closer to that of the through traffic.

The site investigations conducted estimated in 35% of the routes studied, that failure to adequately assimilate the 'slower' traffic with the 'faster' traffic, may have contributed to the occurrence of a crash. As a potential contributing factor the value was estimated at 63%.
Relatively low cost measures that may be implemented to address this conflict includes:

* the establishment of painted protected right turn lanes at intersections. This may require a review of current practices that stipulate minimum traffic flow conditions for different right turn lane configurations.
* the establishment of both acceleration and deceleration lanes.

10.4 Hazardous Poles / Trees

Hazardous poles or trees were implicated as crash or high severity contributing factors on approximately 33% each of the routes under investigation. Hazardous poles were considered a potential contributing factor in 40% of the routes examined, and trees in 36%.

Measures that may be considered in order to reduce poles and trees as accident contributory factors include:

* where appropriate the replacement of vulnerable poles with frangible or slip base poles,
* increasing the set back of poles to at least 9 metres,
* remove trees located within 9 metres of the carriageway and replant with non hazardous vegetation in their place,
* the installation of guard fencing to protect from trees or poles that are unable to be removed or relocated,
* where possible poles should be widely spaced and set away from intersections.

10.5 Unsealed or Partially Sealed Shoulders

Of the total number of feeder roads investigated it was considered that on 19% of those roads, unsealed shoulders contributed to the occurrence of a crash, while in 37% of cases had the potential to contribute to a crash. When considering shoulder seals up to one metre, it was determined that this feature contributed to casualty crashes occurring on 14% of the roads, and with the potential to contribute to a crash on 40% of the roads. It should be noted that where the partial seal was considered to be inadequate, it generally occurred where the edgeline was in close proximity to the edge of seal, or where there was substantial variability in the in the width of the seal.

The locations within the transitional zone where inadequate shoulder seals are considered be particularly hazardous are at intersections and other access points to the feeder roads.
Measures that may be implemented to reduce the incidence of crashes where inadequate shoulder sealing is a contributing factor include:

* full width shoulder sealing on the approaches and departures of the feeder road at its intersection with minor roads. This measure coincides with the provision of both acceleration and deceleration lanes recommended in section 9.2 above. The lengths of these lanes should conform to current practices.

* full width shoulder seals should also be provided on both sides of the feeder road, other major road access points (ie, driveways to shopping complexes, commercial premises and private driveways). The lengths of these full seal shoulders may be restricted if access points to the main road are only sparsely located. A minimum length shoulder seal would be considered to be in the order of 60 metres.

* road shoulders, particularly on the approaches and departures to intersections and other points of access should regularly maintained.

10.6 Edgelines Not Provided or Poorly Maintained

Within the transitional zone the absence of edgelines was considered to be an accident contributing factor in 12% of road segments examined, while poorly maintained edgelines contributed to crashes in 9% of the roads. The absence of edgelines, or their poor maintenance may be closely linked to the performance of the shoulder as a possible accident contributory factor.

Measures recommended designed to improve road delineation and thereby improve vehicle lane discipline include:

* ensure that all arterial roads are edgelined,
* on the approaches and departures to intersections and other access points on the major road provide wider edgelines,
* ensure that edgelines are regularly maintained.

10.7 Culverts

Culverts were considered to have contributed to the occurrence of casualty crashes on 16% of the transitional road segments investigated.

The measures that are recommended to treat culverts that are hazardous include:

* extension of culverts that are hazardous out beyond a 9 metre clear zone out from the trafficked lanes,
* replace hazardous culvert types with a potentially less threatening culvert design,
* install guard fencing to prevent impact with hazardous culverts that are unable to be treated in an alternate feasible manner,
* ensure the section of carriageway in which the culvert lies has improved delineation (ie, additional raised reflective pavement markers RRPM’s along the centreline).
* ensure linemarking (ie., edgelines and centreline) and road shoulders through the section of road are regularly maintained.

10.8 Improving Sight Distance
(both at intersections and other access points on the feeder)

As a contributing factor it is estimated that on 19% of the routes examined, poor sight distance at intersections was a contributing factor to the occurrence of casualty crashes.

For other points of access to the arterial, 7% of routes investigated experienced poor sight distance as an accident contributing factor.

Measures that may be undertaken to improve sight distances at both intersections and driveways include:
* clear obstructing vegetation,
* relocate where possible roadside furniture that may obscure vehicles,
* ensure road sign mountings are not placed at the motorists’ eye level,
* relocate where possible hazardous access points from driveways onto feeder roads to minimise poor sight distances that may result from adverse vertical or horizontal road alignments,
* provide where possible flatter batters at points of access to feeder roads.
11.0 SUMMARY

The major findings of the study were that:

(i) a partially developed urban/rural road environment is unique, and consequently it experiences different crash characteristics to those in either a total urban or total rural road environment.

(ii) feeder roads experience casualty crash rates that are substantially higher in an environmental transition zone than in a rural zone.

* Casualty Crash Rate Per Vehicle Kilometre Travelled per Year

Transitional Zone = 45 cas/100 mill-vehicle km/year
Rural Zone = 27 * * * * *

* Casualty Crash Rate Per Kilometre Per Year

Transitional Zone = 1.3 cas/km/year
Rural Zone = 0.4 * * *

(iii) changes in dominant crash types and the characteristics of their occurrence, which varied at differing points on the feeder roads, generally occurred within the relatively short length of the transitional/partially developed road environment.

(iv) as the distance from the city centres increases:

* the severity of crashes on feeder roads on the outskirts of provincial cities increases substantially.
* the proportions of the potentially serious head-on and out-of-control types of crashes increase significantly through the transitional zone.

(v) the cost of casualty crashes in transitional urban/rural road environments is estimated to be $70,000.

(vi) as the level of abutting roadside development increased the proportions and number of cross-traffic, right-turn-against and pedestrian types of crashes also increased. These increases were generally experienced within intermediate speed zones which reflect varying levels of abutting development.

(vii) as a proportion of total crashes, rear-end types of crashes peaked within the partially developed transitional road environment.
(viii) characteristic of casualty crashes also changed with the transitional urban/rural road environment. As the roadside development increased the proportion of:

* intersection casualty crashes also increased,
* night-time crashes decreased,
* crashes occurring during rainy/snowy conditions increased markedly.

(ix) proportion of casualty crashes involving semi-trailers commenced to increase out from the urban area within the transitional zone.

(x) the highest proportion of casualty crashes occurring during the dusk/dawn period prevailed within the transitional zone.

(xi) site investigations confirmed the unique characteristics of the transitional road environment identifying the major accident contributing, and potentially contributing factors that prevailed within this partially developed road environment. Those accident contributory factors identified include:

* poor curve delineation,
* turning lanes were not provided,
* shoulder sealing was inadequate on the approaches and departures to intersections and in the vicinity of access points to the feeder roads,
* the need for acceleration and deceleration lanes at access points to the feeder roads,
* poles located in hazardous locations or unprotected.

(xii) the site investigations also underlined the importance of safety auditing, identifying potential road characteristics which may contribute to the occurrence of a crash or to increasing their severity.

(xiii) the site investigations identified relatively low cost remedial or pro-active road safety treatments (section 10 of this report), for partially developed road environments.
12.0 CONCLUSIONS AND RECOMMENDATIONS

The identification and investigation of the unique characteristics of road crashes within an environment that is only partially developed:

(I) revealed that the road design had failed to respond to the hazardous interaction that occurs between the locally generated traffic, traffic that is often accelerating decelerating or propping when entering or exiting feeder roads, and the non-local through traffic which generally travel at more uniform high speeds.

(II) identified measures designed to reduce the incidence and severity of casualty accidents on roads in partially developed areas (section 10).

(III) will enable a more comprehensive assessment of candidate sites to be determined within road authorities' future works program.

(IV) will enable road design elements to be either corrected or appropriately designed and implemented prior to abutting roadside development occurring out from the city centres.

(V) identifies the need for road design standards and practices within partially developed roadside environments to be reviewed, particularly as they relate to:

* curve delineation,
* intersection layout design, and the provision of turning lanes,
* increased use of both acceleration and deceleration lanes at minor road intersections,
* use of intermittent full width shoulder sealing at major access points on major roads (ie commercial premises, schools, parkland carparks, etc.). This practice offers the potential to better target shoulder sealing practices and programs.
* guard fencing practices,
* the treatment of hazardous poles.

(VI) enabled the identification of characteristics of the road environment that have contributed to, or may potentially contribute to a crash that are able to be readily or inexpensively treated.

(VII) the findings of the study provide a basis for prioritising and acting upon safety audit checks. While road authorities practices may be to promote safety auditing within a rural environment the findings of this study indicate the need to concentrate in these areas.
(VIII) While the study examined the accident experience specifically on feeder roads to major rural cities, the findings and conclusions are considered to be applicable to all major arterials on the approaches to rural towns irrespective of the city size, provided the roads experience an environmental transition from one that is urban to one that is rural in nature.

(IX) The study which confined itself to rural Victoria provides the basis for the examination of intermediate zones on the major feeder routes on the outskirts of Melbourne's outer metropolitan area, and also on the arterial roads that traverse these routes. Such a study will enable the identification of features that may be common on transitional zones in rural Victoria, and Melbourne's outer areas, as well as identifying unique characteristics of their own.
ACKNOWLEDGEMENTS

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Peter Cleal, Manager, Office of Road Safety, South Australia
Peter Willett, Senior Research Officer, Main Roads Department, Western Australia.
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12. Road and Environment Safety Branch, Road Safety Division, VIC ROADS December 1990, 'Guidelines for the Selection of Projects Under the Roads Conditions Sub-Program'.


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**APPENDIX A**

**ACCIDENT CONTRIBUTING FACTORS AND SAFETY CHECK**

**ROAD NAME:**

**LOCATION:**

<table>
<thead>
<tr>
<th>Potential Accident Contrib Factor</th>
<th>Accident Contrib Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y/N</td>
<td>Y/N</td>
</tr>
</tbody>
</table>

1.0 **ALIGNMENT**

1.1 *Sight distance* is poor
   - (a) at the intersection
   - (b) at other points of access (eg property access)
   - (c) for overtaking
   - comment:

1.2 *Confusing alignment*
   - (a) of roadway (ie new roadway)
   - (b) of old disused pavement (ie not removed)
   - (c) realignment due to old pavement markings not removed
   - (d) due to informal delineation (eg row of trees)
   - (e) vertical due to excessive undulations
   - comment:

1.3 *Glare* due to
   - (a) oncoming headlights
   - (b) the sun (ie dusk/dawn)
   - (c) 2-way service road
   - comment:

1.4 Un satisfactory *transition* from old realignment to new
   - comment:

1.5 *Unexpected change in alignment standard*
   - comment:

2.0 **SIGNING AND DELINEATION**

2.1 *Ambiguous and unclear*
   - (a) directional signing
   - (b) advisory/warning signs
   - comment:

2.2 (a) *Unnecessary signing*
   - (b) *Insufficient signing*
   - (c) Sign hidden or inconspicuous
   - comment:
<table>
<thead>
<tr>
<th>Potential Accid Contrib Factor Y/N</th>
<th>Accid Contrib Factor Y/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3(a) Non-Frangible poles</td>
<td></td>
</tr>
<tr>
<td>(b) Unprotected poles/posts</td>
<td></td>
</tr>
<tr>
<td>comment:</td>
<td></td>
</tr>
<tr>
<td>2.4 Roadside furniture is located in a vulnerable location.</td>
<td>comment:</td>
</tr>
<tr>
<td>2.5 Excessive number of signs</td>
<td></td>
</tr>
<tr>
<td>comment:</td>
<td></td>
</tr>
<tr>
<td>2.6 Inadequate sited distance to sign</td>
<td>comment:</td>
</tr>
<tr>
<td>2.7 Sign restricts site distance</td>
<td></td>
</tr>
<tr>
<td>comment:</td>
<td></td>
</tr>
<tr>
<td>2.8 Sign mounted at an inappropriate height</td>
<td>comment:</td>
</tr>
<tr>
<td>2.9 Incorrect sign size</td>
<td></td>
</tr>
<tr>
<td>comment:</td>
<td></td>
</tr>
<tr>
<td>2.10 Inadequate guideposts(eg insufficient, poorly spaced)</td>
<td>comment:</td>
</tr>
<tr>
<td>2.11 Poor curve delineation</td>
<td></td>
</tr>
<tr>
<td>comment:</td>
<td></td>
</tr>
<tr>
<td>2.12(a) Edgelines poorly maintained</td>
<td>comment:</td>
</tr>
<tr>
<td>(b) Edgelines not provided</td>
<td></td>
</tr>
<tr>
<td>comment:</td>
<td></td>
</tr>
<tr>
<td>2.13(a) Centreline not provided</td>
<td></td>
</tr>
<tr>
<td>(b) Centreline is poorly maintained</td>
<td>comment:</td>
</tr>
<tr>
<td>comment:</td>
<td></td>
</tr>
<tr>
<td>2.14(a) R.R.P.M.'s not provided</td>
<td></td>
</tr>
<tr>
<td>(b) R.R.P.M.'s insufficient</td>
<td></td>
</tr>
<tr>
<td>(c) R.R.P.M.'s poorly maintained</td>
<td></td>
</tr>
<tr>
<td>comment:</td>
<td></td>
</tr>
<tr>
<td>2.15(a) Other linemarkings (eg turn arrows) poorly maintained</td>
<td>comment:</td>
</tr>
<tr>
<td>(b) Other linemarkings insufficient</td>
<td>comment:</td>
</tr>
<tr>
<td>2.16 Lack of advisory speed signs</td>
<td>comment:</td>
</tr>
<tr>
<td>2.17 Unclear vehicle path through the intersection.</td>
<td>comment:</td>
</tr>
<tr>
<td>2.18(a) Traffic islands poorly delineated/inconspicuous</td>
<td>comment:</td>
</tr>
<tr>
<td>(b) Traffic islands poorly located</td>
<td>comment:</td>
</tr>
<tr>
<td>(c) Traffic islands not mountable</td>
<td>comment:</td>
</tr>
<tr>
<td>(d) Traffic islands not provided</td>
<td></td>
</tr>
</tbody>
</table>
2.19(a) **Potential Accid Contrib Factor**
- Speed zone inappropriate .................................................................
  - Speed zone sign poorly sited ..............................................................
  comment: ..........................................................................................

3.0 **ROADSIDE HAZARDS**
3.1(a) tree/s ..............................................................................................
  (b) pole/s ..............................................................................................
  (c) culvert/s ...........................................................................................
  (d) other (specify) ..................................................................................
  comment: ..............................................................................................

3.2(a) Shoulder unsealed ...........................................................................
  (b) Shoulder partially sealed (up to 1 metre) ..........................................
  comment: ..............................................................................................

3.3 **Poor maintenance of shoulder**
(a) unsealed ..............................................................................................
(b) partially sealed ...................................................................................
(c) fully sealed ........................................................................................
 comment: ..............................................................................................

3.4 Steep batter slopes/embankments ......................................................
 comment: ..............................................................................................

4.0 **GUARDFENCING**
(a) Not provided ........................................................................................
(b) Poorly maintained ............................................................................... 
(c) Inadequate ..........................................................................................
 comment: ..............................................................................................

5.0 **UNPROTECTED BRIDGE END POSTS**
Specify ......................................................................................................
 comment: ..............................................................................................

6.0 **FENCING**
Existing fencing poorly designed (specify) ..............................................
 comment: ..............................................................................................

7.0 **PEDESTRIANS / CYCLISTS**
7.1 Absence of pedestrian/cyclist facilities ..............................................
  comment: ..............................................................................................
7.2 Inadequate pedestrian/cyclist standing area ....................................... 
  comment: ..............................................................................................
7.3 Insufficient site distance to ped/cyclist facilities

comment:

7.4 Existing ped barriers (fence) not satisfactory

comment:

7.5 Road surface unsafe for cyclist

comment:

7.6 Bus Stop poorly
(a) located
(b) designed (specify)

comment:

8.0 TRAFFIC SIGNALS

8.1 Traffic signals are,
(a) obscured by queued vehicles
(b) obscured by poles, trees, signs, etc.
(c) effected by the sun rising/setting

comment:

8.2 Traffic signals are poorly laid out

comment:

8.3 Phasing of signals operation is unsatisfactory

comment:

9.0 PARKING AND ACCESS

9.1 Inadequate parking facilities (specify)

comment:

9.2 Unsatisfactory re-entry to carriageway

comment:

9.3 Unsatisfactory entry to carriageway from,
(a) service road
(b) private driveway
(c) public facility (e.g. shopping centre)

comment:

10.0 STREET LIGHTING

(a) not provided
(b) low level

comment:

11.0 ROAD PAVEMENT

(a) too narrow
(b) poorly maintained (e.g. rough/smooth)
(c) has poor drainage

comment:
APPENDIX B
### ACCIDENT CONTRIBUTING FACTORS

| Poor curve delineation | Hazardous Poles | Roadside Hazards - trees | Roadside Hazards - culverts | Traffic islands not provided | Shoulder Unsealed or Partially Sealed (up to 1m) | Guard Fencing - not provided | Sight distance is poor at the junction | Roadside Hazards - other | Unusually re-entry to clover from service road | Edgelines not provided | Inadequate edge line | Edgelines poorly maintained | Poor maintenance of shoulder partially sealed | Sight distance is poor at other points of access | Confusing alignment/vertical due to excessive undulation | RRRPM not provided | Phasing of signals inoperable unsatisfactory | Unusually re-entry to clover from public facility | Guard Fencing - inadequate | Other markings insufficient | Traffic islands poorly delineated/inconspicuous | Road pavement poorly maintained | RRRPM a insufficient | Confusing alignment of roadway | Other markings poorly maintained | Glare due to the sun (dusk/dawn) | Glare due to 2-way service road | Unexpected change in alignment standard | Contraband is poorly maintained | Insufficient signing | RRRPM a poorly maintained | Traffic signs poorly laid out | Inadequate guideposts | Lack of advisory speed sign | Traffic signs are obscured by ground vehicles |

### POTENTIAL ACCIDENT CAUSATION FACTORS

| 75/80/90 km/h ZONE |

### CONTRIBUTING AND POTENTIALLY CONTRIBUTING FACTORS -

75/80/90 km/h ZONE
ACCIDENT CONTRIBUTING AND POTENTIALLY CONTRIBUTING FACTORS - 100 km/h ZONE
### Accident Contributing Factors - 75/80/90 km/h Zones and 100 km/h Zone

#### 75.80.90 km/h Speed Zone
- Poor curve delineation
- Roadway not clear (up to 1 mile)
- Roadside hazards - line(s)
- Hazardous Poles
- Traffic islands not provided
- Guard Fencing - not provided
- Slight distance is poor at the 60 km/h
- Roadside hazards - other
- Undersized path through the intersection
- Absence of pull-off/shoulder
- Unsatisfactory re-entry to centerline
- Edges not provided
- Unsatisfactory to change from service road
- Sleepers/roadbeds
- Poor maintenance of shoulder - part
- Edges poorly maintained
- Slight distance is poor at other points of access
- Controlling alignment/vertical due to uneven pavements
- RRPMs not provided
- Phasing of signals operable
- Unsatisfactory
- Other
- Road pavement poorly maintained
- Guard Fencing - inadequate
- RRPMs insufficient
- Traffic islands poorly maintained
- Inadequate/insufficient
- Unsatisfactory re-entry to change from public facility
- Inadequate signage
- Controlling alignment of roadway
- Lack of advisory speed signs
- Glare due to the sun (dusk/dawn)
- Other
- Other maintenance poorly maintained
- Centralline is poorly maintained
- Glare due to 2-way service road
- Inadequate guardrails
- Road pavement too narrow
- RRPMs poorly maintained

#### 100 km/h Speed Zone
- Poor curve delineation
- Roadway not clear (up to 1 mile)
- Roadside hazards - line(s)
- Hazardous Poles
- Traffic islands not provided
- Guard Fencing - not provided
- Slight distance is poor at the 60 km/h
- Roadside hazards - other
- Undersized path through the intersection
- Absence of pull-off/shoulder
- Unsatisfactory re-entry to centerline
- Edges not provided
- Unsatisfactory to change from service road
- Sleepers/roadbeds
- Poor maintenance of shoulder - part
- Edges poorly maintained
- Slight distance is poor at other points of access
- Controlling alignment/vertical due to uneven pavements
- RRPMs not provided
- Phasing of signals operable
- Unsatisfactory
- Other
- Road pavement poorly maintained
- Guard Fencing - inadequate
- RRPMs insufficient
- Traffic islands poorly maintained
- Inadequate/insufficient
- Unsatisfactory re-entry to change from public facility
- Inadequate signage
- Controlling alignment of roadway
- Lack of advisory speed signs
- Glare due to the sun (dusk/dawn)
- Other
- Other maintenance poorly maintained
- Centralline is poorly maintained
- Glare due to 2-way service road
- Inadequate guardrails
- Road pavement too narrow
- RRPMs poorly maintained
APPENDIX C
APPENDIX C1

A

B