University of Southern Queensland
Faculty of Engineering and Surveying

Investigation of Driver Fatigue Problems on the Oakey-Cooyar Road

A dissertation submitted by

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in fulfilment of the requirements of

Course ENG4111 and 4112 Research Project

towards the degrees of

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Abstract

The Oakey-Cooyar Road (417) provides an alternate route to the New England Highway (22A) for the north-south movement of freight, especially the heavy vehicles. Currently articulated vehicles and road trains are the major types of heavy vehicles which are using the Oakey-Cooyar Road.

The investigation of the historical crash data has found that the crashes occurred on 417 were more likely to be fatigue related although those crashes were less severe than the ones occurred on 22A. Thus fatigue management measures must be implemented to reduce the chance of fatigue-related crashes on the road for future increasing volume of heavy vehicles.

The field investigation has found that there is little strategic planning for existing facilities. The current rest area and stopping areas are not well defined and most are not signposted. The recommended strategies to be adopted on the Oakey-Cooyar Road are:

- Upgrading the current motorist rest area to a clearly identified heavy vehicle rest area near Kulpi;
- Establishing at least three clearly identified and signed heavy vehicle stopping places on each direction, which may be used by other vehicles too;
- Establishing an overtaking lane before the south-bound 10% steep ascent section.

It is also recommended that extra signs be posted to redirect the heavy vehicle to use the West Oakey Connection Road, therefore bypass Oakey. Further research needs to be conducted on the usage of rest areas and an estimate of costs for the suggested improvements to the road needs to be carried out in order to analyse the cost-benefit aspects of the proposals due to the time constraint of this project.

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ENG4111 & ENG4112 *Research Project*

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Certification

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I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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Date

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Chapter 1 Introduction

1.1 Project Background

Toowoomba is located at 140km west of Brisbane, the capital city of Queensland, Australia (Figure 1.1). Heading north from Toowoomba, the New England Highway (22A in Figure 1.2) passes through lush green dairying pastures and thick vegetation up into Crows Nest, then winding its way further north past Cooyar before reaching the D'Aguilar Highway at Yarraman. Dual carriageway exists only from Toowoomba to Highfields and a few overtaking lanes are available thereafter. The development of the Highfields area and increase in traffic volume have pushed Main Roads to consider alternative routes for the traffics in the future, especially the heavy vehicles. The data showed that the Average Annual Daily Traffic (AADT) had reached 14411 in this section of the New England Highway in 2002 and the yearly growth rate was approximately 4%.

Figure 1.1: South-east and Southern Queensland Road Network, Australia

The Oakey-Cooyar Road (417 in Figure 1.2) provides an alternate route to the New England Highway for the north-south movement of freight. The

alignment of the Oakey-Cooyar Road is generally better than the New England Highway, and at this stage the road is not subject to adjoining residential development. This project will examine the current use of the road by commercial vehicles and the historical crash data for the road, and compare the result to the New England Highway. The feasibility of the Oakey-Cooyar Road being an alternate route to the New England Highway will also be assessed, from the perspective of driver fatigue.

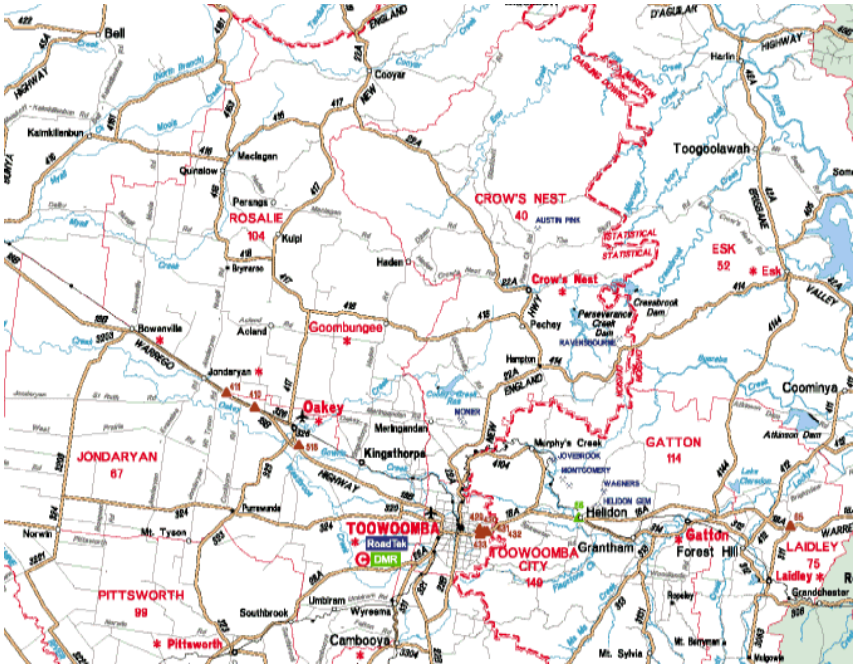

Figure 1.2: Map of Partial Southern District of Main Roads

(Appendix B shows the entire Southern District of Main Roads)

1.2 Project Aims

The aims of this project are to investigate the feasibility of the Oakey-Cooyar Road being used as an alternate route to the New England Highway, from the perspective of driver fatigue, and provide recommendations for the staged implementation of driver fatigue amelioration measures.

1.3 Specific Objectives

The specific objectives of the project are:

- Research the background information relating to driver fatigue and in particular (i) road safety and driver fatigue, (ii) fatigue and heavy vehicle operation, and (iii) fatigue amelioration measures and guidelines;
- Examine the physical and operational characteristics of the New England Highway (Toowoomba to Cooyar) and the Oakey-Cooyar Road;
- Analyse the historical crash data for the roads and in particular examine problems associated with driver fatigue crashes;
- Identify appropriate design guidelines for provision of fatigue amelioration facilities such as truck stops and rest areas;
- Conduct a field investigation to identify potentially adverse geometric features, existing fatigue amelioration devices and areas, and potential sites for new facilities;
- Devise a fatigue management strategy for the Oakey-Cooyar Road, and recommend on the introduction of new facilities or the upgrading of existing facilities;
- Report findings through oral presentation at the Project Conference, and in the required written format; and

- As time permits, carry out a preliminary estimate of costs for the suggested improvements to the road, and analyse the cost-benefit aspects of the proposals.

Chapter 2 Literature Review

2.1 Defining Fatigue

The phenomenon of fatigue, while heavily researched, does not have a universally accepted definition. As identified by Roads and Traffic Authority (RTA) NSW, fatigue is a general term commonly used to describe the experience of being "sleepy", "tired" or "exhausted". Fatigue is also defined as "a disinclination to continue performing the task at hand" (Brown 1994). Fatigue is both a physiological and a psychological experience. The effects of sleepiness and fatigue on driving are very much the same, which is a progressive withdrawal of attention from the road and traffic demands leading to impaired driving performance (Brown 1994). For the purpose of this project, the ultimate impairment is falling asleep at the wheel.

The three main determinants of fatigue are: lack of sleep, time of day or circadian factors, and time spent performing a task. Other individual factors that affect the incidence of fatigue include age, physical fitness and medical condition (Dobbie 2002).

The primary cause of sleepiness is not getting adequate sleep, resulting in a state of sleep deprivation and building up a 'sleep debt'. Research has found that as little as two hours sleep loss on one occasion can result in degraded reaction time, cognitive functioning, memory, mood and alertness. Cumulative sleep debt significantly reduces alertness and performance, especially on attention based tasks such as driving (Dobbie 2002).

Sleepiness can also occur in persons who are not sleep deprived. Human's sleep and wake cycles are regulated by an internal body clock that programs

the body to feel sleepy during the middle of night-time sleep period, and again 12 hours later, between two and four o'clock in the afternoon. This pattern of sleep and wakefulness is referred to as the circadian sleep cycle, or circadian rhythm – one of the main determinants of fatigue (Stutts 2000). Many studies have confirmed that drowsiness is at peak between late evening and dawn and the circadian rhythm was the most consistent factor influencing driver fatigue (Dobbie 2002).

In addition to 'lack of sleep' and 'time of day', 'time on task' is another determinant of fatigue. Prolonged physical activity without rest leads to muscular fatigue whereas a prolonged mental workload without rest will lead to reduced alertness and disinclination to continue the effort. Research based on driving tasks has shown that as time spent on driving increased, the level of fatigue is increased, reaction time is slowed and the probability of falling asleep is increased (Dobbie 2002).

Therefore the common countermeasures of drivers' fatigue problem are to have adequate sleep before driving, avoid driving during peak fatigue times and have a rest every two hours.

2.2 Road Safety and Driver Fatigue

Driver fatigue is a serious problem resulting in many thousands of road accidents each year. It can severely impair judgment, result in poor concentration, reduced alertness and slow reactions.

High risk times for fatigue-related fatal crashes are night time/early morning (10pm-6am) and afternoon (2pm-4pm), which coincide with dips in the body's circadian rhythms. Those crashes are also more likely to occur during public and school holiday periods, contributing nearly 30 per cent of all fatal fatigue accidents. Fatigue-related accidents tend to be more severe, possibly because

of the higher speeds involved and because the driver is unable to take any avoiding action, or even brake, prior to collision.

There are difficulties in determining the level of fatigue related accidents because there is no simple, reliable way for an investigating police officer to determine whether fatigue was a factor in an accident. This results in varying estimates of the proportion of crashes attributable to driver fatigue which varies from five per cent to 50 per cent. However, most experts estimated that 20 per cent to 30 per cent of fatal road crashes could result from driver fatigue (Dobbie 2002). The Australian Transport Safety Bureau (ATSB) operational definition of a fatigue-related crash employs some of the criteria used in the United States, the United Kingdom and some Australian States, which:

- includes single vehicle crashes that occurred during 'critical times' (midnight – 6am and 2pm-4pm);
- includes head-on collisions where neither vehicle was overtaking at the time;
- excludes crashes that:
  - occurred on roads with speed limits under 80 kilometres per hour;
  - involved pedestrians;
  - involved unlicensed drivers;
  - involved drivers with high levels of alcohol (blood alcohol over 0.05g/100ml).

  (Dobbie 2002)

In Queensland the definition of a fatigue-related crash is simpler. A crash in Queensland was assessed as being fatigue-related if a single vehicle crashed in 100km/h or higher speed zone during typical fatigue times (2pm-4pm or 10pm-6am), or the reporting officer considered that fatigue was a contributory factor in the crash (Dobbie 2002).

2.3 Fatigue and Heavy Vehicle Operation

Fatigue is one of the biggest causes of accidents for heavy vehicle drivers. A study in 2000 found that 45 per cent of long distance heavy vehicle drivers in Australia had experienced fatigue during their last trip (RTA NSW undated).

Fatigue is a significant problem in road transport, especially in view of long distances and the structure of commercial/industrial operations, and the geographical spread of industry and commerce in Australia. Fatigue was believed to contribute directly to between 5 per cent and 50 per cent of road crashes as stated previously by Dobbie, and there were probably many more in which fatigue might have played a part but was not identified, or the crash was attributed to other causes such as inattention. Fatigue of heavy vehicle drivers was believed to contribute to about four per cent of heavy vehicle crashes (NRTC 2001).

There are three reasons noted by the Fatigue Expert Group from Australian Transport Safety Bureau why fatigue is an important road safety issue for heavy truck drivers and operators. Firstly, truck crashes are often more severe than non-truck crashes and in multiple vehicle crashes the risk of being injured is greater for the non-truck occupants. Secondly, fatigue is proportionally more significant than other risk factors, such as drink-driving and excessive speeding which are less common to the truck drivers. Finally, fatigue is an occupational health and safety issue as truck drivers could spend a considerable amount of time on the road as part of the job. A report by the Western Australian Department of Transport on fatigue management for commercial truck drivers noted that many truck drivers worked more than 12 hours per day with at least 60 per cent of this time spent driving. Therefore, the nature of the transport industry had also contributed to the incidence of fatigue-related crashes (Dobbie 2002).

Traditionally Australian governments had sought to minimise the safety and health consequences of fatigue by limiting daily and weekly hours of driving

for long distance operations. It is now considered that this is not sufficient, and that account must be taken of the causes and precursors of fatigue (NRTC 2001). The regulatory framework approved by the Australian Transport Council (ATC) had removed the inconsistencies between states which had previously applied prescriptive regulation, introduced some flexibility and incorporated 'chain of responsibility' provisions. The national provisions apply to vehicles of greater than 12 tonnes gross mass and have three components:

- a regulated driving hours regime,
- a Transitional Fatigue Management Scheme,
- provision for a full fatigue management scheme.

(Moore 2002)

'Chain of responsibility' offences had been included in the provisions to place liability on employers, consigners or other parties who took action which leaded to breaches of the provisions because road transport is just one part of a distribution chain, and often the root problem of fatigue in the road transport industry is the demand of industry, commerce and the consuming public for movement of goods to particular schedules (NRTC 2001).

2.4 Fatigue Amelioration Measures and Guidelines

There are many fatigue amelioration measures, from government regulations, to public educations and technological countermeasures. For the purpose of this project, fatigue amelioration measures had been focused on the physical design of the road and its roadside amenities which included rest areas, stopping places, overtaking lanes and rumble strips.

2.4.1 Rest Area for Motorist

A rest area for motorists is an attractive, park-like area separated from, but within general sight of, the through pavement with parking suitable for cars, and cars with caravans or trailers. Minimum facilities required in a rest area for motorists are shade, picnic tables, benches and rubbish bins. The provision of toilets, water, barbecue facilities with fuel, and lighting will depend on local conditions. In isolated locations which attract overnight use, showers may be provided in rest areas, where practical (Anon 2002, Chapter 20).

2.4.2 Heavy Vehicle Rest Area

A heavy vehicle rest area is a sealed or paved area, with safe entrance and exit for heavy vehicles, with adequate space to accommodate at least 2 heavy vehicles, but with sufficient separation from the through pavement to provide a reasonably quiet and restful environment. The parking area should be screened from headlights on the through pavement. The area should have trees for shade, otherwise an area of artificial shade should be provided. Minimum facilities required in a heavy vehicle rest area are shade, a table, benches and a rubbish bin. In addition, water and barbecue facilities with fuel may be provided where feasible and appropriate. It is reiterated that additional facilities made available at the above rest areas are variable and are dependent on:

- the amount of usage;
- expectation of the level of service; and
- the practicality of maintaining the facilities to a safe and consistent standard.

(Anon 2002, Chapter 20)

2.4.3 Stopping Places

Stopping places are areas made available to enable drivers to undertake short stops for a variety of reasons, such as checking loads, tyres, enjoying a scenic view, making a phone call etc. They serve the purpose of providing a relatively safe location for immediate stopping needs at a safe distance from through traffic (Anon 2002, Chapter 20).

Stopping places are designed to meet the specific needs of both motorists and heavy vehicle operators. Motorist stopping places are sealed or paved areas clear of the through pavement, allowing adequate space for a car towing a caravan or trailer, with safe access and egress, and sufficient width to allow safe inspection of the vehicle. Heavy vehicle stopping places are sealed or paved areas with safe entrances and exits for heavy vehicles and with sufficient clearance from the through pavement to allow loads to be inspected and adjusted safely. A spacing of 25-100m between adjacent tapers should be satisfactory (Anon 2002, Chapter 20).

2.4.4 Distance Between Rest Areas

The benchmark spacing for rest areas as defined by Main Roads (1999a) is:

- Motorist rest areas – 110 km
- Heavy vehicle rest areas – 100 km
- Motorist stopping places – 15 km
- Heavy vehicle stopping places – 45 km

These spacings can be varies to suit the circumstances of a particular route and the location of centres generating significant traffic.

2.4.5 Overtaking Lanes

Two lane two-way roads can only operate satisfactorily if adequate opportunities for overtaking are provided. These opportunities gradually disappear and increasingly long queues occur as traffic increases. Overtaking lanes are provided to break up bunches and improve traffic flow over a section of road. On an existing road, the most cost effective way to improve overtaking opportunities is to provide an auxiliary lane (Anon 2002, Chapter 15).

Table 15.2 of the chapter 15 in the Department of Main Roads 'Road Planning and Design Manual' provides recommended traffic volume guidelines for providing overtaking lanes. For example, this table indicates that for moderate overtaking opportunities (10 – 30% of the road length) provision of overtaking lanes are normally warranted when AADT is above 2470 when there are 20% slow vehicles in the traffic stream.

2.4.6 Rumble Strips

Rumble strips are raised or grooved patterns placed in the paved surface of a roadway that produces both noise and vibration when a vehicle's tyres travel across them. The continuous shoulder rumble strip and centre line rumble strips are very successfully employed countermeasures. Both the sound and the vibration alert fatigued drivers that they are beginning to drift off the road or cross over to the opposite side of the road, and hopefully in time they can recover and return safely to the travel lane. According to Stutts (2000), numerous studies had confirmed the effectiveness of rumble strips in preventing run-off-road crashes and head-on collisions, which were most likely to be fatigue related crashes.

Chapter 3 Methodology and Risk Assessment

3.1 Methodology

The aim of the project is to investigate the feasibility of the Oakey-Cooyar Road being used as an alternate route to the New England Highway from the perspective of driver fatigue.

This project was started by literature review on driver's fatigue problem, followed by examining the physical and operational characteristics of the Oakey-Cooyar Road and the New England Highway. The data was provided by Professor Ron Ayers, the project supervisor, and was edited and rearranged where necessary. Both roads were divided into urban and rural sections for the comparison based on a number of criteria, such as speed and adjacent land uses. The comparison was on pavement details, lengths, existing traffic volumes, speed zones, adjacent land uses, traffic signals and pedestrian crossings in the urban sections, and in addition, the location of bridges, rest areas and stops in the rural sections.

The historical crash data of both roads were extracted from the database of the Department of Main Road, Toowoomba District. The data range selected was from 1 August 1994 to 31 July 2004. The crash statistics of both urban and rural sections were analysed for both roads, in particular the problems associated with driver fatigue crashes. The analysis on each road included the total number of crashes, severity, time of day, direction of travel, vehicle type, and percentage of fatigue related crashes for the 10 year period selected.

After the analysis of historical crash data, design guidelines for provision of fatigue amelioration facilities such as truck stops and rest areas were identified.

Meanwhile, a field investigation was conducted to identify potentially adverse geometric features, existing fatigue amelioration devices and areas, and potential sites for new facilities.

Finally a fatigue management strategy for the Oakey-Cooyar road was established according to the findings through route comparison, crash data analysis and field investigation. A recommendation on the introduction of new facilities or the upgrading of existing facilities was provided if the heavy vehicles on the New England Highway were to be redirected to use the Oakey-Cooyar Road.

3.2 Risk Assessment

The risk involved in this project was relatively low as most of the work was done in front of the computer. However, the project required field investigation on the roads. Vehicles passing-by while doing investigation or taking photos on the side of the road had been the major risk during field investigation. The other risks involved are travelling on the way for the field investigation, computer crashes and data losses.

In order to reduce the risks associated with the project, a safety jacket had been worn during the field trip. The car was parked off the main road and only stopped when it was safe to do so. An off-peak time on Sunday was chosen for the field trip in order to minimise the risks and reduce the effects on traffic flows. A copy of data and files on the computer had been stored on a CD and the project work was backed up regularly on a flash disk.

Chapter 4 Route Comparison

For the purpose of this project, route comparison was carried out for the section of the New England Highway (22A) from Toowoomba to Cooyar, and the Oakey-Cooyar Road (417). These two routes were divided into urban sections and rural sections for the route comparison. The definition of the urban section was that the speed limit was 80 km/h or less with substantial adjacent development or residential areas and buildings along the road, such as schools, houses, pedestrian crossings, shops etc. The rest of road was defined as the rural section. The details of the division of these sections are represented in the following tables. Please note that in order for the Oakey-Cooyar Road to be used as an alternative route to the New England Highway, traffics would have to use the Warrego Highway (18B) from Toowoomba to Oakey Connection Road. The length of this section of Warrego Highway is about 27.18 km.

Road Section ID: 22A New England Highway (Toowoomba – Cooyar) INT 22A/18A (Warrego Highway) – INT 22A/417 (Oakey-Cooyar Road)	
Urban Sections	
Through Distance (km)	**Length (km)**
0-8	8
11-14	3
31-32	1
42-45	3
Total:	**15**
Rural Sections	
Through Distance (km)	**Length (km)**
8-11	3
14-31	17
32-42	10
45-85.08	40.08
Total:	**70.08**
Total: 85.08 km	

Table 4.1: Division of Urban and Rural Sections for 22A

Road Section ID: 417 Oakey-Cooyar Road (Oakey – Cooyar) INT 417/326 (Oakey Connection Road) – INT 417/22A (New England Highway)	
Warrego Highway 18B (Toowoomba – Oakey Connection Road) INT 18B/22A – INT 18B/326	**27.18 km**
Urban Sections	
Through Distance (km)	**Length (km)**
0-1	1
29-31	2
Total:	**3**
Rural Sections	
Through Distance (km)	**Length (km)**
1-29	28
31-55.72	24.72
Total:	**52.72**
Total: 55.72 km	

Table 4.2: Division of Urban and Rural Sections for 417

4.1 Urban Sections

4.1.1 Pavement Details

The pavement details to be examined were width, sight distance, grades and horizontal curves.

The average pavement widths of the urban section of both roads are shown in the following table.

Road Section ID	22A	417
Average Pavement Width (Urban)	16.06m	8.30m

Table 4.3: Comparison of Pavement Width in Urban Sections

It shows that the urban section of the New England Highway is twice as wide as the Oakey-Cooyar Road mainly due to the divided four-lane highway from Toowoomba to Highfields.

Sight distance is the length of roadway ahead over which an object of a specific height, in this case vehicles, is continuously visible to the driver. The sight distance of 417 is generally better than 22A along both sections of the roads from the experience of the field investigation. No specific measurement was carried out.

Grade is the slope of the roadway surface. It is expressed as the change in elevation per 100 feet of horizontal distance. There are only 3 km of 417 defined as urban. 2 km of the length (67%) are in rolling grade, meaning the average slope is greater than 5%. There are 15 km of 22A defined as urban. Only 1 km is in level grade and the rest 14 km (93%) are in rolling grade. Therefore, the urban sections of 22A are steeper than 417.

Most horizontal curves are smooth along 22A and do not require speed reduction. However, there are three sharp turns along 417 which require the speed to drop below 40 km/h or even more for heavy vehicles. Two of them are in the urban section. The first one is at through distance 300 m, turning right. The second one is at through distance 30km, turning right in the town of Kulpi. Apart from these two sharp turns, the rest of the horizontal curves of the urban section of 417 are smooth and identical to 22A.

4.1.2 Lengths

The total length of the urban section of the New England Highway is approximately 15 km, accounting for 17.6% of the total length 85.08 km. The length of the urban section of the Oakey-Cooyar Road is only 3 km, accounting for 5.4% of the total length 55.72 km. Therefore, the New England Highway is more likely subject to substantial development and different adjacent land uses along the road than the Oakey-Cooyar Road.

4.1.3 Existing Traffic

The Average Annual Daily Traffic (AADT) was used to compare the existing traffic for both routes. AADT is the total yearly traffic divided by 365. The data for the year 2000 was obtained from the Department of Main Roads, Toowoomba District Office. The average AADTs in the urban sections of both roads are shown in the following table.

Road Section ID	Average AADT (Urban)
22A	9025
417	1735

Table 4.4: Comparison of Traffic Volumes in Urban Sections

The percentage of heavy vehicles of both roads is shown in the following bar charts.

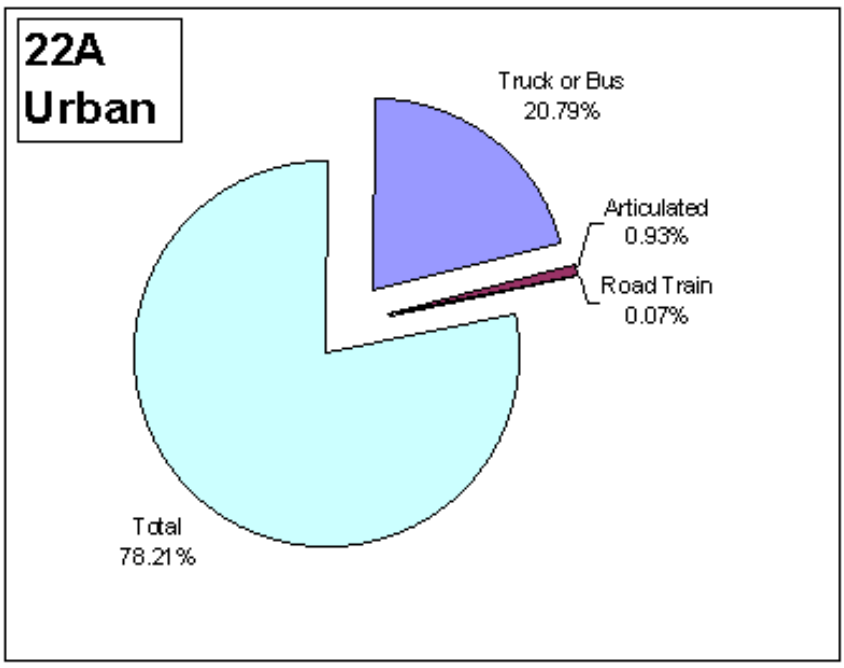

Figure 4.1: Percentage of Heavy Vehicles on the urban section of 22A

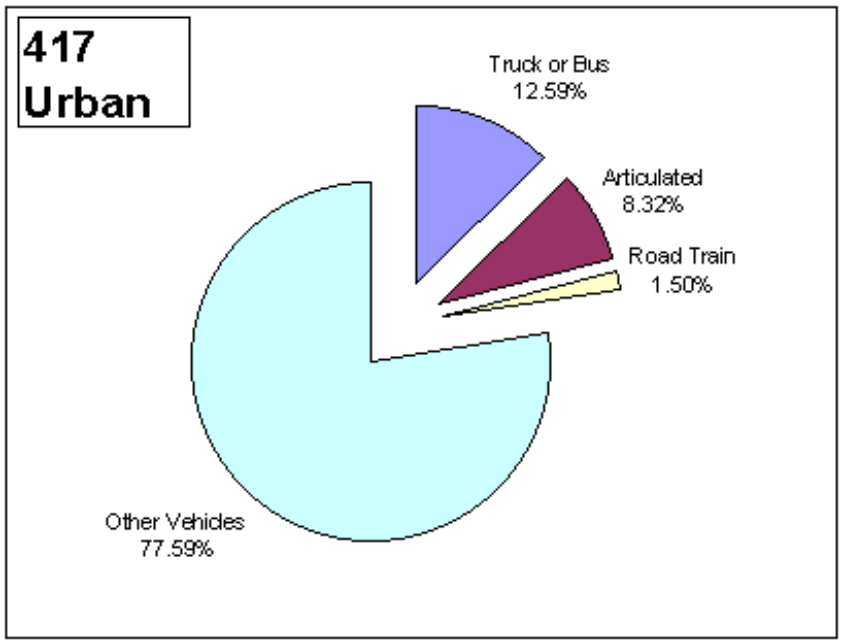

Figure 4.2: Percentage of Heavy Vehicles on the urban section of 417

The figures above show that the total traffic volume and the heavy vehicle volume of 417 are significantly less than 22A in the urban section. However, the percentage of heavy vehicles of 417 is slightly higher than 22A, especially for the articulated vehicles and road trains.

4.1.4 Speed Zones

As defined previously, the speed limit of urban sections must be 80 km/h or less.

Road Section ID	Length of Speed Zones (km)	
	60km/h	80km/h
22A	6.27	9
417	3	0

Table 4.5: Length of Speed Zones in Urban Sections

The speed zones of the urban sections of these two roads are shown in the table above. It indicates that most of the urban section of 22A is in the 80 km/h zone, but all of the urban section of 417 is in 60 km/h zone. This implies that the speed transition between urban and rural sections of 417 is much larger than 22A, ie. from 100km/h to 60km/h directly, which is not very suitable for heavy vehicles.

4.1.5 Adjacent Land Use

The land uses along the urban section of 22A include schools, residential areas, real estate, shops and so on. 22A passes through three major towns - Highfields, Hampton and Crows Nest, from Toowoomba to Cooyar.

The land uses along the urban section of 417 are less complex, which include a few houses and a factory near Oakey, and a residential area in Kulpi.

4.1.6 Traffic Signals and Pedestrian Crossings

Traffic signals exist from Toowoomba to Highfields on 22A. There is also one pedestrian crossing on the Hume Street between James and Herries Street.

There is no traffic signals or pedestrian crossing on 417. However, a rail signal exists at the start of 417, just next to the Oakey railway station.

4.2. Rural Sections

4.2.1 Pavement Widths

The average pavement widths of the rural sections of both roads are shown in the following table.

Road Section ID	22A	417
Average Pavement Width (Rural)	9.72m	7.96m

Table 4.6: Comparison of Pavement Width in Rural Sections

It shows that the rural section of the New England Highway is also wider than the Oakey-Cooyar Road. The possible reasons are that 22A has a 2km overtaking lane north-bound and more pavement widths are provided for emergent stopping along 22A.

The sight distances of both sections had been covered previously.

There are 52.72 km of 417 defined as rural. 10 km of the length (19%) are in level grade, meaning the average slope was less than 5%. There are 70.08 km of 22A defined as rural. Only 6 km (9%) are in level grade and the rest are in rolling grade. Therefore, 22A is steeper than 417 in the rural section.

Most horizontal curves in the rural section are smooth along 22A and do not require speed reduction. However, there is one sharp turn along 417 which requires the speed to drop below 40 km/h or even more for heavy vehicles. It is a left turn with a left turn facility at the intersection of 417 and 418, about 16.5 km north of Oakey. Apart from this sharp turn, the rest horizontal curves of 417 are smooth and identical to 22A.

4.2.2 Lengths

The total length of the rural section of the New England Highway is approximately 70.08 km, accounting for 82.4% of the total length 85.08 km. The length of the rural section of the Oakey-Cooyar Road is 52.72 km, accounting for 94.6% of the total length 55.72 km. Therefore, most of the Oakey-Cooyar Road is in rural areas and not subject to as much adjacent land development as the New England Highway.

4.2.3 Existing Traffic

The average AADTs in the rural section of both roads are shown in the following table.

Road Section ID (Rural)	22A	417
Average AADT	2427	667

Table 4.7: Comparison of Traffic Volumes in Rural Sections

The percentages of heavy vehicles of both roads are shown in the following pie charts.

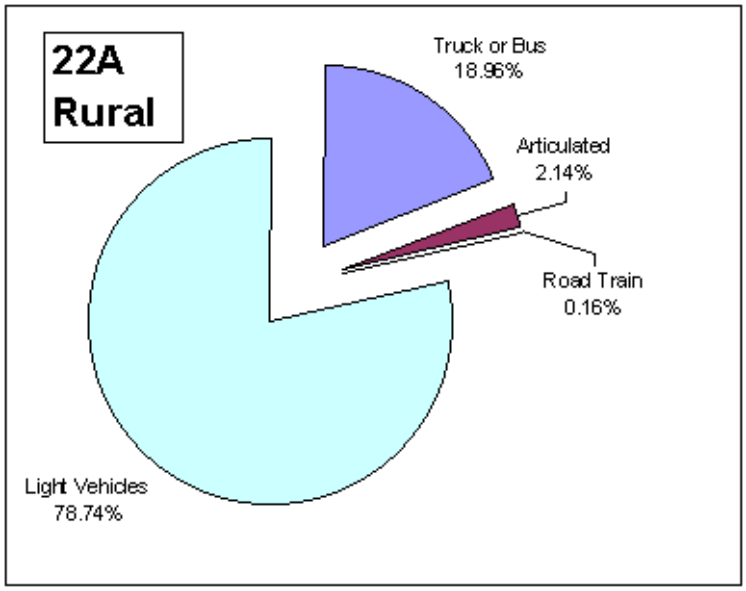

Figure 4.3: Percentage of Heavy Vehicles on the Rural Section of 22A

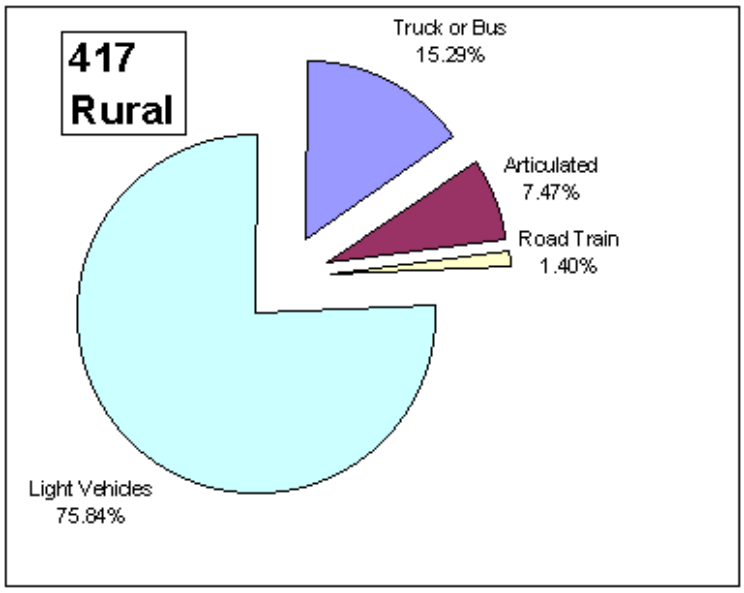

Figure 4.4: Percentage of Heavy Vehicles on the Rural Section of 417

The figures above show that the total traffic volume and the heavy vehicle volume of 417 are significantly less than 22A in the rural sections. However, the percentage of heavy vehicles of 417 is higher than 22A, especially for the articulated vehicles and road trains.

4.2.4 Speed Zones and Pedestrian Crossings

The rural sections of both roads are all in the 100 km/h zone. No pedestrian crossing exists for both roads.

4.2.5 Bridges

There are two bridges along 22A. One is at 64 km north of Toowoomba, crossing the Emu creek. The other one is at 71 km north of Toowoomba, which is a narrow bridge and the north-bound traffic has to give way to the south-bound traffic.

4.2.6 Rest Areas and Rest Stops

The Guide to Queensland Roads, 2004 includes the following motorist rest areas in its 'table of rest areas and facilities' along 22A from Toowoomba to Cooyar:

Road/Town	Location	No.	Control	Facilities							
				WT	ET	DT	WS	BB	Ta	Sh	Pl
22A	7.2 km N of Toowoomba	82	Local	*			*		*		
22A	13.5 km N of Toowoomba	522	Local	*			*		*		
22A	18.7 km N of Toowoomba	521	Local				*		*		
Hampton	East Side	81	Local	*			*		*	*	
Crows Nest	Town	381	Local	*			*	*	*	*	
Crows Nest	North Side	380	Local	*			*		*	*	
Cooyar	Town	80	Local	*			*		*	*	
Cooyar	Town	519	Local	*			*		*	*	

Facilities: WT = Water Toilet; ET = Earth Toilet; DT = Disabled Toilet; WS = Water Supply; BB = BBQ; Ta = Tables; Sh = Shelter; Pl = Playground
Note: The rest area number 80 and 519 are outside the route comparison scope.

Table 4.8: "Guide To Queensland Roads" Motorist Rest Areas along 22A

Table 4.9 shows that there is only one motorist rest area along the Oakey-Cooyar Road as identified by "The Guide to Queensland Roads, 2004".

Road/Town	Location	No.	Control	Facilities							
				WT	ET	DT	WS	BB	Ta	Sh	Pl
Kulpi	Town	352	Local	*			*		*	*	

Table 4.9: "Guide To Queensland Roads" Motorist Rest Areas along 417

The Guide to Queensland Roads, 2004 does not include heavy vehicle rest areas in the table, but they are shown on the map. The approximate distances shown below were scaled from the map using a scale rule.

Road	HV Rest Area Number	Location (Approximate)
22A	404	25 km N of Toowoomba
22A	428	65.7 km N of Toowoomba

Table 4.10: "Guide To Queensland Roads" HV Rest Areas along 22A

There is no heavy vehicle rest area identified by the Guide to Queensland Roads along 417.

4.2.7 Overtaking Lanes

There is only one overtaking lane in the rural section of 22A.

Toowoomba – Cooyar (22A)
Northbound traffic:
(i) 21.3 to 23.3 km from Toowoomba
Southbound traffic: Nil

There is no overtaking lane in the rural section of 417.

Chapter 5 Analysis of Crash Statistics

5.1 General

The crash data were generated from the database of the Department of Main Roads, Toowoomba District Office. The crash data investigated were from 1 August 1994 to 31 July 2004 (10 years) in order to gain an understanding of the characteristics of fatigue related crashes on the section of the New England Highway (22A) between Toowoomba and the intersection of 22A and 417, and the Oakey-Cooyar Road (417).

Examination of available literature showed varying definitions for fatigue related crashes, even between the various State Road Authorities in Australia. The definition used in Queensland is:

"…a crash is assessed as being fatigue-related if:

- A single vehicle crashes in 100 km/h or higher speed zone during typical fatigue times (2pm – 4pm or 10pm – 6pm); or
- The reporting officer considered that fatigue was a contributory factor in the crash."

(Dobbie 2002)

The fatigue related crash data on both roads were based on this definition.

5.2 Analysis of Crash Data

The following table shows the statistics for fatigue related crashes. This data is for the 10 year period from 1 August 1994 to 31 July 2004.

Road Section ID	Approximate Length (km)	Recorded Crashes	Fatigue Related Crashes	Fatigue Crashes as % of Total
22A	85.08	537	31	5.8
417	55.72	23	4	17.4

Table 5.1: Recorded Crashes, 1994 to 2004

The data shows that more fatigue related crashes occurred on 22A in those 10 years. But the crashes occurred on 417 were more likely to be fatigue related.

5.2.1 Severity

Table 5.2 shows the severity of fatigue related crashes for the total road length of the two road sections. The serious accidents per kilometre per year are based on a definition of fatal and hospitalisation accidents as “serious”.

Road Section ID	Total Length (km)	Fatal Crashes	Hospitalisation Crashes	Medical Treatment Crashes	Property Damage Only Crashes	Serious Accidents per km per year
22A	85.08	2	4	9	16	0.0071
417	55.72	0	2	1	1	0.0036

Table 5.2: Severity of Fatigue Related Crashes

Considering the total road section of 22A, of the total 7 fatal accidents, 2 were attributed to fatigue (29%). Of the total 86 crashes involving hospitalisation, 4 were attributed to fatigue (5%). Considering the total road section of 417, there was no fatal crashes during the ten year period. Of the total 6 crashes

involving hospitalisation, 2 were attributed to fatigue (33%). The data shows that the serious fatigue related crashes on 22A were more likely to be fatal whereas the serious fatigue related crashes on 417 were more likely involving hospitalisation.

5.2.2 Speed Zone

The majority of the 31 crashes on 22A occurred in 100 km/h speed zone. Only 4 crashes were in 60 km/h zone. All of the 4 crashes on 417 occurred in 100 km/h speed zone.

5.2.3 Time of Day

The following table shows the number of crashes for each hour of the day. The danger periods are shaded in the table.

AM	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
22A	3	3	4	0	0	2	0	0	1	0	0	0
Total	14	6	8	1	3	5	13	22	35	28	36	36
417	0	1	0	0	1	0	0	0	0	0	0	0
Total	1	1	0	0	1	0	0	0	3	1	2	2
PM	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
22A	0	0	4	7	0	1	2	0	0	0	1	3
Total	38	33	26	41	35	44	25	24	22	16	17	9
417	0	0	0	0	0	0	0	0	0	1	1	0
Total	1	2	1	3	0	0	2	0	1	1	1	0

Table 5.3: Fatigue Related Crashes by Time of Day

The following figure represents the total fatigue related crashes of both roads by time of day, as well as the percentage of fatigue related crashes by time of day.

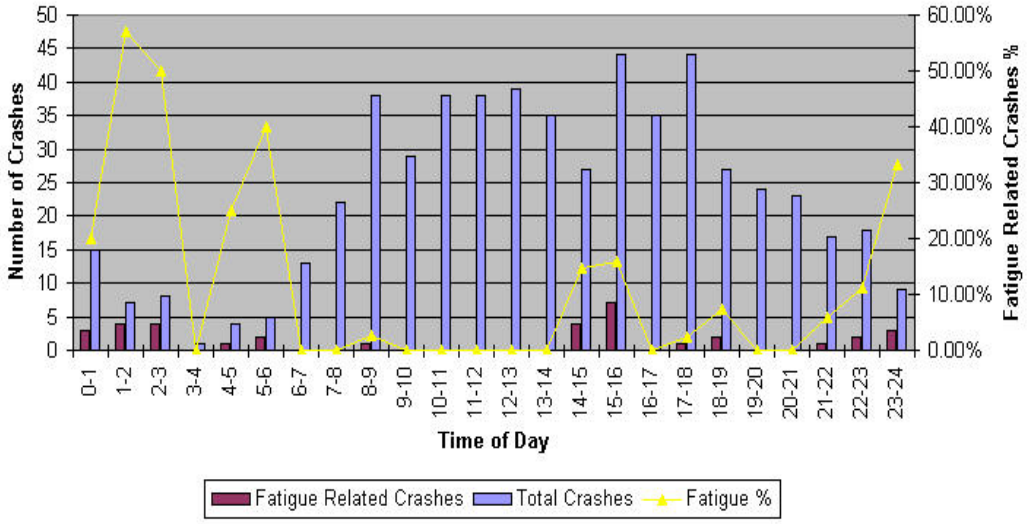

Figure 5.1: Fatigue Related Crashes by Time of Day (22A and 417)

The data in the table and the figure indicate that the propensity for fatigue related crashes for the "night hours" danger period (10pm to 6am) was much greater than the "afternoon" danger period (2pm-4pm) for both roads, especially the Oakey-Cooyar Road, where there was no fatigue related crashes in the "afternoon" danger period at all and all of its fatigue related crashes occurred between 9pm and 5am.

5.2.4 Direction of Travel

Table 5.4 shows the direction of travel for vehicles involved in fatigue related crashes:

Road Section ID	Travelling **Towards** Toowoomba (South direction)	Travelling **From** Toowoomba (North direction)
22A	15	10
417	3	1

Table 5.4: Direction of Travel for Fatigue Related Crashes

The figure shows that a much greater proportion of fatigue related crashes occurred with vehicles travelling in the south direction, than in the north direction for both roads.

5.2.5 Vehicle Type

The crash data shows that there was no articulated vehicle, road train or bus involved in the fatigue related crashes for both roads. The only heavy vehicle type which involved in the fatigue related crashes was rigid truck. Heavy vehicles were involved in 1 out of 31 fatigue related crashes on 22A, and 1 out of 4 on 417.

Road Section ID	Fatigue Related Crashes	Fatigue Crashes involving HV	% of Fatigue Crashes involving HV	% of HV in Traffic Stream
22A	31	1	3%	14% (1)
417	4	1	25%	16% (2)
Total	35	2	6%	

(1) Average traffic court information from the count sites along 22A.

(2) Average traffic court information from the count sites along 417.

Table 5.5: Involvement of Heavy Vehicles in Fatigue Related Crashes

5.2.6 Yearly Variation

Over the 10 year analysis period the number of fatigue related crashes of 22A varied from 0 per year in 1994 to 5 per year in 2003, with an average of 3.1 per year.

Over the 10 year analysis period the number of fatigue related crashes of 417 varied from 0 per year (7 out of 10 years) to 2 per year in 1999, with an average of 0.4 per year. Therefore, the number of fatigue related crashes

occurred on 22A were about 8 times more than the ones occurred on 417 per year.

5.2.7 Monthly Variation

Table 5.6 shows that monthly totals of fatigue related crashes for the 10 year analysis period ranged from 1 in July and November to 6 in September for road 22A. Road 417 only had one fatigue related crash in January, March, July and November, respectively during the 10 year period.

	22A			417			22A and 417		
Month	Fatigue Crashes	Total Crashes	Fatigue Crashes %	Fatigue Crashes	Total Crashes	Fatigue Crashes %	Fatigue Crashes	Total Crashes	Fatigue Crashes %
Jan	2	45	4.44%	1	1	100.00%	3	46	6.52%
Feb	3	36	8.33%	0	2	0.00%	3	38	7.89%
Mar	2	47	4.26%	1	2	50.00%	3	49	6.12%
Apr	3	38	7.89%	0	2	0.00%	3	40	7.50%
May	4	52	7.69%	0	2	0.00%	4	54	7.41%
Jun	2	49	4.08%	0	2	0.00%	2	51	3.92%
Jul	1	57	1.75%	1	3	33.33%	2	60	3.33%
Aug	2	53	3.77%	0	1	0.00%	2	54	3.70%
Sep	6	42	14.29%	0	6	0.00%	6	48	12.50%
Oct	3	50	6.00%	0	0	-	3	50	6.00%
Nov	1	35	2.86%	1	1	100.00%	2	36	5.56%
Dec	2	33	6.06%	0	1	0.00%	2	34	5.88%
Average	**2.58**	**44.75**		**0.33**	**1.92**		**2.92**	**46.67**	

Table 5.6: Monthly Variation of Fatigue Related Crashes

The combined monthly variation of fatigue related crashes of both roads are shown in the following figure.

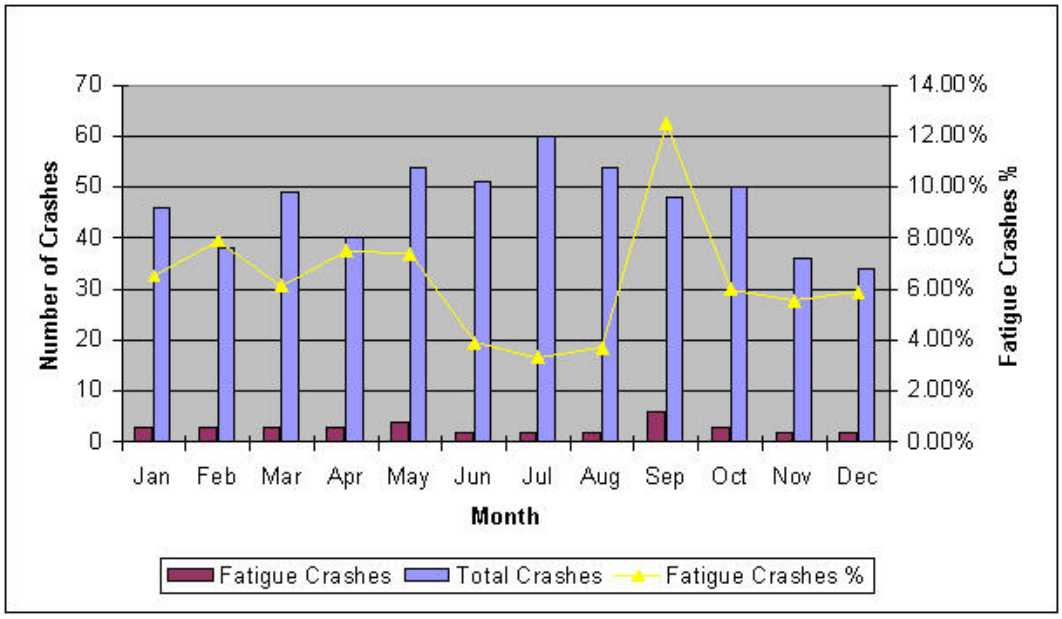

Figure 5.2: Monthly Variation of Fatigue Related Crashes (22A and 417)

5.2.8 Day of the Week Variation

The total number of fatigue related crashes for various days of the week are shown in Table 5.7:

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
22A	4 (5%)	8 (11%)	1 (1%)	2 (3%)	6 (7%)	6 (6%)	4 (5%)
417	1 (33%)	0 (0%)	2 (67%)	0 (0%)	1 (33%)	0 (0%)	0 (0%)
Total	5 (6%)	8 (11%)	3 (4%)	2 (3%)	7 (8%)	6 (6%)	4 (5%)

Table 5.7: Variation of Fatigue Related Crashes with Day of the Week

The data indicates that fatigue related crashes were evenly distributed for 22A during the week, with the highest fatigue rate occurring on Monday and the lowest on Tuesday. Fatigue related crashes were more likely to occur on Tuesday for 417.

5.2.9 Summary of Crash Statistics for Fatigue Related Crashes

The crash statistics shows that fatigue-related crashes on the Oakey-Cooyar Road (417) constituted a more significant proportion of the total accidents than the New England Highway (22A). However, the fatigue-related crashes on 22A were more likely to be fatal. Fatigue related crashes most frequently occurred in the two time periods commonly recognized as fatigue danger times (10pm to 6am, and 2pm to 4pm). However, the statistics showed that the fatigue related crashes were more likely to occur during the "night hours" danger period for both roads. Fatigue related crashes were more prevalent for vehicles travelling to Toowoomba as compared to vehicles travelling from Toowoomba. Rigid trucks were the only heavy vehicle type that was represented in fatigue-related crashes for both roads. Fatigue-related crashes were more likely to occur from Thursday to Monday for 22A, and Sunday, Tuesday and Thursday for 417. Appendix C shows the location of fatigue-related crashes on both roads.

Chapter 6 Design Guidelines for Provision of Facilities

The physical design of the road and its roadside amenities are the major fatigue amelioration measures for this project. The roadside amenities considered here were rest areas, stopping places and overtaking lanes.

It is important to note that there are many different standards of roadside amenities for fatigue management. The one used here was based on the Road Planning and Design Manual from the Queensland Department of Main Roads. The purpose of this manual is to set the policy and framework for the planning and design for the Department of Main Roads of new and upgraded roads in Queensland. It is an agreed set of corporate standards that includes consideration of local circumstances. Hence it was adopted for this project as the Oakey-Cooyar Road is located in Queensland and the project is sponsored by the Department of Main Roads, Toowoomba District. Any variation from the design intent of the manual would require the appropriate approval.

6.1 Rest Areas

"Chapter 20: Roadside Amenities" in the Department of Main Roads "Road Planning and Design Manual" gives details for the provision of rest areas and stopping places on the road net work within Queensland. The benchmark spacing for rest areas (Main Roads, 1999a) is:

- Motorist rest areas – 110 km
- Heavy vehicle rest areas – 100 km

Apart from the distance to the next rest area, detailed siting should also been taken into consideration. The siting of rest areas for the Oakey-Cooyar road needs to consider:

- Sight distance at the intended location, to maximise safe access and egress;
- Placing heavy vehicle sites at or near a crest so that vehicles entering the roadway take less time to reach cruising speed thus reducing a potential traffic hazard.
- The proximity to services, such as water and power supplies that may be used to enhance facilities at the amenity.

The manual also suggests that the ability of towns along that route to serve as rest areas and provide the facilities required should be considered.

6.2 Stopping Places

The benchmark spacing for stopping places (Main Roads, 1999a) is:

- Motorist stopping places – 15 km;
- Heavy vehicle stopping places – 45 km.

The first two considerations for siting rest areas in the above section are also relevant for stopping places. In brief, they are:

- Sight distance for safe access and egress;
- Placing heavy vehicle sites at or near a crest.

Since the Oakey-Cooyar Road is to be used more by heavy vehicles in the future, suitable sites for heavy vehicle stopping places should be determined first when assessing a length of road for appropriate location of stopping bays, especially on crests.

6.3 Overtaking Lanes

"Chapter 15: Auxiliary Lanes" in the Department of Main Roads "Road Planning and Design Manual" gives details for the provision of overtaking lanes on the road network within Queensland. Table 15.2 of the chapter provides recommended traffic volume guidelines for providing overtaking lanes.

This table indicates that for moderate overtaking opportunities (10-30% of the road length) provision of overtaking lanes are normally warranted when AADT is above 2470 when there are 20% slow vehicles in the traffic stream. The traffic information on 417 indicated an average AADT of 667 and a heavy vehicle percentage of 24% in the rural section. The low AADT indicated that overtaking opportunities were likely to be frequent along 417, and overtaking lanes would not be necessary for 417 at present according to the manual.

Chapter 7 Field Investigation

A field inspection of the Oakey-Cooyar Road and associated facilities was undertaken on 5 September 2004. The trip started from Toowoomba to Oakey on the Warrego Highway, then followed the Oakey-Cooyar Road to the intersection of 22A and 417, and finally came back to Toowoomba on the New England Highway (see below).

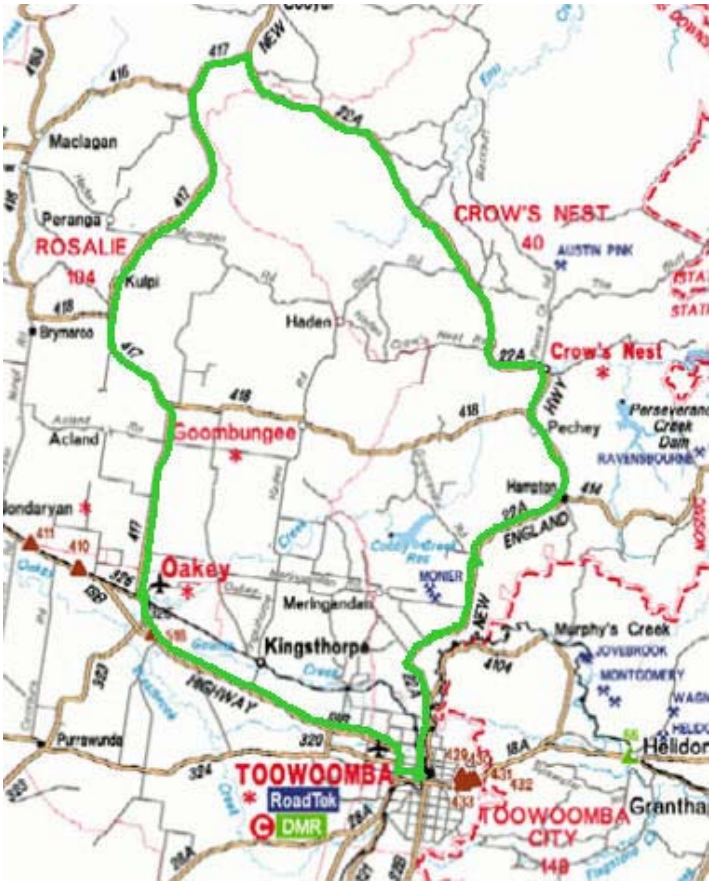

Figure 7.1: Field Trip Route

The field investigation has found:

(i) Traffics from Toowoomba currently are using the East Oakey Connection Road (326) to go through Oakey before it reaches the Oakey-Cooyar Road. There are schools, residential houses, parks, shops, and pedestrian crossings along the East Oakey Connection Road. The increase of heavy vehicles in the future would have a large impact on the local community. During the investigation, it was found that heavy vehicles could be redirected to use the West Oakey Connection Road along which only a few houses and shops exist. This redirection will minimise the impact on the local community and save the cost of building another bypass. But extra signs will need to be posted around the Oakey area in order to direct all heavy vehicles to use the West Oakey Connection Road.

(ii) There is a railway crossing controlled by signals at the south end of the Oakey-Cooyar Road just next to the Oakey railway station. However, it did not appear to be a problem because the frequency of train passing seemed to be low. See the pictures below.

Figure 7.2a: Railway Signal at the South End of 417

Figure 7.2b: Railway Crossing at the South End of 417

(iii) There appeared to be little strategic planning for existing facilities. The rest area and stopping areas were not well defined and most were poorly signposted along 417. In most cases the motorist using a facility would be unaware that the facility was part of a planned rest area or stopping area system. For example, the stopping area pictured below was made by regular stops of vehicles over the years rather than as part of the strategic planning.

Figure 7.3: Stop Areas Made by Drivers
(16.8 km North of Oakey, Northbound)

(v) There appeared to be a need for a well formulated strategy for the provision of signed rest and stopping areas on this road. For example, Kulpi was shown as the only rest area along 417 by the Guide to Queensland Roads, 2004. But there was no rest area sign at all.

(vi) It appeared unclear that some areas were considered as rest areas or stopping areas. For example, the large unsealed area pictured below could either be a rest area or stopping area for either car or trucks.

Figure 7.4: Stopping or Rest Area

(47 km North of Oakey, Northbound, on the crest)

(vi) There was a 10% climbing section southbound at 48 km north of Oakey. But there was no overtaking lane available before the steep climbing.

(vii) The Oakey-Cooyar road is only about 56 km long connecting two towns. No research appeared to have been carried out on the usage of current rest and stopping areas along the road, and hence whether the provision of additional facilities would be cost effective should be further examined.

Chapter 8 Provision of Fatigue Amelioration Facilities

In the previous chapters, the physical characteristics of the Oakey-Cooyar Road and the major roadside amenities as the fatigue amelioration measures have been examined. This chapter will provide recommendations on the provision of facilities to ameliorate fatigue related crashes on the Oakey-Cooyar Road.

8.1 Recommended Strategy

The recommended strategies to be adopted for the fatigue management on the Oakey-Cooyar Road are:

- Establishes a system of clearly identified:
    - Heavy vehicle rest areas;
    - Stopping areas; and
- Provides reasonable overtaking opportunities via overtaking lanes for traffic along the road, particularly before steep ascent;

Motorist rest areas were excluded from the system because the benchmark spacing for motorist rest areas was 110 km as stated in the guideline. The total length of the Oakey-Cooyar Road is only about half of that distance and motorist can have rest at either Oakey or Cooyar. Furthermore, the Oakey-Cooyar Road will be mainly used by heavy vehicles redirected from the New England Highway, and there is no scenic views along the road for motorist to stop. Motorist can use stopping spaces assigned for heavy vehicles for emergent stop. Hence there is no need to provide extra motorist rest areas on the Oakey-Cooyar Road from the economic point of view.

8.2 Recommended Facilities

8.2.1 Overtaking Lanes

Although overtaking lanes are not required with the current AADT on 417, it is recommended that a passing lane be established for southbound traffic at 48 km north of Oakey, just before the 10% ascent. The Table 15.3 of "Chapter 15: Auxiliary Lanes" in the Department of Main Roads "Road Planning and Design Manual" suggested that with the design speed of 100 km/h, the overtaking lane length should be no less than 1200 m where road trains operate.

It is also recommended that an overtaking lane should be established northbound before the start of rolling grade of the road at through distance of 10-11 km with the increase of heavy vehicles in the future. The suggested overtaking lanes are summarised in the following table:

Direction	Through Distance	Minimum Length	Priority
Northbound	10	1 km	Low
Southbound	48	1.2 km	High

Table 8.1: Recommended Overtaking Lanes

8.2.2 Heavy Vehicle Rest Areas

It is recommended that one designated and signed heavy vehicle rest areas be established at each direction along the Oakey-Cooyar Road after considering the total length and traffic volume of the road.

Kulpi is located in the middle of the Oakey-Cooyar Road and is the only motorist rest area along 417 as identified by "The Guide to Queensland Roads, 2004". However, the usage of Kulpi as a motorist rest area is in doubt due to

low AADT and percentage of light vehicles of the road and there is no scenic view around. The examination of crash data found that three out of four fatigue related crashes happened near Kulpi in the last ten years (see Appendix C). Therefore, it is recommended that Kulpi should be upgraded to heavy vehicle rest area to minimize the cost of construction and reduce the possibility of fatigue related crashes on the Oakey-Cooyar Road.

It is also recommended that the heavy vehicle rest areas at Kulpi should be assigned just before entering the 60 km/h zone north bound for both directions to minimise the impact to the town. Furthermore, an 80 km/h zone should be introduced between the 60 km/h and 100 km/h zones on both directions to allow smooth speed transition for heavy vehicles. The picture below is the recommended site for the heavy vehicle rest area at Kulpi.

Figure 8.1: Recommended Heavy Vehicle Rest Area at Kulpi

The following table gives the summary of recommended heavy vehicle rest areas on the Oakey-Cooyar Road.

Direction	Through Distance (km)	Current Facility	Upgrade Action
Northbound	30.4	Water Toilet, Water Supply, Tables, Shelter, Roadside – sealed, unsigned	Seal larger area before the current "60 km/h" sign, Signage, Clear definition of area, Add 80 km/h zone
Southbound	30.4		

Table 8.2: Summary of Recommended Heavy Vehicle Rest Area at Kulpi

8.2.3 Stopping Places

The stopping places will be utilized by both motorists and heavy vehicle users as long as the facility is of adequate size. It is recommended that designated and signed stopping places be established at no more than 20 km spacing. Therefore, at least three stopping places need to be established on each direction along 417. Priorities had been established attempting to make best use of existing facilities. The following table shows the recommended stopping spaces.

Direction	Through Distance	Facility	Upgrade Action	Priority
Northbound				
	12.0 km	Current: Roadside - unsealed, unsigned	Seal, Signage	Low
	16.8 km	Current: Roadside - unsealed, unsigned	Seal, Phone, Signage	High
	46.5 km	Current: Roadside - unsealed, unsigned, on the crest	Seal, Phone, Signage	High
	56.3 km	Current: Roadside - unsealed, unsigned	Seal, Signage	Low
Southbound				
	12.0 km	Current: Roadside - unsealed, unsigned	Seal, Phone, Signage	High
	31.0 km	Current: Roadside - unsealed, unsigned	Seal, Signage	Low
	46.0 km	Current: Roadside - unsealed, unsigned, on the crest	Seal, Phone, Signage	High

Table 8.3: Recommended Stopping Places

Figure 8.2 shows a typical sealed heavy vehicle stopping place (see Appendix D for signing arrangements). The parking area is a minimum of 4.5 m wide and 100 m long with suitable tapers for entry and exit from the edge of the sealed road shoulder. The signing arrangements for motorist and heavy vehicle roadside stopping places are shown in Appendix D.

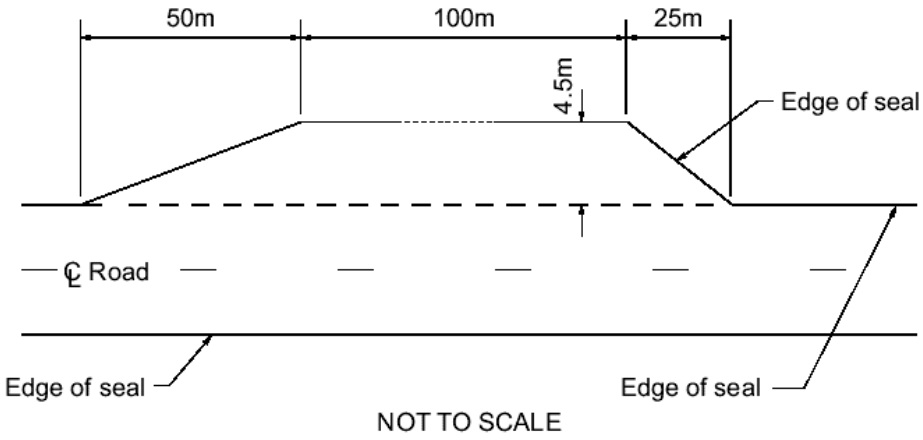

Figure 8.2: Typical Stopping Place for Heavy Vehicles

(Anon 2002)

However, this guideline should be used as a reference only. The actual design may be restricted by the current road condition, geometry and budget. Hence it may not be applied to some of the recommended stopping places. For example, a shorter length and longer tapes may be provided for safe entry and exit on the crest.

Chapter 9 Recommendations

Apart from the recommended strategies to ameliorate fatigue related crashes above, there are a few other improvements or changes recommended if more heavy vehicles are to be directed to use the Oakey-Cooyar Road.

9.1 Oakey Connection Road Signage

As heavy vehicles are recommended to use the West Oakey Connection Road, special signs will be required on both ends of the Oakey Connection Road in order to redirect the heavy vehicles of both directions. The redirection should be applied to all through heavy vehicles travelling between the Warrego Highway and the Oakey-Cooyar Road.

9.2 Addition of Speed Zone

An 80 km/h speed zone was recommended near Kulpi to allow smooth speed changes for heavy vehicles. It was suggested that the 80 km/h speed zone should be established before the current 60 km/h zone with a minimum length of 1 km for both directions.

9.3 Stopping Places on the Crest

Some of the stopping places suggested were on the crest so that vehicles entering the roadway would take less time reach cruising speed thus reducing a potential traffic hazard. However, the length and width available for stopping places may be restricted on the crest. Therefore, the design guidelines discussed previously may not apply to those stopping places for economical and practical reasons. The stopping places on the crest may be shorter, but no less than 50 m long with suitable tapers for entry and exit from the edge of the sealed road shoulder. It is also recommended to put a "slow vehicle entering" sign before the crest.

9.4 Further Studies

It is recommended that further research be conducted on the usage of rest areas and a preliminary estimate of costs for the suggested improvements to the road be carried out so that the cost-benefit aspects of the proposals can be further analysed.

Chapter 10 Conclusions

The investigation of historical crash data has found that the crashes occurred on 417 were more likely to be fatigue related although those crashes were less severe than the ones occurred on 22A. It has also noted that time of day was an important factor on fatigue related crashes and the statistics showed that the fatigue related crashes were more likely to occur during the "night hours" danger period.

The field investigation has found that an increase of heavy vehicles would have large impact on the town of Oakey and therefore heavy vehicles should be redirected to bypass Oakey. The West Oakey Connection is the proposed solution for this problem. The investigation has also found that there was little strategic planning for existing facilities. The rest area and stopping areas were not well defined and most were not signposted on the Oakey-Cooyar Road. In order for the heavy vehicles to use the Oakey-Cooyar Road, fatigue management measures must be implemented to reduce the chance of fatigue-related crashes. The recommended strategies to be adopted for the fatigue management on the Oakey-Cooyar Road are:

- Upgrading the current motorist rest area to a clearly identified heavy vehicle rest area near Kulpi;
- Establishing at least three clearly identified and signed heavy vehicle stopping places on each direction and they may be used by other vehicles when needed;
- Establishing an overtaking lane before the south-bound 10% steep ascent section.

It is also recommended that further research be conducted on the usage of rest areas and an estimate of costs for the suggested improvements to the road be carried out in order to analyse the cost-benefit aspects of the proposals due to the time constraint of this project.

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Appendix A: Project Specification

FOR: **DAVID LI**

TOPIC: Investigation of Driver Fatigue Problems on the Oakey-Cooyar Road

SUPERVISOR: Associate Professor Ron Ayers

ENROLMENT: ENG4111 – S1, D, 2004 ENG4112 – S2, D, 2004

SPONSORSHIP: Department of Main Roads, Queensland - Toowoomba District

PROJECT AIM: To investigate the feasibility of the Oakey-Cooyar Road being used as an alternate route to the New England Highway, from the perspective of driver fatigue.

PROGRAMME: Issue A, 22 March 2004

1. Research the background information relating to driver fatigue and in particular (i) road safety and driver fatigue, (ii) fatigue and heavy vehicle operation, and (iii) fatigue amelioration measures and guidelines.
2. Examine the physical and operational characteristics of the New England Highway (Toowoomba to Cooyar) and the Oakey-Cooyar Road.
3. Analyse the historical crash data for the roads and in particular examine problems associated with driver fatigue crashes.
4. Identify appropriate design guidelines for provision of fatigue amelioration facilities such as truck stops and rest areas.
5. Conduct a field investigation to identify potentially adverse geometric features, existing fatigue amelioration devices and areas, and potential sites for new facilities.
6. Devise a fatigue management strategy for the Oakey-Cooyar Road, and recommend on the introduction of new facilities or the upgrading of existing facilities.
7. Report findings through oral presentation at the Project Conference, and in the required written format.

As time permits:

8. Carry out a preliminary estimate of costs for the suggested improvements to the road, and analyse the cost-benefit aspects of the proposals.

AGREED: _____ (student) _____ (supervisor)

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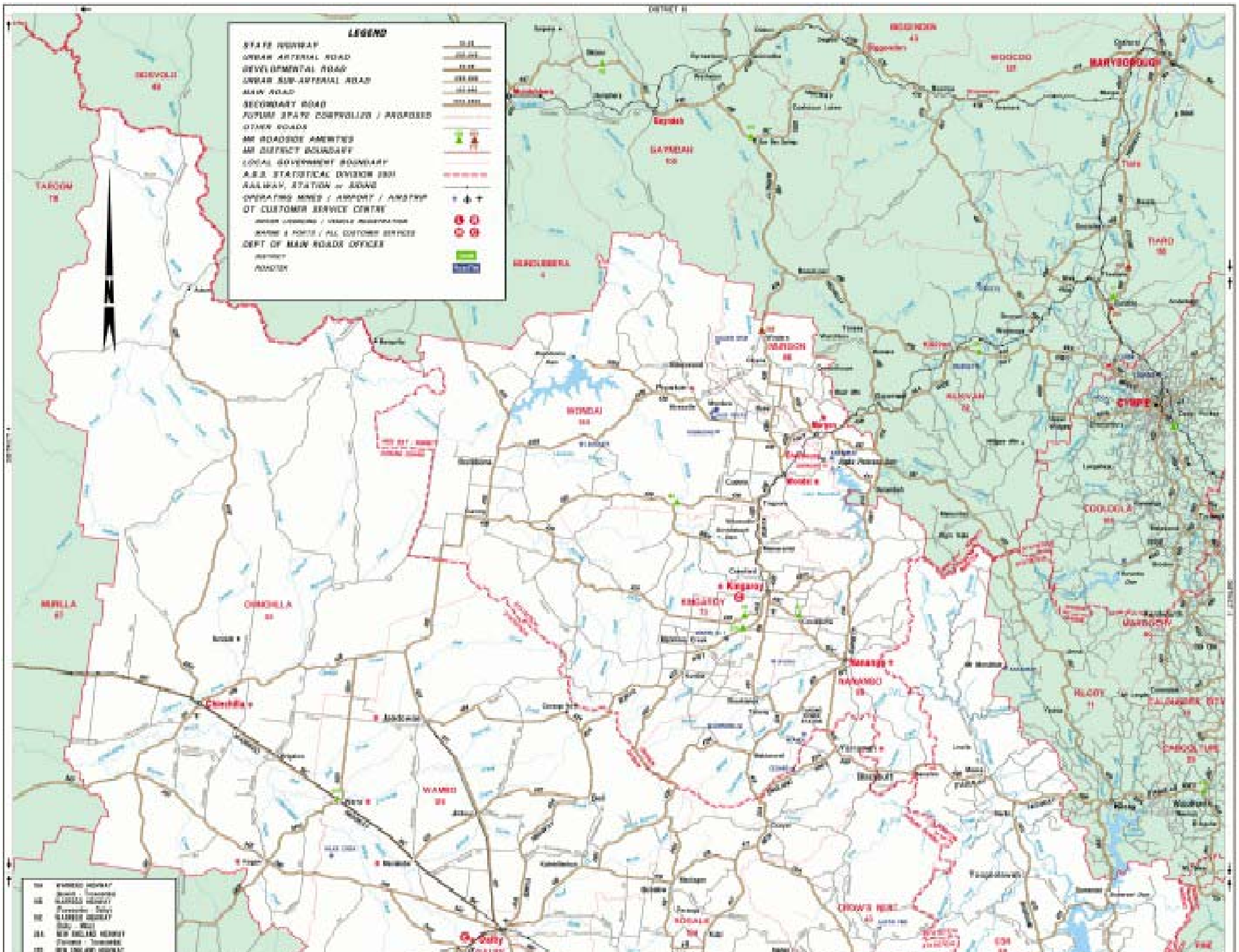
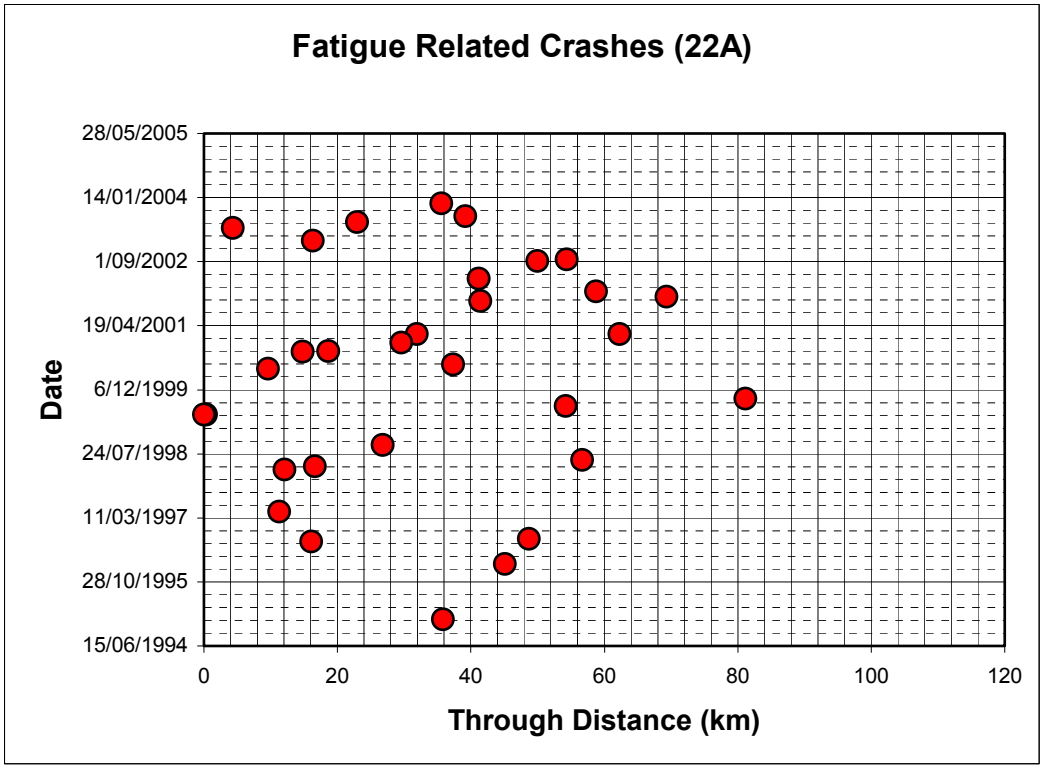
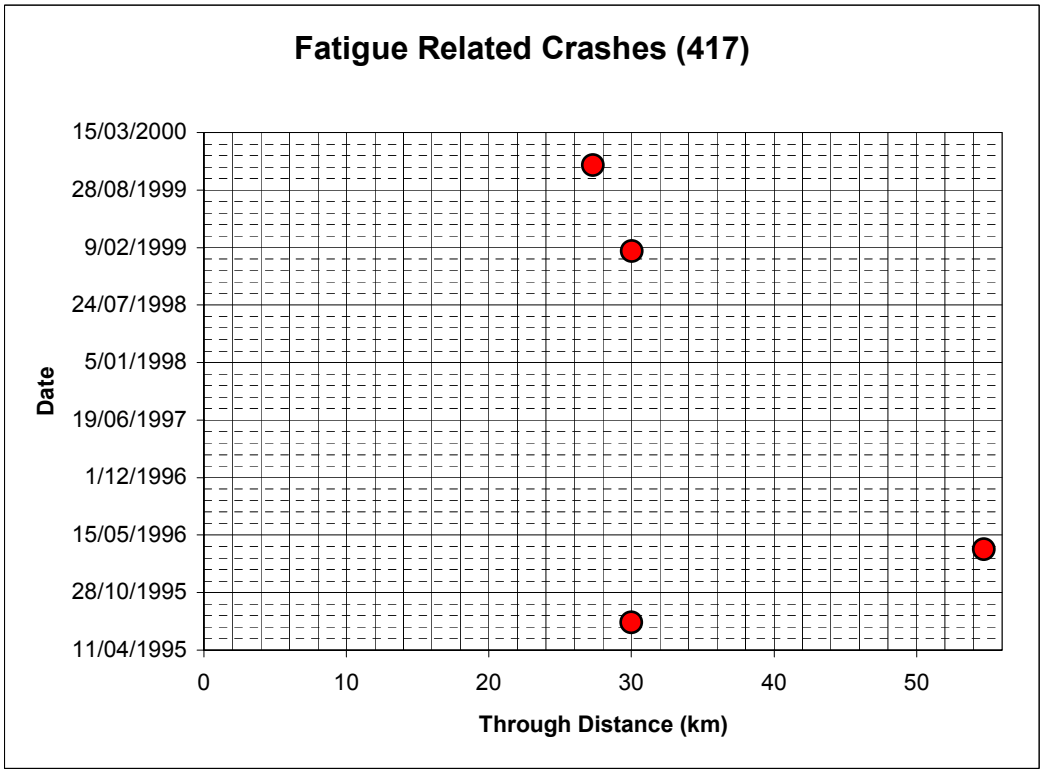
Appendix B: Map of Southern District of Main Roads

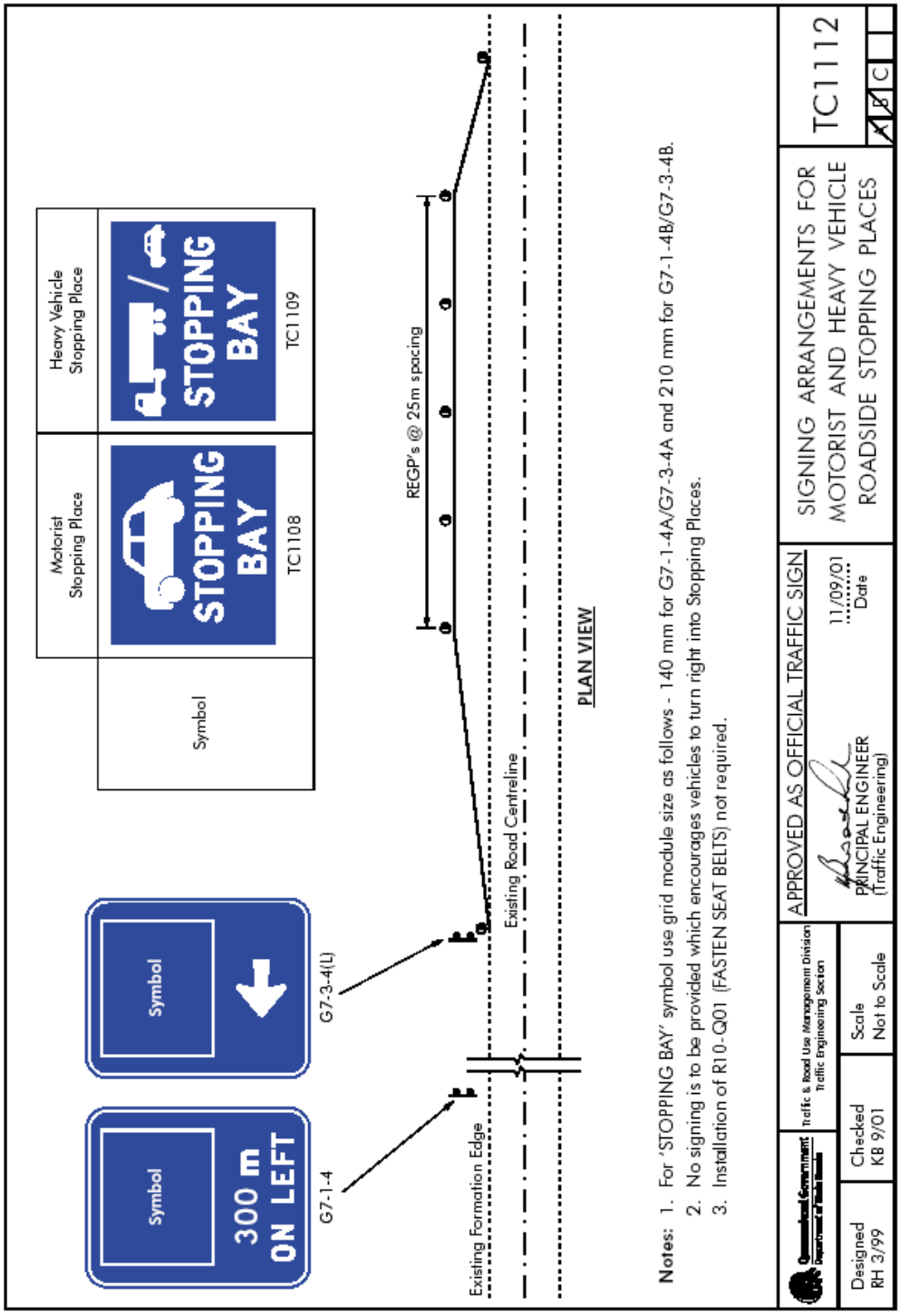

LEGEND
TOOWOOMBA
DALBY
WARWICK
CHINCHILLA
KINGAROY
GYMPIE
MARYBOROUGH
IPSWICH
Queensland Government
SOUTHERN
BRISBANE
BUNDABERG
TOWNSVILLE

Appendix C: Locations of Fatigue-related Crashes on 22A and 417





Appendix D: Signing Arrangements for Stopping Places



(Anon 2002, p. 20-25)