University of Southern Queensland

Faculty of Health, Engineering and Sciences

Improving Design Standards for Passing Lanes on Rural Highways in Queensland

A dissertation submitted by

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Abstract

Vehicles traveling at consistently slower speeds are a common occurrence on Queensland's regional highways and as a consequence this leads to problematic queuing congestion. Reducing congestion on regional highways can be achieved through the implementation of auxiliary overtaking lanes. The leading problem of overtaking lane placement occurs when heavy vehicles need to overtake slower vehicles, as heavy vehicles require a longer amount of road. Overtaking lanes located on upgrades makes it near impossible for heavy vehicles to overtake safely, thus heavy vehicles still remain behind the slower vehicles causing congestion to occur. The purpose of this project was to design overtaking lanes for heavy vehicles to overtake slower vehicles and then compare these designs to current standards and selected highway's overtaking lanes.

Methodology of this report was to thoroughly analyse crash data to then determine which three highways within Queensland had the highest crash rates of overtaking related crashes. High crash prone sections were then found through further analysis of crash data from selected highways. Heavy vehicle designed overtaking lanes were determined and then compared with overtaking lanes located within the selected crash prone highway sections.

Results showed the New England, Bruce and Warrego Highways were identified as having the highest overtaking related crash rates within Queensland. Crash data results displayed that heavy vehicles were involved in at least 50 percent of overtaking related crashes within the chosen crash prone highway sections. Results indicated that heavy vehicle designed overtaking lanes were found to be considerably longer than current design standard lengths.

Findings showed that the highway with the most amount of crashes did not always achieve the highest crash rate. Lastly findings suggest that current design standards are inadequate for providing a safe option for heavy vehicles to overtake slower vehicles. This project raised results that if overtaking lanes were designed to accommodate for heavy vehicles this would help to reduce amount of overtaking related crashes and would provide better opportunities to break up congestion an increase the service limit of a section of road. Results achieved within this project could be viewed upon by state road authorities to review their current design standards for overtaking lanes.

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Limitations of Use

Certification

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

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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Student Number: 0061046132

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Signature

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Date

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Acronyms

AAA – Australian Automobile Association

AADT – Average Annual Daily Traffic

ABS – Australian Bureau of Statistics

AGRD – Austroads Guide to Road Design

ARRB – Australian Road Research Board

AusRAP – Australian Road Assessment Program

EB – Eastbound

GVM – Gross Vehicle Mass

HV – Heavy Vehicle

LCV – Long Combination Vehicle

NB – Northbound

NHVR – National Heavy Vehicle Regulator

OCD – Overtaking Continuation Sight Distance

OED – Overtaking Establishment Sight Distance

OL – Overtaking Lane

OP – Overtaking percentage

PTSF – Percentage of Time Spent Following

RMS – Roads and Maritime Services

RPDM – Road and Planning Design Manual

SB - Southbound

SRIPs – Safer Road Investment Plans

TMR – Queensland Department of Transport and Main Roads

TRARR – Traffic on Rural Roads (Simulation software)

VKT – Vehicle kilometres of travel

WB - Westbound

Chapter 1

Introduction

1.1 Background

Congestion of traffic on regional highways is an ever growing problem being faced by Queensland drivers. Congestion on regional highways is more than commonly created by slower moving vehicles travelling along the highway. These slower moving vehicles can range from older trucks, heavily loaded trucks, caravans or motorhomes and slow travelling cars. Drivers may not always feel comfortable driving at high speeds or the signed speed limit, however when drivers chose to do a slower speed it means that faster travelling vehicles are essentially made to either follow or to overtake them.

Opportunity for faster vehicles to overtake is becoming increasingly difficult on regional Queensland highways as more and more vehicles are occupying these roads. The opportunities to overtake are also limited by the natural terrain of the road and in some cases lack of infrastructure to support the increase in vehicles therefore making overtaking increasingly difficult to do. These factors then limit the amount of area vehicles have the opportunity to overtake which causes congestion to occur. Congestion on regional highways consequently increases the probability of a crash occurring (Farah & Toledo 2010).

The safety of drivers on regional highways is highly important as serious injury crashes that happen in remote or regional areas are significantly more likely to end in a fatality compared with urban traffic crashes (Palamara, Kaura & Fraser 2013). Regional highway crashes are increasingly fatal as regional highways have signed speeds of 100 km/h or more in some cases. These speeds mixed with slow moving vehicles increases the amount of overtaking that is undertaken by drivers, this then increases the possibility of a head-on or cross over centreline crash to occur. The increase of possible crashes occurring reduces the safety of the highway; which is the problem being faced by regional highways within Queensland.

The main cause of Queensland’s poor safety on regional highways is due to slower traveling vehicles congesting the roadways. The option to reducing congestion on the regional highways is through the implementation of auxiliary overtaking lanes. Overtaking lanes are widely used throughout Australia on regional highways in a way to keep traffic flowing and to provide a method to reduce congestion, they are often seen on two lane two way roads which is a common configuration for regional highways. The placement of overtaking lanes is so slower travelling vehicles can be overtaken by faster travelling vehicles to prevent congestion occurring and to also provide a safer opportunity to overtake. Implementations of overtaking lanes are used to raise the level of service of a road if the roadway is approaching its limits (TMR, 2002).

Overtaking lanes are currently used on Queensland regional highways however their location doesn’t always benefit to reducing congestion. Most common location for overtaking lanes are on upgrades as heavy vehicles slow right down due to the large loads they are carrying, these locations are suitable as heavy vehicles do become the slower vehicle in these circumstances. The main problem of overtaking lane location occurs when heavy vehicles need to overtake slower vehicles, as heavy vehicles require a longer amount of road to overtake these slower vehicles.

Overtaking these slower vehicles is close to impossible for heavy vehicles as they do not have the acceleration compared to a car to overtake slower vehicles quickly. Heavy vehicles therefore rely on overtaking lanes to overtake the slower vehicles safely, however with most overtaking lanes being located on upgrades it is near impossible for heavy vehicles to overtake. The problem of congestion will therefore still remain as the heavy vehicles are unable to overtake the slower vehicle’s which then causes other vehicles to queue behind both the slow vehicle and then the heavy vehicle. Vehicles behind the heavy vehicle are forced to follow as for these vehicles to overtake it would require them to overtake both the heavy vehicle and the slow vehicle which is increasingly unsafe. Queueing then calls the need for overtaking lanes as the overtaking demand is not met as the volume of traffic approaching has increased to point were overtaking cannot be undertaken safely (TMR 2002).

1.2 Queensland Department of Transport and Main Roads

Queensland Department of Transport and Main Roads (TMR) is the state body that controls the management of transport and main roads within the state of Queensland. TMR is responsible for the planning, managing and delivery of Queensland's integrated transport environment to achieve a sustainable transport solution for road, rail, air and sea (TMR 2016). TMR are responsible for the planning and delivery of state controlled transport infrastructure. State controlled roads are managed and maintained by TMR to ensure the Queensland public are provided with suitable infrastructure to connect townships. TMR's integrated transport planning approach aims to provide for (TMR 2016):

- Publics quality of life
- Queensland's Economic wellbeing
- Sustainable Environment

Queensland has a total public road network of 186,550 kilometres; the state controlled network in Queensland is a total of 33,343 kilometres which is managed by TMR (TMR 2015). The state-controlled roads consist of different road types throughout the state. Different road types consist of the National Land Transport Network (National Network), state strategic roads and regional and district roads (TMR 2015). These road network types' total lengths are as following (TMR 2015):

- National Network 4,991 kilometres
- State Strategic Roads 4,108 kilometres
- Regional and District roads 24,244 kilometres

National Network is the highway network that links the country together with the network connecting all the major cities of the country together. National network is vital to Australia's freight industry as it provides the necessary infrastructure for the industry to transport freight between Australia's capitals. TMR works closely with the Australian Government through the National Partnership Agreements on land transport infrastructure projects to manage the 4,991 kilometres of National network (TMR 2015). National road network consists of Queensland's most heavily used highways within the state which are used by the travelling public and greatly used by the freight transport industry. National Network comprises of highways either entirely or it contains sections of the following (TMR 2015):

- Bruce Highway
- Pacific Highway
- Landsborough Highway
- Flinders Highway
- Barkly Highway
- Cunningham Highway
- Warrego Highway
- New England Highway
- Leichhardt Highway
- Gore Highway
- Gateway Motorway
- Port of Brisbane Motorway

A map displaying the different types of state controlled roads can be seen on the TMR website at Queensland State-controlled roads and region maps.

1.3 Auxiliary Lanes

Auxiliary lane is an additional lane added to the through lanes to help increase the traffic flow and maintain the required service level (TMR 2002). Auxiliary lanes cover a range of alignments such as acceleration lanes, deceleration lanes, overtaking lanes, climbing lanes, descending lanes, passing bays and speed change lanes (TMR 2002). An auxiliary lane is a road alignment design used to improve traffic flow which is commonly seen applied on roads throughout the state of Queensland and throughout Australia. Implementation of an auxiliary lane is used to remove traffic that is causing major disruption to the flow of traffic, therefore allowing through traffic to maintain their flow with minor disruptions (TMR 2002).

Overtaking lanes are the auxiliary lane that is being strongly focused on for the purpose of this dissertation. Overtaking lanes are provided to provide traffic the opportunity to overtake slower vehicles, which results in long queues (bunches) being broken up and traffic flow being improved (TMR 2002). Implementation of overtaking lanes allows traffic to overtake slower vehicles safely without having to enter into the opposing traffics direction of travel lane to overtake. Overtaking lanes are a road alignment design which benefits from safe overtaking opportunities in cases where overtaking lanes are only chance for an overtaking manoeuvre to occur (TMR 2002).

1.4 Australian Heavy Vehicles

Heavy vehicles (HV) make up a big proportion of the traffic on Queensland regional highways as most of these highways are the main routes for the freight transport industry. Information needs to be known about the characteristics of these vehicles as they are more than often mentioned as the vehicles to blame for causing congestion. This is however not to be true as heavy vehicles within Australia come in very large sizes both in length and mass an therefore require longer distances to overtake which is not often easy on regional two-lane highways. Following knowledge aims at understanding more about the lengths of these heavy vehicles and any restrictions these vehicles have applied to them.

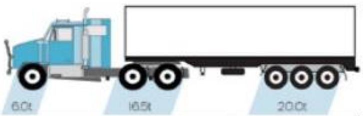
Most common truck trailer combination seen on Queensland roads is the single trailer combination which involves one truck and a single trailer. Maximum length of a single trailer truck is 19 metres (NHVR 2016). The length of a truck pulling a single trailer is far greater than that of a car and would be equivalent to overtaking two to three cars. Trucks on regional Queensland highways however come in far greater lengths than 19 metres, as common truck trailer combinations seen on regional highways in Queensland include B-doubles and road trains.

B-double truck trailer combination includes one full size trailer and a half size trailer that has an extended connection point for the second trailer these configurations can be up to a maximum length of 25 metres (NHVR 2016).

B-doubles are a common sight on regional highways as these types of configurations allow for more freight to be transported.

Road trains are also a common configuration seen on Queensland regional highways; road trains however are limited to where they can operate as there are a select amount of roads that they can use. There are a range of different configurations for road trains; the most common is a type 1 road train which uses two full size trailers and has a maximum length of up to 36.5 m (NHVR 2016). Overtaking a road train of this length would be similar to overtaking 5-6 cars. A type 2 road train can reach a maximum length of 53.5 metres as they have three full size trailers (NHVR 2016). Overtaking a type 2 road train would be similar to overtaking 7-9 cars. This information provided about heavy vehicle lengths is important as it displays exactly how big they can be and the similar length of them compared to cars.

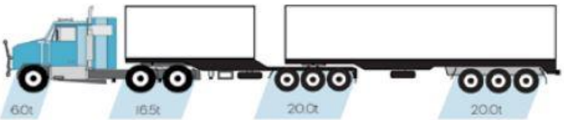
Common
6 Axle Semitrailer



Type of Mass Limits	Maximum Length (metres)	Allowable CVM/CCM (tonnes)	Single Steer Axle (tonnes)	Twin Steer Axle Group (tonnes)	Single Axle (tonnes)	Tandem Axle Group (tonnes)	Triaxle Group (tonnes)
GML	19.0m	42.5t	6.0t[*]	N/A	N/A	16.5t	20.0t
CML	19.0m	43.5t	6.0t[*,a]	N/A	N/A	17.0t	21.0t
HML	19.0m	45.5t	6.0t[*]	N/A	N/A	17.0t	22.5t

Common
9 Axle B-double

[#]26m is available for eligible vehicles.
[*]Combination must meet mass limits relating to axle spacing's for the full mass entitlement.



Type of Mass Limits	Maximum Length (metres)	Allowable CVM/CCM (tonnes)	Single Steer Axle (tonnes)	Twin Steer Axle Group (tonnes)	Single Axle (tonnes)	Tandem Axle Group (tonnes)	Triaxle Group (tonnes)
GML	25.0m[#]	62.5t	6.0t[*]	N/A	N/A	16.5t	20.0t per tri axle group
CML	25.0m[#]	64.5t	6.0t[*,a]	N/A	N/A	17.0t	21.0t per tri axle group
HML	25.0m[#]	68.0t	6.0t[*]	N/A	N/A	17.0t	22.5t per tri axle group

Common
Road train (Type I)

Type of Mass Limits	Maximum Length (metres)	Allowable CVM/CCM (tonnes)	Single Steer Axle (tonnes)	Twin Steer Axle Group (tonnes)	Single Axle (tonnes)	Tandem Axle Group (tonnes)	Triaxle Group (tonnes)
GML	36.5m	79.0t	6.0t[*,b]	N/A	N/A	16.5t per tandem axle group	20.0t per tri axle group
CML	36.5m	81.0t	6.0t[*,a]	N/A	N/A	17.0t per tandem axle group	21.0t per tri axle group
HML	36.5m	85.0t	6.0t[*]	N/A	N/A	17.0t per tandem axle group	22.5t per tri axle group

Common
Road train (Type 2)

Type of Mass Limits	Maximum Length (metres)	Allowable CVM/CCM (tonnes)	Single Steer Axle (tonnes)	Twin Steer Axle Group (tonnes)	Single Axle (tonnes)	Tandem Axle Group (tonnes)	Triaxle Group (tonnes)
GML	53.5m	115.5t	6.0t[*,b]	N/A	N/A	16.5t per tandem axel group	20.0t per tri axle group
CML	53.5m	118.5t[c]	6.0t[*,a]	N/A	N/A	17.0t per tandem axle group	21.0t per tri axle group
HML	53.5m	124.5t	6.0t[*]	N/A	N/A	17.0t per tandem axle group	22.5t per tri axle group

Figure 3.1: Common Truck Trailer Configurations on QLD Highways (NHVR, 2016)

Heavy vehicles are also limited to the speed they can travel, due to Australian legislation. The Road Transport (Safety and Traffic Management) Act 1999 states that heavy vehicles exceeding a gross vehicle mass (GVM) of 12 tonnes have to have a speed limiter fitted and restricted to a top speed of 100 km/h (Australian Government 1999). This makes it increasingly difficult for these heavy vehicles to overtake as they are limited to 100 km/h therefore they cannot speed up to pass a vehicle quickly.

1.5 Project Aim

Studies undertaken in this dissertation aim to analyse the current standards used in designing Queensland regional highway passing lanes. Project aims to analyse the crash data from a selected range of highways to investigate the standards effectiveness and to then develop design improvements to reduce the regional traffic congestion. Project aims to design overtaking lengths required by HV and to compare these lengths with overtaking lanes from selected highways and the current design standards. The project will then determine if the selected highways and current design standards require any improvement to reduce congestion and increase safety benefits.

1.6 Project Objective

The objectives of this project are to:

1. Examine the design standards and guidelines used for the design of passing lane in Queensland on rural highways.
2. Analyse crash data and select the three rural highways with the highest crash rates.
3. Analysis of the crash records to determine the most crash prone segments of highway to make relationship between the availability & characteristics of passing lane and crash occurrence.
4. Analyse selected highway segments to examine their compatibility to the required design standards examined in section one.
5. Develop models/methodologies to determine the overtaking length required for heavy vehicles on two-way rural highways in Queensland.
6. Comparison of heavy vehicle overtaking lengths with provided overtaking lane lengths and design standards, then propose strategies for improving design standards to reduce rural congestion and enhance the road safety.
7. Cost benefit analysis of heavy vehicle designed overtaking lanes.
8. If time permits, use TRARR (Traffic on Rural Roads) or another traffic model to examine the effectiveness of proposed changes to the road alignments.

Chapter 2

Literature Review

Literature review findings for this project provide a summary of the relevant literature available at time this project was undertaken. The use of overtaking lanes is a procedure that has been developed to improve level of service of roads through improving traffic flow of roads that have congestion problems. During the commencement of this literature review it became apparent that finding literature about analysing the effectiveness of overtaking lanes was going to be difficult. Literature relevant to overtaking lane design and reduction in congestion were extremely difficult as only one literature seemed similar to this project, however the PH.D dissertation done by C, Hoban called ‘Overtaking lanes on two-lane rural highways’ was not in electronic form and could only be accessed at the Monash University in Melbourne.

Literature that was found was however relevant to the project as the literature included research of drivers overtaking behaviour, overtaking heavy vehicles and also the time drivers spend following on rural roads. The relevant overtaking lane design standards used by TMR and other states were found so that further analysis of these standards can be undertaken within this project. The literature search also found that there was no information to be found about heavy vehicles being able to overtake. The aim of this literature review is to analyse the information that can provide further information to benefit towards the knowledge of the design of overtaking lanes on rural highways.

The review was undertaken to determine the following:

- Driver Overtaking Behaviour and Judgement
- Safety risks of Overtaking heavy vehicles
- Congestion on Regional two lane Highways
- Overtaking lane benefits on two-lane highways

2.1 Driver Overtaking Behaviour and Judgment

Behaviour of drivers when travelling along a road determines greatly the effectiveness of the roads design. The behaviour of driver can display whether the driver feels comfortable or not travelling along a road. The attitude from the driver's behaviour can also cause the judgement of the driver to be either good or a very poor decision which could lead to the driver making a poor judgement resulting in a crash.

Driver frustration is a feeling that can lead drivers to making poor judgements which causes their driving behaviour to become increasingly dangerous on Queensland roads. The frustration of drivers causes them to make judgment errors which can result in a crash and unfortunately this is when road fatalities occur. Determining the point when a driver becomes frustrated can provide vital information which can then be used to either redesign a section of road or design a solution to reduce the chances of driver's behaviours changing. The reduction of driver frustration could then reduce the judgement errors which consequently reduces the chance of crashes occurring.

The literature obtained within the review found that many studies have been undertaken into the effects and behaviours of drivers when choosing to overtake. The literature study's findings are important into determining driver's behaviours and the reasons to why drivers take the risk of overtaking. Bar-Gera and Shinar (2005) explained how overtaking has significant impacts on the safety and performance of the road as vehicles overtaking have to enter a lane that is travelling in the other direction increasing the chance of a head on collision.

The literature found on driver passing behaviour all used experimental testing where a simulation was used by a group of people to determine in which situations people would chose to overtake another vehicle. Study conducted by Bar-Gera and Shinar on their paper 'The tendency of drivers to pass other vehicles', stated that the basic motivation of drivers to pass other vehicles is to avoid any loss of time that results from traveling at a lower speed forced by a slower moving vehicle ahead (Bar-Gera & Shinar 2005). Findings from Bar-Gera and Shinar simulation testing proved to reflect this statement as almost all of the participants when encountering with slower vehicles traveling at speeds slower than 3 km/h of the driver they would pass them, and in two thirds of the encounters when the lead vehicles were moving at their speed they passed them too (Bar-Gera & Shinar 2005).

Results obtained by Bar-Gera and Shinar proved that drivers are always going to try and overtake slower vehicles and even vehicles travelling the same speed. Bar-Gera and Shinar however also found some astonishing results, 50 percent of the drivers overtook vehicles travelling ahead that were travelling at a slightly higher speed. The results of Bar-Gera and Shinar can be seen in the figure 4.1 below.

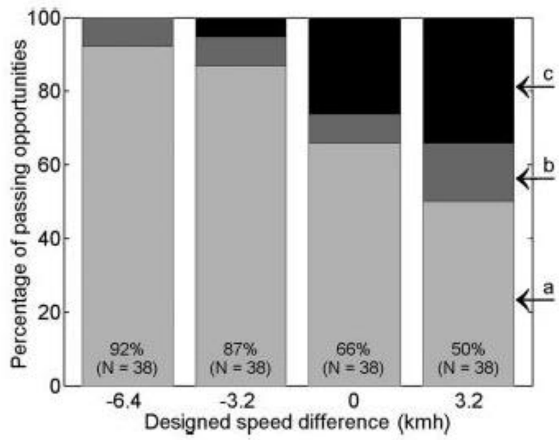


Fig. 1. Distribution of driver actions as a function of designed speed difference. (a) Did pass; (b) did not pass, but wanted to; (c) did not pass.

Figure 4.1: Bar-Gera and Shinar Overtaking Simulation Results (Bar-Gera & Shinar 2005)

Farah and Toledo had conducted a similar test in their paper ‘Passing behaviour on two-lane highways’ their research aimed at developing a model of passing behaviour. The testing involved in their research aimed at capturing a driver’s desire to pass and the driver’s accepted gap distance when overtaking another vehicle (Farah & Toledo 2010). The research to determine the acceptable gap distance when desiring to overtake is important as it provides information on what driver’s class as an acceptable distance when following a slower vehicle.

Farah and Toledo’s results were similar to that of Bar-Gera and Shinar as they found that even when the leading vehicle was equal to that of the desired speed the drivers still had a desire to overtake the leading vehicle. The results obtained in the tests conducted by Farah and Toledo's are consistent with the results found by Bar-Gera and Shinar which helps to reinforce the fact that drivers have the desire and will overtake leading vehicles even when they are travelling at the same speed. Farah and Toledo's also examined two vitally important variables that exhibited driver's frustration when desiring to overtake a slow vehicle; the two variables were the waiting time from when the driver was interrupted by the slower lead vehicle and when the number of opportunities to overtake was rejected.

Results found in the literature are vitally important for the knowledge of this project as it gives proven fact that drivers have the desire to overtake slower vehicles and even faster travelling vehicles. The results prove that drivers do not like following other vehicles on two lane roads and that drivers are therefore prepared to increase their speed considerably just to avoid following another vehicle.

Reason for drivers desiring to overtake leading vehicles could be due to the added stress of having to be more alert of what the lead vehicle is doing. Following vehicles on two lane roads causes the mental stress of drivers to be disrupted as these drivers have to give extra attention when following a vehicle. The mental stress of a driver can be caused by constantly having to adjust their speed with the leading vehicle and having to be prepared for the leading vehicle to make any quick braking or turning off. The mental stress of drivers could also be increased due to the fact that they cannot fully view the oncoming road for any hazards that may cause a crash. The increase in this mental stress can also cause a driver to be out of their comfort zone which increases the risk of a crash occurring.

Information details that the risk of crashes occurring is high on regional highways as drivers will more than often overtake other vehicles even when they are travelling at the same speed. It is for this reason that roads have to be designed so that risk of a crash occurring is lowered. The information provide greatly displays why the use of overtaking lanes would reduce traffic crashes as drivers are able to overtake other vehicles without having to make any risking manoeuvres. The information found within the literature also highlights an important message just as car drivers feel uncomfortable following vehicles it could be assumed that heavy vehicle drivers feel the same way. Overtaking process however is a simple task for cars compared to heavy vehicles as cars require a smaller overtaking gap. It is for this reason that overtaking lanes need to be designed in favour of heavy vehicles.

Figure 2.2: Vehicle overtaking a slower vehicle on two-lane road (SA DPTI 2015)

2.2 Overtaking Heavy Vehicles on Regional Highways

Overtaking heavy vehicles often trucks can be a difficult task for some drivers as trucks are often long in length and very wide. Overtaking these long heavy vehicles can be extremely dangerous as some drivers do not fully anticipate the length of these heavy vehicle and they do not provide themselves with enough of an overtaking gap to complete the pass safely. Upon searching literature about safety of overtaking heavy vehicles only one good piece of literature could be found on the topic.

Hanley and Forkenbrock (2005) conducted a study for their project paper ‘Safety of passing longer combination vehicles on two-lane highways’. The aim of their research was to research and determine the added risks of overtaking long combination vehicles. The location of their research and testing was in United States of America on two-lane highways. The results found by Hanley and Forkenbrock will still provide beneficial knowledge as the results are based on the same road configuration as chosen for this project. Hanley and Forkenbrock (2005) reported that increasing long combination vehicles (LCV) traffic on two-lane highways could lead to an increase in overtaking manoeuvres. An increase in overtaking manoeuvres drastically reduces the safety level of a road.

Hanley and Forkenbrock (2005) state in their paper that if a driver queues behind a longer vehicle waiting for a larger gap to make the pass, congestion on the two-lane road will increase. It is for this reason that congestion is a problem on two-lane highways as when LCV have to queue behind a slower vehicle they have to wait for an even large gap to appear before they can safely make the pass this significantly increases congestion. Results found through applying a model created by Hanley and Forkenbrock found that the when the impeding vehicle length increased that the chance of passing was likely to end in a failure (Hanley & Forkenbrock 2005). Results founded from their model also showed that the current acceptable gaps were not adequate enough to safely overtake LCVs (Hanley & Forkenbrock 2005). Model presented results that it is highly risky to overtake an obstructive LCV as the gap required for overtaking the LCV needs to be of considerable length.

Safety risks when a car comes in contact with a heavy vehicle are very high as heavy vehicles are far greater in size compared to cars. Crashes therefore involving heavy vehicles do not often end well and may more than likely end with a fatality depending on the circumstances. Hanley and Forkenbrock (2005) stated in their paper that the percentage of overtaking related crashes resulting in a fatality was on average higher than that of non-passing crashes, even though overtaking crashes only accounted for 1.4% - 2.6% of crashes on two lane highways from three states in the US. The stats given by Hanley and Forkenbrock really highlight the safety concerns of overtaking crashes as there is an increased chance of a fatality occurring compared to non-overtaking related crashes.

Forkenbrock and Hanley also conducted another study called ‘Fatal crash involvement by multiple-trailer trucks’, in this study they looked at the involvement multiple-trailer truck combinations had with fatality rates in crashes. The analysis findings from Forkenbrock and Hanley (2003) detailed that multiple-trailer trucks are seven percent more likely to be involved in fatal crashes involving three or more vehicles. This could be due to the fact that multiple vehicle crashes will often occur quickly or on a section of road not seen until the last minute making it extremely difficult for large multiple trailer trucks to brake in time. Forkenbrock and Hanley (2003) also stated in their findings that multiple vehicle crashes occur usually in high traffic volumes and that multiple trailer trucks like b-doubles and road trains are less manoeuvrable than cars therefore they are unable to avoid such crashes. Speed is also another factor that makes it increasingly difficult for trucks to avoid crashes if they happen quickly in front of a truck. Forkenbrock and Hanley (2003) made mention of this in their paper saying that multiple trailer trucks are nine percent more likely to be involved in a fatal crash on highways with high posted speed limits of 65 – 75 miles per hour. The high speed limits of 65-75 miles per hour are equivalent to Australia’s high posted speed limits of 100-110 kilometres per hour on regional highways.

Valuable information provided by Forkenbrock and Hanley in their two papers is important to understanding the impacts heavy vehicles have on crashes on regional two lane roads. Added knowledge from their studies helps to identify the fact that heavy vehicles have a higher percentage of causing a fatality when involved within a crash. Forkenbrock and Hanley also presented the fact the vehicles need a longer gap to complete the pass on a LCV; this provided the conclusion that when LCV need to perform a pass they require an even bigger gap to perform the pass safely. As heavy vehicles are a common sight on Queensland regional highways it is important to design these roads so that the percentage rate of a truck being involved in a crash is reduced so that the number of fatalities of heavy vehicle related crashes is reduced greatly.

2.3 Congestion on Regional two lane Highways

Congestion is the leading problem to large queues forming on regional two lane highways, queues tend to build as drivers decide or are forced to follow slower vehicles causing more vehicles to wait. There are a range of congestion solution methods however most of these solutions are designed for high congestion areas which mainly occur within urban areas. These methods include toll roads, congestion charging, vehicle to vehicle communication systems and electronic systems to avoid congestion. These are all options to reduce heavy congestion; however regional highways are affected by different kind of congestion. The regional congestion is represented in the form of queueing and bunching of vehicles behind a slower vehicle, compared to traffic jams on large highways which are commonly caused by crashes and the volume of cars reaching the maximum service level of that highway.

Chakwizira. et al. (2014) conducted a study into the methods used to manage traffic congestion in rural towns. Although the study by Chakwizira. et al. is not conducted for two-lane highways it provides information about congestion in a rural setting which is similar to regional highways within Queensland. Chakwizira. et al. (2014) reported in their paper that congestion on rural roads and highways can be caused by some of the following reasons:

- Bottlenecks - regular traffic demands cause traffic to backup due to a lack of needed capacity. Example based by number of lanes to carry traffic, curvature of highway/road and gradient.
- Traffic Incidents - Crashes, debris or rock falls on the road, broken down vehicles, trucks and buses on the roads and slow moving vehicles on the roads/highways.
- Work zones – new road construction and maintenance
- Bad Weather – rain, mist and fog can cause drivers to slow down causing congestion
- Special events – festivals, community events and school holidays can cause roads to become congested with extra volumes of traffic

- Transport governance - Lack of capacity and mechanism to effectively manage use of road/highway capacity (Chakwizira, Mudau & Radali 2014).

Bottlenecks, traffic incidents, work zones, bad weather and transport governance are all forms of congestion that occur on regional highways within Queensland. Chakwizira. et al. (2014) reported how traffic congestion is measured when the volume of traffic demands for space that is greater than the already provided capacity. In terms of two-lane highways the capacity is determined by the amount of overtaking opportunities traffic have along that section of road. Chakwizira. et al. (2014) stated in their report that once a road approaches or hits its capacity congestion and vehicle queuing occurs as the movement of traffic becomes restricted. The road capacity is determined by a scale which is based upon the traffic flow conditions and the degree of freedom that vehicles have with speed. The standard level of service table can be seen below in table 2.1.

Table 2.1: Road Level of Service Table (CHAKWIZIRA, et al., 2014)

Level of Service	Description
A	Free flow with low volumes and high speeds.
B	Reasonably free flow, but speeds beginning to be restricted by traffic conditions.
C	In stable flow zone, but most drivers are restricted in the freedom to select their own speeds.
D	Approaching unstable flow; drivers have little freedom to select their own speeds.
E	Unstable flow; may be short stoppages
F	Unacceptable congestion; stop-and-go; forced flow.

Chakwizira. et al. (2014) then reports that to improve a congested road different solutions can be adopted for different cases of congestion, for rural roads they suggest that road widening, ring road constructions and tolling can be used to reduce congestion. The solutions suggested by Chakwizira. et al. are solutions that would reduce congestion however as regional highways in Queensland are over a long distance and that most in Queensland are National highways, the construction of ring roads and tolling is not an option for reducing the congestion. Only real option of reducing congestion on regional highways is to widen the roads by adding another lane of travel or by introducing more overtaking lanes.

Report called 'Estimating percent-time-spent-following on two-lane rural highways' written by Cohen and Polus looks at the time drivers spend following other vehicles on two-lane rural highways. Cohen and Polus explain how one of the measures for level of service is to determine the proportion of time that fast vehicles travel in queues behind slow vehicles, also measured as Percentage of Time Spent Following (PTSF). The studies undertaken by Cohen and Polus is helpful for added knowledge as it helps to identify what PTSF is and how it applies to the effect of overtaking lane locations.

Cohen and Polus displayed in their report through using headway data collected they were able to determine an estimated value of PTSF as a function of traffic flow through using their model. Cohen and Polus report through the development of their new estimating method of PTSF a measure of level-of-service could be found from easily obtainable observations. The method of finding PTSF in Cohen and Polus paper is beneficial to the knowledge of this project as it describes another method to determining the service level of a road. The method of finding the PTSF is important on two lane roads as determining how long vehicles are waiting in queues is vital to knowing if the road needs improvement or not.

2.4 Overtaking lane benefits on two-lane highways

Finding literature that analysed the performance of overtaking lanes was very limited, however the literature that was found were all based studies in the US. Findings found in these studies however do not differ from the road conditions in Queensland as the road layout is the same. Most of the literature obtained focused on examining the benefits of passing lanes on rural two-lane highways.

Paper titled 'Empirical Examination of Passing Lane Operational Benefits on Rural Two-Lane Highways' written by Al-Kaisy and Freedman the purpose of the paper was to provide a reliable assessment of passing lane benefits. The information provided within this paper is going to be vitally important for this project as it will provide further knowledge and allow this project to focus more deeply on the selected road designs. The study aims of Al-Kaisy and Freedman were to determine the benefits of overtaking lanes from the start of the lane and further downstream from the lane to see how long the benefits last. Climbing lanes (passing lanes on upgrades) were not considered within their studies as it was beyond the scope. Al-Kaisy and Freedman conducted their empirical investigations through collecting data using automatic traffic recorders. Three main performance principles were used by Al-Kaisy and Freedman to determine the effect of the passing lane and the change in effect as traffic travelled away from the lane.

Al-Kaisy and Freedman reported that out of the two test sites they used the test site with the longer passing lane recorded the greater percent changes in performance. This would seem true as longer passing lanes gives the faster vehicles more time to work their way forward past the slower vehicles. Al-Kaisy and Freedman also found in their results that when the traffic levels were lower the percentage change in percent followers and follower density was better than high traffic volumes. These results would also be expected as in low traffic level conditions faster vehicles have a smaller amount of vehicles to overtake compared to high traffic levels. The results in their report then found how the percent followers and follower density improve in performance for a short distance downstream of the passing lane (Al-Kaisy & Freedman 2011). The results then displayed that 1.5 miles (2.4 kilometres) after the passing lane the platooning level starts to increase slowly as the distance from the passing lane increases.

Increase in platooning the further vehicles travel downstream from a passing lane is expected as faster vehicles begin to slowly close in on the slower vehicles that made the first passes in the passing lane. Al-Kaisy and Freedman results found at one location that the residual benefits from the passing lane could be seen 6.6 miles (10.6 kilometres) downstream from the end of the passing lane. Fact that the benefits of an overtaking lane were still increasing the performance of the road shows that overtaking lanes change the performance for a far greater length of road than just the length of the passing lane.

The literature report ‘Passing Lane Effectiveness on Two-Lane Roads’ written by D Harwood provides important information into the design effectiveness of overtaking lanes. Harwood explains how overtaking lanes on upgrades are not overtaking lanes however climbing lanes are designed to only consider bottleneck regions and not actually for passing improvements. The statement given by Harwood identifies that many overtaking lanes on regional highways within Queensland are in fact climbing lanes and are not actually designed for passing improvements. Harwood then states the same findings that Al-Kaisy and Freedman did in their report, that overtaking lanes reduce the percent of following vehicles dramatically and the passing lanes 'effective length' ranges for a significant distance downstream of the actual passing lane. Harwood illustrates the effective length of the passing lane in figure 2.3.

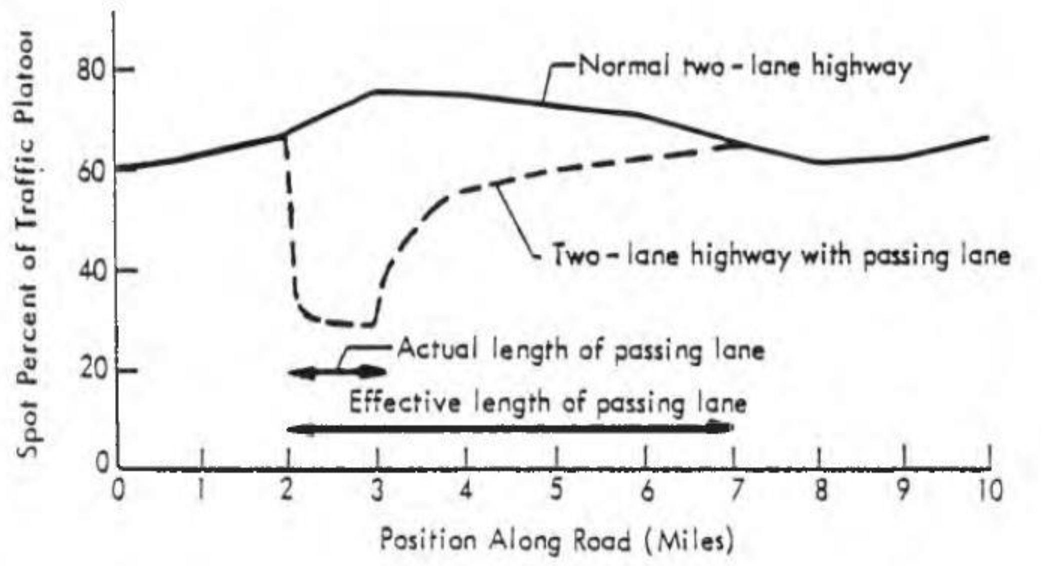


Figure 2.3: Effect of a passing lane on following traffic (Harwood n.d.)

Harwood states that the effective length of a passing lane can vary from 3 to 8 miles (5 to 13 kilometres) depending on passing lane length, traffic flow and arrangement and downstream passing opportunities. Harwood then details in his paper that the optimum passing lane length can be determine through a cost-effectiveness analysis, which he then displays in a table 2.2.

Table 2.2: Reduction in Percent Time Delay Per Unit Length of Passing Lane (Imperial)

One-Way Flow Rate (veh/hr)	Passing Lane Length (mi)[a] 0.25	0.50	0.75	1.00	1.50	2.00
100	2.8	8.2	8.1	8.1	6.8	6.2
200	11.1	13.1	14.0	11.7	10.6	9.5
400	2.8	8.2	13.1	9.0	8.1	9.5
700	2.8	8.2	8.1	9.0	8.7	9.0

[a] Unit length of passing lanes increased by 600 ft to account for cost of constructing lane addition and lane drop tapers.

The optimum design lengths for passing lanes are based from the data in table 2.2 and then found in table 2.3.

Table 2.3: Optimum passing lane length in imperial measurements (Harwood n.d.)

One-Way FLow Rate (veh/hr)	Optimal Passing Lane Length (mi)
100	0.50
200	0.50-0.75
400	0.75-1.00
700	1.00-2.00

Harwood then explains in his paper that short passing lanes are usually more effective per unit length and therefore when designing passing improvement for a highway often constructing three shorter passing lanes will be more effective than one large passing lane. The design of shorter passing lanes at set intervals would be better than one large passing lane as the shorter lanes would have a longer effective length on the performance of the highway. Towards the end of Harwood’s findings he reports that through the installation of a passing lane on a two-lane highway it would reduce the crash rate by approximately 25 percent. The information provided by the two pieces of literature will be vitally important when analysing the highway sections as it provides information about the optimum design lengths and the approximate effective length these passing lanes will create.

Chapter 3

Methodology

Analysing the need for an overtaking lane is a difficult task to conduct as congestion on long regional highways is usually not affected by external sources such as signalised intersections. Regional highways are typically classed as free flowing traffic conditions as regional highways often entail high speed limits. High speed limited roads allows drivers the opportunity to travel at these high speeds allowing drivers to arrive at their intended destination faster, however not all drivers feel comfortable travelling at these speeds. Uncomfortable drivers will therefore travel at a speed lower than the roads signed limit, determining points where drivers feel uncomfortable is an impossible task as every driver has a different comfort level.

Determining the overtaking demand of the selected highways for the intentions of this project was conducted through analysing crash data that may have occurred due to regional congestion. Overtaking crash related data for each highway was then used to determine the crash rate to evaluate which highways were prone to overtaking related crashes. Crash data period was chosen to be for a five year period from 2009 to 2013 as some highways had missing data for 2014 onwards, this also allowed for the 2013 traffic census data to be used for analysing. Satellite imagery then provided vital information into the location of overtaking lanes along the highway section lengths.

3.1 Auxiliary lane Design Standards

Design standards for overtaking lanes in Australia are presented in the Austroads 'Guide to Road Design' (AGRD). TMR implements design standards from the Austroad road design guide into their state design standards called the 'Road Planning and Design Manual' (RPDM). RPDM is TMR's primary reference for designing and planning of roads within the state (TMR 2016). RPDM refers TMR's designers to relevant Austroad publications for technical information and then outlines where TMR's practices differ from Austroad guides (TMR 2016).

Overtaking lanes are classed under the section Auxiliary lanes chapter 9 in the Austroads 'Guide to Road Design Part 3: Geometric Design'. The RPDM refers to auxiliary lane design in chapter 15 of the manual. Auxiliary lane design standards cover the large variety of auxiliary lanes which include speed change lanes, overtaking lanes, climbing lanes, descending lanes, passing bays and runaway facilities. Design standards presented in the RPDM and AGRD detail the reasons for implementing such lanes and then the geometric standards for deigning such lanes.

Overtaking lane design represents a large portion of chapter 15 in the RPDM as it explains the need for implementing overtaking lanes. The manual says that once the overtaking demand of a road is no longer met traffic begins to form long queues also referred to as bunches causing driver frustration and delay (TMR 2002). This is the point where an auxiliary lane is required. AGRD states how a proportion of the journey time spent following slower moving vehicles is measurement of quality of service seen by the drivers (Barton 2010). TMR bases this process of designing auxiliary lanes as cheaper option is often the best option as stated in section 15.3.2,
'The latter is often the most cost effective, particularly if the additional lane can be constructed in an area of lower construction costs' (TMR 2002).

RPDM then continues to explain that studies conducted by the ARRB found that providing auxiliary lanes at regular spacing led to greater improvements in traffic flow compared to major road alignment improvements (TMR 2002).

3.1.1 Overtaking Demand

RPDM describes that the level of service of a road can be found through using percent time following, results for this method can be found through using Traffic on Rural Roads (TRARR) modelling simulation (TMR 2002). TRARR access for the purpose of this research project was not available therefore the percent time following method could not be used.

RPDM however provides another approach to determining the overtaking demand which is described in the Austroads publication 'Guide to the geometric Design of Rural Roads' (TMR 2002). The 1989 publication by Austroads has now been translated into the AGRD part 3: Geometric Design publication and is recorded under the warrants section for overtaking lanes. The alternative to model simulation is to adopt the method of using traffic volume, percentage of slow vehicles, and the availability of overtaking opportunities on adjoining sections (Barton 2010). Table 3.1 gives the design table used to determine the overtaking demand of overtaking.

Table 3.1: Traffic Volume guidelines for providing overtaking lanes (Barton 2010)

Overtaking opportunities over the preceding 5 km (1)		Current-year design volume (AADT)		
Description	Percent length providing overtaking (2)	Percentage of slow vehicles (3)		
		5	10	20
Excellent	70 – 100	5,670	5,000	4,330
Good	30 – 70	4,330	3,670	3,330
Moderate	10 – 30	3,130	2,800	2,470
Occasional	5 – 10	2,270	2,000	1,730
Restricted	0 – 5	1,530	1,330	1,130
Very Restricted (4)	0	930	800	670

1. Depending on road length being evaluated, this distance could range from 3 to 10 km.
2. See Section 3.2
3. Including light trucks and cars towing trailers, caravans and boats.
4. No overtaking for 3 km in each direction.

3.1.2 Overtaking Lane Location

RPDM reports that the location of overtaking lanes depends on the following (Barton 2010):

Strategic planning – strategy to obtain best use of funds of entire length of section.

Nature of traffic – if queuing occurs along entire section of road any location will provide improvement, specific locations where slow vehicles cause queuing should be chosen.

Location of grades – overtaking lanes on grades may be more effective to overtake slower moving vehicles.

Costs of Construction – location of overtaking lanes may be more cost effective solution due to cheaper construction costs.

Geometry of road – sections of road that have curved alignments and restricted sight distances are preferable than straight alignments. Locating overtaking lanes on these locations will make it appear more appropriate to the drivers. Curved alignments with reduced safety speeds are not appropriate locations.

Conflict with intersections – locations where entering and existing traffic could prove a potential danger are unsuitable and should be located to reduce this danger.

RPDM states that if the decision id to locate the overtaking on a grade the lane should cover the entire length of the grade so that slower vehicles like trucks can be overtaken (TMR 2002). Previously mentioned in section 2.5 an overtaking lane on a upgrade is not an overtaking lane however a climbing lane as it only raises the level of service on the grades so they are similar to the roads overall level of service. Overtaking lanes on grades do not provide a solution to overtaking performance however an improvement to bottlenecking. The manual also documents how the length of these overtaking lanes on the grades depends on the cost and whether the cost outweighs the benefits achieved (TMR 2002).

3.1.3 Overtaking Lane length

RPDM states that the length of an overtaking lane needs to be long enough so that at least one overtaking manoeuvre can be performed to allow the queues to dissipate (TMR 2002). RPDM then details that results found by TMR showed that overtaking manoeuvres occur at beginning of the overtaking lane and that making the lane longer does not provide any addition improvements (TMR 2002). Table 3.2 shows the minimum lengths overtaking lanes set by TMR can be at the set design speeds. The RPDM states that these minimum distances only provide for a majority of single overtaking manoeuvres and that this distances do not accommodate for multiple manoeuvres (TMR 2002).

Table 3.2: Overtaking Lane Design Lengths (TMR 2002)

Design Speed (km/h) (a)	Total Taper Length (m) (b)	Overtaking Lane Length Including Tapers (m)		
		Absolute Min.	Desirable Min.	Normal Max. (c)
50	130	200	350	450
60	160	250	400	550
70	185	300	500	650
80	210	400	600	850
90	240	500	700	1000
100	265	600	800	1200
110	290	700	900	1350
120	315	800	1000	1500

(a) For the section on which the overtaking lane is constructed.

(b) See "Geometry" below.

(c) Adopt as minimum where road trains operate.

Absolute minimum overtaking lane length in table 3.2 accounts for one single overtaking manoeuvre to be performed (TMR 2002). Desirable minimum accounts for multiple overtaking manoeuvres to be performed and the normal maximum is the maximum length to fit in the terrain (TMR 2002). RPDM also states that on roads used by road trains the normal maximum length should be used as the minimum length value.

3.1.4 Overtaking Lane Spacing

Spacing distance between overtaking lanes is the distance from the end of the first overtaking lane to the start of the next overtaking lane. The RPDM states that the spacing between the overtaking lanes first depends on the location and the length of the designed overtaking lane (TMR 2002). Spacing is affected by location as the length of road may have two upgrades within close proximity to each other therefore the spacing of the overtaking lanes placed on these upgrades will be relatively close.

RPDM states that the spacing for passing lanes of 20 kilometres may be appropriate for the first installation of overtaking lanes (TMR 2002). The RPDM recommends a distance of 20 kilometres for the first overtaking lanes as separating the lanes over a longer distance will provide a higher service level benefit compared to two lanes in close proximity of each other (TMR 2002). The RPDM states that the desired spacing is 10-15 kilometres with a target of providing overtaking opportunities every 5 kilometres as the traffic volume increases (TMR 2002).

3.2 Analysing crash data of Queensland Highways

Selection of three highways will be conducted through analysing the crash data which is made accessible to the general public on the Queensland Government data website. The crash data is extracted from the Queensland Road Crash Database and is presented in a spreadsheet (QLD GOV 2016). Crash data provided by the Queensland Government only reported fatal crashes to 31 December 2013, hospitalisation crashes to 30 September 2013 and minor injury crashes to 31 December 2011 (QLD GOV 2016). Analysis period was therefore narrowed down to fatal and hospitalisation crashes for the past five years from 2013. The crash data downloaded reports the following details: crash ID number, crash severity, year, month, day, hour, crash nature, crash type, coordinates, street name, location (district, suburb etc), signed speed limit, weather, road alignment and crash description. Figure 3.1 shows what the first eight columns of the crash data spreadsheet looks like.

Crash_Ref_Number	Crash_Severity	Crash_Year	Crash_Month	Crash_Day	Crash_Hour	Crash_Nature	Crash_Type
1	Fatal	2007	May	Friday	19	Overturned	Single Vehicle
2	Property damage (	2006	July	Saturday	12	Rear-end	Multi-Vehicle
3	Hospitalisation	2006	October	Tuesday	11	Sideswipe	Multi-Vehicle
4	Medical treatmen	2007	February	Monday	6	Rear-end	Multi-Vehicle
5	Hospitalisation	2006	November	Friday	14	Sideswipe	Multi-Vehicle
6	Property damage (	2006	October	Saturday	21	Angle	Multi-Vehicle
7	Fatal	2007	March	Saturday	16	Rear-end	Multi-Vehicle
8	Fatal	2007	March	Saturday	3	Hit object	Single Vehicle
9	Hospitalisation	2007	February	Tuesday	9	Rear-end	Multi-Vehicle
10	Hospitalisation	2006	December	Sunday	2	Hit pedestrian	Hit pedestrian
11	Hospitalisation	2007	February	Friday	14	Angle	Multi-Vehicle
12	Property damage (	2007	March	Friday	18	Sideswipe	Multi-Vehicle

Figure 3.1: Section of crash data spreadsheet available from Queensland Government

Percentage of crashes on a section of road is calculated at a rate of either number of people per amount of people for example number of people per 100,000 people (ABS 2012). The other rate used to determine the rate of fatalities and crashes is the number of fatalities per 10,000 motor vehicles registered (ABS 2012). An example of the annual crash rates for the states of Australia in 2009 and 2010 can be seen in table 3.3 which was created by the Australian Bureau of Statistics.

Table 3.3: The road Traffic Fatalities of Australia in 2009 & 2010 (ABS, 2012)

24.21 ROAD TRAFFIC FATALITIES

	2009			2010		
	no.	per 100,000 persons(a)	per 10,000 motor vehicles registered(b)	no.	per 100,000 persons(a)	per 10,000 motor vehicles registered(b)
New South Wales	453	6.35	0.71	421	5.82	0.63
Victoria	290	5.32	0.51	288	5.19	0.49
Queensland	331	7.48	0.71	249	5.51	0.51
South Australia	119	7.33	0.80	118	7.17	0.68
Western Australia	190	8.45	0.77	193	8.40	0.79
Tasmania	63	12.52	1.30	61	6.11	0.54
Northern Territory	31	13.71	1.79	49	21.33	2.88
Australian Capital Territory	12	3.40	0.34	18	5.02	0.46
Australia	**1 489**	**6.78**	**0.69**	**1 367**	**6.12**	**0.61**

(a) Estimated resident population at 30 June.
(b) Number of registered motor vehicles and motor cycles (excludes tractors, caravans, plant and equipment) at 31 March.
Source: Department of Infrastructure and Transport.

The number of fatalities for a section of road is also determined as a rate which uses the traffic data for that section of road. The crash rate can be compared between location points, expressed for a common unit of exposure for example crashes per million vehicle kilometres or crashes per million entering vehicles (OSU n.d.). Analysis period can be from a one to three year period as two to three year periods are used for roads with low traffic volume and one year period is often sufficient for roads with high traffic volume (OSU n.d.). There are three methods that can be used in determining crash locations these methods are: Spot Map method, crash frequency method and crash rate method (OSU n.d.).

Spot Map Method – Is simple identifying a spot on the map where crashes have occurred regularly within very close proximity of each other (OSU n.d.).

Crash Frequency Method – This is a ranking method as it ranks the location with the most crashes as 1 and then followed by the second highest location and so on. This method however does not account for the traffic volume (OSU n.d.).

Crash Rate Method – This method compares the number of crashes at a location with the number of vehicles that enter that location. This comparison results in the crash rate for the location, they are then ranked in descending order by their crash rate values (OSU n.d.).

Exposure of a location can either be calculated for a single point or a section length; both use a simple equation to determine these values (OSU n.d.).

Section Exposure - The section exposure uses the length of the section in kilometres to determine the exposure rates.

$$\text{EXPOSURE (VEHICLE KILOMETRES OF TRAVEL)} = ADT \times 365 \times Km \times YRS \tag{3.1}$$

OR

$$\text{EXPOSURE (MILLION VEHICLE KILOMETRES)} = ADT \times 365 \times Km \times YRS/1{,}000{,}000 \tag{3.2}$$

Where:

Rsp = Crash rate at a spot in crashes per million vehicles,

A = Number of crashes for the study period,

Yrs = Period of study (years or fraction of years),

ADT = Average Annual Daily Traffic (AADT) during the study period (OSU n.d.).

Section Crash Rate

$$Rse = A / Exposure\ (Million\ vehicle\ kilometres) \tag{3.3}$$

OR

$$Rse = (A)\ (1{,}000{,}000) / ADT\ (365)\ (Km)\ (Yrs) \tag{3.4}$$

Where:

Rse = crash rate of the section in crashes per million vehicle kilometres of travel,

Km= Length of the section (in kilometres). Roadway sections with lengths less than 0.5 kilometres should not be considered as sections (OSU n.d.).

Through the use of these equations and the crash data obtained by TMR the crash rate of all regional highways can be calculated to determine the three highways with the highest crash rates. The highways that will be used for this stage of analysis will include all the highways that form a part of the National highway network as these are major highways and are major transport routes for heavy vehicles throughout Queensland.

The crash data first has to be organized so that the crashes are relevant to overtaking related crashes and congestive queuing. Crash severity was filtered from fatal, Hospitalisation, Medical treatment, minor injury and property damage only down to fatal and hospitalisation related crashes only as these types of crashes often entail high speeds. Reducing the number of fatalities occurring on Queensland roads is always of high importance; it is therefore important for purposes of this study that sections with high fatality rates are found.

Crash nature was filtered down to head-on, rear-end and sideswipe crashes as these types of crashes are assumed to be more related to overtaking or congestive queueing related crashes. Remoteness classification was also filtered down to inner regional, outer regional, remote and very remote locations as these classifications represent regional highways in Queensland most accurately. Figure 3.2 represents the levels of remoteness in Queensland.

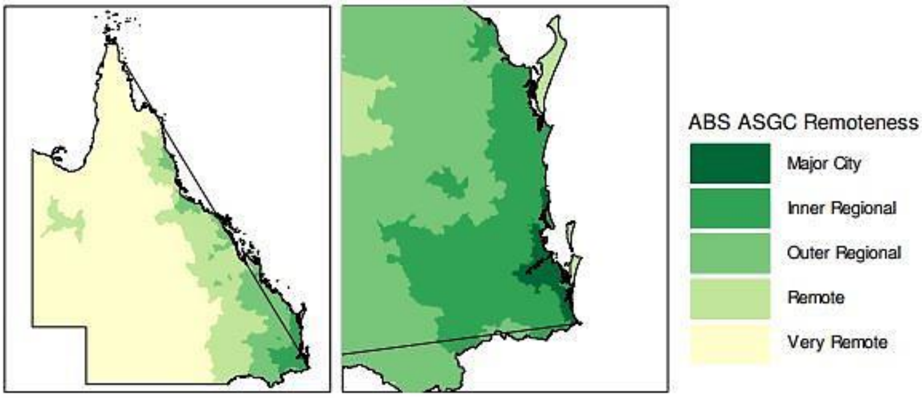


Figure 3.2: Remoteness classification of Queensland (TMR 2014)

Speed limit of crash sites was filtered to speeds from 80 km/h to speeds of 110 km/h; these speeds were chosen as they meet the regional highway requirements. Speeds below 80 km/h were believed to be too slow to be classed as regional highway speeds.

Once all arranging of crash data was conducted, total number of crashes could be found for each regional highway so that crash rates could be calculated. Determining the crash rate for each highway within Queensland will be calculated through using the Section crash Rate equation, however the crash rate will be per 100 million vehicle kilometres of travel (VKT) as the highways traffic volume will be high compared to a rural road. The equation for calculating the crash rate for each highway will be:

$$\text{Highway Crash Rate} = \frac{\text{A}\times 100{,}000{,}000}{\text{AADT}\times 365\times \text{km}\times 5} \tag{3.5}$$

Where A is the number of crashes to occur within the period of 5 years, AADT is the Annual Average Daily Traffic and km is the length of the highway in kilometres. Once the crash rate for each highway has been calculated the crash rates will be compared from the highest rate down to the smallest rate. Highest three highways will then be selected to perform further analysis for the project.

3.3 Analysing Crash Data of Crash Prone Sections

Crash prone sections of the three selected highways can then be found through analysing the crash locations along the length of the highway. Sections along the highways chosen can be analysed to find out which section of road has the worst crash rate. Defining which section has the worst crash rate will allow further analysis to be undertaken to see what aspects of the road design had to do with the crashes and to determine if the addition of an overtaking lane would reduce these crashes.

Crash prone sections will be found by through determining distances between crash point locations, these distances will then be analysed to find points that are in close proximity of each other. Proximity of crash points will be limited sections no longer than 25 kilometres, distances between crash points that are more than 10 kilometres will be classed as to far and therefore be the terminating point of a section. Crash sections once analysed will then be compared by finding the percentage of crashes per kilometre along that section using equation 3.6.

$$P\text{ercentage of crashes per km} = \frac{\text{NO.Crashes}}{\text{Length of Section}} \times 100 \tag{3.6}$$

Sections with the higher percentage of crashes per kilometre were then analysed using satellite imagery to view the section of road to determine if it was classed as a regional highway. Regional highway sections had to have a two lane configuration on a single carriageway to be classed as a regional highway. Figure 3.3 displays a section of road that was analysed for the project which was classed as a two lane configured road.

Figure 3.3: Section of Highway displaying two lane configurations (Google Earth, 2016)

Crash sections once classified as a regional two lane highway were then ranked with the top three sections with the higher percentage of crashes per kilometre being used for crash rate calculations. Crash rate of each section was found using the same equation 3.5 which was used to find the highways crash rate. Crash section with the highest crash rate was then chosen to analyse and compare with design standards.

3.3.1 Australian Road Assessment Program Section Comparison

The Australian Road Assessment Program (AusRAP) is written by the Australian Automobile Association (AAA) which releases a report of the national network of highways and gives all the highways star ratings. AAA star ratings rate highways on their safety with one star being the least safe, the AAA assess roads on design elements such as lane designs so single or dual lanes divided or undivided, line marking, width of lanes and hazards close to road (AAA 2013).

AusRAP report for 2013 for the first time developed a Safer Road Investment Plans (SRIPS) this plan generates a costed road upgrade proposal to improve the roads assessed over a twenty year period (AAA 2013). The AusRAP 2013 report is beneficial as it identifies which highways are classed as the least unsafe and can therefore be compared with the selected crash sections to see any resemblance. The AAA released a report in 2011stating that the road network they analysed accounts for roads travelled upon by 15 percent of the nation’s traffic and resulted in 1,170 road crash deaths between 2005-2009 (AAA 2011). The number of deaths in Queensland on the highway network was counted at 333 which was the second state with the highest amount of deaths (AAA 2011). Figure 3.4 displays the AAA safety ratings of Queensland highways.

Figure 3.4: AusRap Star Ratings of Queensland Highways released in their 2013 report (AAA 2013).

3.4 Analysis of Overtaking Lane Availability

Determining total amount of overtaking opportunities is important in understanding the need to implement the design and construction of an overtaking lane. Section 3.4 Analysis of overtaking lane availability will be determined through following the methodologies described within this section. Methodology processes within this section will determine the percentage of road providing overtaking, analysis of overtaking lane availability and a comparison of overtaking lane availability with design standards.

3.4.1 Percentage of Road Providing Overtaking

Percentage of overtaking length available along a section of road can be determined using equations given in the Austroads AGRD. Part 3: Geometric Design of the AGRD provides technical information on how to determine the percentage of overtaking available. The percentage of overtaking length is to begin when the overtaking establishment sight distance (OED) is available to the required length (Barton 2010). The overtaking section will end when the Overtaking Continuation Sight Distance (OCD) is no longer available (Barton 2010). Figure 3.5 displays the four stages of an overtaking manoeuvre and the stages OED and OCD apply to the manoeuvre.

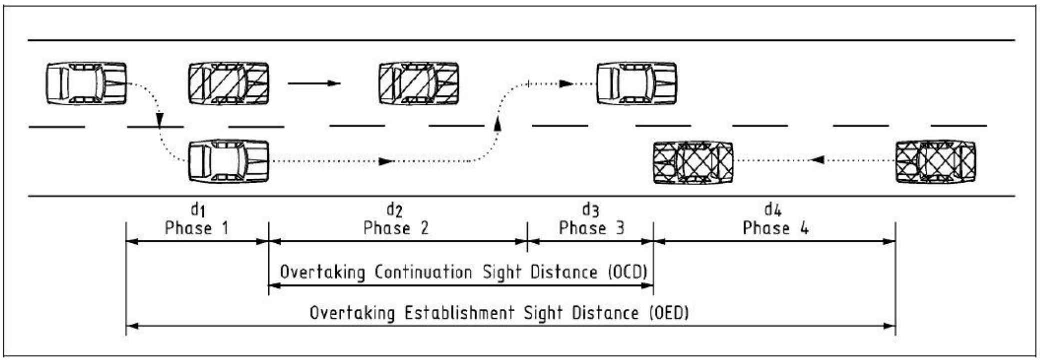


Figure 3.5: Four stages of an overtaking manoeuvre (Barton 2010)

OED is calculated through using equation 3.7 which takes into consideration the design speed, slower vehicle speed and the 85th percentile time gap in seconds. OCD is found by deriving from the time taken to complete phases 2 and 3 of the manoeuvre which can be seen in figure 3.1 (Barton 2010).

$$\mathrm{OED} = G_{T85}\frac{(V+u)}{3.6} \quad (3.7)$$

Where G_{T85} is the 85th percentile critical time gap in seconds, u equals V/1.17 (speed of slower vehicle) and V equals the operating speed. Through using equation 3.9 the sight distances are calculated into a design table which can be seen in table 3.4 and table 3.5.

Table 3.4: Overtaking sight distances for determining overtaking zones on MCV routes when MCV speeds are 10 km/h less than the operating speed (Barton 2010)

Road section operating speed (km/h)	Overtaken vehicle speed (km/h)		Establishment sight distance (m)				Continuation sight distance (m)			
	Semi-trailer B-double	Road trains	Prime mover semi-trailer	B-double	Type 1 road train	Type 2 road train	Prime mover semi-trailer	B-double	Type 1 road train	Type 2 road train
70	50	50	490	510	540	580	260	280	310	350
80	59	59	610	630	670	730	320	340	380	430
90	67	67	740	770	820	890	370	400	460	530
100	76	76	890	930	990	1,080	450	490	550	650
110	84	84	1,070	1,120	1,200	1,310	540	580	660	770

Table 3.5: Overtaking sight distances for determining overtaking zones on MCV routes when MCV speeds are equal to the operating speed (Barton 2010)

Road section operating speed (km/h)	Overtaken vehicle speed (km/h)		Establishment sight distance (m)				Continuation sight distance (m)			
	Semi-trailer B-double	Road trains	Prime mover semi-trailer	B-double	Type 1 road train	Type 2 road train	Prime mover semi-trailer	B-double	Type 1 road train	Type 2 road train
70	60	60	570	600	640	690	300	320	360	420
80	69	69	710	740	790	860	370	400	450	510
90	77	77	850	890	950	1,040	440	470	530	620
100	86	84	1,020	1,070	1,130	1,240	530	560	630	740
110	94	84	1,230	1,290	1,200	1,310	620	680	660	770

Through using the sight distances shown in the design tables the proportion of road offering overtaking can be determined through using equation 3.8.

$$\text{O.P.} = \frac{\sum \text{O.L's}}{\text{T.S.L.}} \times 100 \tag{3.8}$$

Where O.P. is the proportion of road offering overtaking in percentage, ∑O.L.'s is the sum of overtaking lengths in the road section in metres and T.S.L. is the total road section length in metres (Barton 2010).

The overtaking lengths along selected sections on three highways were found through using satellite imagery and street views provided by TMR transport globe available for Google Earth. Overtaking opportunity is when centre road line markings are broken allowing vehicles to undertake an overtaking manoeuvre when safe to perform. Length of broken centre line sections were measured through using measuring tool available on Google Earth. Total section lengths were determined from section lengths found from previous sections 3.3.

3.4.2 Analysis of overtaking lane availability

Determining availability of overtaking lanes along the selected road sections is a vital process for the project in being able to compare with the TMR design standards. Finding the overtaking lane locations was conducted through using satellite imagery and recording the coordinates of starting points and end points of the overtaking lanes. Direction of travel and the length of the overtaking lane were also recorded, chainage point at the start of the overtaking lane was also found through using the TMR globe which is available on the Queensland Government data website. Distance between available overtaking lanes was also found through using the chainage markers provided by the TMR globe. Further information was also recorded about the location of all the overtaking lanes relating to road level and possible reasons to why they were located where they are.

3.4.3 Comparison of overtaking lanes and design standards

Overtaking lanes that were found on the selected crash sections were then compared with the design standards which were mentioned in section 3.1. Overtaking lanes were compared with their length compared to design standards and possible reasons of why the overtaking lanes were of chosen length. Spacing between the provided overtaking lanes was also studied to see if the spacing was within the expectations of the RPDM. Location of the available overtaking lane was then compared with the location reasoning criteria mentioned in section 3.1.2 to determine the reasoning behind the designers decision to place the overtaking lane in that location.

3.5 Heavy Vehicle Overtaking Length Design

Heavy Vehicles as previously mentioned in section 1.4 are very long vehicles and are speed limited to 100 km/h; this makes it increasingly difficult for heavy vehicles to overtake vehicles that are going slightly slower than them. Determining the required length to overtake for different types of heavy vehicles is vital in determining a safe distance these vehicles required to perform an overtaking manoeuvre. Finding the length required to overtake for a HV requires knowing the acceleration rate of different kinds of HV. Australian Standard

1742.7:2016 'Manual of uniform traffic control devices Part 7: Railway crossings', provides a table of acceleration rates for different types of HV. Acceleration rate figures for the different types of HV can be seen in table 3.6.

Table 3.6: Acceleration rates for different forms of HV (AS 2016)

DESIGN VEHICLE STOPPING, START-UP AND CLEARANCE PARAMETERS

Vehicle type	*L* m	*GCM* t	B_T s	*J* s	Acceleration (*a*), m.s^{-2}	
					'Normal' driving behaviour	'Cautious' driving behaviour
Level 1—Semi-trailer	20.0	50	1.0	2.0	0.52	0.37
Level 2a—B-double	26.0	69	1.0	2.0	0.40	0.31
Level 2b—Pocket road train	30.0	85	1.5	2.5	0.39	0.30
Level 3a—Double road train	36.5	91.5	1.5	2.5	0.36	0.29
Level 3b—B-triple	42.0	91.5	2.0	2.5	0.36	0.28
Level 4a—AAB-Quad	53.5	143	2.0	2.5	0.27	0.22
Level 4b—AAB-Quad	60.0	150	2.0	2.5	0.26	0.21

NOTE: Levels are defined in the NHVR website.

Types of HV vehicle using the selected highway has to be determined to ensure that the appropriate acceleration rate is chosen. Limited types of HV that can use a highway in Queensland can be viewed on TMR website under 'Multi-combination routes and zones in Queensland'. Once the types of HV that are limited to the select highways are found the safe overtaking distances can be found.

Models using velocity calculations will be the method used to determine the safe overtaking distances required. Method required determining the overtaking distance is of the following:

Calculations will be made for type of HV that the section of road is limited to overtaking a vehicle which is going 5 km/h and 10 km/h slower than the signed limit.

Safe following distances are recommended as two seconds for cars and four seconds for HV (QLD GOV 2015). Analysis for this project however assumed that the following distance of HV will reduce to 2 seconds as vehicles approach to overtaking lane. Following distance of two seconds will be used for determining the safe required length to overtake.

Calculation for the overtaking length will assume that the HV is following the slower vehicle at an equal speed to the slower vehicle with a two second following gap as they approach the overtaking lane. HV will then accelerate at start of the overtaking lane to overtake slower vehicle, time taken to accelerate from slower vehicles speed to speed limit is determined through equation 3.11.

$$t = \frac{V_f - V_i}{a} \quad (3.9)$$

Time required to accelerate to signed speed is presented as t in seconds, V_f is final velocity, V_i is initial velocity before acceleration takes place and *a* is acceleration rate from table 3.6 of chosen HV for required test. Distance required to accelerate from initial speed to final speed is represented as *s* which will be found through using equation 3.12.

$$s = V_i t + \frac{1}{2} a t^2 \quad (3.10)$$

The test will then involve that once HV has accelerated to the speed limit vehicle will conduct overtaking manoeuvre and once completed will then return in front of the slower vehicle with a two second following gap between the slower vehicle and the HV. Distance required to perform overtaking manoeuvre will determine through comparing the distance travelled between both overtaken vehicle and the overtaking HV. Speed will be recorded as metre per sec as a measurement of velocity. Once HV has overtaken the slower vehicle and distance between both vehicles is equal to sum of HV's length and two second following gap the manoeuvre is complete. Figure 3.6 displays the overtaking procedure that will be adopted for the calculations.

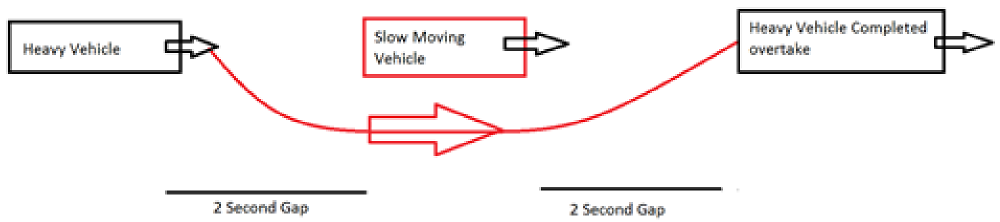


Figure 3.6: Overtaking procedure adopted for HV overtaking length calculations

Total of four tests will be undertaken to help generate models for different overtaking situations HV's may encounter where they are forced to follow slower vehicles. Three tests that will be commenced will be conducted for each type of limiting vehicle found for each section of highway found will include the following tests:

- Limiting HV overtaking a car
- Limiting HV overtaking a car towing a trailer
- Limiting HV overtaking other HV classes (semitrailer, B-doubles and road trains depending on highway)

The lengths of different HV can be seen in section 1.4 which has lengths of different classes of HV's. Maximum length a light rigid motor vehicle can be is 12.5 metres; this length however also applies for small buses and trucks (RMS 2015). Length of a car used for calculations however assumed to be a length of five metres after personal measurements were made on a number of cars and five metres was an average length found. Length of five metres was also used as this would be more suitable for amount of cars on Queensland highways around this same length. Maximum length for a vehicle towing a trailer was found to equal to 19 metres which is the same length found for semitrailers (RMS 2015). Figure 3.7 displays the points where length of a towing vehicle applies.

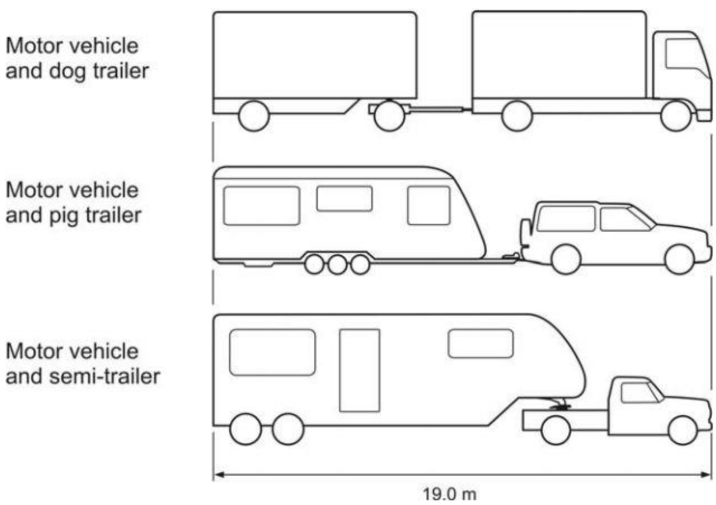


Figure 3.7: Maximum allowable lengths for vehicle combination (RMS 2015)

3.6 Heavy Vehicle Overtaking Length Comparison

Heavy Vehicle overtaking lengths once calculated will then be compared to overtaking lengths provided along selected highways and also compared with RPDM design lengths. Comparing the HV overtaking lane length is vital as it will determine whether the design lengths of overtaking lanes are appropriate for heavy vehicles and whether the service level of these regional highways could be greatly increased by these new lengths found.

Comparison of the design lengths will then determine if HV can safely perform an overtaking manoeuvre with the overtaking lanes that are provided throughout the regional highways within Queensland. Comparison results will deliver the critically findings of this project as it may or may not provide additional information towards improving the service level of many regional highways located throughout the state of Queensland and the country of Australia.

3.7 Cost Benefit Analysis

Cost benefit analysis will be determined once the HV overtaking lengths have been calculated and compared with design standards. Cost benefit of each overtaking length will include the estimated cost of construction and safety benefit costs of designed overtaking lane lengths. Cost benefit analysis will determine potential benefits HV overtaking lane lengths will have on amount of crashes that will be prevented and costs saved through reducing amount of crashes.

Cost benefit analysis section itself can be an extensively long project, for purpose of this dissertation cost and benefits values will be adopted from a report released by the Australian Automobile Association (AAA). AAA released report previously mentioned section 3.3.1 called "Star Rating Australia's National Network of Highways' within this report AAA developed the Safer Roads Investment Plans (SRIPs) (AAA 2013). SRIPs within the report provides costed engineering countermeasures that can be implemented to improve safety of all analysed highways, using countermeasures that can provide positive returns on in countermeasure investments (AAA 2013). SRIPs proposed a selection of countermeasures that could reduce amount of fatalities and injuries report than determined a benefit cost ratio (BCR) for each safety countermeasure and a total BCR for each state/territory of Australia.

The countermeasure that will be used from AAA report is the implantation of an additional lane and costings and benefits found within their report. AAA countermeasure costs and benefits for implementation of additional lance can be seen in table 3.7.

Table 3.7: AAA report Countermeasure cost and benefit values (AAA 2013).

Countermeasure	Length (km)	Fatalities and Serious Injuries Saved	Safety Benefit ($ million)	Estimated Cost ($ million)	Program BCR
Additional Lane (2+1 road with barrier)	98	950	432	361	1.2

Values obtained from AAA in table 3.7 will then be used to determine estimated cost per and safety benefit cost per kilometre which will then determine costs of each HV overtaking length. Fatalities and serious injuries saved will also then be determined for per kilometre then applied to lengths found for HV's overtaking lengths. Estimated costs, safety benefits and prevented casualties determined for each overtaking length will display the cost benefits of designed overtaking lane lengths.

3.8 TRARR

Traffic on Rural Roads (TRARR) is a simulation program developed by the Australian Road Research Board (ARRB) to analyse the flow of a rural road section (Koorey 2002).The simulation is purely made to simulate and analysis rural road alignments mostly two-lane roads. Simulation generates inputted values to generate vehicles that enter the road section the simulation then analyses the flow of travel that vehicle will experience due to road alignment and other vehicle (Koorey 2002).

This program is ideal for analysing overtaking lane designs as it can give real data feedback of whether the design is going to improve the roads service level or if the service level does not change. For the purpose of this project the ARRB has been contacted about the use of the TRARR program, the ARRB replied stating that access to the program cannot be approved for the purposes of this project.

Chapter 4

Analysis

Chapter 4 reports about the analysis that was performed in this study, analysis follows the methodology which was explained in chapter three. This chapter explains the processes in performing the statistical analysis so that the analysis can provide the necessary results required for this project.

Purpose of this analysis was to select three highways within Queensland that have the highest crash rates that are caused by overtaking and regional congestion. Selected highways were analysed based upon three types of crashes to determine sections along these highways that may experience regional congestion causing an increase in dangerous overtaking manoeuvres. Crash data was analysed for the following types of crashes:

1. Head-on crashes
2. Rear-end crashes
3. Sideswipe

Chapter four has been separated into five sections which describe the main parts of this projects analysis. Five sections include; Highway selection, Road section selection, analysis of available overtaking lanes, heavy vehicle overtaking length design and heavy vehicle design length comparison with available overtaking.

4.1 Analysing Crash Data of Queensland Highways

The methodology described in chapter three sections 3.2 explains processes that were adopted for this analysis section. Determining the national highway network within Australia was found through the AusRap report released in 2013 called 'Australia's National Network of Highways' which was mentioned in section 3.3.1. AusRap reports a list of national highways within Queensland and their corresponding length and safety star ratings. Table 4.1 displays the national highways within Queensland.

Table 4.1: AusRap review table of Queensland National Highways (AAA 2013)

Highways	Length (km)	Proportion in each Star Rating				
		1-Star	2-Star	3-Star	4-Star	5-Star
A2 Barkly Highway	312.1	0%	10%	74%	16%	0%
M1/A1 Bruce Highway	1,673.1	3%	42%	52%	3%	0%
M15/A15 Cunningham Highway	130.1	9%	58%	28%	0%	0%
A6 Flinders Highway	743.3	0%	20%	76%	3%	0%
M1 Gateway Arterial	79.0	0%	12%	48%	37%	4%
A39 Gore Highway	193.4	0%	53%	47%	0%	0%
M7/M2 Ipswich Motorway	38.4	0%	0%	16%	55%	10%
A2 Landsborough Highway	1,011.2	0%	13%	86%	0%	0%
A15 New England Highway	92.5	0%	46%	54%	0%	0%
M1 Pacific Motorway	158.8	0%	0%	63%	37%	0%
M2/A2 Warrego Highway	676.6	2%	37%	53%	7%	1%
Total	**5,108.5**	**1%**	**29%**	**63%**	**6%**	**0%**

The highways listed in table 4.1 then had to be analysed to determine which highways are classed as regional highways by having a two lane configuration. Highways were then viewed using both satellite imagery and digital images to determine if they class as a regional highway. Analysing these highways found that three out of eleven highways did not class as regional highways these highways were; M1 Gateway Arterial, M7/M2 Ipswich Highway and M1 Pacific Motorway.

Analysis found that two highways did not fully class as regional, Bruce and Warrego highways both had sections that were beyond the classification of being classed as a two lane regional highway. Bruce highway when being analysed was found that the highway begins in Brisbane where the highway has a four lane configuration that begins in Brisbane and travels north to just below the south of Gympie. Purposes of this project the Bruce highway was adopted to begin from Gympie and finish in Cairns. Warrego highway begins off the Ipswich motorway and then ends west at Charleville, section between Ipswich and Toowoomba however has a four lane configuration therefore does not classify as a regional highway section. Satellite imagery displayed that section of road between Toowoomba and Charlton is been re aligned to four lines, therefore this section was excluded from the analysis. New England highway is classified only as national highway from Warwick to the New South Wales Border, however for the purpose of this project it was decided to also review the section of New England between Warwick and Toowoomba. Highways that were used for this projects analysis and their corresponding lengths can be seen in table 4.2.

Table 4.2: Highways used for analysis

Highways	Length (km)	Starting point	End Point
A2 Barkly Highway	323.2	Cloncurry	N.T Border
M1/A1 Bruce Highway	1414.8	Gympie	Cairns
M15/A15 Cunningham Highway	313.1	Ipswich	Goondiwindi
A6 Flinders Highway	743.3	Townsville	Cloncurry
A39 Gore Highway	193.4	Toowoomba	N.S.W Border
A2 Landsborough Highway	1011.2	Morven	Flinders Highway
A15 New England Highway	157.7	Toowoomba	N.S.W Border
M2/A2 Warrego Highway	605	Toowoomba	Charleville

TMR crash data was obtained from the Queensland Government data website which was freely accessible to the general public via a downloadable spreadsheet called ‘Road crash locations’. Crash data spreadsheet is a large spreadsheet as it has all crashes that have been recorded from 2001 till 2013 for fatal and hospitalisation crashes and till 2011 for medical treatment and minor injury crashes.

Crashes that have been recorded cover all the roads across the whole of Queensland, data therefore needs to be organized to ensure the correct data is found for the projects list of highways. Recorded crashes are information that has been attained from police reports that have been filled out upon a crash occurring. Police crash reports include a large amount of detail to ensure as much information is recorded about the crash that has occurred. Crash data spreadsheet includes the following categories:

- ◊ Crash reference number
- ◊ Crash severity (fatal, hospitalisation, medical treatment, minor injury and property damage only)
- ◊ Crash time (year, month, day and hour)
- ◊ Crash nature (angle, collision, fall from vehicle, head-on, hit animal, hit object, hit parked vehicle, hit pedestrian, non-collision, overturned, rear-end, sideswipe, struck by external load or struck by internal load)
- ◊ Crash type (single vehicle, multi vehicle or hit pedestrian)
- ◊ Crash coordinates (latitude and longitude)
- ◊ Crash Street name
- ◊ Crash street intersection (only if crash was at an intersection)
- ◊ Location fields (all of the following fields: suburb, local government area, post code; police district, division and region; transport region, main roads region, state electorate and federal electorate)
- ◊ Level of remoteness (Inner regional, major cities, outer regional, remote, or very remote)
- ◊ Crash control (local or state)
- ◊ Crash roadway feature (type of intersection, merging lane, bikeway, bridge or rail crossing only if applicable)
- ◊ Crash traffic control (signage or traffic guidance only if applicable)
- ◊ Crash Speed limit
- ◊ Crash road surface
- ◊ Crash weather (clear or raining)
- ◊ Crash lighting (night, day, dusk, dawn or street lighting)
- ◊ Crash road horizontal alignment (curved open or obstructed and straight)
- ◊ Crash road vertical alignment (level, grade, dip or crest)
- ◊ Crash DCA code
- ◊ Crash DCA description
- ◊ Crash DCA group description
- ◊ Number of victims (fatalities, hospitalisations, minor injuries and total number of victims)

- ◊ Number and types of vehicles (car, motorcycle, truck, bus, bicycle and pedestrian)

Analysis for this project did not require all of the fields listed within the crash data spreadsheet, as the project is not focusing on analysing the crash data in-depth just the amount of crashes that occurred. Analysis of crashes only required the following fields:

- ◊ Crash reference number
- ◊ Crash severity (fatal and hospitalisation crashes only)
- ◊ Crash time (year only from 2009 to 2013)
- ◊ Crash nature (head-on, rear-end and sideswipe crashes only)
- ◊ Crash type (single vehicle, multi vehicle or hit pedestrian)
- ◊ Crash coordinates (latitude and longitude)
- ◊ Crash Street name
- ◊ Crash street intersection (only if crash was at an intersection)
- ◊ Location fields (only suburbs that are applicable to the project)
- ◊ Level of remoteness (Inner regional, outer regional, remote, or very remote only no major city related crashes)
- ◊ Crash roadway feature (type of intersection, merging lane, bikeway, bridge or rail crossing only if applicable)
- ◊ Crash Speed limit (speed zone between 80 – 110 km/h)
- ◊ Crash road horizontal alignment (curved open or obstructed and straight)
- ◊ Crash road vertical alignment (level, grade, dip or crest)
- ◊ Crash DCA code
- ◊ Crash DCA description
- ◊ Crash DCA group description
- ◊ Number of victims (fatalities, hospitalisations, minor injuries and total number of victims)
- ◊ Number and types of vehicles (car, motorcycle, truck, bus, bicycle and pedestrian).

For selection analysis the crash severity was narrowed down to just fatal and hospitalised crashes as these types of crashes will help in finding the higher fatality prone highways and sections. Chapter one also mentioned how regional highways are prone to fatalities due to their high speed limits and distant location from medical services, it is therefore vital these fatality hot spots are found. Crash nature was also arranged to just head-on, rear-end and sideswipe crashes as it was found in the crash data that these forms of crashes are heavily related to vehicles attempting to overtake. Rear-end and sideswipe crashes were also chosen as while vehicles are queuing and creating congestion the likelihood of a rear-end or sideswipe crash is higher due to vehicles following closely giving drivers smaller amount of time to react to hazards. Level of remoteness was also organised to remove major cities related crashes so that only regional crashes were being analysed. Speed limits were also narrowed down to crashes that occurred on roads with speed limits ranging between 80-110 km/h.

Crash data locations was then organised for each section that applied to each highway being analysed. Crash data for all the highways was then organised to display the relevant crash data from their respective starting point and end point which was presented in table 4.2. Total number of crash locations for each highway was then found so that crash rates could be determined. Table 4.3 displays the crash data spreadsheet that had been organised for the Warrego highway.

Table 4.3: Section of organised crash data spreadsheet for Warrego highway

Crash_ Ref_ Number	Crash_ Severity	Crash _Year	Crash_ Nature	Crash_ Street	Location_ Suburb	Location_ ABS_ Remoteness	Crash_ Speed_ Limit
165350	Hospitalisation	2009	Sideswipe	Warrego Hwy	Warra	Outer regional	100-110 km/h
171700	Hospitalisation	2011	Rear-end	Warrego Hwy	Pickanjinnie	Remote	80-90 km/h
185495	Hospitalisation	2011	Rear-end	Warrego Hwy	Charlton	Inner regional	80-90 km/h
185943	Fatal	2009	Head-on	Warrego Hwy	Oakey	Inner regional	100-110 km/h
189013	Hospitalisation	2011	Sideswipe	Warrego Hwy	Macalister	Inner regional	100-110 km/h
190036	Hospitalisation	2010	Head-on	Warrego Hwy	Bowenville	Inner regional	100-110 km/h

Crash rate of each highway was conducted to find the overall average crash rate of each highway. Average crash rate was found as the length of the highways varies with the largest being the Bruce with a length of 1414 kilometres it would require a very in-depth analysis to determine the crash rate for each section of each highway. Purposes of this project it was decided to find the average of the Annual Average Daily Traffic (AADT) to use for the crash rate equation. AADT was accessed from the Queensland Government database website where the 2013 traffic census was presented in a spreadsheet. Traffic census data was then filtered for each highway so that the average AADT could be found for the census recorded sites between the highways starting and end points. Table 4.4 displays a section of the traffic census data provided.

Table 4.4: Section of the traffic census data spreadsheet (TMR 2015)

SITE_ID	DESCRIPTION	LONGITUDE	LATITUDE	AADT	TDIST	PERCENT_HV	RSECT_ID	ROAD_NAME	TDIST_START	TDIST_END
140035	17A Wst of Church Street Ramps Goodna	152.89253	-27.605	85582	2.63		17A	CUNNINGHAM HIGHWAY	0	3.7
140027	17A - At Mine Street Redbank	152.87367	-27.601	80352	4.6		17A	CUNNINGHAM HIGHWAY	3.7	6.35
136081	17A Ipswich MwyEast ofWarrego Hwy OnRamp	152.84564	-27.597	86490	7.7		17A	CUNNINGHAM HIGHWAY	6.35	7.7
140001	17B - South of Barclay St Overpass PTC	152.83259	-27.601	26234	3.8	15.82	17B	CUNNINGHAM HIGHWAY	0	5.46
135718	100m North of Swanbank Road at creek	152.79364	-27.642	27465	7.8	15.61	17B	CUNNINGHAM HIGHWAY	5.46	10.01
135782	0.8k West of Ripley Rd	152.76995	-27.659	16930	10.8	17.94	17B	CUNNINGHAM HIGHWAY	10.01	14.08
135773	At Warrill Ck	152.70291	-27.658	19981	17.6	13.6	17B	CUNNINGHAM HIGHWAY	14.08	18.38
131819	west of Champion Way - Willowbank	152.6713	-27.703	6306	24.2	26.51	17B	CUNNINGHAM HIGHWAY	18.38	32.85
11583	460m north of Charles Chauvel Dr	152.648	-27.781	5512	33.36	25.42	17B	CUNNINGHAM HIGHWAY	32.85	39.67
10014	1.77km Nth of Kalbar Connection Rd	152.59749	-27.916	4786	50.06	27.73	17B	CUNNINGHAM HIGHWAY	39.67	55.61

Total number of crashes, length of highways and the average AADT was then all used to calculate the highways crash rate. Crash rate as previously mentioned in section 3.2 equation 3.5 was used to determine the crash rate. Crash rate values achieved displayed that although a highway may have a higher number of crashes it may not achieve a high crash rate as AADT has a relatively large effect on the crash rate. Highway with a high total of crashes with a high AADT produced a small crash rate compared to a highway that had a lower amount of total crashes however had a small AADT produced a higher crash rate. Higher crash rates are achieved by these lower AADT as the proportion of crashes compared to the amount of vehicles using that road is very high.

New England displayed this as this highway had the third highest amount of crashes with a total of 21 overtaking related crashes compared with the Bruce highway which had the most crashes of 317 overtaking related. New England highway however produced the highest crash rate of 1.57 crashes per 100 million vehicle kilometres. Crash rates and the crash rate equation constant values for each highway can be seen in table 4.5.

Table 4.5: Highway Crash rates

Highway	Crashes	Length	AADT (Average)	Crash Rate (per 100 million VKT)	Rank
New England	21	157.7	4653	1.57	1
Bruce	317	1414.8	10931	1.12	2
Warrego	42	605	4609	0.83	3
Landsborough	6	1011.2	631	0.52	4
Flinders	11	743.3	1680	0.48	5
Gore	9	193.4	5502	0.46	6
Cunningham	14	313.1	5600	0.44	7
Barkly	1	323.20	1729	0.10	8

Analysing the highways in relation to overtaking related crashes showed that the New England, Bruce and Warrego highways produce the highest three crash rates. Figure 4.1 displays the three highways that were selected for further analysis.

Figure 4.1: New England, Bruce and Warrego Highways (Google Earth 2016)

4.2 Analysing Highways Crash Prone Selection

The New England, Bruce and Warrego highways have been found to be highways with the highest crash rate within Queensland, determining crash prone sections along these highways is the next process in analysis. Chapter 3 section 3.3 outlines the approach that was taken to determine the crash prone sections. Crash data locations found in section 4.1 were placed onto the satellite images using Google earth software. Crash location coordinates were converted into a KML file then opened in Google earth to display their exact positions along their respective highway. Crash site locations were placed on the satellite image so that a crash spot analysis could be undertaken to visually identify where crash prone sections occur along the highways.

4.2.1 New England Highway Crash Analysis

New England highway starting in Toowoomba and ending at the New South Wales border is a highway which is configured as a two-lane two way road. New England highway is a major transport route for the freighting industry as it links the Queensland capital of Brisbane with the New South Wales capital of Sydney. New England is also a major route for holiday travellers as it links the south states with the north state of Queensland, highway is therefore increasingly busy during school holiday seasons. New England Highway stops in Warwick from the southern direction as the highway comes a part of the Cunningham highway which goes from Warwick and travels towards Brisbane, New England however does continue on towards Toowoomba as it merges off the Cunningham on north side of Warwick.

Terrain of the highway varies between connecting townships, from NSW border through to township of Warwick highway travels through hilly terrain with the road consisting of many curves and grades as the road weaves through the terrain. Terrain between Warwick and Toowoomba consists of mainly level sections of road with few grades spaced out along the section, more curves in the road begins more apparent as the road enters the urban areas of Toowoomba.

New England highway recorded a total of twenty one overtaking related crashes along its entire length in Queensland. New England also received the highest crash rate of all the national highways in Queensland with a crash rate of 1.57 crashes per 100 million VKT. Crash locations along the New England can be seen in figure 4.2.

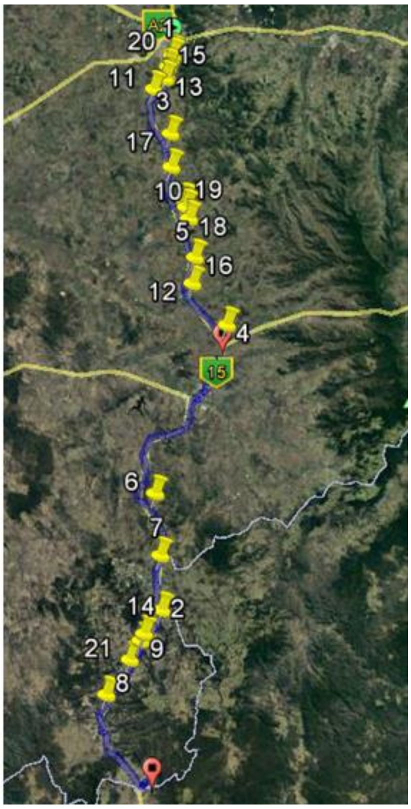


Figure 4.2: New England Highway Crash Locations (Google Earth 2016)

Figure 4.2 was used to analyse crash prone sections along the highway, upon analysing the crash locations it could be seen that there were three sections that appeared to be common sections for crashes to occur. Three apparent crash sections were

1. Between Toowoomba and Cambooya turn off
2. Between Greenmount and Allora
3. Between Stanthorpe and Ballandean

Crash sections now that they were found visually these sections crash data was then analysed to determine their respective crash rates. Crash data was then used to find the percentage that a crash had occurred every kilometre using equation 3.6 from section 3.3 which has previously be stated. Crash rate of each section using equation 3.5 in section 3.2 was than determined through using that sections length and AADT from the 2013 Traffic Census data. Satellite images and through the use of TMR road chainage available on the Queensland Government transport map on Google earth the following lengths were determined:

Table 4.6: New England Crash Section Lengths

Section of Road	Chainage Start (km)	Chainage Finish (km)	Length of Section (km)	Number of Crashes	AADT
Toowoomba-Cambooya (22B)	5	15	10	6	9143
Greenmount-Allora (22B)	32	52	20	5	3320
Stanthorpe-Ballandean (22C)	55	78	23	5	2798

The lengths of each crash section were then used to determine the percentage of crashes per kilometre and the crash rate with respect to daily traffic conditions experienced by each section. AADT was found through traffic census locations within each crash road section. Table 4.7 displays these crash rate figures.

Table 4.7: Crash Rate figures New England Highway Crash Sections

Section of Road	AADT	Crash occurring per kilometre (%)	Crash Rate per 100 million VKT
Toowoomba-Cambooya (22B)	9143	60	3.6
Greenmount-Allora (22B)	3320	25	4.13
Stanthorpe-Ballandean (22C)	2798	21.74	4.26

Table 4.7 shows that section between Toowoomba and Cambooya had the higher percentage of crashes per kilometre and how the section between Stanthorpe and Ballandean had the lowest percentage of crashes per kilometre. Stanthorpe section however returned the highest crash rate of 4.26 per 100 million VKT compared to the Toowoomba section which then returned the lowest crash rate of 3.6 per 100 million VKT. Stanthorpe crash section was therefore chosen to conduct further analysis.

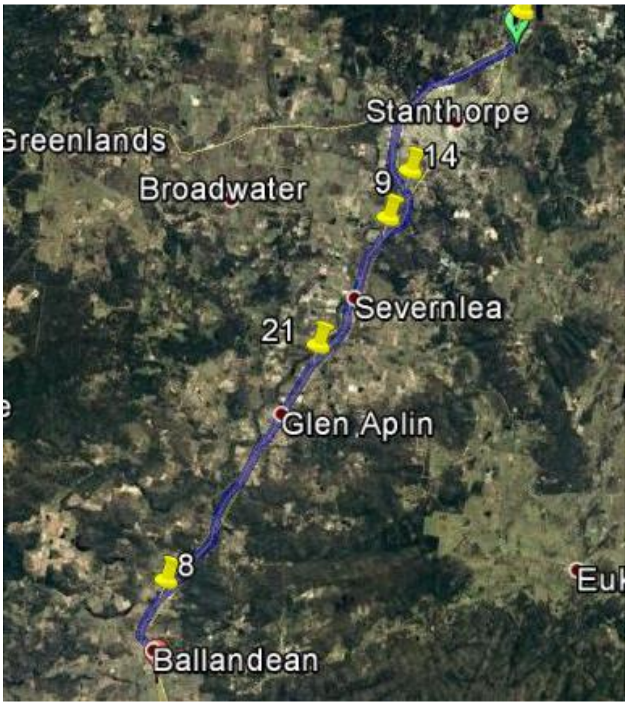


Figure 4.3: New England chosen Crash Section (Google Earth 2016)

Crashes within the Stanthorpe crash section also entailed the most fatalities out of the three road sections with four of the five crashes resulting in a fatality. Four fatal crashes equalled to a total of five fatalities occurring along this section of road. Three of the five crashes also involved a heavy freight vehicle with all three ending in a fatality.

4.2.2 Warrego Highway Crash Analysis

Warrego highway starting in Toowoomba and ending at Charleville is a highway which is configured as a two-lane two way road. Warrego highway is a major transport route for the freighting industry as it links the Queensland capital of

Brisbane with the Northern Territory capital of Darwin. Warrego is also a major freighting route as it is the highway that links the western part of Queensland with the eastern. Highway is well used by heavy freight vehicles as the large townships of Roma, Chinchilla, Dalby and more in western Queensland rely on the freight that is transported alone the Warrego.

Terrain along the Warrego is relatively level as the western side of the Great Dividing Range is level terrain of open farming land and highway encounters a small number of grades along its length. Road alignment along the highway contains numerous straight open sections of road spanning for kilometres which can be seen in figure 4.4.

Warrego highway recorded a total of forty two overtaking related crashes along its entire length in Queensland. Warrego also received the third highest crash rate of all the national highways in Queensland with a crash rate of 0.83 crashes per 100 million VKT. Crash locations along the Warrego can be seen in figure 4.4.

Figure 4.4: Warrego Highway Crash locations (Google Earth 2016)

Figure 4.4 was analysed to determine crash prone sections along the highway. Analysing the crash locations on google earth it was seen that a larger percentage of the crashes occurred at the eastern end of the highway between Toowoomba and Dalby. Analysis also found that as the further the highway travelled west the amount of crashes decreased and crash locations begin to disperse further apart. Dispersion of crash locations on the western end of the highway was predicted as the daily traffic along this section of highway was expected to reduce the further west the highway travels.

Upon analysing the crash locations it could be seen that there were a possible two sections that appeared to be common sections for crashes to occur. Traffic crash locations had to be further analysed in a spreadsheet to determine the spacing between sites as they appeared close together on the satellite images however when analysed they were between twenty kilometres apart. Further analysis off distance between crash sites locations found three apparent crash sections these were:

1. Between Toowoomba and Oakey
2. Between Oakey and Bowenville
3. Between Bowenville and Dalby

Crash sections that were found through visual and analytical methods were then selected to analyse their crash data to determine their respective crash rates. Crash data was used to find the percentage that a crash had occurred every kilometre using equation 3.8 from section 3.3 which has previously be stated. Crash rate of each section using equation 3.7 in section 3.2 was than determined through using that sections length and AADT from the 2013 Traffic Census data. Satellite images and through the use of TMR road chainage available on the Queensland Government transport map on Google earth the following lengths were determined:

Table 4.8: New England Crash Section Lengths

Section of Road	Chainage Start (km)	Chainage Finish (km)	Length of Section (km)	Number of Crashes	AADT
Toowoomba-Oakey (18B)	15	29	14	11	13244
Oakey-Bowenville (18B)	36	59	23	9	6603
Bowenville-Dalby (18B)	68	77	9	3	6603

Lengths of each crash section were then used to determine the percentage of crashes per kilometre and the crash rate with respect to daily traffic conditions experienced by each section. AADT was found through traffic census locations within each crash road section. Table 4.9 displays these crash rate figures.

Table 4.9: Crash Rate figures New England Highway Crash Sections

Section of Road	AADT	Crash occurring per kilometre (%)	Crash Rate per 100 million VKT
Toowoomba-Oakey (18B)	13244	78.57	3.25
Oakey-Bowenville (18B)	6603	39.13	3.25
Bowenville-Dalby (18B)	6603	33.33	2.77

Table 4.9 shows that section between Toowoomba and Oakey had the higher percentage of crashes per kilometre and how the two sections between Oakey and Dalby had the lowest percentage of crashes per kilometre. Two sections however both returned the highest crash rate of 3.25 per 100 million VKT. Both sections were then compared against one another to determine which section to conduct further analysis. Section between Toowoomba and Oakey had a total of three fatal crashes compared to the Oakey to Bowenville section which had a total of five fatal crashes. Involvement of HV is a focus of this project therefore the involvement of HV was compared between the two. Section between Toowoomba and Oakey found that HV had a total involvement four of the eleven crashes. Section between Oakey and Bowenville found that HV had a total involvement of six of the nine crashes. Comparing the fatalities and truck involvement the section from Oakey to Bowenville was chosen to conduct further analysis.

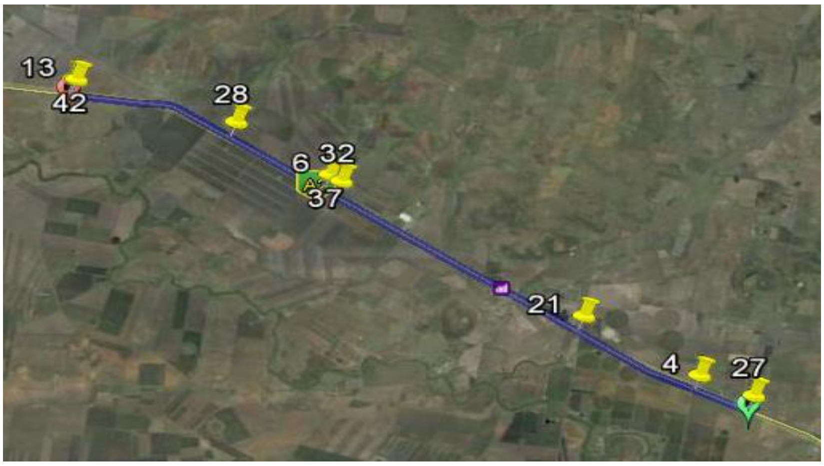


Figure 4.5: Warrego Crash Section from Oakey to Bowenville (Google Earth 2016)

4.2.3 Bruce Highway Crash Analysis

Bruce highway starting in Brisbane and ending at Cairns is a highway which is configured as a two-lane two way roads for a majority of it length. Starting point was Gympie and ending point was Cairns for this project as the highway between Brisbane and Gympie is configured as four lane two way roads. Bruce highway is also like the New England and Warrego as previously mentioned a major transport route for the freighting industry as it links the Queensland capital of Brisbane with the Northern part of Queensland.

Bruce is regarded as a major freighting route as it is the highway that links the northern part of Queensland with the southern part. Highway is well used by heavy freight vehicles as the large townships of Rockhampton, Townsville, Cairns and Mackay and more in along the Queensland coast rely on the freight that is transported alone the Bruce. Bruce also connects the road freight industry with the exporting sea transport as Queensland has many of the country's export ports with many being some of the largest natural resources ports in the world (TMR 2016).

Bruce Highway covers a vast range of terrain as the highway reaches across a large distance. Bruce has terrain from travelling right on coastline to inland mountainous terrain weaving through and over hills along the Queensland coast. Bruce highway covers such a great length that the terrain cannot be classified as a single type. Bruce highway length can be seen in figure 4.6.

Bruce highway recorded a total of 317 overtaking related crashes along its entire length in Queensland. Bruce also received the second highest crash rate of all the national highways in Queensland with a crash rate of 1.12 crashes per 100 million VKT. Bruce highway also recorded the most crashes out of all the highways within Queensland. Crash locations along the Bruce can be seen in figure 4.6.

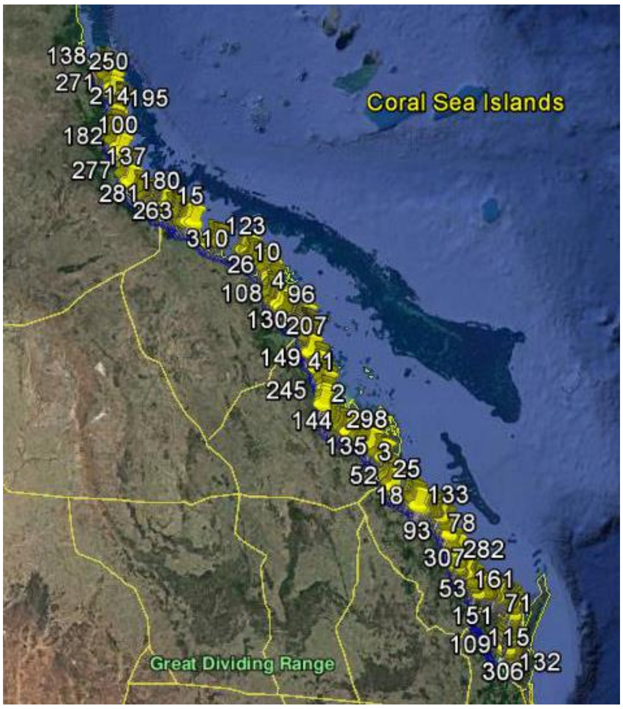


Figure 4.6: Bruce Highway Crash Locations (Google Earth 2016)

Analysing crash prone sections using the satellite images was too difficult to determine, as the highway had so many crash locations it was challenging determining which sections were worse than others. Bruce required a different analysis approach compared to the previous New England and Warrego highways, analysing the crash prone section was conducted through finding the distances between each crash site. Crash site spacing was then analysed to find sections where a group of crashes had occurred within close proximity by finding sections with small spacing distances. Crash data was used to find the percentage that a crash had occurred every kilometre using the total distance between the first crash location and the last crash location through using equation 3.8 from section 3.3 which has previously be stated. Percentage of crashes per kilometre was compared against total amount of crashes; top three sections were found which had the highest percentage of crashes per kilometre. Three selected crash sections were the following:

1. Between Aloomba and Cairns
2. Between Mackay (Glenella) and The Leap
3. Sarina and Mackay

Crash sections that were selected through visual and analytical methods were then used to analyse their crash data to determine their respective crash rates. Crash rate of each section using equation 3.5 in section 3.2 was than determined through using that sections length and AADT from the 2013 Traffic Census data. Satellite images and through the use of TMR road chainage available on the Queensland Government transport map on Google earth the following lengths were determined:

Table 4.10: New England Crash Section Lengths

Section of Road	Chainage Start (km)	Chainage Finish (km)	Length of Section (km)	Number of Crashes	AADT
Aloomba-Cairns (10P)	60	72	12	12	16604
Mackay-The Leap (10H)	5	22	17	12	10305
Sarina-Mackay (10G)	126	148	22	16	7282

Lengths of each crash section were then used to determine the new percentage of crashes per kilometre with respect to section lengths. Crash rate of each section was also found through using the daily traffic conditions experienced by each section. AADT was found through traffic census locations within each crash road section. Table 4.11 displays these crash rate figures.

Table 4.11: Crash Rate figures New England Highway Crash Sections

Section of Road	AADT	Crash occurring per kilometre (%)	Crash Rate per 100 million VKT
Aloomba-Cairns (10P)	16604	100	3.30
Mackay-The Leap (10H)	10305	70.6	3.75
Sarina-Mackay (10G)	7282	72.72	5.47

Table 4.11 shows that section between Sarina and Mackay had the higher crash rate with a rate of 5.47 per 100 million VKT. Table also displays how the Aloomba to Cairns section of highway had the highest crash rate per kilometre with their being a crash every kilometre over that section. Section between Sarina and Mackay had a total of three fatal crashes out of the sixteen crashes that occurred. Crash data also displayed that exactly half of the sixteen crashes

involved a HV, as the section had a HV percentage of 12.36 of the AADT which equalled to 900 HV per day use that section of road. Section between Sarina and Mackay can be seen in figure 4.7.

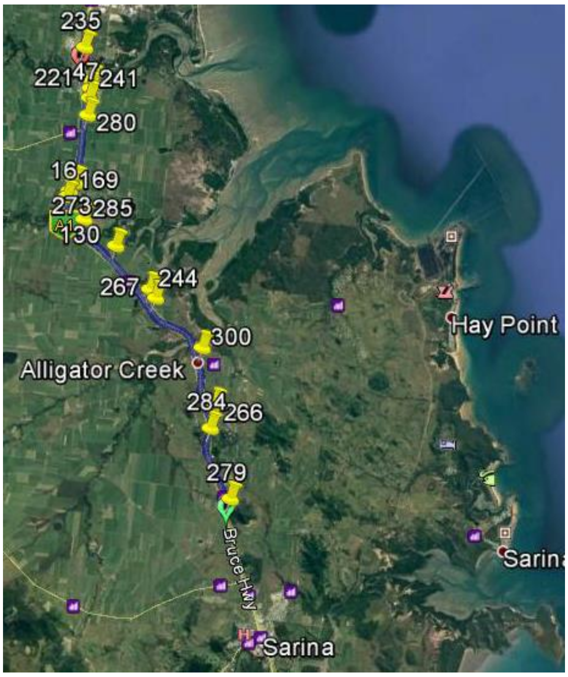


Figure 4.7: Bruce Highway Crash Section between Sarina and Mackay (Google Earth 2016)

4.2.4 AusRap Report Safety Rating

AusRap report released in 2013 was used to review and compare their findings of the Queensland National highways with the crash section findings found in sections 4.2.1 to 4.2.3. AusRap findings were compared against these previous sections findings to determine if the methods undertaken were achieving realistic results.

4.2.5 New England Highway Ratings

AusRap report released the following ratings for the New England Highway.

Table 4.12: AusRap rating for New England Highway (AAA 2013)

15 New England Highway	**92.5**	**0%**	**46%**	**54%**	**0%**	**0%**
Warwick to Stanthorpe	53.2	0%	52%	48%	0%	0%
Stanthorpe to NSW border	39.3	0%	37%	63%	0%	0%

AusRap rating for New England displayed that the section from Stanthorpe to the New South Wales Border received an average of 2.63% for its star safety rating. Crash prone section found in section 4.2.1 was found to be within the Stanthorpe to N.S.W Border section that the AusRap report reviewed. AusRap ratings display that the section between Warwick and Stanthorpe with an average rating of 2.48% although not much different the rating is still lower than the section the crash section was found. AusRap safety ratings are based on road alignment and how safe the road is for vehicles to travel. AusRap report therefore reveals that the New England Highway between Warwick and the N.S.W border has an average safety rating of around 2.5 percent. AusRap findings display that the New England Highway is indeed an unsafe road and that improvements need to be made to increase the roads safety.

4.2.6 Warrego Highway Ratings

AusRap report released the following ratings for the Warrego Highway.

Table 4.13: AusRap rating for Warrego Highway (AAA 2013)

M2/A2 Warrego Highway	586.9	2%	39%	52%	6%	1%
Cunningham Highway to Gatton	55.6	0%	36%	57%	3%	1%
Gatton to Helidon	19.9	0%	0%	70%	30%	0%
Helidon to Toowoomba	15.1	0%	0%	93%	7%	0%
Toowoomba to Dalby	71.3	0%	46%	54%	0%	0%
Dalby to Roma	253.2	0%	48%	47%	5%	0%
Roma to Morven	171.5	7%	31%	53%	7%	2%

AusRap rating for Warrego highway displayed that the section from Toowoomba to Dalby received an average of 2.54% for its star safety rating. Toowoomba to Dalby section of Highway received the lowest rating of the whole length of the Warrego highway. Crash prone section found in section 4.2.2 was found to be within the Toowoomba to Dalby section that the AusRap report reviewed as the most unsafe section of the highway. AusRap safety ratings are based on road alignment and how safe the road is for vehicles to travel. AusRap findings display that the Warrego Highway is indeed an unsafe road and that improvements need to be made to increase the roads safety. AusRap findings support the findings found in section 4.2.2 as the road alignment is unsafe for traffic, as section 4.2.2

found that most of the overtaking related crashes focused on for this project occurred between Toowoomba and Dalby.

4.2.7 Bruce Highway Ratings

AusRap report released the following ratings for the Bruce Highway.

Table 4.14: AusRap rating for Bruce Highway Northbound (AAA 2013)

M1/A1 Bruce Highway	1,555.2	3%	45%	50%	2%	0%
Bald Hills to Caloundra	61.0	0%	5%	66%	30%	0%
Caloundra to Cooroy	41.1	0%	0%	94%	6%	0%
Cooroy to Gympie	38.3	0%	92%	7%	1%	0%
Gympie to Childers	131.1	9%	70%	21%	0%	0%
Childers to Miriam Vale	149.5	6%	39%	54%	1%	0%
Miriam Vale to Rockhampton	162.7	0%	44%	55%	1%	0%
Rockhampton to St Lawrence	164.6	5%	76%	18%	0%	0%
St Lawrence to Sarina	122.5	2%	48%	50%	0%	0%
Sarina to Mackay	23.0	27%	63%	10%	0%	0%
Mackay to Proserpine	118.5	0%	40%	60%	0%	0%
Proserpine to Ayr	163.2	0%	7%	93%	0%	0%
Ayr to Townsvlle	75.1	0%	73%	27%	0%	0%
Townsvlle to Ingham	100.7	0%	34%	63%	2%	0%
Ingham to Innisfail	136.5	2%	46%	51%	1%	0%
Innisfail to Cairns	67.4	5%	52%	43%	1%	0%

Table 4.15: AusRap rating for Bruce Highway Southbound (AAA 2013)

M1/A1 Bruce Highway (southbound)	117.9	1%	3%	74%	19%	3%
Cairns to Innisfail	2.4	0%	0%	50%	50%	0%
Innisfail to Ingham	2.3	0%	0%	100%	0%	0%
Ingham to Townsville	3.6	0%	56%	44%	0%	0%
Townsville to Ayr	0.9	0%	100%	0%	0%	0%
Mackay to Sarina	0.9	33%	67%	0%	0%	0%
Childers to Gympie	2.9	41%	0%	59%	0%	0%
Gympie to Cooroy	3.1	0%	0%	19%	71%	10%
Cooroy to Caloundra	40.8	0%	0%	90%	10%	0%
Caloundra to Bald Hills	61.0	0%	0%	70%	25%	5%

AusRap rating for Bruce highway displayed that the section from Sarina to Mackay received an average of 1.83% for northbound and 1.67% for southbound for its star safety rating. Sarina to Mackay section of Bruce highway received the lowest rating of the whole length of the Bruce highway. Crash prone section found in section 4.2.3 was found to be from Sarina to Mackay that the AusRap report reviewed as the most unsafe section of the highway. AusRap safety ratings are based on road alignment and how safe the road is for vehicles to travel. AusRap findings display that the Bruce Highway between Sarina and Mackay is indeed an unsafe road and that improvements need to be made to increase the roads safety. AusRap findings support the findings found in section 4.2.3 as the road alignment is unsafe for traffic, as section 4.2.3 found that highest crash rate of the highway related to overtaking crashes focused on for this project occurred between Sarina and Mackay.

4.2.8 AusRap Ratings Comparison

AusRap report released in 2013 supports the findings found in sections 4.2.1 to 4.2.3 as all the crash prone sections found are found in the lowest rating sections found in the AusRap report. AusRap ratings found in their report helped to identify that the crash sections found in sections in 4.2 do relate to the safety of that section of road. Comparison of AusRap and findings in section 4.3 displays that these road sections have a road configuration issue and that action needs to be taken to address this safety concern. Figure 3.4 in section 3.3.1 displays the overall map of Queensland’s highway safety ratings.

4.3 Analysis of Overtaking Lane Availability

Availability to overtake slower vehicles is an important aspect to traffic flow on regional highways. Lengths, location and direction of travel was found through applying the methods stated in section 3.4, percentage of road providing overtaking was then found through using methodology presented also in section 3.4.

4.3.1 New England Highway

Available overtaking section lengths for New England section was found through using Google earth which supply's satellite imagery and roadside imagery, overtaking lengths can be seen in table 4.16 and table 4.17.

Table 4.16: New England Highway road section overtaking availability northbound lane

Northbound Travel Direction			
Section	Chainage Start (km)	Chainage end (km)	Length (km)
1	78	77.56	0.44
1st O.L	56.45	55	1.45
2	72.87	72.34	0.53
3	72.12	71.49	0.63
4	70.45	70.15	0.3
5	69.92	69.17	0.75
6	67.36	67.12	0.24
2nd O.L	65.1	64	1.1
7	57.06	56.64	0.42
3rd O.L	56.45	55	1.45

Table 4.17: New England Highway road section overtaking availability southbound lane

Southbound Travel Direction			
Section	Chainage Start (km)	Chainage end (km)	Length (km)
1	56.5	56.82	0.32
1st O.L	63.45	64.6	1.15
2	66.85	67.16	0.31
3	68.95	70.29	1.34
4	71.24	71.88	0.64
5	72.12	72.67	0.55
2nd O.L	73.5	74.5	1
6	77.35	77.79	0.44

Total length of available overtaking sections and the percentage of overtaking provided within the section of highway are presented in table 4.18.

Table 4.18: Total Overtaking lengths on New England Road Section

`	Total Length of O.L (km)	Total Length overtaking available (km)	Proportion of overtaking provided over section (%)
Northbound Lane	4	7.31	31.78
Southbound Lane	2.15	5.75	25

Total length of available overtaking and proportion of overtaking displays that the southbound lane is slightly lower than the northbound lane lanes with the highway providing a quarter to a third of overtaking available along this section of road. Comparison of this proportion of overtaking was compared with the RPDM to determine if the highway is providing adequate overtaking opportunities. Section of road however had to be divided into three sections in order to use the RPDM overtaking demand table, road section was therefore divided into two ten kilometre sections and one three kilometre section. Sections chainage and proportion of overtaking offered can be seen in table 4.19.

Table 4.19: Divided Sections of New England for Comparison with RPDM

Sections Chainage	South bound lane Proportion of Overtaking (%)	North Bound lane Proportion of Overtaking (%)
55 - 65	14.7	28.7
65 - 75	38.4	33.3
75 - 78	14.67	36.33

Design chart for the RPDM displayed in section 3.1.1 stated that the AADT and percentage of HV was required to determine the overtaking demand. AADT had already been found in section 4.2.1 to be 2798 the 2013 traffic census also revealed that the road had a HV percentage of 17.85. Comparison of overtaking demand was conducted through using table 3.1 previously stated in section 3.1.1.

Overtaking opportunity description and the percentage region of overtaking provided for each section can be seen in table 4.20.

Table 4.20: Divided Sections of New England for Comparison with RPDM

Sections Chainage	Southbound lane RPDM overtaking opportunity description	North Bound lane RPDM overtaking opportunity description
55 - 65	Moderate (10-30%)	Moderate (10-30%)
65 - 75	Good (30-70%)	Good (30-70%)
75 - 78	Moderate (10-30%)	Good (30-70%)

RPDM design table comparison displays that at least half of the sections only provide moderate overtaking opportunities therefore these road sections would require more overtaking opportunities. Road sections that equalled to a moderate description all required further overtaking opportunities as design chart stated that with the AADT and percentage of HV using these roads, an AADT of more than 2470 at 20 percent HV would be recommended for overtaking lanes. Overall percentage length providing overtaking for the entire length of the section of highway resulted in a moderate overtaking opportunity description suggesting that more overtaking opportunities are needed.

New England highway however did have overtaking lanes already established; locations of these lanes were in sections 55-65 and 65-75. Placement of these overtaking lanes would therefore meet design tables requirements in providing additional overtaking opportunities. Section 75-78 however did not provide overtaking lanes within this section, as the section was only three kilometres long it was found that there were no overtaking lanes provided if this section was increased to ten kilometres. Section 75-78 would still not meet requirements of design table and overtaking lanes would be required for this section.

4.3.2 Warrego Highway

Available overtaking lengths for Warrego section was found through using Google earth which supply's satellite imagery and roadside imagery, overtaking lengths can be seen in table 4.21 and table 4.22.

Table 4.21: Warrego Highway road section overtaking availability westbound lane

Westbound Travel Direction			
Section	Chainage Start	Chainage end	Length (km)
1	36	41.46	5.46
1st o.l	42	43.25	1.25
2	44	47.76	3.76
3	47.17	49	1.83
2nd o.l	49.11	50.88	1.77
4	51.06	55.53	4.47
5	55.81	56.09	0.28
6	56.48	57.28	0.8
7	57.63	59	1.37

Table 4.22: Warrego Highway road section overtaking availability eastbound lane

Eastbound Travel Direction			
Section	Chainage Start	Chainage end	Length (km)
1	59	57.85	1.15
2	57.49	56.91	0.58
3	56.84	56.57	0.27
4	56.21	55.81	0.4
5	55.58	51.06	4.52
1st o.l	50.88	49.11	1.77
6	49	48.17	0.83
7	47.85	44.67	3.18
8	44.17	44.02	0.15
2 o.l	43.75	42	1.75
9	41.57	36	5.57

Total length of available overtaking sections and the percentage of overtaking provided within the section of highway are presented in table 4.23.

Table 4.23: Total Overtaking lengths on Warrego Road Section

	Total Length of O.L (km)	Total Length overtaking available (km)	Proportion of overtaking provided over section (%)
Westbound Lane	3.02	20.99	91.26
Eastbound Lane	3.52	20.17	87.69

Table 4.23 displayed that both lanes were providing similar lengths of available overtaking and both lanes achieved high proportions of overtaking of the road section. Comparison of this proportion of overtaking was compared with the RPDM to determine if the highway was providing adequate overtaking opportunities. Section of road however had to be divided into three sections in order to use the RPDM overtaking demand table, road section was therefore divided into two ten kilometre sections and one three kilometre section. Sections chainage and proportion of overtaking offered can be viewed in table 4.24.

Table 4.24: Divided Sections of Warrego for Comparison with RPDM

Sections Chainage	West bound lane Proportion of Overtaking (%)	East Bound lane Proportion of Overtaking (%)
36-46	87.1	88
46-56	100	92
56-59	75.33	73.67

Design chart for the RPDM displayed in section 3.1.1 stated that the AADT and percentage of HV was required to determine the overtaking demand. AADT had already been determined in section 4.2.2 to be 6603 the 2013 traffic census displayed that the road had a HV percentage of 26.63. Comparison of overtaking demand was conducted through using table 3.1 previously stated in section 3.1.1.

RPDM overtaking demand design chart could however not be used in this case as the AADT and percentage of HV were values higher than the maximum values displayed in the table it was therefore assumed that the highway would require the further implantation of overtaking lanes. Design table displayed that for a road section with 70-100 percent overtaking opportunities with a HV percentage of 20 required overtaking lanes when AADT was more than 4330. Assumption was therefore made as the AADT and percentage of HV were both larger than this value it would be assumed with a higher percentage of HV the required AADT would be even lower than 4330. Establishment of overtaking lanes would therefore be required to improve the road sections traffic flow.

Warrego highway however did have overtaking lanes already established; locations of these lanes were in sections 36-46 and 46-56. Placement of these overtaking lanes would therefore meet design tables requirements in providing additional overtaking opportunities. Section 56-59 however did not provide overtaking lanes within this section, however as the section was only three kilometres long it was found that overtaking lanes were provided if this section was increased to ten kilometres. Section 56-59 would then meet the requirements of the design table if section length use was longer.

4.3.3 Bruce Highway

Available overtaking lengths for Bruce section was found through using Google earth which supply's satellite imagery and roadside imagery, overtaking lengths can be seen in table 4.25 and table 4.26.

Table 4.25: Bruce Highway road section overtaking availability northbound lane

Northbound			
Section	Chainage Start	Chainage end	Length (km)
1	126.29	126.71	0.42
2	127.27	127.87	0.6
O.L 1	128.25	129.6	1.35
O.L 2	133.7	134.68	0.98
O.L 3	136.9	137.78	0.88
3	138.37	138.64	0.27
4	138.82	139.35	0.53
5	141.47	141.75	0.28
6	142.51	143.23	0.72
7	145.14	145.8	0.66

Table 4.26: Bruce Highway road section overtaking availability southbound lane

Southbound			
Section	Chainage Start	Chainage end	Length (km)
1	146.03	145.26	0.77
O.L 1	144.3	143.55	0.75
2	143.45	142.74	0.71
3	141.94	141.62	0.32
4	139.35	139.04	0.31
5	138.87	138.54	0.33
O.L 2	136	134.45	1.55
O.L 3	131.4	130.4	1
6	128.1	127.48	0.62
7	126.93	126.53	0.4

Total length of available overtaking sections and the percentage of overtaking provided within the section of highway are presented in table 4.27.

Table 4.27: Total Overtaking lengths on Bruce Road Section

	Total Length of O.L (km)	Total Length overtaking available (km)	Proportion of overtaking provided over section (%)
Northbound Lane	3.21	6.69	30.41
Southbound Lane	3.3	6.76	30.73

Table 4.27 displayed that both lanes were providing similar lengths of available overtaking and both lanes achieved a third of overtaking of the road sections entire length. Comparison of this proportion of overtaking was compared with the RPDM to determine if the highway was providing adequate overtaking opportunities. Section of road had to be divided into three sections in order to use the RPDM overtaking demand table, road section was therefore divided into two nine kilometre sections and one four kilometre section. Sections chainage and proportion of overtaking offered can be viewed in table 4.28.

Table 4.28: Divided Sections of Warrego for Comparison with RPDM

Sections Chainage	Northbound lane Proportion of Overtaking (%)	Southbound lane Proportion of Overtaking (%)
126-135	37.22	28.55
135-144	29.78	34.67
144-148	16.5	26.75

Design chart for the RPDM displayed in section 3.1.1 stated that the AADT and percentage of HV was required to determine the overtaking demand. AADT had already been determined in section 4.2.3 to be 7282 the 2013 traffic census displayed that the road had a HV percentage of 12.36. Comparison of overtaking demand was conducted through using table 3.1 previously stated in section 3.1.1.

RPDM design table comparison displayed that four out of six sections only provide moderate overtaking opportunities therefore these road sections would require more overtaking opportunities. Road sections that equalled to a moderate description all required further overtaking opportunities as design chart stated that with the AADT and percentage of HV using these roads, an AADT of more than between 2800-2470 at 10-20 percent HV would be recommended for overtaking lanes. AADT for the Bruce highway was 7282; design table shows that even if the percentage of overtaking length was 70 - 100 the section would still require an overtaking lane as the AADT is still higher than the design table.

Overtaking lanes were provided in both sections 126-135 and 135-144 and therefore these sections comply with the design table; although these sections do provide overtaking lanes the percentage length of overtaking is still very small for a highly travelled road. Section 144-148 provided a very low percentage length of overtaking and therefore would require more overtaking availability, section however when increased from four kilometres becomes dual lanes in both directions as the road enters into Mackay. Section 144-148 would therefore comply when the section is increased with more than four kilometres due to the road alignment changing to dual lanes.

4.3.4 Overtaking Lane Comparison

Analysing the length and spacing of the provided overtaking lanes is vital so that further analysis and strategies can be found. Analysing the overtaking lanes provided will follow the methodology in section 3.4. Overtaking lane locations and lengths were found in previous sections of 4.3 and with satellite imagery and roadside imagery the locations were further analysed.

Overtaking design length as previously mentioned in chapter 3 section 3.1.3 is presented in the RPDM through a design table. Design table seen as table 3.2 presents the absolute minimum, desired minimum and normal maximum lengths of overtaking lane designs required at different design speeds. Design speed of 100 km/hr design chart provided the following:

Absolute minimum: 600 metres

Desirable Minimum: 800 metres

Normal Maximum: 1200 metres

Design Chart value lengths were compared against all the overtaking lane lengths found on all three road sections.

4.3.5 New England Highway Overtaking Lanes

New England highway was found to have two established overtaking lanes in both directions of travel with the northbound lane ending on a long two lane section of road which provides overtaking same as an overtaking lane. Established overtaking lanes chainage start and finish, length; vertical and horizontal alignment; and spacing between each other were found and can be seen in table 4.29.

Table 4.29: New England highways provided overtaking lanes

Section	Chainage Start (km)	Chainage End (km)	Length (km)	Spacing (km)	Horizontal Alignment	Vertical Alignment
SB O.L 1	63.45	64.6	1.15	8.9	Curved	Level
SB O.L 2	73.5	74.5	1		Curved	Level
NB O.L 1	75.65	74.22	1.43	9.12	Straight	Grade
NB O.L 2	65.1	64	1.1		Curved	Level
NB Two Lane Section	56.45	55	1.45	7.55	Straight	Slight Grade then level

Length of all overtaking lanes found within the New England highway section were found to be within design limits, except for the first northbound overtaking lane which had a length of 1.43 kilometres which was more than the normal maximum of 1.2 kilometres. Location of this overtaking lane was located on a considerable grade; overtaking lane was therefore performing as a climbing lane as it allows slower vehicles to climb the grade. Length of the additional lane would have been longer to accommodate for the length of the grade. Harwood's findings in section 2.5 stated that overtaking lanes on grades do not benefit as an overtaking lane however the lane performs as a climbing lane as it prevents bottlenecks at that point in the section of road. Harwood also stated that overtaking lanes on grades do not improve the passing availability over the entire section of road however it only improves overtaking for that point.

Spacing of the overtaking lanes was found to comply with RPDM as it stated that a spacing of 10 to 15 kilometres was desirable length. Objective stated by RPDM was to provide overtaking lanes every 5 kilometres. Spacing lengths found on New England highway were within the design standards of RPDM as spacing's were found to be between desired spacing and long term objective spacing.

4.3.6 Warrego Highway Overtaking Lanes

Warrego highway was found to have two established overtaking lanes in both directions. Established overtaking lanes chainage start and finish, length; vertical and horizontal alignment; and spacing between each other were found and can be seen in table 4.30.

Table 4.30: Warrego Highway provided overtaking lanes

Section	Chainage Start (km)	Chainage End (km)	Length (km)	Spacing (km)	Horizontal Alignment	Vertical Alignment
WB O.L 1	42	43.25	1.25	5.86	straight	level
WB O.L 2	49.11	50.88	1.77		straight	level
EB O.L 1	50.88	49.11	1.77	5.36	straight	level
EB O.L 2	43.75	42	1.75		straight	level

Length of all overtaking lanes found within the Warrego highway section were found to be within design limits with all having lengths longer than the normal maximum. Longer lengths of these overtaking lanes were found to be longer due to the Warrego highway being a route for type one road trains, RPDM design chart states that when road is used by road trains the normal maximum becomes the minimum length the additional lane can be.

Spacing of the overtaking lanes was found to comply with RPDM as it stated that a spacing of 10 to 15 kilometres was desirable length. Objective stated by RPDM was to provide overtaking lanes every 5 kilometres. Spacing lengths found on Warrego highway were within the design standards of RPDM as spacing's were found to be at long term objective spacing.

4.3.7 Bruce Highway Overtaking Lanes

Bruce highway was found to have three overtaking lanes in both directions. Established overtaking lanes chainage start and finish, length; vertical and horizontal alignment; and spacing between each other were found and can be seen in table 4.31.

Table 4.31: Bruce Highway provided overtaking lanes

Section	Chainage Start (km)	Chainage End (km)	Length (km)	Spacing (km)	Horizontal Alignment	Vertical Alignment
NB O.L 1	128.25	129.6	1.35	4.1	Curved	Slight Grade
NB O.L 2	133.7	134.68	0.98	2.22	Curved-open	Level
NB O.L 3	136.9	137.78	0.88		Straight	Level
SB O.L 1	144.3	143.55	0.75	7.55	Straight	Level
SB O.L 2	136	134.45	1.55	3.05	Straight	Level
SB O.L 3	131.4	130.4	1		Curved	Slight Grade

Length of all overtaking lanes found within the Bruce highway section were found to be within design limits with all having lengths within design limits. One section was just below the desirable minimum with a length of 750 metres however still within design limits as minimum length is 600 metres. Two sections Northbound O.L 1 and Southbound O.L 2 were found to have lengths longer than the normal maximum of 1200 metres. Northbound O.L 1 length may have been more than the normal maximum as location was around the base of hill which entailed a slight gradient; length was therefore longer to provide for the length of grade.

Spacing of the overtaking lanes was found to comply with RPDM as all spacing of sections were below the desired 10 to 15 kilometre length. Objective stated by RPDM was to provide overtaking lanes every 5 kilometres. Spacing lengths found on Bruce highway were all within the design standards of RPDM as spacing's were found to be at or close to the desired spacing length.

4.4 Heavy Vehicle Overtaking Length Design Models

Overtaking distance required for heavy vehicles making an overtaking manoeuvre was determine through using methodology from section 3.5. Determining type of heavy vehicles that use each highway was found through TMR website under 'Multi-combination routes and zones in Queensland'. Limiting HV group was determined for each highway so that the minimum overtaking length could be determined for each limiting HV class.

New England Highway limiting HV class allowed on the section of road between Stanthorpe and Ballandean used for analysis was found through using section number two map from the South Queensland map. Limiting class of HV allowed on the New England Highway was found to be 23 and 25 metre B-doubles. Section map for New England Highway can be viewed in appendix.

Warrego Highway limiting HV class allowed on the section of road between Oakey and Bowenville used for analysis was found through using section number 3A map from the South Queensland map. Limiting class of HV allowed on the Warrego highway was found to be type one road trains. Section map for Warrego highway can be viewed in appendix.

Bruce Highway limiting HV class allowed on the section of road between Sarina and Mackay used for analysis was found through using section number ten map from the South Queensland map. Limiting class of HV allowed on the Bruce highway was found to be 23 and 25 metre B-doubles. Section map for Bruce highway can be viewed in appendix.

Limiting HV classes had been determined the maximum length of each class had to then be determined to perform the calculations detailed in methodology 3.5. Length of each HV class was determined through information which had already been specified in section 1.4 of this report. Lengths of each limiting HV class and other vehicle lengths used in calculations can be seen in table 4.32.

Table 4.32: Limiting HV class and vehicle lengths

HV Class	Length (m)
Car	5
Car towing trailer	19
Semitrailer	19
B-doubles	25
Type 1 Road Trains	36.5

Signed speed limit for majority of length of sections on all three highways was found to be a speed limit of 100 km/h. Speed of the slower vehicle being overtaken by these HV classes was set at a speed of 95 km/h for the first analysis and a speed of 90 km/h for the second analysis. Following distance of HV before the overtaking manoeuvre was undertaken was set at two seconds as this was mentioned in section 3.10 as being assumed following distance for HV's. Following distance set for between the slower vehicle and back of HV once overtaking manoeuvre had be completed was set as two seconds as this was mentioned in section 3.10 as being a safe following distance for cars. Following distance however for analysis when a HV was set to overtake another HV was set for between the two HV's once overtaking manoeuvre had be completed was set as two second as this is was assumed following distance for HV's when overtaking.

Analysis tests that were undertaken for both speeds of 95 km/h and 90 km/h were the following:

- Limiting HV overtaking car
- Limiting HV overtaking car towing trailer
- Limiting HV overtaking other HV classes (semitrailer, B-doubles and road trains depending on highway)

Calculations were conducted for three tests for both speeds for both B-doubles and type one road trains as these were the two types of limiting HV classes. Calculations conducted for B-doubles as limiting HV were used for both the New

England and Bruce highway as B-doubles were their highest HV class allowed. Calculations were conducted within an excel spreadsheet which can be viewed in appendix which displays the full calculations taken.

Acceleration rates of both B-doubles and type one road trains was calculated for both speed scenarios of accelerating from 90 km/h and accelerating from 95 km/h. Methodology stated in section 3.5 was followed to generate time and distances required by both HV's to accelerate to 100 km/h, these acceleration values can be viewed in table 4.33.

Table 4.33: Acceleration values for both limiting HV classes

Vehicle Class	Acceleration Rate (m/s^2)	Speed (km/h)	Time (sec)	Distance (m)
B-doubles	0.4	90-100	6.945	183.27
		95-100	3.472	94.041
Type one road trains	0.36	90-100	7.717	203.64
		95-100	3.858	104.49

Acceleration values found revealed that acceleration time and distance between B-doubles and type one road trains were very similar and difference between the two were quite minor. Values achieved shows that when both classes when accelerating from 90 km/h there is only a twenty metre difference between them when they reach 100 km/h, an only a ten metre difference when accelerating from 95 km/h. Total acceleration time between both vehicle classes for both speed scenarios were all within one second of each other showing that acceleration between two HV classes is not highly different. Acceleration values showed that acceleration of HV's does not cover large distance spanning for kilometres however they only accelerate for a maximum distance of approximately 200 metres. Acceleration rate of a semi-trailer was also calculated to compare difference between higher HV classes and single trailer semi-trailer HV class; difference can be seen in figure 4.9 which displays acceleration rates for 90 km/h scenario.

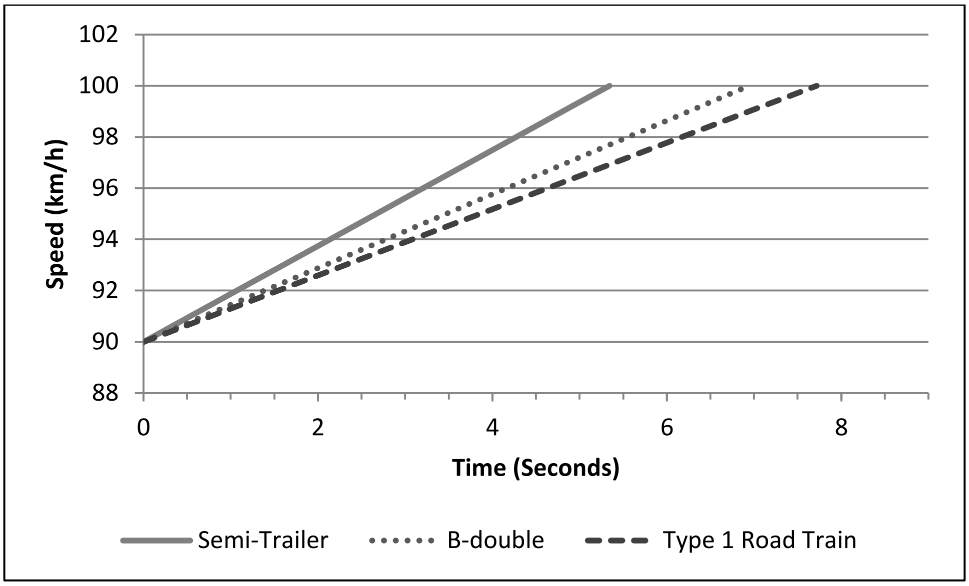


Figure 4.8: Acceleration rates for HV classes for 90-100 km/h scenario

4.4.1 New England and Bruce Highway HV Overtaking Lengths

New England and Bruce highway had B-doubles as their limiting HV class that can access these road sections. Limiting HV class allowed for both twenty-five metre and twenty-three metre length B-doubles, as twenty-five metres was the longest size of HV allowed calculations were conducted using that length. Overtaking lengths required for B-doubles at both speed scenarios for three tests can be seen in table 4.34.

Table 4.34: B-double Overtaking Lengths

Test	Speed (km/h)	Distance (m)
B-double overtaking car	90 -100	1387
	95 -100	2761
B-double overtaking car towing trailer	90 -100	1527
	95 -100	3041
B-double overtaking another B-double	90 -100	1587
	95 -100	3161

Overtaking lengths required for B-doubles to perform a safe manoeuvre display that the long spans of road are required for these HV's to overtake safely.

Overtaking lengths display that length required when slower vehicle is travelling at a speed 5 km/h slower than speed limit it takes very long section of road as all three tests required lengths around three kilometres. Speed scenario at 90 km/h all required an overtaking length of around 1.5 kilometres. Overtaking length required for test overtaking car towing a trailer is also length required to overtake semitrailers as length used for car towing is equal to length of semi-trailers.

4.4.2 Warrego Highway HV Overtaking Lengths

Warrego had type one road trains as their limiting HV class that can access these road sections. Warrego highway allows for type one road trains and also B-doubles, as road trains lengths are greater with a total length of 36.5 metres calculations used road trains length. Overtaking lengths required for type one road trains at both speed scenarios for three tests can be seen in table 4.35.

Table 4.35: Road train overtaking lengths

Test	Speed (km/h)	Distance (m)
Road Train overtaking car	90 -100	1511
	95 -100	3001
Road Train overtaking car towing trailer	90 -100	1651
	95 -100	3281
Road Train overtaking another Road Train	90 -100	1826
	95 -100	3631

Overtaking lengths required for road trains to perform a safe manoeuvre displays that long spans of road are required to overtake safely. Overtaking lengths required when a slower vehicle is travelling at a speed 5 km/h slower than speed limit it takes long section of road as all three tests required lengths around 3-3.5 kilometres. Speed scenario at 90 km/h all required an overtaking length of around 1.5-1.8 kilometres. Overtaking length required for test overtaking car towing a trailer is also length required to overtake semitrailers as length used for car towing is equal to length of semi-trailers.

4.5 Heavy Vehicle Overtaking Length Comparison

Overtaking distances for HV’s found in section 4.4 provided vital values as it allowed for a comparison of lengths to determine if the O.L provided were effectively safe for HV’s to use. OL lengths provided on each of three selected highway sections was previously found in section 4.3 which had the total lengths of all overtaking lanes and also sections of road where overtaking is available. This section a comparison of lengths was done to determine if safe overtaking distances found for HV’s in section 4.4 was accommodated for on each selected section of road for each highway.

4.5.1 New England Highway Length Comparison

New England highway was found in section 4.3 to provide two established overtaking lanes in both directions of travel, with the northbound lane ending on a long two lane section of road which provides overtaking same as an overtaking lane. New England highway also provides a total length of 7.31 kilometres of available overtaking on northbound lane and a total of 5.75 kilometres of available overtaking on southbound lane. Available overtaking lengths were also compared with B-doubles overtaking lengths to determine the amount of sections HV’s have opportunity to overtake. Table 4.36 shows the comparison of lengths that was analysed and displays what sections accommodate for HV’s overtaking.

Table 4.36: New England overtaking available comparison B-double lengths

<table>
<tr><th colspan="8">Southbound Lane</th></tr>
<tr><th colspan="2"></th><th colspan="2">B-double Overtaking Car length (km)</th><th colspan="2">Overtaking Car Towing length (km)</th><th colspan="2">Overtaking B-double length (km)</th></tr>
<tr><th>Overtaking available Section</th><th>Length (km)</th><th>90-100</th><th>95-100</th><th>90-100</th><th>95-100</th><th>90-100</th><th>95-100</th></tr>
<tr><td>1</td><td>0.32</td><td rowspan="8">1.39</td><td rowspan="8">2.76</td><td rowspan="8">1.53</td><td rowspan="8">3.04</td><td rowspan="8">1.59</td><td rowspan="8">3.16</td></tr>
<tr><td>1st O.L</td><td>1.15</td></tr>
<tr><td>2</td><td>0.31</td></tr>
<tr><td>3</td><td>1.34</td></tr>
<tr><td>4</td><td>0.64</td></tr>
<tr><td>5</td><td>0.55</td></tr>
<tr><td>2nd O.L</td><td>1</td></tr>
<tr><td>6</td><td>0.44</td></tr>
<tr><th colspan="8">Northbound lane</th></tr>
<tr><td>1</td><td>0.44</td><td></td><td rowspan="9">2.76</td><td rowspan="9">1.53</td><td rowspan="9">3.04</td><td rowspan="9">1.59</td><td rowspan="9">3.16</td></tr>
<tr><td>1st O.L</td><td>1.43</td><td>1.39</td></tr>
<tr><td>2</td><td>0.53</td><td rowspan="7">1.39</td></tr>
<tr><td>3</td><td>0.63</td></tr>
<tr><td>4</td><td>0.3</td></tr>
<tr><td>5</td><td>0.75</td></tr>
<tr><td>6</td><td>0.24</td></tr>
<tr><td>2nd O.L</td><td>1.1</td></tr>
<tr><td>7</td><td>0.42</td></tr>
</table>

Comparison table 4.36 displayed from all available overtaking sections along New England Highway road section only one section on northbound lane was suitable for a B-double overtaking a car which was travelling 10 km/h slower. Overtaking lane three for the northbound lane previously found in section 4.3.1 could not be compared as this is a dual lane section which spans long distance and speed limit for this section is reduced to 80 km/h to accommodate for increased activity due to nearby urban and commercial areas.

4.5.2 Warrego Highway Length Comparison

Warrego highway in section 4.3.2 was found to have two established overtaking lanes in both directions. Warrego highway was found to provide a total length 20.99 kilometres of available overtaking on westbound lane and a total of 20.17 kilometres of available overtaking on eastbound lane. Available overtaking lengths were compared with road-train overtaking lengths to determine the amount of sections HV's have opportunity to overtake. Table 4.37 shows the comparison of lengths that was analysed and displays what sections accommodate for HV's overtaking.

Table 4.37: Warrego overtaking available comparison type one road train lengths

Westbound Lane							
		Road Train Overtaking Car Length (km)		Overtaking Car Towing Length (km)		Overtaking Road train Length (km)	
Overtaking Available Section	Length (km)	90-100	95-100	90-100	95-100	90-100	95-100
1	5.46						
1st O.L	1.25						
2	3.76						
3	1.83						
2nd O.L	1.77						
4	4.47						
5	0.28						
6	0.8						
7	1.37						
Eastbound Lane							
1	1.15						
2	0.58						
3	0.27						
4	0.4						
5	4.52						
1st O.L	1.77						
6	0.83						
7	3.18						
8	0.15						
2 O.L	1.75						
9	5.57						

Comparison table 4.37 displayed from all available overtaking sections along Warrego Highway road section every overtaking length required by road trains can achieved along at least one overtaking section. Provided overtaking lanes however are seen to not meet all length requirements, as first O.L on westbound lane does not meet any of road trains overtaking length requirements. All other O.L are seen to only fulfil requirements of a road train overtaking a car and also a car towing a trailer both at speed scenario of 90-100km/h. Overtaking opportunities suitable for all road train lengths occurs on sections of road that allows overtaking, however depending on traffic flow these opportunities may not be suitable enough for road trains.

4.5.3 Bruce Highway Length Comparison

Bruce highway was found in section 4.3.3 to have three overtaking lanes in both directions. Bruce highway was found in section 4.3.3 to provide a total length 6.69 kilometres of available overtaking on northbound lane and a total of 6.76 kilometres of available overtaking on southbound lane. Available overtaking lengths were compared with b-double overtaking lengths to determine the amount of sections HV's have opportunity to overtake. Table 4.38 shows the comparison of lengths that was analysed and displays what sections accommodate for HV's overtaking.

Table 4.38: Bruce Highway overtaking available comparison B-double lengths

Northbound							
		B-double Overtaking Car Length (km)		Overtaking Car Towing Length (km)		Overtaking B-double Length (km)	
Overtaking Available Section	Length (km)	90-100	95-100	90-100	95-100	90-100	95-100
1	0.42	1.39	2.76	1.53	3.04	1.59	3.16
2	0.6						
O.L 1	1.35						
O.L 2	0.98						
O.L 3	0.88						
3	0.27						
4	0.53						
5	0.28						
6	0.72						
7	0.66						
Southbound							
1	0.77						
O.L 1	0.75						
2	0.71						
3	0.32						
4	0.31						
5	0.33						
O.L 2	1.55						
O.L 3	1						

6	0.62						
7	0.4						

Comparison table 4.38 displayed from all available overtaking sections along Bruce Highway only one section provided for two overtaking length requirements. Overtaking lane two on southbound lane was only overtaking section that accommodated for two length requirements out of possible six. Overtaking lane satisfied b-double overtaking a car and a car towing both at speed scenario of 90-100 km/h.

4.6 Cost Benefit Analysis

Section 3.7 states the methodology taken to determine cost benefit of HV overtaking lengths. Cost benefit values for additional lane obtained from AAA 2013 report previously displayed in table 3.7 were used to determine cost benefits per kilometre. Cost benefits per kilometre were determined through dividing the cost values by length value of 98 kilometres, thus obtaining costs per kilometre. Table 4.39 displays the cost benefits per kilometre.

Table 4.39: Countermeasure Additional Lane Cost Benefits

Countermeasure	Fatalities and Serious Injuries Saved	Safety Benefit ($ million)	Estimated Cost ($ million)
Additional Lane (2+1 road with barrier)	9.7	4.41	3.68

Cost benefit values determined found that estimated cost of constructing a kilometre section of overtaking lane was 3.68 million dollars which provides a safety benefit of 4.41 million dollars. Kilometre section of overtaking lane was also found to prevent 9.7 fatalities and serious injuries. Table 4.39 values were then used to determine cost benefit of HV overtaking lengths previously found in section 4.4. Table 4.40 displays cost benefits for overtaking lane lengths for b-double class HV.

Table 4.40: Cost Benefit for B-double class HV overtaking lengths

Test	Speed (km/h)	Length (km)	Fatalities and Serious Injuries Saved	Safety Benefit ($ million)	Estimated Cost ($ million)
B-double overtaking car	90 -100	1.4	13	6.1	5.1
	95 -100	2.8	27	12.2	10.2
B-double overtaking car towing trailer	90 -100	1.5	15	6.7	5.6
	95 -100	3.0	30	13.4	11.2
B-double overtaking another B-double	90 -100	1.6	15	7.0	5.8
	95 -100	3.2	31	13.9	11.6

Table 4.40 cost benefit values displayed that smallest overtaking length for a B-double overtaking a car travelling at 90 km/h was found to have the possibility of preventing 13 fatalities and serious injuries. Longest overtaking length of 3.2 kilometres for a B-double overtaking another B-double was found to have the potential of preventing a total of 31 fatalities and serious injuries. Estimated cost of overtaking lanes started from a cost of 5.1 million dollars and was found to increase to a maximum of 11.6 million dollars. Safety benefit was also found to range from 6.1 million dollars to a maximum safety cost benefit of 13.9 million dollars.

Table 4.41 displays the cost benefit values for overtaking lengths for a type I road train class HV.

Table 4.41: Cost Benefit for Road Train Type I class HV overtaking lengths

Test	Speed (km/h)	Length (km)	Fatalities and Serious Injuries Saved	Safety Benefit ($ million)	Estimated Cost ($ million)
Road Train overtaking car	90 -100	1.5	15	6.7	5.6
	95 -100	3.0	29	13.2	11.1
Road Train overtaking car towing trailer	90 -100	1.7	16	7.3	6.1
	95 -100	3.3	32	14.5	12.1
Road Train overtaking another Road Train	90 -100	1.8	18	8.0	6.7
	95 -100	3.6	35	16.0	13.4

Table 4.41 cost benefit values displayed that smallest overtaking length for a road train overtaking a car travelling at 90 km/h was found to have the possibility of preventing 15 fatalities and serious injuries. Longest overtaking length of 3.6 kilometres for a road train overtaking another road train was found to have the potential of preventing a total of 35 fatalities and serious injuries. Estimated cost of overtaking lanes started from a cost of 5.6 million dollars and was found to increase to a maximum of 13.4 million dollars. Safety benefit was also found to range from 6.7 million dollars to a maximum safety cost benefit of 16 million dollars.

Chapter 5

Results

Analysis chapter achieved many results and returned important information about development of overtaking lane design. Analysis of crash data showed that New England, Warrego and Bruce highways were top three highways with worst crash rate for overtaking related crashes which entailed head-on, rear-end and sideswipe crashes. Crash rate data exhibited evidence that highest total amount of crashes does not always mean that highway has a higher crash rate as it depends heavily on amount of AADT. Figure 5.1 and 5.2 display difference between total amounts of crashes compared with crash rates achieved.

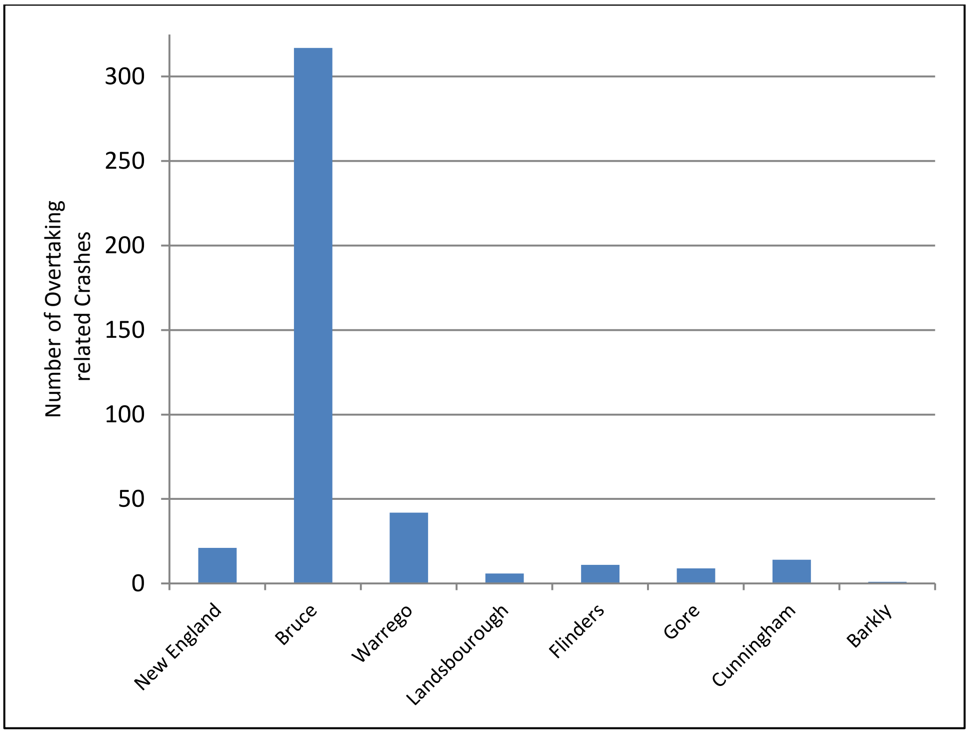


Figure 5.1: Crash Frequency of all Highways analysed

Figure 5.1 displayed that Bruce highway achieved the most crashes with three hundred plus crashes compared to Warrego which had second highest of fifty.

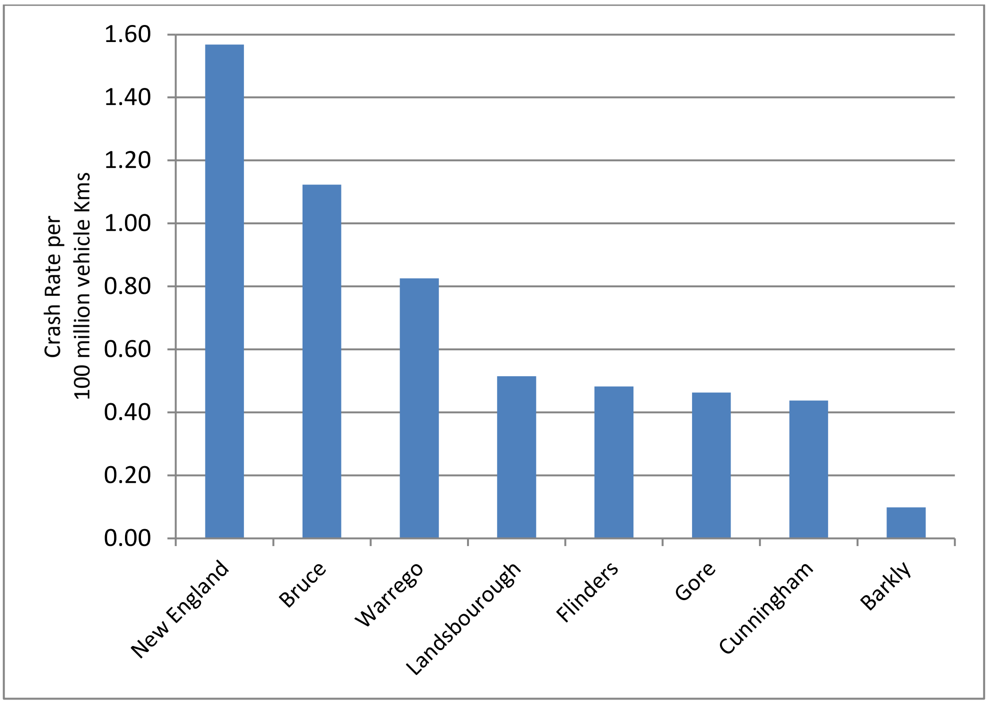


Figure 5.2: Crash rate of all Highways analysed

Figure 5.2 shows that once the crash rates were determined using the AADT and lengths found in analysis chapter the priority of highways changes. Figure 5.1 and 5.2 show how high numbers when looking at crash data does not always mean that particular road is more dangerous than other roads. Results found showed that length and AADT of a road play a key importance to determining which roads are more prone to crashes occurring.

Sections of highway found within section 4.2 showed that selected sections for analysis all shared a common factor. HV involvement was common factor found for the three selected crash zones for each highway. Road sections found with highest crash rate for each highway out of the top three road sections all had the highest amount of HV involvement. High HV involvement in these high crash rate road sections raised assumptions that overtaking for HV's in these road sections was a problem and therefore these sections needed to be further analysed. Figure 5.3 displays the amount of crashes for selected road sections and number of crashes that involved a HV.

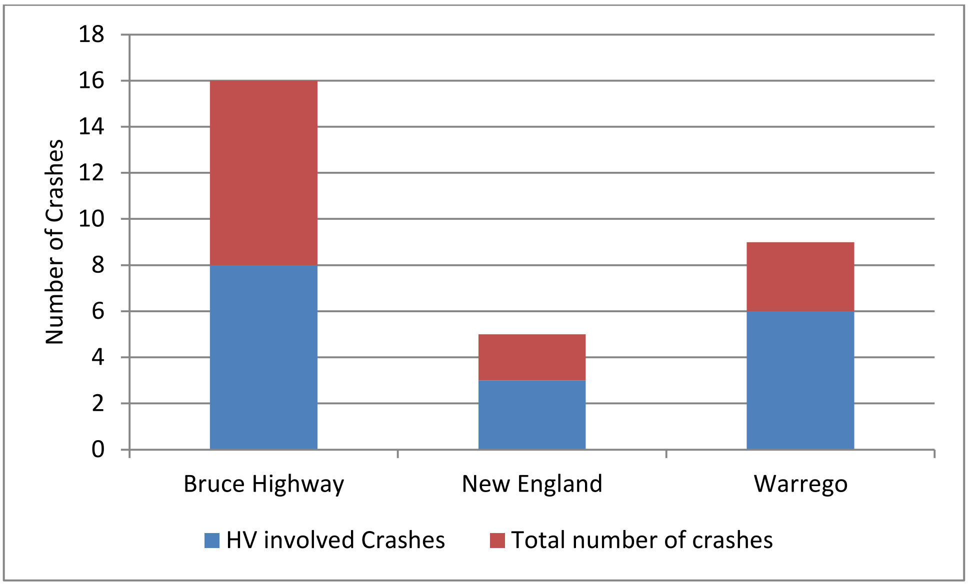


Figure 5.3: HV involvement for each selected section of road for each highway

Bruce had 50 percent of its total crashes involved a HV, New England had 60 percent of its total crashes involved a HV and Warrego had two thirds of its total crashes involve a HV.

Overtaking lengths available provided vital information towards purpose of this project. Analysis conducted in sections 4.3 reported overtaking lengths that were available on three highway sections. Section 4.3 found that all three highways had very different percentages of available overtaking lengths which can be seen in table 5.1.

Table 5.1: Percentage of overtaking available found for each highway

	New England Highway		Warrego Highway		Bruce Highway	
	NB Lane	SB Lane	WB Lane	EB Lane	NB Lane	SB Lane
% Total overtaking availability	31.8	25	91.3	87.7	30.4	30.7
% overtaking provided by O.L	17.3	9.35	13.1	15.3	14.6	15

Analysis found that Warrego highway offered most amount of overtaking opportunities; this was assumed to be due to the level terrain Warrego travels along and the long straights Warrego is aligned with. Table 5.1 values display that percentage of overtaking provided by O.L is relatively small with most values ranging between 10-15 percent of overtaking available from O.L. Table 5.1 shows that the percentage of overtaking provided by O.L on Warrego Highway is comparatively small when compared with its overall overtaking availability percentage.

Length of provided overtaking lanes found in section 4.3 displayed that all overtaking lanes were found to be within design standards of RPDM. Provided lengths of O.L compared with required lengths for HV overtaking manoeuvres showed that a large majority of O.L lengths were not adequate enough to be used for HV's to safely perform an overtake. Section 4.5 revealed that only one overtaking lane on New England provided required length for one of the HV overtaking scenarios. Three of four overtaking lanes on Warrego highway were found to be adequate in length for two of HV overtaking scenarios. Bruce Highway was seen to provide one overtaking lane which could satisfy two of the HV overtaking tests. Figures 5.4 and 5.6 display the overtaking lengths provided compared with overtaking lengths required by the limiting HV for each highway.

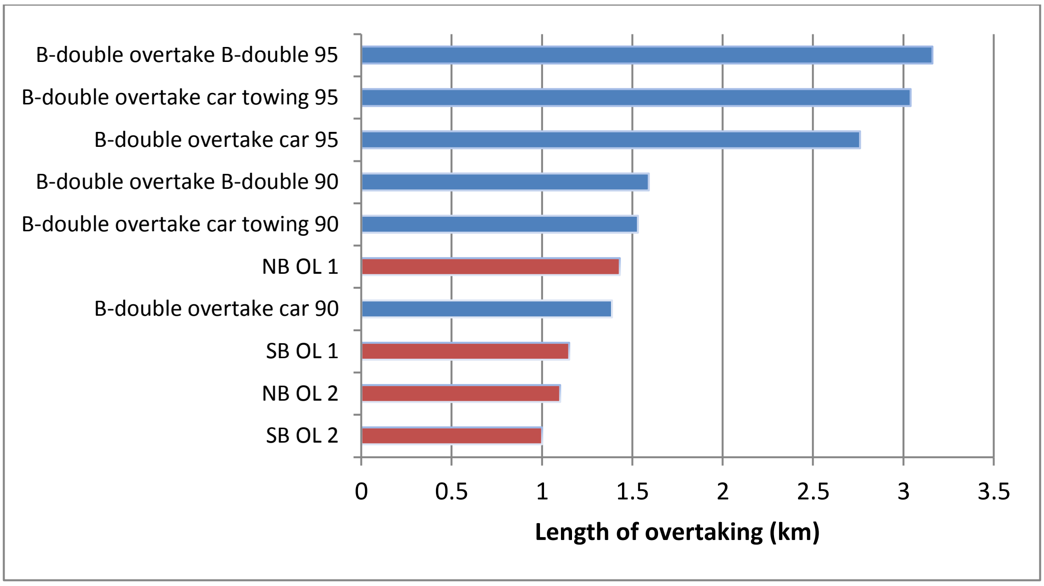


Figure 5.4: Overtaking lengths for New England highway compared with B-double required lengths

1: NB = northbound lane

2: SB = southbound lane

3. 90 = 90-100km/h speed scenario

4. 95 = 95-100 km/h speed scenario

Figure 5.4 displays that only one of the New England Highways overtaking lanes provided meet required length for one of the HV test scenarios. Northbound O.L one however would not meet requirements of HV overtaking as this lane is located on a grade therefore HV's would not be able to build enough speed to perform the overtaking manoeuvre. Overtaking lanes provided on New England are therefore not adequate enough in length to provide suitable and safe overtaking locations for HV's. Figure 5.4 shows that lengths of the overtaking lanes were much lower than any of the required overtaking lengths needed for HV's.

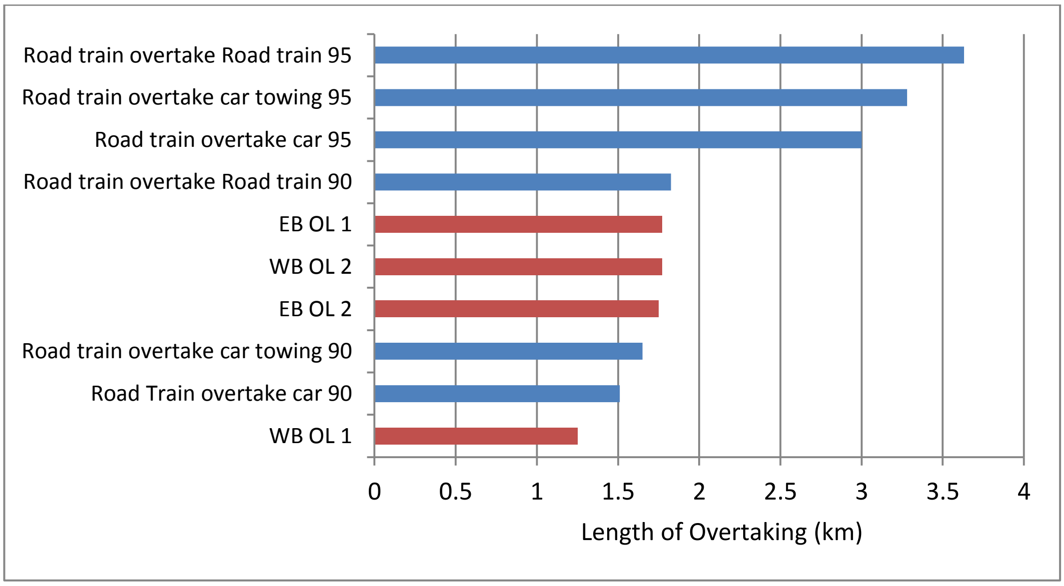


Figure 5.5: Overtaking lengths for Warrego highway compared with Road train required lengths

1: WB = westbound lane
2: EB = eastbound lane
3. 90 = 90-100km/h speed scenario
4. 95 = 95-100 km/h speed scenario

Figure 5.5 displays that three of four of the Warrego Highways overtaking lanes provided meet required length for two of the HV test scenarios. Westbound OL was found to not satisfy any of the required lengths needed for HV's to perform overtaking. Three remaining OL were found to provide an adequate length for HV's to overtake a car and a car towing a trailer at speed of 90 km/h. Overtaking lanes however did not satisfy four of the six HV overtaking test lengths.

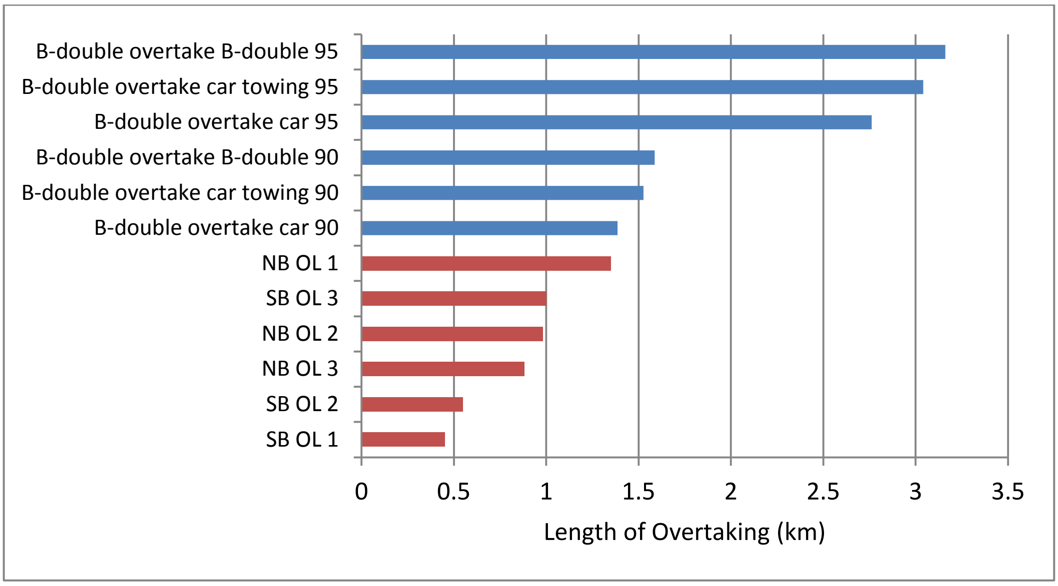


Figure 5.6: Overtaking lengths for Bruce highway compared with B-double required lengths

1: NB = northbound lane

2: SB = southbound lane

3. 90 = 90-100km/h speed scenario

4. 95 = 95-100 km/h speed scenario

Figure 5.6 displays that not one of the Bruce Highways overtaking lanes provided meet required lengths required for HV test scenarios. Figure 5.6 shows that OL lengths provided on Bruce are not adequate enough in length to provide suitable and safe overtaking locations for HV's. Figure 5.6 shows that lengths of the OL were much lower than any of the required overtaking lengths needed for HV's.

Table 5.2 displays percentage of overtaking lanes that satisfy each HV test scenarios required length for each highway.

Table 5.2: Percentage of OL providing required length for HV test lengths

Highway	Overtaking Car length 90 (%)	Overtaking Car length 95 (%)	Overtaking Car Towing length 90 (%)	Overtaking Car Towing length 95 (%)	Overtaking same HV length 90 (%)	Overtaking same HV length 95 (%)
New England	0	0	0	0	0	0
Warrego	75	0	75	0	0	0
Bruce	0	0	0	0	0	0

Table 5.2 shows that only one highway satisfied two test scenarios and that overall most of the provided OL do not satisfy required lengths for HV to overtake slower vehicles safely. HV's are therefore provided with little to no opportunities to overtake slower vehicles safely. HV's therefore have no other options then to either follow slower vehicles until they turn off the road, causing vehicles to queue behind causing congestion and increasing the chances of crashes occurring due to frustrated drivers. Second option for HV drivers is to attempt to overtake slow vehicles at any opportunity provided no matter how safe conditions are; therefore increasing chances of a crash occurring as these HV are forced to perform increasingly unsafe overtakes.

Section 4.6 determined cost benefits of design lengths for HV overtaking lanes. Section 4.6 displayed findings for amount of fatalities and serious injuries that could be saved, safety benefit costs and estimated costs of implementation of each overtaking lane design length for HV's. Table 3.38 from section 4.6 found that for a kilometre section of an additional overtaking lane could prevent 9.7 fatalities and serious injuries from occurring at a cost of 3.68 million dollars. Estimated safety benefits were found to be 4.41 million dollars achieving a benefit cost ratio of 1.2. Results found in section 4.6 demonstrate that a considerable amount of crashes could be prevented with possibility of saving ten fatalities or serious injuries. Figure 5.7 presents the total preventable fatalities and serious injuries for shortest and longest overtaking lengths for both B-double HV's and type I road Train HV's taken from table from table 4.39.

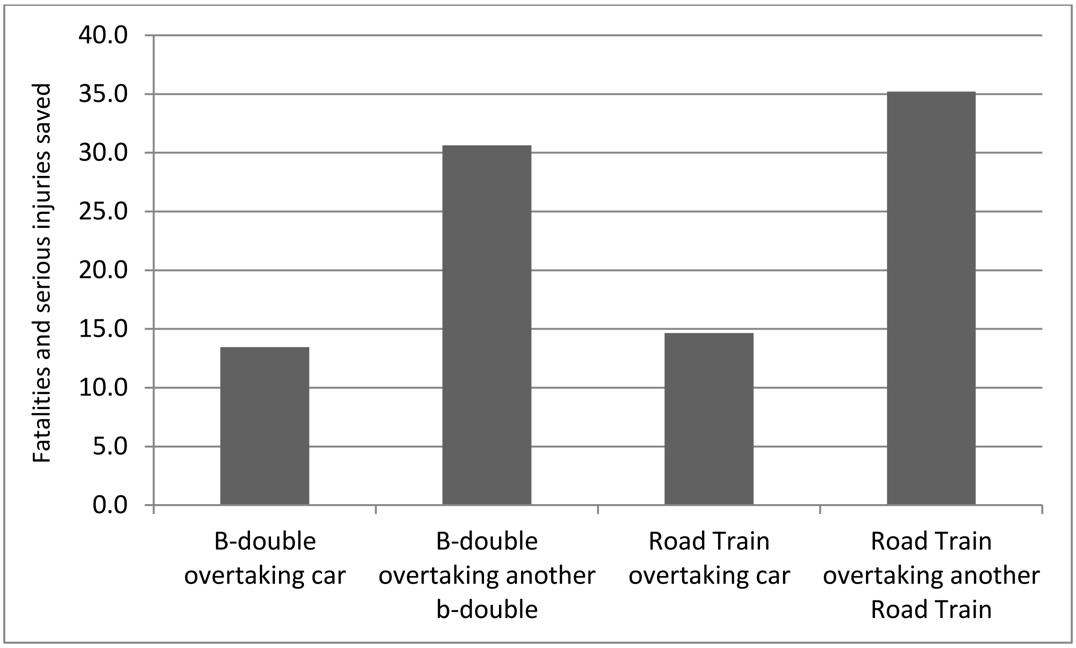


Figure 5.7: Preventable Fatalities for shortest and longest overtaking lengths

Figure 5.7 illustrates that a large amount of fatalities and serious injuries could be made preventable through implementation of HV designed overtaking lanes. Road train overtaking another road train presented highest amount of preventable fatalities with total of 35 at a total cost of 11.6 million dollars for the 3.2 kilometre length OL. Shortest OL lengths for both HV classes were test scenario speed of 90 – 100 km/h and longest OL lengths for both HV classes were test scenario speed of 95 – 100km/h.

Safety costs and estimated costs of construction can be viewed in section 4.6; prevention of fatalities was taken into more consideration as reducing amount of fatalities on rural Queensland roads was seen as a higher importance. Preventing between 13 to 35 fatalities and serious injuries is seen as a positive result to proposing HV OL designs as a great solution to reducing both rural road congestion and also reducing crash rates on Queensland rural roads.

Results discovered throughout this project display that design standards for overtaking lanes do not accommodate for roads largest vehicles being HV’s. Results found show that overtaking lanes provided on selected highways for this project provided little to no opportunities for HV’s to overtake a slower moving vehicle. Findings raised thoughts that if overtaking lanes were designed to accommodate for HV’s this would help to reduce amount of overtaking related crashes as longer OL would provide better opportunities to break up congestion an increase service limit of a section of road. Reducing amount of times that a HV has to enter opposing traffics lane to perform an overtake would be assumed to be of high importance in wanting to reduce head-on, rear-ends and sideswipe overtaking related crashes which were found to have a high fatality rate.

Chapter 6

Conclusions and Further Work

6.1 Conclusion

Outcomes of this project found that New England, Warrego and Bruce Highways were the three highest overtaking related crash rated highways within Queensland. Analysis results then went on to find that section from Stanthorpe to Ballandean was highest overtaking crash prone section along the New England Highway. Section from Oakey to Bowenville was found to be the highest overtaking crash prone section along the Warrego Highway. Section analysis found that section between Sarina and Mackay was the highest overtaking crash prone section for the Bruce Highway.

Findings found within this project displayed that at least 50 percent of all overtaking related crashes involved a HV. Project findings found that provided overtaking lanes on the three selected highway road sections all offered between 10-15 percent of the available overtaking length of road sections. Percentage of length of overtaking provided from OL was far smaller than overall overtaking percentages available with Warrego highway OL providing far smaller percentage of overtaking.

Comparison of provided OL lengths on selected road sections were all within design standards of TMR’s RPDM. OL lengths on New England and Bruce highways were found to be all ranging between desired minimum length and normal maximum desired length. Warrego highway OL lengths were found to be all longer than the design normal maximum desired length, as Warrego Highway is marked as a road train route and therefore OL’s were following design standards through providing longer OL’s on road train routes.

New England and Bruce Highway were found to be a limited route for 25 metre long B-doubles and Warrego highway was found to be a limited route for type one road trains with a length of 365.5 metres. Overtaking distances of these limiting

HV's was determined to compare with the design standards. Results of this study indicated that lengths of provided overtaking lanes on selected highways do not accommodate fully for heavy vehicles wishing to overtake other slower vehicles. Results indicated that for heavy vehicles to overtake safely they require long sections of road to complete the manoeuvre. Report found that provided OL and the lengths recommended in design standards of TMR's RPDM do not provide adequate distances when compared to HV design lengths found within this project.

Cost benefit analysis conducted within this project also supported HV OL design lengths as they provide positive opportunities to preventing and reducing amount of fatalities that could occur along a section of road. Cost benefit analysis findings support HV designed OL as they achieve a total in fatality prevention.

Results found within this project raised thoughts that if overtaking lanes were designed to accommodate for HV's this would help to reduce amount of overtaking related crashes as longer OL's would provide better opportunities to break up congestion an increase service limit of a section of road. Project concludes that overtaking lanes need to be designed for HV as opportunities provided for these types of vehicles to overtake is very little to no opportunities at all. Heavy vehicle designed overtaking lanes are a positive solution to reducing both rural road congestion and also reducing crash rates on Queensland rural roads.

Findings of this report could be reviewed by state and national road authorities to reassess their design standards for overtaking lane. Project results could provide these authorities with information that could be adopted to help reduce regional congestion.

6.2 Further Work

Recommended further work towards this study would to conduct a detailed simulation and analysis using the HV overtaking lengths found within results of this project. Traffic simulation could be conducted through using software like TRARR or simular software so that HV overtaking lengths could be adopted to determine what traffic flow improvements these result lengths could provide. Traffic simulation would have to be focused on HV's overtaking slower vehicles compared to traffic software that focuses on cars overtaking HV. Traffic on Rural Roads (TRARR) is a traffic simulation software program that could be utilized to conduct these further studies. TRARR was previously explained in section 3.8 as this is the program that would've been used to conduct this further work.

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Appendices

Appendix A Project Specification

ENG4111/4112 Research Project

PROJECT SPECIFICATION

For:	**Benjamin Mear**
Title:	Improving Design Standards for Passing Lanes on Rural Highways in Queensland
Major:	Civil Engineering
SUPERVISOR:	Soma Somasundaraswaran
Enrolment:	ENG4111 – ONC S1, 2016 ENG4112 – ONC S2, 2016
Project Aim:	This project seeks to analyse the current standards used in designing Queensland regional highway passing lanes. The project then aims to analyse selected highways to investigate the standards effectiveness and to then develop design improvements to reduce regional traffic congestion.
PROGRAMME:	**Issue C, 10th October 2016**

The objectives of this project are to:

1. Examine the design standards and guidelines used for the design of passing lane in Queensland on rural highways.
2. Analyse crash data and select the three rural highways with the highest crash rates.
3. Analysis of the crash records to determine the most crash prone segments of highway to make relationship between the availability & characteristics of passing lane and crash occurrence.
4. Analyse selected highway segments to examine their compatibility to the required design standards examined in section one.
5. Develop models/methodologies to determine the overtaking length required for heavy vehicles on two-way rural highways in Queensland.
6. Comparison of heavy vehicle overtaking lengths with provided overtaking lane lengths and design standards, then propose strategies for improving design standards to reduce rural congestion and enhance the road safety.
7. Cost benefit analysis of heavy vehicle designed overtaking lanes.

If time and resources permits

8. Use TRARR (Traffic on Rural Roads) or another traffic simulation program to examine the effectiveness of proposed changes to the road alignments.

Title of project was changed from ‘Developing strategies for improving design standards for passing lane design on Rural Highways in Queensland’ to ‘Improving Design Standards for Passing Lanes on Rural Highways in Queensland’ for purposes of pronouncing the project for 2016 project conference. Title was changed to help introduce the topic without having a long title for readers to view. Project objectives were changed throughout the time of the project as the objectives set at the start of the year did not fully understand the processes that would be required to undertake this project. Cost benefit was also added into the objectives after good feedback was received from audience during the project conference and how a cost benefit would help people understand impacts of project.

Appendix B Crash Data

Warrego Highway Crash Data

Crash_Ref_Number	Crash_Severity	Crash_Year	Crash_Nature	Crash_Type	Crash_Longitude_GDA94	Crash_Latitude_GDA94	Crash_Street	Loc_Suburb	Loc_Police_Division	Loc_ABS_Remoteness	Crash_Speed_Limit
165350	Hospitalisation	2009	Sideswipe	Multi-Veh	150.950151	-26.9478	Warrego Hwy	Warra	Chinchilla	Outer regional	100 - 110 km/h
171700	Hospitalisation	2011	Rear-end	Multi-Veh	149.104528	-26.5815	Warrego Hwy	Pickanjinnie	Wallumbi	Remote	80 - 90 km/h
185495	Hospitalisation	2011	Rear-end	Multi-Veh	151.850013	-27.5206	Warrego Hwy	Charlton	Toowoom	Inner regional	80 - 90 km/h
185943	Fatal	2009	Head-on	Multi-Veh	151.645319	-27.3996	Warrego Hwy	Oakey	Oakey	Inner regional	100 - 110 km/h
189013	Hospitalisation	2011	Sideswipe	Multi-Veh	151.099831	-27.0638	Warrego Hwy	Macalister	Dalby	Inner regional	100 - 110 km/h
190036	Hospitalisation	2010	Head-on	Multi-Veh	151.539298	-27.3354	Warrego Hwy	Bowenville	Jondaryan	Inner regional	100 - 110 km/h
191750	Hospitalisation	2009	Rear-end	Multi-Veh	151.741263	-27.4714	Warrego Hwy	Oakey	Oakey	Inner regional	100 - 110 km/h
193572	Hospitalisation	2009	Rear-end	Multi-Veh	151.826949	-27.5077	Warrego Hwy	Kingsthorpe	Oakey	Inner regional	80 - 90 km/h
196605	Hospitalisation	2009	Rear-end	Multi-Veh	151.78572	-27.4887	Warrego Hwy	Kingsthorpe	Oakey	Inner regional	100 - 110 km/h
197030	Fatal	2009	Head-on	Multi-Veh	151.798003	-27.4945	Warrego Hwy	Kingsthorpe	Oakey	Inner regional	100 - 110 km/h
199390	Hospitalisation	2009	Rear-end	Multi-Veh	151.75749	-27.4789	Warrego Hwy	Oakey	Oakey	Inner regional	100 - 110 km/h
210311	Hospitalisation	2009	Rear-end	Multi-Veh	151.846162	-27.5189	Warrego Hwy	Charlton	Oakey	Inner regional	80 - 90 km/h
220253	Fatal	2010	Head-on	Multi-Veh	151.466607	-27.3047	Warrego Hwy	Bowenville	Dalby	Inner regional	100 - 110 km/h
226359	Hospitalisation	2010	Head-on	Multi-Veh	151.78646	-27.4885	Warrego Hwy	Kingsthorpe	Oakey	Inner regional	100 - 110 km/h
229244	Hospitalisation	2011	Rear-end	Multi-Veh	149.160402	-26.5868	Warrego Hwy	Wallumbilla	Wallumbi	Remote	100 - 110 km/h
233048	Hospitalisation	2011	Head-on	Multi-Veh	151.860228	-27.5241	Warrego Hwy	Charlton	Toowoom	Inner regional	80 - 90 km/h
233792	Hospitalisation	2011	Sideswipe	Multi-Veh	150.348481	-26.6753	Warrego Hwy	Columboola	Miles	Outer regional	100 - 110 km/h
233898	Hospitalisation	2009	Rear-end	Multi-Veh	149.916141	-26.6376	Warrego Hwy	Drillham	Dulacca	Remote	100 - 110 km/h
234633	Hospitalisation	2012	Head-on	Multi-Veh	150.665918	-26.7621	Warrego Hwy	Chances Plain	Chinchilla	Outer regional	100 - 110 km/h
236110	Fatal	2011	Head-on	Multi-Veh	149.077722	-26.5849	Warrego Hwy	Pickanjinnie	Wallumbi	Remote	100 - 110 km/h
238639	Fatal	2012	Head-on	Multi-Veh	151.612132	-27.3806	Warrego Hwy	Jondaryan	Jondaryan	Inner regional	100 - 110 km/h
240206	Hospitalisation	2012	Rear-end	Multi-Veh	151.24018	-27.1731	Warrego Hwy	Dalby	Dalby	Inner regional	80 - 90 km/h
240808	Fatal	2012	Head-on	Multi-Veh	150.797688	-26.8482	Warrego Hwy	Brigalow	Chinchilla	Outer regional	100 - 110 km/h
240813	Hospitalisation	2011	Head-on	Multi-Veh	150.831851	-26.8706	Warrego Hwy	Brigalow	Chinchilla	Outer regional	100 - 110 km/h
241201	Hospitalisation	2012	Rear-end	Multi-Veh	151.34792	-27.244	Warrego Hwy	Bowenville	Dalby	Inner regional	100 - 110 km/h
241830	Fatal	2012	Head-on	Multi-Veh	151.815634	-27.5038	Warrego Hwy	Kingsthorpe	Oakey	Inner regional	80 - 90 km/h
242408	Hospitalisation	2012	Sideswipe	Multi-Veh	151.660881	-27.4061	Warrego Hwy	Oakey	Oakey	Inner regional	100 - 110 km/h
243658	Fatal	2012	Sideswipe	Multi-Veh	151.512377	-27.3185	Warrego Hwy	Bowenville	Jondaryan	Inner regional	100 - 110 km/h
244619	Hospitalisation	2013	Head-on	Multi-Veh	151.817766	-27.5048	Warrego Hwy	Kingsthorpe	Oakey	Inner regional	100 - 110 km/h
244931	Hospitalisation	2012	Sideswipe	Multi-Veh	151.71829	-27.4564	Warrego Hwy	Oakey	Oakey	Inner regional	100 - 110 km/h
245087	Hospitalisation	2013	Rear-end	Multi-Veh	151.875347	-27.529	Warrego Hwy	Charlton	Toowoom	Inner regional	80 - 90 km/h
245208	Fatal	2013	Head-on	Multi-Veh	151.542586	-27.3374	Warrego Hwy	Bowenville	Jondaryan	Inner regional	100 - 110 km/h
245603	Hospitalisation	2013	Rear-end	Multi-Veh	148.836766	-26.5757	Warrego Hwy	Roma	Roma	Outer regional	100 - 110 km/h
247464	Hospitalisation	2012	Rear-end	Multi-Veh	0	0	Warrego Hwy	Unknown	Unknown	Unknown	80 - 90 km/h
247679	Fatal	2013	Head-on	Multi-Veh	151.382608	-27.27	Warrego Hwy	Bowenville	Dalby	Inner regional	80 - 90 km/h
247912	Hospitalisation	2013	Rear-end	Multi-Veh	151.807534	-27.4997	Warrego Hwy	Kingsthorpe	Oakey	Inner regional	80 - 90 km/h
248293	Hospitalisation	2013	Rear-end	Multi-Veh	151.53924	-27.3353	Warrego Hwy	Bowenville	Jondaryan	Inner regional	80 - 90 km/h
248382	Fatal	2013	Rear-end	Multi-Veh	151.233607	-27.171	Warrego Hwy	Dalby	Dalby	Inner regional	80 - 90 km/h
249386	Hospitalisation	2013	Rear-end	Multi-Veh	150.411011	-26.6773	Warrego Hwy	Goombi	Chinchilla	Outer regional	100 - 110 km/h
249427	Fatal	2013	Head-on	Multi-Veh	151.321777	-27.2241	Warrego Hwy	Dalby	Dalby	Inner regional	80 - 90 km/h
249776	Fatal	2013	Head-on	Multi-Veh	151.803352	-27.4975	Warrego Hwy	Kingsthorpe	Oakey	Inner regional	100 - 110 km/h
250513	Hospitalisation	2013	Rear-end	Multi-Veh	151.465864	-27.3047	Warrego Hwy	Bowenville	Dalby	Inner regional	80 - 90 km/h

New England Highway Crash Data

Crash_Ref_Number	Crash_Severity	Crash_Year	Crash_Nature	Crash_Type	Crash_Longitude_GDA94	Crash_Latitude_GDA94	Crash_Street	Loc_Suburb	Loc_Local_Government_Area	Loc_ABS_Remoteness	Crash_Speed_Limit
168	Fatal	2009	Head-on	Multi-Vehicle	151.9425	-27.6259	New England	Top Camp	Toowoomba Region	Inner regional	80 - 90 km,
190964	Fatal	2009	Rear-end	Multi-Vehicle	151.9541	-28.6299	New England	Applethorpe	Southern Downs Region	Outer regional	80 - 90 km,
203366	Hospitalis	2009	Rear-end	Multi-Vehicle	151.9322	-27.6646	New England	Hodgson Vale	Toowoomba Region	Inner regional	100 - 110 k
203653	Hospitalis	2010	Rear-end	Multi-Vehicle	152.0652	-28.1147	New England	Glengallan	Southern Downs Region	Inner regional	100 - 110 k
212317	Hospitalis	2010	Rear-end	Multi-Vehicle	151.9767	-27.9023	New England	Missen Flat	Toowoomba Region	Inner regional	100 - 110 k
214371	Fatal	2010	Head-on	Multi-Vehicle	151.9364	-28.4197	New England	Dalveen	Southern Downs Region	Inner regional	100 - 110 k
217890	Hospitalis	2009	Head-on	Multi-Vehicle	151.9496	-28.5314	New England	Cottonvale	Southern Downs Region	Outer regional	100 - 110 k
224719	Fatal	2010	Rear-end	Multi-Vehicle	151.8441	-28.7842	New England	Fletcher	Southern Downs Region	Outer regional	100 - 110 k
225732	Fatal	2010	Head-on	Multi-Vehicle	151.9128	-28.6858	New England	Severnlea	Southern Downs Region	Outer regional	100 - 110 k
236383	Hospitalis	2011	Rear-end	Multi-Vehicle	151.9452	-27.8293	New England	Nobby	Toowoomba Region	Inner regional	100 - 110 k
242635	Hospitalis	2012	Rear-end	Multi-Vehicle	151.906	-27.6875	New England	Cambooya	Toowoomba Region	Inner regional	100 - 110 k
243303	Fatal	2012	Head-on	Multi-Vehicle	151.9932	-28.0406	New England	Allora	Southern Downs Region	Inner regional	80 - 90 km,
243308	Fatal	2012	Head-on	Multi-Vehicle	151.9286	-27.6681	New England	Hodgson Vale	Toowoomba Region	Inner regional	100 - 110 k
243865	Fatal	2012	Head-on	Multi-Vehicle	151.9197	-28.673	New England	Stanthorpe	Southern Downs Region	Outer regional	100 - 110 k
243933	Hospitalis	2012	Rear-end	Multi-Vehicle	151.9347	-27.6457	New England	Hodgson Vale	Toowoomba Region	Inner regional	80 - 90 km,
244317	Hospitalis	2012	Head-on	Multi-Vehicle	151.997	-27.9931	New England	Allora	Southern Downs Region	Inner regional	100 - 110 k
245807	Hospitalis	2013	Head-on	Multi-Vehicle	151.9424	-27.7683	New England	East Greenmoun	Toowoomba Region	Inner regional	100 - 110 k
248747	Hospitalis	2012	Sideswipe	Multi-Vehicle	151.9833	-27.9224	New England	Missen Flat	Toowoomba Region	Inner regional	100 - 110 k
249143	Hospitalis	2013	Head-on	Multi-Vehicle	151.9729	-27.8909	New England	Nevilton	Toowoomba Region	Inner regional	100 - 110 k
249552	Fatal	2013	Head-on	Multi-Vehicle	151.9423	-27.62	New England	Kearneys Spring	Toowoomba Region	Inner regional	80 - 90 km,
251601	Hospitalis	2013	Head-on	Multi-Vehicle	151.8912	-28.7204	New England	Glen Aplin	Southern Downs Region	Outer regional	100 - 110 k

Landsborough Highway Crash Data

Crash_Ref_Number	Crash_Severity	Crash_Year	Crash_Nature	Crash_Type	Crash_Longitude_GDA94	Crash_Latitude_GDA94	Crash_Street	Crash_Street_Intersecting	Loc_Suburb	Loc_Local_Government_Area	Loc_ABS_Remoteness	Crash_Speed_Limit
171045	Fatal	2011	Rear-end	Multi-Vehicle	146.6674	-25.9709	Landsborough Hwy		Clara Creek	Murweh Shire	Very remote	100 - 110 k
210470	Fatal	2010	Sideswipe	Multi-Vehicle	146.6021	-25.6138	Landsborough Hwy		Nive	Murweh Shire	Very remote	100 - 110 k
212975	Fatal	2010	Rear-end	Multi-Vehicle	144.4678	-23.4797	Landsborough Hwy		Ilfracombe	Longreach Region	Very remote	100 - 110 k
224060	Hospitalis	2010	Sideswipe	Multi-Vehicle	146.6069	-25.5432	Landsborough Hwy		Nive	Murweh Shire	Very remote	100 - 110 k
237050	Hospitalis	2011	Rear-end	Multi-Vehicle	142.5776	-21.8429	Landsborough Hwy		Kynuna	Winton Shire	Very remote	100 - 110 k
243312	Hospitalis	2012	Sideswipe	Multi-Vehicle	143.395	-22.5277	Landsborough Hwy		Corfield	Winton Shire	Very remote	100 - 110 k

Gore Highway Crash Data

Crash_Ref_Number	Crash_Severity	Crash_Year	Crash_Nature	Crash_Type	Crash_Longitude_GDA94	Crash_Latitude_GDA94	Crash_Street	Loc_Suburb	Loc_Local_Government_Area	Loc_ABS_Remoteness	Crash_Speed_Limit
185365	Hospitalis	2009	Rear-end	Multi-Vehicle	151.8953	-27.606	Gore Hwy	Drayton	Toowoomba Region	Inner regional	100 - 110 k
190353	Hospitalis	2009	Rear-end	Multi-Vehicle	151.8473	-27.6149	Gore Hwy	Westbrook	Toowoomba Region	Inner regional	100 - 110 k
199448	Fatal	2009	Head-on	Multi-Vehicle	150.3758	-28.2857	Gore Hwy	Goondiwindi	Goondiwindi Region	Outer regional	100 - 110 k
206215	Hospitalis	2011	Rear-end	Multi-Vehicle	151.7442	-27.6361	Gore Hwy	Southbrook	Toowoomba Region	Inner regional	100 - 110 k
212188	Hospitalis	2010	Rear-end	Multi-Vehicle	151.7802	-27.6165	Gore Hwy	Athol	Toowoomba Region	Inner regional	100 - 110 k
241366	Hospitalis	2012	Sideswipe	Multi-Vehicle	151.7125	-27.6711	Gore Hwy	Southbrook	Toowoomba Region	Inner regional	100 - 110 k
244323	Hospitalis	2012	Rear-end	Multi-Vehicle	151.8322	-27.6132	Gore Hwy	Westbrook	Toowoomba Region	Inner regional	100 - 110 k
245476	Hospitalis	2013	Rear-end	Multi-Vehicle	151.8246	-27.6123	Gore Hwy	Westbrook	Toowoomba Region	Inner regional	100 - 110 k
250877	Hospitalis	2013	Rear-end	Multi-Vehicle	151.8279	-27.6127	Gore Hwy	Westbrook	Toowoomba Region	Inner regional	80 - 90 km,

Flinders Highway Crash Data

Crash_Ref_Number	Crash_Severity	Crash_Year	Crash_Nature	Crash_Type	Crash_Longitude_GDA94	Crash_Latitude_GDA94	Crash_Street	Loc_Suburb	Loc_Local_Government_Area	Loc_ABS_Remoteness	Crash_Speed_Limit
178750	Hospitalis	2009	Head-on	Multi-Vehicle	146.8538	-19.5552	Flinders H	Barringha	Townsville City	Outer regional	100 - 110 k
185934	Fatal	2009	Head-on	Multi-Vehicle	146.8367	-19.618	Flinders H	Woodstock	Townsville City	Outer regional	100 - 110 k
191126	Hospitalis	2011	Head-on	Multi-Vehicle	146.8435	-19.5681	Flinders H	Barringha	Townsville City	Outer regional	100 - 110 k
199949	Hospitalis	2009	Head-on	Multi-Vehicle	146.8337	-19.7648	Flinders H	Reid River	Charters Towers Region	Remote	100 - 110 k
213547	Hospitalis	2009	Head-on	Multi-Vehicle	145.532	-20.444	Flinders H	The Cape	Charters Towers Region	Very remote	100 - 110 k
219306	Hospitalis	2010	Head-on	Multi-Vehicle	146.8647	-19.5232	Flinders H	Toonpan	Townsville City	Outer regional	100 - 110 k
233548	Hospitalis	2011	Rear-end	Multi-Vehicle	146.8345	-19.3758	Flinders H	Roseneath	Townsville City	Outer regional	100 - 110 k
235082	Hospitalis	2011	Rear-end	Multi-Vehicle	146.8586	-19.5038	Flinders H	Toonpan	Townsville City	Outer regional	100 - 110 k
243073	Hospitalis	2012	Collision -	Other	143.73	-20.8806	Flinders H	Stamford	Flinders Shire	Very remote	100 - 110 k
244306	Hospitalis	2012	Rear-end	Multi-Vehicle	146.4138	-20.0081	Flinders H	Broughton	Charters Towers Region	Outer regional	100 - 110 k
246249	Hospitalis	2013	Sideswipe	Multi-Vehicle	146.8327	-19.3794	Flinders H	Oak Valley	Townsville City	Outer regional	100 - 110 k

Cunningham Highway Crash Data

Crash_Ref_Number	Crash_Severity	Crash_Year	Crash_Nature	Crash_Type	Crash_Longitude_GDA94	Crash_Latitude_GDA94	Crash_Street	Loc_Suburb	Loc_Local_Government_Area	Loc_ABS_Remoteness	Crash_Speed_Limit
182030	Hospitalisatio	2009	Head-on	Multi-Veh	152.6261	-27.801	Cunningha	Warrill View	Scenic Rim Region	Inner regional	100 - 110 k
184295	Fatal	2009	Rear-end	Multi-Veh	152.6547	-27.7451	Cunningha	Mutdapilly	Scenic Rim Region	Inner regional	100 - 110 k
189911	Hospitalisatio	2009	Head-on	Multi-Veh	152.4482	-28.0414	Cunningha	Clumber	Scenic Rim Region	Inner regional	80 - 90 km,
199172	Fatal	2009	Head-on	Multi-Veh	152.4463	-28.0475	Cunningha	Tarome	Scenic Rim Region	Inner regional	80 - 90 km,
220585	Hospitalisatio	2011	Sideswipe	Multi-Veh	152.5214	-28.0138	Cunningha	Mount Edwards	Scenic Rim Region	Inner regional	100 - 110 k
224133	Hospitalisatio	2010	Head-on	Multi-Veh	152.6052	-27.904	Cunningha	Silverdale	Scenic Rim Region	Inner regional	100 - 110 k
230141	Hospitalisatio	2010	Sideswipe	Multi-Veh	151.8167	-28.1833	Cunningha	Cunningham	Southern Downs Region	Outer regional	100 - 110 k
234429	Fatal	2011	Head-on	Multi-Veh	152.0719	-28.1531	Cunningha	Sladevale	Southern Downs Region	Inner regional	100 - 110 k
237584	Hospitalisatio	2011	Rear-end	Multi-Veh	152.0679	-28.1228	Cunningha	Glengallan	Southern Downs Region	Inner regional	80 - 90 km,
237596	Fatal	2011	Head-on	Multi-Veh	152.5618	-27.9721	Cunningha	Aratula	Scenic Rim Region	Inner regional	100 - 110 k
239952	Hospitalisatio	2012	Rear-end	Multi-Veh	152.5995	-27.9132	Cunningha	Silverdale	Scenic Rim Region	Inner regional	100 - 110 k
243513	Hospitalisatio	2012	Rear-end	Multi-Veh	152.6137	-27.8548	Cunningha	Warrill View	Scenic Rim Region	Inner regional	100 - 110 k
249263	Fatal	2013	Rear-end	Multi-Veh	150.5827	-28.5014	Cunningha	Kurumbul	Goondiwindi Region	Outer regional	100 - 110 k
251265	Hospitalisatio	2013	Head-on	Multi-Veh	151.604	-28.1994	Cunningha	Karara	Southern Downs Region	Outer regional	100 - 110 k

Bruce Highway Crash Data

Crash_Ref	Crash_Sev	Crash_Yea	Crash_Nat	Crash_Typ	Crash_Lon	Crash_Lati	Crash_Str	Crash_Str	Loc_Suburb	Loc_Local_Government_	Loc_ABS_Remoter	Crash_Spe
187	Fatal	2009	Head-on	Multi-Veh	152.7047	-26.2609	Bruce Hwy		Kybong	Gympie Region	Inner regional	80 - 90 km,
151692	Fatal	2009	Head-on	Multi-Veh	149.4618	-22.4093	Bruce Hwy		St Lawrence	Isaac Region	Remote	100 - 110 k
158823	Fatal	2009	Sideswipe	Multi-Veh	150.5587	-23.5355	Bruce Hwy		Midgee	Rockhampton Region	Outer regional	100 - 110 k
160307	Fatal	2009	Head-on	Multi-Veh	148.7896	-20.918	Bruce Hwy		Mount Pelion	Mackay Region	Outer regional	100 - 110 k
164960	Fatal	2009	Head-on	Multi-Veh	152.7107	-26.2892	Bruce Hwy		Kybong	Gympie Region	Inner regional	80 - 90 km,
166944	Hospitalis	2009	Rear-end	Multi-Veh	145.7598	-16.9461	Bruce Hwy		Portsmith	Cairns Region	Outer regional	80 - 90 km,
175383	Hospitalis	2009	Rear-end	Multi-Veh	146.7891	-19.3177	Bruce Hwy		Annandale	Townsville City	Outer regional	80 - 90 km,
175671	Hospitalis	2011	Rear-end	Multi-Veh	145.9659	-17.8888	Bruce Hwy		Midgenoo	Cassowary Coast Region	Outer regional	80 - 90 km,
176583	Fatal	2009	Head-on	Multi-Veh	145.7442	-16.9721	Bruce Hwy		Woree	Cairns Region	Outer regional	80 - 90 km,
178178	Fatal	2009	Head-on	Multi-Veh	148.5912	-20.4766	Bruce Hwy		Goorganga Plair	Whitsunday Region	Outer regional	100 - 110 k
178293	Fatal	2011	Rear-end	Multi-Veh	146.0442	-17.6809	Bruce Hwy		Cowley	Cassowary Coast Region	Outer regional	100 - 110 k
178713	Hospitalis	2009	Sideswipe	Multi-Veh	145.7467	-16.9631	Bruce Hwy		Woree	Cairns Region	Outer regional	80 - 90 km,
179791	Hospitalis	2009	Rear-end	Multi-Veh	146.6294	-19.2271	Bruce Hwy		Black River	Townsville City	Outer regional	100 - 110 k
179901	Fatal	2011	Head-on	Multi-Veh	151.6129	-24.5117	Bruce Hwy		Colosseum	Gladstone Region	Outer regional	100 - 110 k
180438	Hospitalis	2011	Rear-end	Multi-Veh	147.3227	-19.5705	Bruce Hwy		Brandon	Burdekin Shire	Outer regional	100 - 110 k
182483	Hospitalis	2009	Head-on	Multi-Veh	149.1389	-21.2668	Bruce Hwy		Chelona	Mackay Region	Outer regional	100 - 110 k
182574	Hospitalis	2009	Head-on	Multi-Veh	149.5241	-22.1558	Bruce Hwy		St Lawrence	Isaac Region	Remote	100 - 110 k
183170	Hospitalis	2011	Head-on	Multi-Veh	151.0808	-23.9453	Bruce Hwy		West Stowe	Gladstone Region	Inner regional	80 - 90 km,
184089	Fatal	2009	Rear-end	Multi-Veh	146.0363	-17.5613	Bruce Hwy	Comoon L	Comoon Loop	Cassowary Coast Region	Outer regional	80 - 90 km,
184106	Fatal	2009	Sideswipe	Multi-Veh	145.7682	-17.0495	Bruce Hwy		Wrights Creek	Cairns Region	Outer regional	100 - 110 k
184503	Hospitalis	2010	Rear-end	Multi-Veh	146.6871	-19.2513	Bruce Hwy		Deeragun	Townsville City	Outer regional	80 - 90 km,
185259	Fatal	2011	Head-on	Multi-Veh	148.6968	-20.8487	Bruce Hwy		Yalboroo	Mackay Region	Outer regional	100 - 110 k
185449	Hospitalis	2010	Sideswipe	Multi-Veh	148.5097	-20.2994	Bruce Hwy	Collinvale	Gregory River	Whitsunday Region	Outer regional	100 - 110 k
186415	Hospitalis	2011	Rear-end	Multi-Veh	152.2366	-25.2167	Bruce Hwy		Apple Tree Cree	Bundaberg Region	Inner regional	80 - 90 km,
187066	Fatal	2010	Head-on	Multi-Veh	150.9258	-23.7845	Bruce Hwy	Sinclair St	Ambrose	Gladstone Region	Outer regional	100 - 110 k
189404	Hospitalis	2009	Rear-end	Multi-Veh	148.5913	-20.4261	Bruce Hwy		Breadalbane	Whitsunday Region	Outer regional	100 - 110 k
189510	Hospitalis	2009	Head-on	Multi-Veh	146.1655	-18.6232	Bruce Hwy		Hawkins Creek	Hinchinbrook Shire	Remote	100 - 110 k
189592	Fatal	2011	Head-on	Multi-Veh	152.4682	-25.3104	Bruce Hwy		Cherwell	Fraser Coast Region	Inner regional	100 - 110 k
190379	Hospitalis	2009	Rear-end	Multi-Veh	152.7119	-26.2821	Bruce Hwy		Kybong	Gympie Region	Inner regional	80 - 90 km,
190732	Hospitalis	2009	Rear-end	Multi-Veh	145.7505	-17.0321	Bruce Hwy		Mount Peter	Cairns Region	Outer regional	80 - 90 km,
190965	Fatal	2009	Head-on	Multi-Veh	152.6122	-25.6753	Bruce Hwy		Owanyilla	Fraser Coast Region	Inner regional	100 - 110 k
191859	Hospitalis	2011	Rear-end	Multi-Veh	145.7469	-16.9669	Bruce Hwy		Woree	Cairns Region	Outer regional	80 - 90 km,
191930	Hospitalis	2011	Sideswipe	Multi-Veh	145.7604	-17.0396	Bruce Hwy		Wrights Creek	Cairns Region	Outer regional	80 - 90 km,
192002	Hospitalis	2009	Head-on	Multi-Veh	148.4979	-20.2917	Bruce Hwy		Gregory River	Whitsunday Region	Outer regional	100 - 110 k
194379	Hospitalis	2009	Head-on	Multi-Veh	145.9074	-18.087	Bruce Hwy		Bilyana	Cassowary Coast Region	Remote	100 - 110 k
194524	Hospitalis	2011	Head-on	Multi-Veh	145.7671	-17.0451	Bruce Hwy		Wrights Creek	Cairns Region	Outer regional	80 - 90 km,
194588	Hospitalis	2009	Rear-end	Multi-Veh	145.759	-17.0388	Bruce Hwy		Wrights Creek	Cairns Region	Outer regional	80 - 90 km,
194907	Hospitalis	2009	Rear-end	Multi-Veh	146.6136	-19.2221	Bruce Hwy		Black River	Townsville City	Outer regional	100 - 110 k
195040	Hospitalis	2009	Rear-end	Multi-Veh	146.6434	-19.2297	Bruce Hwy		Jensen	Townsville City	Outer regional	100 - 110 k
195092	Hospitalis	2009	Sideswipe	Multi-Veh	149.1007	-21.1086	Bruce Hwy		Farleigh	Mackay Region	Outer regional	100 - 110 k
195096	Hospitalis	2010	Head-on	Multi-Veh	149.5113	-22.1648	Bruce Hwy		St Lawrence	Isaac Region	Remote	100 - 110 k
195099	Hospitalis	2009	Sideswipe	Multi-Veh	146.7776	-19.3177	Bruce Hwy		Annandale	Townsville City	Outer regional	80 - 90 km,
195416	Hospitalis	2009	Rear-end	Multi-Veh	146.0212	-17.787	Bruce Hwy		Daveson	Cassowary Coast Region	Outer regional	100 - 110 k
195631	Hospitalis	2011	Rear-end	Multi-Veh	152.3245	-25.2472	Bruce Hwy		Horton	Bundaberg Region	Inner regional	100 - 110 k
196366	Hospitalis	2011	Head-on	Multi-Veh	149.4575	-21.991	Bruce Hwy		Clairview	Isaac Region	Remote	100 - 110 k
196894	Hospitalis	2010	Rear-end	Multi-Veh	148.5959	-20.7058	Bruce Hwy		Bloomsbury	Mackay Region	Outer regional	80 - 90 km,
197674	Hospitalis	2011	Rear-end	Multi-Veh	149.1478	-21.2305	Bruce Hwy		Rosella	Mackay Region	Inner regional	100 - 110 k
197782	Hospitalis	2009	Head-on	Multi-Veh	149.1354	-21.1155	Bruce Hwy		Glenella	Mackay Region	Inner regional	100 - 110 k
198922	Hospitalis	2011	Rear-end	Multi-Veh	150.5	-23.4194	Bruce Hwy		Port Curtis	Rockhampton Region	Inner regional	80 - 90 km,
199445	Fatal	2009	Head-on	Multi-Veh	149.0007	-21.068	Bruce Hwy		The Leap	Mackay Region	Outer regional	100 - 110 k
200069	Hospitalis	2010	Rear-end	Multi-Veh	145.7462	-16.9681	Bruce Hwy		Woree	Cairns Region	Outer regional	80 - 90 km,
200320	Fatal	2009	Head-on	Multi-Veh	150.6394	-23.6487	Bruce Hwy		Bajool	Rockhampton Region	Outer regional	100 - 110 k
200533	Hospitalis	2010	Rear-end	Multi-Veh	151.7036	-24.814	Bruce Hwy		Kolonga	Bundaberg Region	Outer regional	100 - 110 k
200687	Hospitalis	2009	Rear-end	Multi-Veh	149.1663	-21.1346	Bruce Hwy		Mackay	Mackay Region	Inner regional	80 - 90 km,
200753	Hospitalis	2009	Sideswipe	Multi-Veh	152.6039	-25.929	Bruce Hwy		Glenwood	Fraser Coast Region	Inner regional	100 - 110 k
200809	Hospitalis	2010	Head-on	Multi-Veh	151.3297	-24.002	Bruce Hwy		Benaraby	Gladstone Region	Inner regional	80 - 90 km,

200906	Hospitalis	2009	Rear-end	Multi-Veh	145.9478	-18.1948	Bruce Hwy		Kennedy	Cassowary Coast Region	Remote	100 - 110 k
200933	Fatal	2010	Head-on	Multi-Veh	150.1319	-22.9072	Bruce Hwy		Canoona	Livingstone Shire	Outer regional	100 - 110 k
201954	Hospitalis	2011	Rear-end	Multi-Veh	145.7441	-16.9727	Bruce Hwy		Woree	Cairns Region	Outer regional	80 - 90 km,
202156	Hospitalis	2009	Rear-end	Multi-Veh	148.1316	-20.0093	Bruce Hwy		Bowen	Whitsunday Region	Outer regional	100 - 110 k
202786	Hospitalis	2009	Head-on	Multi-Veh	146.0328	-17.5488	Bruce Hwy		South Innisfail	Cassowary Coast Region	Outer regional	80 - 90 km,
202960	Hospitalis	2009	Rear-end	Multi-Veh	149.1631	-21.129	Bruce Hwy	Rockleigh	Mount Pleasant	Mackay Region	Inner regional	80 - 90 km,
203000	Hospitalis	2009	Sideswipe	Multi-Veh	152.4864	-25.3127	Bruce Hwy		Cherwell	Fraser Coast Region	Inner regional	100 - 110 k
203043	Hospitalis	2009	Rear-end	Multi-Veh	146.682	-19.248	Bruce Hwy		Deeragun	Townsville City	Outer regional	80 - 90 km,
203336	Hospitalis	2009	Rear-end	Multi-Veh	145.7441	-17.0031	Bruce Hwy		Edmonton	Cairns Region	Outer regional	80 - 90 km,
203535	Hospitalis	2009	Rear-end	Multi-Veh	146.6849	-19.2497	Bruce Hwy		Deeragun	Townsville City	Outer regional	80 - 90 km,
203638	Fatal	2009	Head-on	Multi-Veh	150.0382	-22.8897	Bruce Hwy		Kunwarara	Livingstone Shire	Remote	100 - 110 k
203643	Hospitalis	2011	Rear-end	Multi-Veh	145.7683	-17.0512	Bruce Hwy	Pine Cree	Gordonvale	Cairns Region	Outer regional	80 - 90 km,
204061	Hospitalis	2010	Rear-end	Multi-Veh	148.0992	-20.0092	Bruce Hwy		Bowen	Whitsunday Region	Outer regional	100 - 110 k
204078	Fatal	2009	Head-on	Multi-Veh	150.5393	-23.4801	Bruce Hwy		Midgee	Rockhampton Region	Outer regional	100 - 110 k
205728	Hospitalis	2009	Head-on	Multi-Veh	152.374	-25.2651	Bruce Hwy		Isis River	Bundaberg Region	Inner regional	100 - 110 k
206676	Hospitalis	2009	Rear-end	Multi-Veh	152.5739	-26.1241	Bruce Hwy		Bells Bridge	Gympie Region	Inner regional	80 - 90 km,
206720	Hospitalis	2010	Sideswipe	Multi-Veh	152.5898	-25.8495	Bruce Hwy		Bauple	Fraser Coast Region	Inner regional	100 - 110 k
206792	Hospitalis	2009	Sideswipe	Multi-Veh	152.5989	-25.9578	Bruce Hwy		Glenwood	Gympie Region	Inner regional	100 - 110 k
206800	Hospitalis	2011	Rear-end	Multi-Veh	147.1019	-19.553	Bruce Hwy		Giru	Burdekin Shire	Outer regional	100 - 110 k
206836	Hospitalis	2011	Rear-end	Multi-Veh	152.6994	-26.2377	Bruce Hwy		Kybong	Gympie Region	Inner regional	80 - 90 km,
207082	Hospitalis	2009	Sideswipe	Multi-Veh	151.7566	-24.8892	Bruce Hwy		Takilberan	Bundaberg Region	Outer regional	100 - 110 k
207091	Hospitalis	2009	Head-on	Multi-Veh	151.4003	-24.0662	Bruce Hwy		Iveragh	Gladstone Region	Inner regional	100 - 110 k
207092	Hospitalis	2009	Rear-end	Multi-Veh	149.1198	-21.1152	Bruce Hwy	Glendarag	Glenella	Mackay Region	Inner regional	100 - 110 k
207095	Fatal	2011	Head-on	Multi-Veh	152.6393	-25.6362	Bruce Hwy		Glenorchy	Fraser Coast Region	Inner regional	100 - 110 k
207102	Fatal	2011	Head-on	Multi-Veh	151.7238	-24.8688	Bruce Hwy		Takilberan	Bundaberg Region	Outer regional	80 - 90 km,
207106	Fatal	2011	Sideswipe	Multi-Veh	149.1659	-21.1331	Bruce Hwy		North Mackay	Mackay Region	Inner regional	80 - 90 km,
207176	Hospitalis	2009	Rear-end	Multi-Veh	145.7964	-17.1042	Bruce Hwy		Aloomba	Cairns Region	Outer regional	100 - 110 k
207774	Hospitalis	2011	Rear-end	Multi-Veh	146.0106	-17.7956	Bruce Hwy		El Arish	Cassowary Coast Region	Outer regional	80 - 90 km,
207925	Hospitalis	2010	Head-on	Multi-Veh	146.0543	-18.305	Bruce Hwy		Damper Creek	Cassowary Coast Region	Remote	100 - 110 k
208309	Hospitalis	2010	Head-on	Multi-Veh	146.0183	-17.7896	Bruce Hwy		Daveson	Cassowary Coast Region	Outer regional	100 - 110 k
208715	Hospitalis	2009	Head-on	Multi-Veh	145.9425	-17.9927	Bruce Hwy		Silky Oak	Cassowary Coast Region	Outer regional	100 - 110 k
209021	Hospitalis	2011	Head-on	Multi-Veh	152.3761	-25.2694	Bruce Hwy		Isis River	Bundaberg Region	Inner regional	80 - 90 km,
209102	Hospitalis	2010	Rear-end	Multi-Veh	152.3204	-25.2469	Bruce Hwy	Conlons R	South Isis	Bundaberg Region	Inner regional	100 - 110 k
209250	Hospitalis	2011	Sideswipe	Multi-Veh	152.5978	-25.7528	Bruce Hwy		Tiaro	Fraser Coast Region	Inner regional	100 - 110 k
209286	Hospitalis	2010	Head-on	Multi-Veh	147.596	-19.8361	Bruce Hwy		Gumlu	Whitsunday Region	Outer regional	100 - 110 k
209288	Hospitalis	2010	Head-on	Multi-Veh	152.447	-25.3035	Bruce Hwy		Cherwell	Fraser Coast Region	Inner regional	100 - 110 k
209405	Hospitalis	2009	Rear-end	Multi-Veh	151.0973	-23.9468	Bruce Hwy		West Stowe	Gladstone Region	Inner regional	100 - 110 k
209462	Hospitalis	2010	Rear-end	Multi-Veh	149.166	-21.1337	Bruce Hwy		North Mackay	Mackay Region	Inner regional	80 - 90 km,
209628	Hospitalis	2010	Rear-end	Multi-Veh	146.6852	-19.2503	Bruce Hwy		Deeragun	Townsville City	Outer regional	80 - 90 km,
210049	Hospitalis	2011	Rear-end	Multi-Veh	149.1663	-21.1348	Bruce Hwy		West Mackay	Mackay Region	Inner regional	80 - 90 km,
210056	Hospitalis	2011	Rear-end	Multi-Veh	145.7442	-17.0037	Bruce Hwy		Edmonton	Cairns Region	Outer regional	80 - 90 km,
210063	Hospitalis	2011	Rear-end	Multi-Veh	145.7442	-17.0046	Bruce Hwy	Robert Rd	Bentley Park	Cairns Region	Outer regional	80 - 90 km,
210251	Fatal	2010	Head-on	Multi-Veh	151.1222	-23.9572	Bruce Hwy		West Stowe	Gladstone Region	Inner regional	100 - 110 k
211069	Fatal	2010	Head-on	Multi-Veh	146.1005	-18.3893	Bruce Hwy		Damper Creek	Cassowary Coast Region	Remote	100 - 110 k
211409	Hospitalis	2011	Rear-end	Multi-Veh	146.0384	-17.5709	Bruce Hwy		Comoon Loop	Cassowary Coast Region	Outer regional	100 - 110 k
212976	Fatal	2010	Head-on	Multi-Veh	152.5934	-26.1349	Bruce Hwy		Chatsworth	Gympie Region	Inner regional	80 - 90 km,
213358	Hospitalis	2010	Rear-end	Multi-Veh	146.7506	-19.3211	Bruce Hwy		Douglas	Townsville City	Outer regional	80 - 90 km,
213640	Hospitalis	2010	Head-on	Multi-Veh	152.4269	-25.2951	Bruce Hwy		Cherwell	Fraser Coast Region	Inner regional	100 - 110 k
213644	Fatal	2010	Head-on	Multi-Veh	146.9921	-19.3917	Bruce Hwy		Alligator Creek	Townsville City	Outer regional	100 - 110 k
213740	Hospitalis	2010	Rear-end	Multi-Veh	146.6963	-19.2886	Bruce Hwy	Dalrymple	Shaw	Townsville City	Outer regional	80 - 90 km,
214178	Hospitalis	2010	Rear-end	Multi-Veh	145.7443	-17.0041	Bruce Hwy		Edmonton	Cairns Region	Outer regional	80 - 90 km,
214738	Hospitalis	2011	Head-on	Multi-Veh	148.7362	-20.8717	Bruce Hwy		Pindi Pindi	Mackay Region	Outer regional	100 - 110 k
214809	Hospitalis	2011	Head-on	Multi-Veh	152.597	-25.8888	Bruce Hwy		Gootchie	Fraser Coast Region	Inner regional	100 - 110 k
215062	Hospitalis	2010	Rear-end	Multi-Veh	146.701	-19.2606	Bruce Hwy	North Sho	Shaw	Townsville City	Outer regional	80 - 90 km,
215130	Hospitalis	2010	Head-on	Multi-Veh	149.6204	-22.6827	Bruce Hwy		Ogmore	Livingstone Shire	Remote	100 - 110 k
215299	Hospitalis	2010	Rear-end	Multi-Veh	145.7452	-16.9705	Bruce Hwy		Woree	Cairns Region	Outer regional	80 - 90 km,
215323	Hospitalis	2010	Rear-end	Multi-Veh	149.8397	-22.8062	Bruce Hwy		Marlborough	Livingstone Shire	Remote	100 - 110 k
215474	Fatal	2010	Head-on	Multi-Veh	150.5845	-23.5873	Bruce Hwy		Bajool	Rockhampton Region	Outer regional	100 - 110 k
215480	Fatal	2010	Head-on	Multi-Veh	152.6604	-25.5362	Bruce Hwy		Tinana	Fraser Coast Region	Inner regional	100 - 110 k
215545	Hospitalis	2009	Rear-end	Multi-Veh	150.9207	-23.7838	Bruce Hwy		Ambrose	Gladstone Region	Outer regional	100 - 110 k
216614	Hospitalis	2011	Rear-end	Multi-Veh	152.5911	-25.8407	Bruce Hwy		Bauple	Fraser Coast Region	Inner regional	100 - 110 k
216663	Hospitalis	2010	Head-on	Multi-Veh	152.638	-25.6442	Bruce Hwy		Owanyilla	Fraser Coast Region	Inner regional	100 - 110 k
217477	Hospitalis	2010	Sideswipe	Multi-Veh	145.7469	-16.9627	Bruce Hwy	Bruce Hwy	Woree	Cairns Region	Outer regional	80 - 90 km,
217783	Hospitalis	2011	Rear-end	Multi-Veh	147.1264	-19.5609	Bruce Hwy		Horseshoe Lago	Burdekin Shire	Outer regional	100 - 110 k
218433	Fatal	2010	Sideswipe	Multi-Veh	149.5042	-22.0789	Bruce Hwy		Clairview	Isaac Region	Remote	100 - 110 k
218641	Hospitalis	2010	Rear-end	Multi-Veh	145.744	-16.9761	Bruce Hwy		Mount Sheridar	Cairns Region	Outer regional	80 - 90 km,
219269	Hospitalis	2009	Sideswipe	Multi-Veh	148.2396	-20.0624	Bruce Hwy		Bowen	Whitsunday Region	Outer regional	100 - 110 k
219479	Hospitalis	2009	Sideswipe	Multi-Veh	146.7527	-19.3209	Bruce Hwy		Douglas	Townsville City	Outer regional	100 - 110 k
219505	Hospitalis	2010	Rear-end	Multi-Veh	145.7468	-17.0237	Bruce Hwy		Edmonton	Cairns Region	Outer regional	80 - 90 km,
220173	Hospitalis	2010	Rear-end	Multi-Veh	145.7471	-16.9562	Bruce Hwy	Mulgrave	Woree	Cairns Region	Outer regional	80 - 90 km,

220244	Fatal	2010	Head-on	Multi-Veh	152.6024	-25.949	Bruce Hwy		Glenwood	Fraser Coast Region	Inner regional	80 - 90 km,
220330	Hospitalis	2011	Head-on	Multi-Veh	152.3869	-25.28	Bruce Hwy		Isis River	Bundaberg Region	Inner regional	100 - 110 k
222855	Hospitalis	2010	Rear-end	Multi-Veh	145.7442	-16.9783	Bruce Hwy		White Rock	Cairns Region	Outer regional	80 - 90 km,
223211	Hospitalis	2011	Rear-end	Multi-Veh	149.1582	-21.2847	Bruce Hwy		Balberra	Mackay Region	Outer regional	100 - 110 k
224010	Hospitalis	2010	Sideswipe	Multi-Veh	152.5867	-25.7404	Bruce Hwy		Tiaro	Fraser Coast Region	Inner regional	100 - 110 k
224671	Hospitalis	2010	Rear-end	Multi-Veh	152.6335	-26.1539	Bruce Hwy	Robert Rd	Chatsworth	Gympie Region	Inner regional	80 - 90 km,
224724	Fatal	2010	Head-on	Multi-Veh	151.0446	-23.9296	Bruce Hwy		East End	Gladstone Region	Outer regional	100 - 110 k
225734	Fatal	2010	Sideswipe	Multi-Veh	152.5973	-25.3549	Bruce Hwy		Torbanlea	Fraser Coast Region	Inner regional	100 - 110 k
225771	Fatal	2011	Sideswipe	Multi-Veh	150.475	-23.2038	Bruce Hwy		Etna Creek	Livingstone Shire	Inner regional	100 - 110 k
225793	Fatal	2011	Head-on	Multi-Veh	151.2905	-24.0008	Bruce Hwy		Benaraby	Gladstone Region	Inner regional	100 - 110 k
226910	Hospitalis	2010	Rear-end	Multi-Veh	146.249	-18.9099	Bruce Hwy		Coolbie	Hinchinbrook Shire	Outer regional	100 - 110 k
226965	Hospitalis	2010	Rear-end	Multi-Veh	145.747	-16.9654	Bruce Hwy		Woree	Cairns Region	Outer regional	80 - 90 km,
227164	Hospitalis	2010	Rear-end	Multi-Veh	146.764	-19.3178	Bruce Hwy		Douglas	Townsville City	Outer regional	80 - 90 km,
227201	Hospitalis	2009	Head-on	Multi-Veh	149.4804	-22.2572	Bruce Hwy		St Lawrence	Isaac Region	Remote	100 - 110 k
227416	Fatal	2011	Head-on	Multi-Veh	148.592	-20.4195	Bruce Hwy		Proserpine	Whitsunday Region	Outer regional	100 - 110 k
228504	Hospitalis	2010	Rear-end	Multi-Veh	152.6034	-25.9315	Bruce Hwy	Cherry Tre	Glenwood	Fraser Coast Region	Inner regional	100 - 110 k
228836	Hospitalis	2011	Rear-end	Multi-Veh	151.4195	-24.1015	Bruce Hwy		Iveragh	Gladstone Region	Inner regional	100 - 110 k
229042	Hospitalis	2010	Rear-end	Multi-Veh	149.8927	-22.8233	Bruce Hwy	Old Bruce	Marlborough	Livingstone Shire	Remote	100 - 110 k
229116	Fatal	2011	Rear-end	Multi-Veh	152.631	-25.6529	Bruce Hwy		Owanyilla	Fraser Coast Region	Inner regional	100 - 110 k
229128	Hospitalis	2010	Rear-end	Multi-Veh	149.0915	-21.1025	Bruce Hwy	Farleigh -	Farleigh	Mackay Region	Outer regional	100 - 110 k
229628	Hospitalis	2010	Rear-end	Multi-Veh	149.1632	-21.1289	Bruce Hwy	Rockleigh	Mount Pleasant	Mackay Region	Inner regional	80 - 90 km,
229677	Hospitalis	2011	Rear-end	Multi-Veh	152.5077	-25.3169	Bruce Hwy		Cherwell	Fraser Coast Region	Inner regional	100 - 110 k
230542	Fatal	2011	Head-on	Multi-Veh	149.3729	-21.8645	Bruce Hwy		Carmila	Isaac Region	Outer regional	100 - 110 k
230765	Hospitalis	2012	Head-on	Multi-Veh	150.9825	-23.8176	Bruce Hwy		Mount Larcom	Gladstone Region	Outer regional	100 - 110 k
231115	Fatal	2011	Head-on	Multi-Veh	152.0446	-25.2172	Bruce Hwy		Booyal	Bundaberg Region	Inner regional	100 - 110 k
232217	Hospitalis	2010	Head-on	Multi-Veh	146.7627	-19.3178	Bruce Hwy		Douglas	Townsville City	Outer regional	80 - 90 km,
232518	Hospitalis	2011	Rear-end	Multi-Veh	152.1984	-25.2156	Bruce Hwy	Kevin Livi	Apple Tree Cre	Bundaberg Region	Inner regional	100 - 110 k
232625	Fatal	2011	Head-on	Multi-Veh	152.5988	-25.7609	Bruce Hwy		Tiaro	Fraser Coast Region	Inner regional	100 - 110 k
232803	Hospitalis	2010	Rear-end	Multi-Veh	146.7731	-19.3178	Bruce Hwy		Murray	Townsville City	Outer regional	80 - 90 km,
232827	Hospitalis	2011	Rear-end	Multi-Veh	149.1176	-21.1149	Bruce Hwy	Miclere Fa	Farleigh	Mackay Region	Outer regional	100 - 110 k
232860	Hospitalis	2010	Head-on	Multi-Veh	152.7445	-26.3595	Bruce Hwy		Coles Creek	Gympie Region	Inner regional	80 - 90 km,
232890	Hospitalis	2010	Head-on	Multi-Veh	145.9079	-18.1062	Bruce Hwy		Bilyana	Cassowary Coast Region	Remote	100 - 110 k
233383	Hospitalis	2011	Rear-end	Multi-Veh	146.5853	-19.2038	Bruce Hwy		Yabulu	Townsville City	Outer regional	100 - 110 k
234424	Fatal	2011	Head-on	Multi-Veh	152.6468	-25.5975	Bruce Hwy		Glenorchy	Fraser Coast Region	Inner regional	100 - 110 k
234885	Hospitalis	2011	Rear-end	Multi-Veh	151.8335	-24.9101	Bruce Hwy		Monduran	Bundaberg Region	Outer regional	80 - 90 km,
235372	Hospitalis	2011	Rear-end	Multi-Veh	150.368	-23.135	Bruce Hwy	Iris St	Yaamba	Livingstone Shire	Outer regional	80 - 90 km,
235772	Hospitalis	2011	Rear-end	Multi-Veh	149.1195	-21.1152	Bruce Hwy		Glenella	Mackay Region	Inner regional	100 - 110 k
236039	Hospitalis	2011	Rear-end	Multi-Veh	148.4563	-20.2543	Bruce Hwy		Gregory River	Whitsunday Region	Outer regional	100 - 110 k
236526	Hospitalis	2011	Rear-end	Multi-Veh	150.5082	-23.4342	Bruce Hwy		Gracemere	Rockhampton Region	Inner regional	100 - 110 k
236641	Hospitalis	2011	Rear-end	Multi-Veh	152.2427	-25.2322	Bruce Hwy		Apple Tree Cre	Bundaberg Region	Inner regional	100 - 110 k
237115	Hospitalis	2011	Rear-end	Multi-Veh	149.12	-21.1153	Bruce Hwy		Glenella	Mackay Region	Inner regional	100 - 110 k
237162	Hospitalis	2011	Head-on	Multi-Veh	151.3962	-24.0591	Bruce Hwy		Iveragh	Gladstone Region	Inner regional	100 - 110 k
237322	Hospitalis	2011	Sideswipe	Multi-Veh	149.1399	-21.2646	Bruce Hwy		Chelona	Mackay Region	Outer regional	100 - 110 k
237409	Hospitalis	2011	Rear-end	Multi-Veh	146.7377	-19.3253	Bruce Hwy		Douglas	Townsville City	Outer regional	80 - 90 km,
237656	Hospitalis	2012	Head-on	Multi-Veh	148.6259	-20.8103	Bruce Hwy		Yalboroo	Mackay Region	Outer regional	100 - 110 k
237708	Hospitalis	2011	Sideswipe	Multi-Veh	151.7098	-24.7584	Bruce Hwy		Kolonga	Bundaberg Region	Outer regional	100 - 110 k
237940	Hospitalis	2011	Head-on	Multi-Veh	147.1278	-19.561	Bruce Hwy		Horseshoe Lago	Burdekin Shire	Outer regional	100 - 110 k
238175	Hospitalis	2011	Rear-end	Multi-Veh	149.0693	-21.0929	Bruce Hwy		Farleigh	Mackay Region	Outer regional	100 - 110 k
238241	Hospitalis	2012	Sideswipe	Multi-Veh	145.9051	-17.2054	Bruce Hwy		Fishery Falls	Cairns Region	Outer regional	100 - 110 k
238454	Hospitalis	2012	Rear-end	Multi-Veh	149.1658	-21.133	Bruce Hwy		North Mackay	Mackay Region	Inner regional	80 - 90 km,
238475	Fatal	2012	Rear-end	Multi-Veh	150.9443	-23.7935	Bruce Hwy		Machine Creek	Gladstone Region	Outer regional	100 - 110 k
238752	Hospitalis	2012	Rear-end	Multi-Veh	145.7731	-17.0711	Bruce Hwy		Gordonvale	Cairns Region	Outer regional	80 - 90 km,
238803	Fatal	2012	Head-on	Multi-Veh	146.1371	-18.7498	Bruce Hwy		Helens Hill	Hinchinbrook Shire	Outer regional	100 - 110 k
238908	Hospitalis	2012	Head-on	Multi-Veh	146.816	-19.3177	Bruce Hwy		Cluden	Townsville City	Outer regional	100 - 110 k
238911	Hospitalis	2012	Rear-end	Multi-Veh	150.8658	-23.7553	Bruce Hwy		Raglan	Gladstone Region	Outer regional	100 - 110 k
238947	Hospitalis	2011	Rear-end	Multi-Veh	146.055	-18.3172	Bruce Hwy		Damper Creek	Cassowary Coast Region	Remote	100 - 110 k
239139	Hospitalis	2012	Rear-end	Multi-Veh	145.747	-16.9628	Bruce Hwy		Woree	Cairns Region	Outer regional	80 - 90 km,
239166	Fatal	2012	Head-on	Multi-Veh	145.7595	-17.0393	Bruce Hwy		Wrights Creek	Cairns Region	Outer regional	80 - 90 km,
239170	Fatal	2012	Head-on	Multi-Veh	149.3639	-21.7424	Bruce Hwy		Ilbilbie	Isaac Region	Outer regional	100 - 110 k
239337	Hospitalis	2012	Rear-end	Multi-Veh	149.1644	-21.1303	Bruce Hwy		Mount Pleasant	Mackay Region	Inner regional	80 - 90 km,

239482	Hospitalis	2012	Rear-end	Multi-Veh	146.8036	-19.3181	Bruce Hwy		Annandale	Townsville City	Outer regional	80 - 90 km,
239567	Hospitalis	2012	Head-on	Multi-Veh	148.5887	-20.6638	Bruce Hwy		Bloomsbury	Mackay Region	Outer regional	100 - 110 k
239584	Hospitalis	2012	Rear-end	Multi-Veh	146.696	-19.2944	Bruce Hwy	Kalynda P	Shaw	Townsville City	Outer regional	80 - 90 km,
239599	Hospitalis	2012	Sideswipe	Multi-Veh	148.1471	-20.0195	Bruce Hwy		Bowen	Whitsunday Region	Outer regional	100 - 110 k
239680	Fatal	2012	Head-on	Multi-Veh	150.5779	-23.5668	Bruce Hwy		Bajool	Rockhampton Region	Outer regional	100 - 110 k
239861	Hospitalis	2011	Rear-end	Multi-Veh	145.7469	-16.9606	Bruce Hwy		Woree	Cairns Region	Outer regional	80 - 90 km,
239871	Hospitalis	2011	Collision -	Other	152.6383	-25.4445	Bruce Hwy		Duckinwilla	Fraser Coast Region	Inner regional	100 - 110 k
239999	Fatal	2012	Head-on	Multi-Veh	150.4608	-23.1809	Bruce Hwy		The Caves	Livingstone Shire	Inner regional	100 - 110 k
240099	Hospitalis	2012	Head-on	Multi-Veh	146.0509	-17.6969	Bruce Hwy		Cowley	Cassowary Coast Region	Outer regional	100 - 110 k
240382	Hospitalis	2012	Rear-end	Multi-Veh	145.7684	-17.0508	Bruce Hwy	Pine Cree	Wrights Creek	Cairns Region	Outer regional	80 - 90 km,
240480	Hospitalis	2012	Rear-end	Multi-Veh	152.5971	-25.8903	Bruce Hwy	Gootchie I	Gootchie	Fraser Coast Region	Inner regional	80 - 90 km,
240555	Fatal	2012	Head-on	Multi-Veh	146.0507	-17.6965	Bruce Hwy		Cowley	Cassowary Coast Region	Outer regional	100 - 110 k
240576	Hospitalis	2011	Head-on	Multi-Veh	150.5038	-23.4278	Bruce Hwy		Port Curtis	Rockhampton Region	Inner regional	100 - 110 k
240628	Hospitalis	2012	Rear-end	Multi-Veh	146.5079	-19.1385	Bruce Hwy		Bluewater	Townsville City	Outer regional	100 - 110 k
240631	Hospitalis	2012	Rear-end	Multi-Veh	146.0032	-17.8174	Bruce Hwy	Millingtor	El Arish	Cassowary Coast Region	Outer regional	100 - 110 k
240655	Hospitalis	2012	Head-on	Multi-Veh	151.9829	-25.1244	Bruce Hwy		Wallaville	Bundaberg Region	Outer regional	100 - 110 k
240814	Fatal	2012	Head-on	Multi-Veh	151.4798	-24.1856	Bruce Hwy		Bororen	Gladstone Region	Outer regional	100 - 110 k
241070	Hospitalis	2012	Head-on	Multi-Veh	152.5996	-25.957	Bruce Hwy		Glenwood	Gympie Region	Inner regional	100 - 110 k
241121	Fatal	2012	Head-on	Multi-Veh	145.9549	-18.2041	Bruce Hwy		Kennedy	Cassowary Coast Region	Remote	80 - 90 km,
241150	Hospitalis	2012	Rear-end	Multi-Veh	147.6747	-19.8739	Bruce Hwy		Gumlu	Whitsunday Region	Outer regional	100 - 110 k
241270	Fatal	2012	Head-on	Multi-Veh	149.2596	-21.6196	Bruce Hwy		Koumala	Mackay Region	Outer regional	100 - 110 k
241310	Hospitalis	2012	Rear-end	Multi-Veh	151.9704	-25.0572	Bruce Hwy	Comonju I	Wallaville	Bundaberg Region	Outer regional	100 - 110 k
241332	Hospitalis	2012	Head-on	Multi-Veh	146.6122	-19.2216	Bruce Hwy		Black River	Townsville City	Outer regional	100 - 110 k
241372	Hospitalis	2012	Sideswipe	Multi-Veh	152.5913	-25.8418	Bruce Hwy		Bauple	Fraser Coast Region	Inner regional	100 - 110 k
241457	Hospitalis	2012	Rear-end	Multi-Veh	149.0562	-21.0911	Bruce Hwy		The Leap	Mackay Region	Outer regional	100 - 110 k
241826	Fatal	2012	Head-on	Multi-Veh	152.2401	-25.227	Bruce Hwy		Apple Tree Cre	Bundaberg Region	Inner regional	100 - 110 k
242008	Hospitalis	2012	Sideswipe	Multi-Veh	152.6022	-25.6917	Bruce Hwy		Owanyilla	Fraser Coast Region	Inner regional	100 - 110 k
242111	Fatal	2012	Head-on	Multi-Veh	145.9544	-17.9061	Bruce Hwy		Birkalla	Cassowary Coast Region	Outer regional	100 - 110 k
242354	Hospitalis	2012	Head-on	Multi-Veh	151.3015	-23.9979	Bruce Hwy	Hoad Rd	Wurdong Heigh	Gladstone Region	Inner regional	100 - 110 k
242362	Fatal	2012	Head-on	Multi-Veh	150.9268	-23.7846	Bruce Hwy		Ambrose	Gladstone Region	Outer regional	100 - 110 k
242477	Hospitalis	2012	Sideswipe	Multi-Veh	149.0036	-21.068	Bruce Hwy		The Leap	Mackay Region	Outer regional	100 - 110 k
242632	Hospitalis	2012	Rear-end	Multi-Veh	148.5855	-20.3925	Bruce Hwy	Proserpin	Hamilton Plains	Whitsunday Region	Outer regional	80 - 90 km,
242651	Fatal	2012	Rear-end	Multi-Veh	152.6616	-25.5447	Bruce Hwy		Tinana	Fraser Coast Region	Inner regional	80 - 90 km,
242655	Fatal	2012	Head-on	Multi-Veh	148.6252	-20.8092	Bruce Hwy		Yalboroo	Mackay Region	Outer regional	100 - 110 k
242696	Hospitalis	2012	Sideswipe	Multi-Veh	149.1482	-21.2271	Bruce Hwy	Holmes Ro	Bakers Creek	Mackay Region	Inner regional	100 - 110 k
242774	Hospitalis	2012	Head-on	Multi-Veh	146.5158	-19.1445	Bruce Hwy		Bluewater	Townsville City	Outer regional	100 - 110 k
242787	Fatal	2012	Head-on	Multi-Veh	148.722	-20.859	Bruce Hwy		Pindi Pindi	Mackay Region	Outer regional	80 - 90 km,
242789	Hospitalis	2012	Head-on	Multi-Veh	152.6714	-26.2049	Bruce Hwy		Gympie	Gympie Region	Inner regional	80 - 90 km,
242973	Hospitalis	2012	Rear-end	Multi-Veh	148.6408	-20.8262	Bruce Hwy		Yalboroo	Mackay Region	Outer regional	100 - 110 k
242993	Hospitalis	2012	Rear-end	Multi-Veh	146.7912	-19.3176	Bruce Hwy		Annandale	Townsville City	Outer regional	80 - 90 km,
243092	Hospitalis	2012	Rear-end	Multi-Veh	150.2599	-23.0248	Bruce Hwy		Kunwarara	Livingstone Shire	Remote	100 - 110 k
243100	Fatal	2012	Head-on	Multi-Veh	152.5936	-25.3499	Bruce Hwy		Torbanlea	Fraser Coast Region	Inner regional	100 - 110 k
243120	Hospitalis	2012	Rear-end	Multi-Veh	151.9974	-25.1317	Bruce Hwy	Mclennan	Duingal	Bundaberg Region	Inner regional	100 - 110 k
243201	Fatal	2012	Head-on	Multi-Veh	150.3929	-23.1301	Bruce Hwy		Yaamba	Livingstone Shire	Outer regional	100 - 110 k
243242	Hospitalis	2012	Rear-end	Multi-Veh	150.5067	-23.4321	Bruce Hwy		Fairy Bower	Rockhampton Region	Inner regional	100 - 110 k
243306	Fatal	2012	Sideswipe	Multi-Veh	146.4069	-19.0638	Bruce Hwy		Rollingstone	Townsville City	Outer regional	100 - 110 k
243366	Hospitalis	2012	Head-on	Multi-Veh	147.0382	-19.4196	Bruce Hwy		Cromarty	Burdekin Shire	Outer regional	100 - 110 k
243415	Fatal	2012	Head-on	Multi-Veh	152.4664	-25.3101	Bruce Hwy		Cherwell	Fraser Coast Region	Inner regional	80 - 90 km,
243490	Hospitalis	2012	Rear-end	Multi-Veh	149.146	-21.2119	Bruce Hwy		Bakers Creek	Mackay Region	Inner regional	100 - 110 k
243583	Hospitalis	2012	Head-on	Multi-Veh	151.9162	-24.9148	Bruce Hwy		Monduran	Bundaberg Region	Outer regional	80 - 90 km,
243688	Hospitalis	2012	Head-on	Multi-Veh	146.3686	-19.0198	Bruce Hwy		Rollingstone	Townsville City	Outer regional	100 - 110 k
243700	Hospitalis	2012	Rear-end	Multi-Veh	145.7625	-17.0401	Bruce Hwy	Davis Rd	Wrights Creek	Cairns Region	Outer regional	80 - 90 km,
243706	Hospitalis	2013	Head-on	Multi-Veh	146.2181	-18.8759	Bruce Hwy		Bambaroo	Hinchinbrook Shire	Outer regional	100 - 110 k
244116	Hospitalis	2012	Rear-end	Multi-Veh	149.0634	-21.0919	Bruce Hwy		Farleigh	Mackay Region	Outer regional	80 - 90 km,
244127	Hospitalis	2013	Rear-end	Multi-Veh	149.1484	-21.224	Bruce Hwy		Bakers Creek	Mackay Region	Inner regional	80 - 90 km,
244206	Hospitalis	2012	Head-on	Multi-Veh	152.7047	-26.2603	Bruce Hwy		Kybong	Gympie Region	Inner regional	80 - 90 km,
244208	Hospitalis	2012	Rear-end	Multi-Veh	149.7786	-22.75	Bruce Hwy		Ogmore	Livingstone Shire	Remote	100 - 110 k
244380	Hospitalis	2012	Rear-end	Multi-Veh	149.1716	-21.3007	Bruce Hwy		Balberra	Mackay Region	Outer regional	80 - 90 km,
244426	Hospitalis	2012	Head-on	Multi-Veh	149.4746	-22.3632	Bruce Hwy		St Lawrence	Isaac Region	Remote	100 - 110 k
244438	Fatal	2012	Rear-end	Multi-Veh	152.2386	-25.2189	Bruce Hwy		Apple Tree Cre	Bundaberg Region	Inner regional	80 - 90 km,
244525	Hospitalis	2012	Rear-end	Multi-Veh	145.7607	-16.9456	Bruce Hwy		Portsmith	Cairns Region	Outer regional	80 - 90 km,
244678	Hospitalis	2012	Head-on	Multi-Veh	148.2787	-20.1395	Bruce Hwy		Bowen	Whitsunday Region	Outer regional	100 - 110 k
244755	Fatal	2012	Head-on	Multi-Veh	149.5258	-22.1547	Bruce Hwy		St Lawrence	Isaac Region	Remote	100 - 110 k
244811	Hospitalis	2012	Head-on	Multi-Veh	145.9282	-17.33	Bruce Hwy		Babinda	Cairns Region	Outer regional	100 - 110 k
244882	Hospitalis	2013	Head-on	Multi-Veh	151.1688	-23.9624	Bruce Hwy		Burua	Gladstone Region	Inner regional	100 - 110 k
244927	Hospitalis	2012	Rear-end	Multi-Veh	148.3566	-20.1864	Bruce Hwy		Bowen	Whitsunday Region	Outer regional	100 - 110 k
244948	Hospitalis	2013	Rear-end	Multi-Veh	146.0069	-17.8091	Bruce Hwy	El Arish - I	El Arish	Cassowary Coast Region	Outer regional	80 - 90 km,
244970	Hospitalis	2012	Head-on	Multi-Veh	149.2297	-21.592	Bruce Hwy		Koumala	Mackay Region	Outer regional	100 - 110 k
245050	Hospitalis	2012	Sideswipe	Multi-Veh	148.8465	-20.9783	Bruce Hwy		Mount Ossa	Mackay Region	Outer regional	100 - 110 k
245211	Fatal	2013	Head-on	Multi-Veh	152.6017	-25.9533	Bruce Hwy		Glenwood	Fraser Coast Region	Inner regional	100 - 110 k

245244	Hospitalis	2012	Head-on	Multi-Veh	152.6227	-26.1477	Bruce Hwy		Chatsworth	Gympie Region	Inner regional	80 - 90 km,
245319	Hospitalis	2013	Rear-end	Multi-Veh	146.0107	-17.7955	Bruce Hwy		El Arish	Cassowary Coast Region	Outer regional	80 - 90 km,
245436	Fatal	2013	Sideswipe	Multi-Veh	148.6152	-20.5523	Bruce Hwy	Maloney R	Thoopara	Whitsunday Region	Outer regional	100 - 110 k
245859	Hospitalis	2013	Head-on	Multi-Veh	146.5915	-19.2094	Bruce Hwy		Yabulu	Townsville City	Outer regional	100 - 110 k
245889	Fatal	2013	Head-on	Multi-Veh	151.898	-24.9132	Bruce Hwy		Monduran	Bundaberg Region	Outer regional	80 - 90 km,
246150	Hospitalis	2013	Sideswipe	Multi-Veh	145.9401	-17.991	Bruce Hwy		Euramo	Cassowary Coast Region	Remote	100 - 110 k
246153	Fatal	2013	Head-on	Multi-Veh	147.2432	-19.5609	Bruce Hwy		Barratta	Burdekin Shire	Outer regional	100 - 110 k
246361	Hospitalis	2013	Head-on	Multi-Veh	147.1633	-19.5644	Bruce Hwy		Horseshoe Lago	Burdekin Shire	Outer regional	100 - 110 k
246535	Hospitalis	2013	Rear-end	Multi-Veh	150.9218	-23.7839	Bruce Hwy		Ambrose	Gladstone Region	Outer regional	80 - 90 km,
246594	Fatal	2013	Head-on	Multi-Veh	149.1973	-21.343	Bruce Hwy		Alligator Creek	Mackay Region	Outer regional	100 - 110 k
246836	Hospitalis	2013	Rear-end	Multi-Veh	149.1739	-21.3038	Bruce Hwy		Balberra	Mackay Region	Outer regional	100 - 110 k
246874	Hospitalis	2013	Head-on	Multi-Veh	151.8871	-24.9088	Bruce Hwy		Monduran	Bundaberg Region	Outer regional	80 - 90 km,
246969	Hospitalis	2013	Head-on	Multi-Veh	148.2507	-20.1155	Bruce Hwy		Bowen	Whitsunday Region	Outer regional	100 - 110 k
247022	Hospitalis	2013	Rear-end	Multi-Veh	149.8783	-22.8207	Bruce Hwy		Marlborough	Livingstone Shire	Remote	100 - 110 k
247193	Hospitalis	2013	Rear-end	Multi-Veh	145.9194	-17.4276	Bruce Hwy	Roper Rd	Eubenangee	Cairns Region	Outer regional	100 - 110 k
247224	Hospitalis	2013	Rear-end	Multi-Veh	150.957	-23.8009	Bruce Hwy		Machine Creek	Gladstone Region	Outer regional	100 - 110 k
247287	Hospitalis	2013	Head-on	Multi-Veh	149.1423	-21.2616	Bruce Hwy		Chelona	Mackay Region	Outer regional	100 - 110 k
247361	Hospitalis	2013	Head-on	Multi-Veh	147.7469	-19.8979	Bruce Hwy		Guthalungra	Whitsunday Region	Outer regional	100 - 110 k
247400	Hospitalis	2013	Rear-end	Multi-Veh	145.7684	-17.0505	Bruce Hwy		Wrights Creek	Cairns Region	Outer regional	80 - 90 km,
247522	Hospitalis	2013	Rear-end	Multi-Veh	149.1659	-21.1338	Bruce Hwy		West Mackay	Mackay Region	Inner regional	80 - 90 km,
247537	Hospitalis	2013	Rear-end	Multi-Veh	146.2276	-18.8843	Bruce Hwy		Bambaroo	Hinchinbrook Shire	Outer regional	100 - 110 k
247562	Fatal	2013	Head-on	Multi-Veh	145.8089	-17.1124	Bruce Hwy		Aloomba	Cairns Region	Outer regional	100 - 110 k
247773	Hospitalis	2013	Rear-end	Multi-Veh	149.2033	-21.3774	Bruce Hwy		Sarina	Mackay Region	Outer regional	100 - 110 k
247927	Hospitalis	2013	Rear-end	Multi-Veh	149.1472	-21.2368	Bruce Hwy	Homebusl	Rosella	Mackay Region	Inner regional	80 - 90 km,
247980	Fatal	2013	Rear-end	Multi-Veh	146.7003	-19.2734	Bruce Hwy		Shaw	Townsville City	Outer regional	80 - 90 km,
248051	Hospitalis	2013	Head-on	Multi-Veh	151.6615	-24.6043	Bruce Hwy		Gindoran	Gladstone Region	Outer regional	100 - 110 k
248110	Fatal	2013	Head-on	Multi-Veh	152.7053	-26.2532	Bruce Hwy		Kybong	Gympie Region	Inner regional	80 - 90 km,
248236	Fatal	2013	Rear-end	Multi-Veh	149.1954	-21.3516	Bruce Hwy	Perry Rd	Alligator Creek	Mackay Region	Outer regional	100 - 110 k
248237	Fatal	2013	Rear-end	Multi-Veh	149.1457	-21.275	Bruce Hwy		Balberra	Mackay Region	Outer regional	100 - 110 k
248327	Hospitalis	2013	Head-on	Multi-Veh	151.227	-23.9905	Bruce Hwy		Calliope	Gladstone Region	Inner regional	80 - 90 km,
248522	Hospitalis	2013	Sideswipe	Multi-Veh	145.7469	-16.9573	Bruce Hwy		Woree	Cairns Region	Outer regional	80 - 90 km,
248547	Hospitalis	2013	Rear-end	Multi-Veh	146.7603	-19.3183	Bruce Hwy		Douglas	Townsville City	Outer regional	100 - 110 k
248549	Hospitalis	2013	Rear-end	Multi-Veh	152.2437	-25.2327	Bruce Hwy	Gentle An	Apple Tree Cre	Bundaberg Region	Inner regional	100 - 110 k
248607	Hospitalis	2013	Rear-end	Multi-Veh	148.6306	-20.5179	Bruce Hwy		Thoopara	Whitsunday Region	Outer regional	100 - 110 k
248658	Hospitalis	2013	Sideswipe	Multi-Veh	152.5825	-25.7323	Bruce Hwy		Tiaro	Fraser Coast Region	Inner regional	80 - 90 km,
248700	Hospitalis	2013	Rear-end	Multi-Veh	146.0333	-17.59	Bruce Hwy		Mourilyan	Cassowary Coast Region	Outer regional	100 - 110 k
248711	Hospitalis	2013	Sideswipe	Multi-Veh	149.7033	-22.7267	Bruce Hwy		Ogmore	Livingstone Shire	Remote	100 - 110 k
248750	Hospitalis	2013	Rear-end	Multi-Veh	145.7516	-16.952	Bruce Hwy		Woree	Cairns Region	Outer regional	80 - 90 km,
248769	Hospitalis	2013	Rear-end	Multi-Veh	147.0216	-19.3965	Bruce Hwy		Mount Elliot	Townsville City	Outer regional	100 - 110 k
248976	Hospitalis	2013	Head-on	Multi-Veh	152.5452	-25.3231	Bruce Hwy		Howard	Fraser Coast Region	Inner regional	100 - 110 k
248981	Hospitalis	2013	Rear-end	Multi-Veh	147.6886	-19.8794	Bruce Hwy		Gumlu	Whitsunday Region	Outer regional	100 - 110 k
249322	Hospitalis	2013	Head-on	Multi-Veh	150.2632	-23.0403	Bruce Hwy		Canoona	Livingstone Shire	Outer regional	100 - 110 k
249405	Hospitalis	2013	Rear-end	Multi-Veh	149.1658	-21.133	Bruce Hwy		North Mackay	Mackay Region	Inner regional	80 - 90 km,
249446	Hospitalis	2013	Rear-end	Multi-Veh	149.1923	-21.3221	Bruce Hwy	Hay Point	Alligator Creek	Mackay Region	Outer regional	80 - 90 km,
249711	Hospitalis	2013	Sideswipe	Multi-Veh	146.9036	-19.3755	Bruce Hwy	Muntalun	Alligator Creek	Townsville City	Outer regional	80 - 90 km,
249777	Fatal	2013	Rear-end	Multi-Veh	152.6393	-25.6373	Bruce Hwy	Old Gymp	Glenorchy	Fraser Coast Region	Inner regional	100 - 110 k
249849	Fatal	2013	Head-on	Multi-Veh	149.0394	-21.0892	Bruce Hwy		The Leap	Mackay Region	Outer regional	100 - 110 k
249857	Fatal	2013	Head-on	Multi-Veh	145.9279	-17.3004	Bruce Hwy		Bellenden Ker	Cairns Region	Outer regional	100 - 110 k
249901	Hospitalis	2013	Rear-end	Multi-Veh	152.6024	-25.6912	Bruce Hwy		Owanyilla	Fraser Coast Region	Inner regional	100 - 110 k
250022	Hospitalis	2013	Head-on	Multi-Veh	152.5839	-26.0614	Bruce Hwy		Curra	Gympie Region	Inner regional	100 - 110 k
250128	Hospitalis	2013	Head-on	Multi-Veh	151.559	-24.3495	Bruce Hwy		Miriam Vale	Gladstone Region	Outer regional	100 - 110 k
250162	Hospitalis	2013	Rear-end	Multi-Veh	146.6948	-19.2566	Bruce Hwy		Shaw	Townsville City	Outer regional	80 - 90 km,
250183	Fatal	2013	Head-on	Multi-Veh	148.2656	-20.137	Bruce Hwy		Bowen	Whitsunday Region	Outer regional	100 - 110 k
250331	Hospitalis	2013	Rear-end	Multi-Veh	148.1684	-20.0156	Bruce Hwy	Champion	Bowen	Whitsunday Region	Outer regional	100 - 110 k
250346	Hospitalis	2013	Rear-end	Multi-Veh	146.7192	-19.3266	Bruce Hwy		Condon	Townsville City	Outer regional	100 - 110 k
250414	Hospitalis	2013	Rear-end	Multi-Veh	146.7028	-19.2615	Bruce Hwy	Townsvill	Shaw	Townsville City	Outer regional	80 - 90 km,
250606	Fatal	2013	Head-on	Multi-Veh	146.613	-19.2219	Bruce Hwy		Black River	Townsville City	Outer regional	100 - 110 k
250911	Hospitalis	2013	Rear-end	Multi-Veh	149.165	-21.1314	Bruce Hwy		Mount Pleasant	Mackay Region	Inner regional	80 - 90 km,
250991	Hospitalis	2013	Rear-end	Multi-Veh	146.9959	-19.3935	Bruce Hwy		Alligator Creek	Townsville City	Outer regional	100 - 110 k
251033	Hospitalis	2013	Head-on	Multi-Veh	149.0479	-21.0902	Bruce Hwy		The Leap	Mackay Region	Outer regional	100 - 110 k
251276	Hospitalis	2013	Rear-end	Multi-Veh	148.2166	-20.0238	Bruce Hwy		Bowen	Whitsunday Region	Outer regional	80 - 90 km,

Barkly Highway Crash Data

Crash_Ref_Number	Crash_Severity	Crash_Year	Crash_Nature	Crash_Type	Crash_Longitude_GDA94	Crash_Latitude_GDA94	Crash_Street	Loc_Suburb	Loc_ABS_Remoteness	Crash_Speed_Limit
164958	Fatal	2009	Head-on	Multi-Vehicle	139.5533	-20.7192	Barkly Hwy	Mount Isa	Very remote	100 - 110 k

Appendix C Road Sections Crash Data

Warrego Highway

No.1

Crash No.	ID Number	Crash Severity	Crash Type	Road Chainage start (km)	Road Chainage after (km)	Road ID	Average Rd Chainage (km)	Difference between crashes (km)	Total Distance	Crash rate per km	Count_Unit_Car	Count_Unit_Truck
8	193572	Hospitalis	Rear-end	15	16	18B	15.5		13	0.769231	2	0
29	244619	Hospitalis	Head-on	16	17	18B	16.5	1			2	0
26	241830	fatal	Head-on	16	17	18B	16.5	0			2	0
36	247912	Hospitalis	Rear-end	17	18	18B	17.5	1			2	0
41	249776	fatal	Head-on	18	19	18B	18.5	1			1	1
10	197030	fatal	Head-on	19	20	18B	19.5	1			2	0
14	226359	Hospitalis	Head-on	20	21	18B	20.5	1			1	1
9	196605	Hospitalis	Rear-end	20	21	18B	20.5	0			1	0
11	199390	Hospitalis	Rear-end	23	24	18B	23.5	3			1	1
7	191750	Hospitalis	Rear-end	25	26	18B	25.5	2			0	2
30	244931	Hospitalis	sideswipe	28	29	18B	28.5	3			2	0
SITE_ID	DESCRIPTI	LONGITUD	LATITUDE	AADT	TDIST	PERCENT_	RSECT_ID	ROAD_NAME				
30025	Approx 30	151.8083	-27.4999	13244	17.63	18.42	18B	WARREGO HIGHWAY				
AADT	13244											
%HV per day	2439.545											
Length of section (km)	14											
CRASH Rate (100 Million Vehicle Kilometres)	3.250743											

No.2

Crash No.	ID Number	Crash Severity	Crash Type	Road Chainage start (km)	Road Chainage after (km)	Road ID	Average Rd Chainage (km)	Difference between crashes (km)	Total Distance	Crash rate per km	Count_Unit_Car	Count_Unit_Truck
27	242408	Hospitalis	sideswipe	36	37	18B	36.5		22	0.363636	1	1
4	185943	fatal	Head-on	37	38	18B	37.5	1			1	1
21	238639	fatal	Head-on	41	42	18B	41.5	4			1	1
32	245208	fatal	Head-on	50	51	18B	50.5	9			1	1
6	190036	Hospitalis	Head-on	50	51	18B	50.5	0			2	0
37	248293	Hospitalis	Rear-end	50	51	18B	50.5	0			4	0
28	243658	fatal	sideswipe	53	54	18B	53.5	3			2	0
13	220253	fatal	Head-on	58	59	18B	58.5	5			1	1
42	250513	Hospitalis	Rear-end	58	59	18B	58.5	0			3	1
SITE_ID	DESCRIPTI	LONGITUD	LATITUDE	AADT	TDIST	PERCENT_	RSECT_ID	ROAD_NAME				
30004	1.2km We	151.59	-27.3669	6603	44.501	26.63	18B	WARREGO HIGHWAY				
AADT	6603											
%HV per day	1758.379											
Length of section (km)	23											
CRASH Rate (100 Million Vehicle Kilometres)	3.247211											

No. 3

Crash No.	ID Number	Crash Severity	Crash Type	Road Chainage start (km)	Road Chainage after (km)	Road ID	Average Rd Chainage (km)	Difference between crashes (km)	Total Distance	Crash rate per km	Count_Unit_Car	Count_Unit_Truck
35	247679	fatal	Head-on	68	69	18B	68.5		9	0.333333	1	1
25	241201	Hospitalis	Rear-end	72	73	18B	72.5	4			2	0
40	249427	fatal	Head-on	76	77	18B	76.5	4			3	0
SITE_ID	DESCRIPTI	LONGITUD	LATITUDE	AADT	TDIST	PERCENT_	RSECT_ID	ROAD_NAME				
30004	1.2km We	151.59	-27.3669	6603	44.501	26.63	18B	WARREGO HIGHWAY				
AADT	6603											
%HV per day	1758.379											
Length of section (km)	9											
CRASH Rate (100 Million Vehicle Kilometres)	2.766143											

New England Highway

No.1								
Crash Number	CRASH_REF_NUMBER	CRASH_SEVERITY	CRASH_NATURE	CRASH_ROADSECTION_TDIST	Difference between distance	Total distance of sections	Crash rate per km	CRASH_FACTOR_UNIT_HFV
20	647	Fatal	Head-on	5.81	0	9.18	0.653595	0
1	1041	Fatal	Head-on	6.4	0.59			0
15	1082	Hospitalis	Rear-end	8.87	2.47			0
3	1046	Hospitalis	Rear-end	11.09	2.22			0
13	1078	Fatal	Head-on	11.56	0.47			1
11	1077	Hospitalis	Rear-end	14.99	3.43			0
SITE_ID	DESCRIPTION	LONGITUD	LATITUDE	AADT	TDIST	PERCENT_	RSECT_ID	
32661	Approx 800m South of Nelson St	151.9429	-27.6185	9143	5.56	7.43	22B	
AADT	9143							
%HV per day	679.3249							
Length of section (km)	10							
CRASH Rate (100 Million Vehicle Kilometres)	3.595834226							

No.2								
Crash Number	CRASH_REF_NUMBER	CRASH_SEVERITY	CRASH_NATURE	CRASH_ROADSECTION_TDIST	Difference between distance	Total distance of sections	Crash rate per km	CRASH_FACTOR_UNIT_HFV
10	1068	Hospitalis	Rear-end	32.19		19.81	0.252398	0
19	753	Hospitalis	Head-on	40.11	7.92			0
5	745	Hospitalis	Rear-end	41.4	1.29			1
18	751	Hospitalis	Sideswipe	43.69	2.29			0
16	726	Hospitalis	Head-on	52	8.31			1
SITE_ID	DESCRIPTION	LONGITUD	LATITUDE	AADT	TDIST	PERCENT_	RSECT_ID	
50212	Approx 1km Nortl	151.9817	-27.9174	3320	42.71	15.43	22B	
AADT	3320							
%HV per day	512.276							
Length of section (km)	20							
CRASH Rate (100 Million Vehicle Kilometres)	4.126093415							

No.3								
Crash Number	CRASH_REF_NUMBER	CRASH_SEVERITY	CRASH_NATURE	CRASH_ROADSECTION_TDIST	Difference between distance	Total distance of sections	Crash rate per km	CRASH_FACTOR_UNIT_HFV
2	916	Fatal	Rear-end	55.13		21.87	0.182899	0
14	947	Fatal	Head-on	61.87	6.74			1
9	933	Fatal	Head-on	63.88	2.01			1
21	955	Hospitalis	Head-on	68.48	4.6			0
8	931	Fatal	Rear-end	77	8.52			1
SITE_ID	DESCRIPTION	LONGITUD	LATITUDE	AADT	TDIST	PERCENT_	RSECT_ID	
50555	200m North of Pa	151.9235	-28.6489	2798	58.77	17.85	22C	
AADT	2798							
%HV per day	499.443							
Length of section (km)	23							
CRASH Rate (100 Million Vehicle Kilometres)	4.257273872							

Bruce Highway

NO. 1							
CRASH_REF_NUMBER	CRASH_SEVERITY	CRASH_YEAR	CRASH_ROADSECTION_TDIST	Distance Between accidents		Crash rate of section per km	CRASH_FACTOR_UNIT_HFV
8902	Fatal	2013	60.496	0	11.234	100	1
8876	Hospitalisation	2009	61.966	1.47		0.267046466	0
8889	Hospitalisation	2012	67.51	5.544			0
8730	Hospitalisation	2012	69.82	2.31			0
8882	Hospitalisation	2011	69.82	0			0
8756	Hospitalisation	2013	69.86	0.04			0
8883	Hospitalisation	2011	70.44	0.58			0
8872	Fatal	2009	70.61	0.17			0
8743	Hospitalisation	2012	71.27	0.66			0
8885	Hospitalisation	2011	71.57	0.3			0
8891	Fatal	2012	71.68	0.11			0
8631	Hospitalisation	2009	71.73	0.05	23		0
SITE_ID	DESCRIPTION	LONGITUDE	LATITUDE	AADT	TDIST	PERCENT_HV	
110032	Meringa, 500m N of Ca	145.7710877	-17.06509284	16604	68.12	8.39	
AADT	16604		Section begins at chainage marker 60 km and ends at chainage marker 72 km				
%HV per day	1393.0756						
Length of section (km	12						
CRASH Rate (Million Vehicle Kilometres)	3.300079532						

NO.2							
CRASH_REF_NUMBER	CRASH_SEVERITY	CRASH_YEAR	CRASH_ROADSECTION_TDIST	Distance Between		Crash rate of section per km	CRASH_FACTOR_UNIT_HFV
5727	Hospitalisation	2009	5.447	#VALUE!	15.614	0.768541053	0
5933	Hospitalisation	2011	7.151	1.704		0.128090175	1
5789	Hospitalisation	2009	7.17	0.019			0
5927	Hospitalisation	2011	7.17	0			0
5936	Hospitalisation	2011	7.39	0.22			0
5412	Hospitalisation	2009	9.371	1.981			1
5427	Hospitalisation	2010	10.5	1.129			0
5431	Hospitalisation	2011	13.09	2.59			0
5439	Hospitalisation	2012	13.71	0.62			0
5448	Hospitalisation	2013	15.264	1.554			0
5450	Fatal	2013	16.148	0.884			0
6087	Fatal	2009	21.061	4.913			0
SITE_ID	DESCRIPTION	LONGITUDE	LATITUDE	AADT	TDIST	PERCENT_HV	
82776	North of QR Underpas	149.1120279	-21.11412543	10305	8.5	8.73	
AADT	10305						
%HV per day	899.6265						
Length of section (km	17						
CRASH Rate (Million Vehicle Kilometres)	3.753370703						

No.3							
CRASH_REF_NUMBER	CRASH_SEVERITY	CRASH_YEAR	CRASH_ROADSECTION_TDIST	Distance Between accidents		Crash rate of section per km	CRASH_FACTOR_UNIT_HFV
6387	Hospitalisation	2013	126.076	0	21.422	0.746895715	0
6391	Fatal	2013	129.132	3.056		0.140042947	1
6382	Fatal	2013	130.126	0.994			1
6392	Hospitalisation	2013	132.566	2.44			1
5996	Hospitalisation	2012	136.296	3.73			0
6007	Hospitalisation	2013	136.516	0.22			0
5923	Hospitalisation	2011	138.156	1.64			1
6019	Fatal	2013	139.908	1.752			1
5947	Hospitalisation	2011	140.776	0.868			1
5198	Hospitalisation	2010	140.888	0.112			0
5719	Hospitalisation	2009	141.894	1.006			0
6013	Hospitalisation	2013	141.916	0.022			0
6022	Hospitalisation	2013	144.706	2.79			1
5939	Hospitalisation	2011	145.332	0.626			0
6002	Hospitalisation	2013	146.116	0.784			1
5990	Hospitalisation	2012	147.498	1.382			0
SITE_ID	DESCRIPTION	LONGITUDE	LATITUDE	AADT	TDIST	PERCENT_HV	
83112	Sarina - Homebush Rc	149.2025438	-21.37129957	7282	126.706	12.36	
AADT	7282						
%HV per day	900.0552						
Length of section (km	22						
CRASH Rate (100 Million Vehicle Kilometres)	5.47247465						

Appendix D Selected Highway Sections overtaking lane locations

Warrego highway

	Start	End
Chainage (km)	36	59
Length (km)	23	

Overtaking lanes	Start Lat	Start Long	END Lat	END Long	Dir Travel	Start	Finish	Length (km)	Distance between same direction lanes
1	-27.3797	151.6104	-27.3733	151.6002	West	42	43.25	1.25	
2	-27.3708	151.5962	-27.3797	151.6104	East	43.75	42	1.75	
3	-27.3432	151.5516	-27.3339	151.5369	west	49.11	50.88	1.77	5.86
4	-27.3339	151.5369	-27.3432	151.5516	East	50.88	49.11	1.77	5.36

New England Highway

	Start	End
Chainage (km)	55	78
Length (km)	23	

Overtaking lanes	Start Lat	Start Long	END Lat	END Long	Dir Travel	Start	Finish	Length (km)	Distance between same direction lanes
1	-28.6382	151.9457	-28.6289	151.9547	North	56.45	55	1.45	
2	-28.6844	151.9152	-28.6916	151.9081	south	63.45	64.6	1.15	
3	-28.6958	151.9066	-28.6876	151.9115	North	65.1	64	1.1	7.55
4	-28.7574	151.8642	-28.7652	151.861	south	73.5	74.5	1	8.9
5	-28.7732	151.8542	-28.7632	151.8613	north	75.65	74.22	1.43	9.12

Bruce Highway

	Start	End
Chainage (km)	126	148
Length (km)	22	

Overtaking lanes	Start Lat	Start Long	END Lat	END Long	Dir Travel	Start	Finish	Length (km)	Distance between same direction lanes
1	-21.359	149.1975	-21.3474	149.1971	north	128.25	129.6	1.35	
2	-21.332	149.1931	-21.3404	149.1962	south	131.4	130.4	1	
3	-21.3123	149.1883	-21.3085	149.1803	north	133.7	134.68	0.98	4.1
4	-21.3001	149.1713	-21.3088	149.1814	south	136	134.45	1.55	3.05
5	-21.2936	149.1665	-21.2875	149.1608	north	136.9	137.78	0.88	2.22
6	-21.2407	149.1467	-21.2471	149.146	south	144.3	143.55	0.75	7.55

Appendix E Overtaking Availability

Warrego Highway Section

Westbound			
Section No	Chainage Start	Chaiange end	length (km)
1	36	41.46	5.46
1st o.l	42	43.25	1.25
2	44	47.76	3.76
3	47.17	49	1.83
2nd o.l	49.11	50.88	1.77
4	51.06	55.53	4.47
5	55.81	56.09	0.28
6	56.48	57.28	0.8
7	57.63	59	1.37

eastbound			
Section No	Chainage Start	Chaiange end	length (km)
1	59	57.85	1.15
2	57.49	56.91	0.58
3	56.84	56.57	0.27
4	56.21	55.81	0.4
5	55.58	51.06	4.52
1st o.l	50.88	49.11	1.77
6	49	48.17	0.83
7	47.85	44.67	3.18
8	44.17	44.02	0.15
2 o.l	43.75	42	1.75
9	41.57	36	5.57

New England Highway Section

Southbound			
Section No	Chainage Start	Chaiange end	length (km)
1	56.5	56.82	0.32
1st O.L	63.45	64.6	1.15
2	66.85	67.16	0.31
3	68.95	70.29	1.34
4	71.24	71.88	0.64
5	72.12	72.67	0.55
2nd O.L	73.5	74.5	1
6	77.35	77.79	0.44

Northbound			
Section No	Chainage Start	Chaiange end	length (km)
1	78	77.56	0.44
1st O.L	75.65	74.22	1.43
2	72.87	72.34	0.53
3	72.12	71.49	0.63
4	70.45	70.15	0.3
5	69.92	69.17	0.75
6	67.36	67.12	0.24
2nd O.L	65.1	64	1.1
7	57.06	56.64	0.42
3rd O.L	56.45	55	1.45

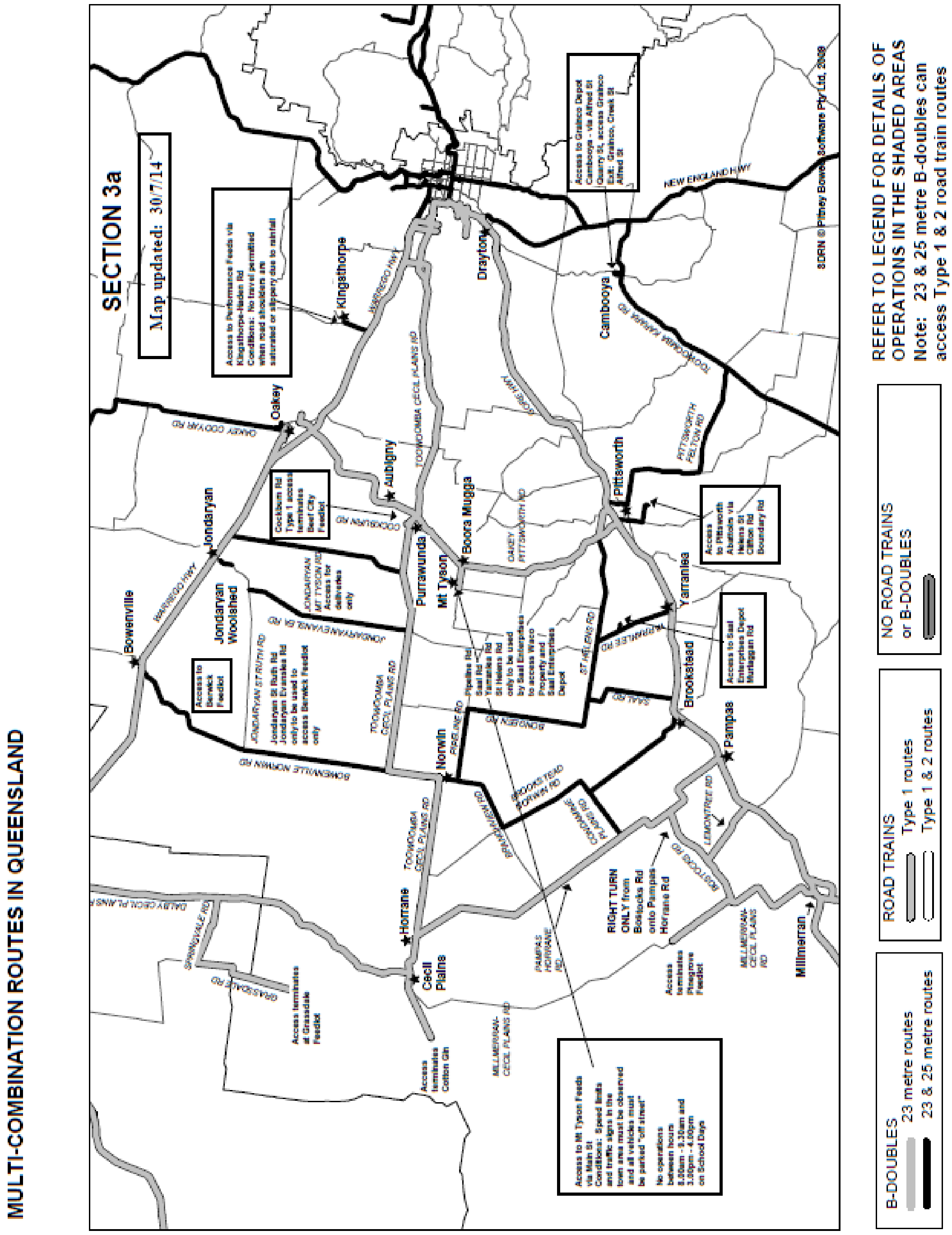
Bruce Highway Section

NorthBound			
Section No	Chainage Start	Chaiange end	length (km)
1	126.29	126.71	0.42
2	127.27	127.87	0.6
o.l 1	128.25	129.6	1.35
o.l 2	133.7	134.68	0.98
o.l 3	136.9	137.78	0.88
3	138.37	138.64	0.27
4	138.82	139.35	0.53
5	141.47	141.75	0.28
6	142.51	143.23	0.72
7	145.14	145.8	0.66

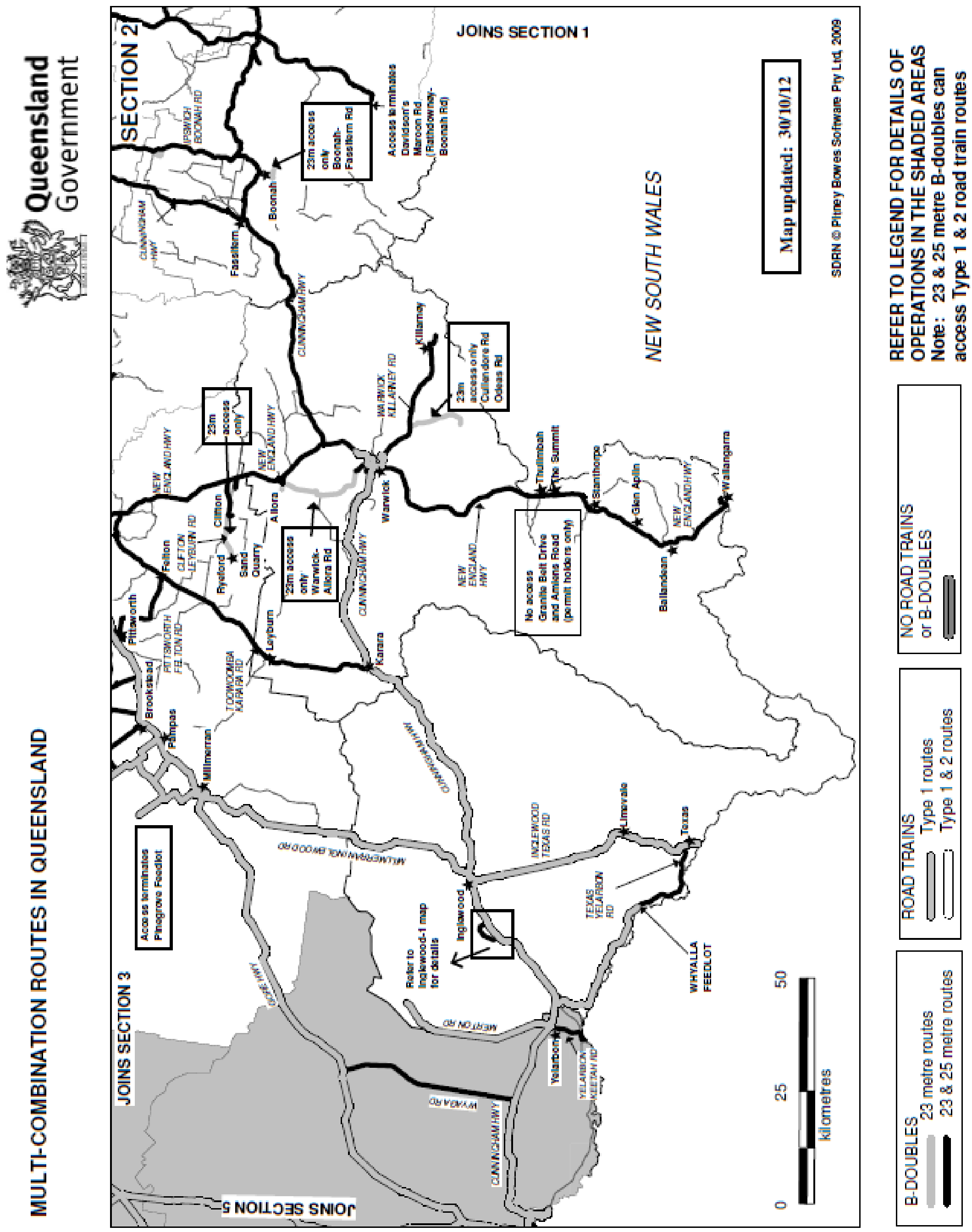
Southbound			
Section No	Chainage Start	Chaiange end	length (km)
1	146.03	145.26	0.77
1 o.l	144.3	143.55	0.75
2	143.45	142.74	0.71
3	141.94	141.62	0.32
4	139.35	139.04	0.31
5	138.87	138.54	0.33
2 o.l	136	134.45	1.55
3 o.l	131.4	130.4	1
6	128.1	127.48	0.62
7	126.93	126.53	0.4

Appendix F Multi-Combination Route Maps

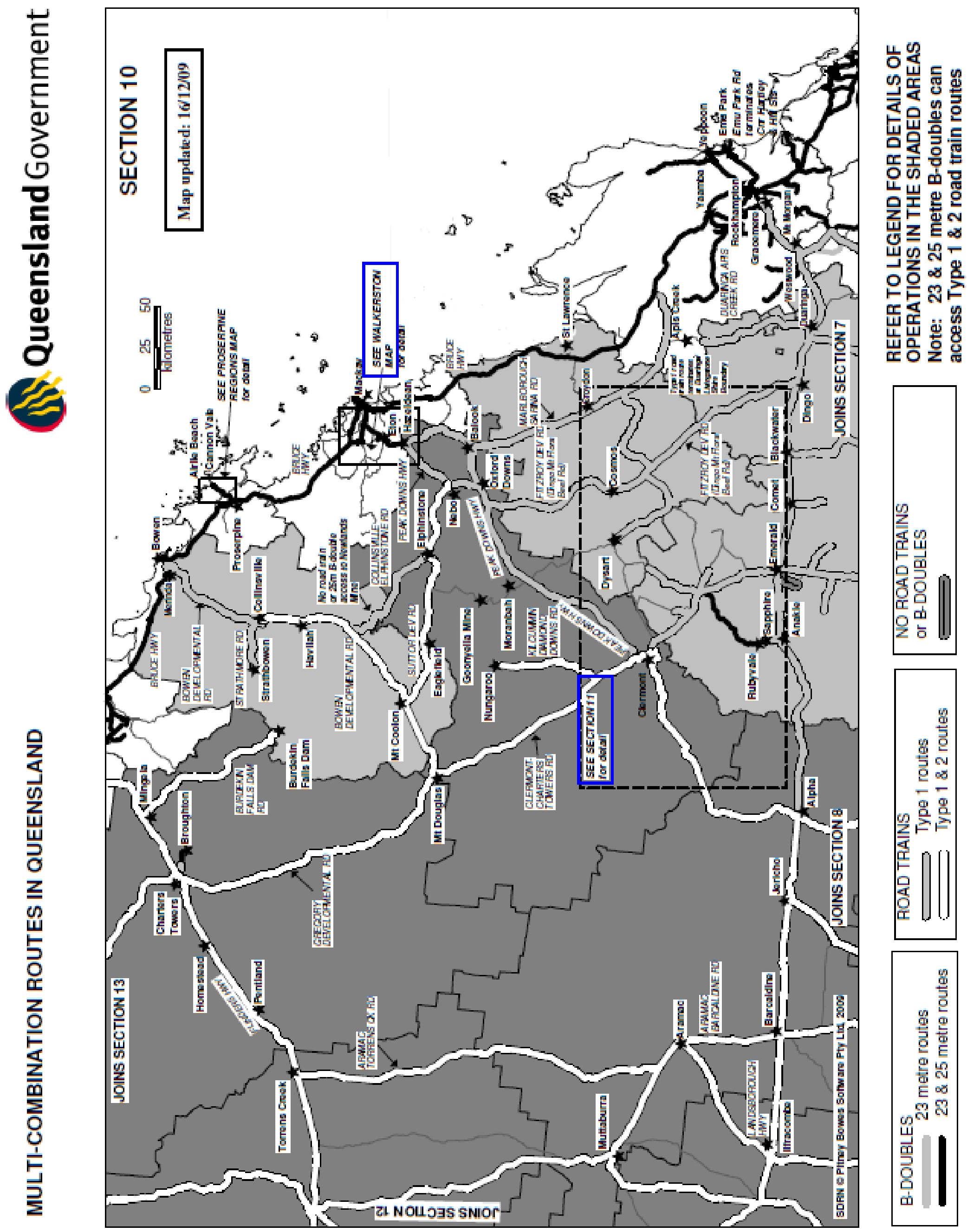
Warrego Highway Multi-combination Route Map



New England Highway Multi-combination Route Map



Bruce Highway Multi-combination Route Map



Appendix G HV Overtaking Length Data Models

Specifications

Vehicle	Length (m)
Semitrailer	19
B-doubles	25
Type 1 road trains	36.5
car	5
Maximum caravan towing	19

Velocity	m/s
100km/h	27.778
95 km/h	26.3891
90 km/h	25

Following Gap	2 Seconds (m)
100km/h	55.556
95 km/h	52.7782
90 km/h	50

Acceleration Rates

Vehicle	Acceleration (m/s/s)
Semitrailer	0.52
B-doubles	0.4
Type 1 road trains	0.36

Vehicle	Speed	Seconds	Distance (m)
Semitrailer	90 ->100	5.342	141.0
	95 ->100	2.671	72.3
B-doubles	90 ->100	6.945	183.3
	95 ->100	3.472	94.0
Type 1 road trains	90 ->100	7.717	203.6
	95 ->100	3.858	104.5

B-double Test Scenario Conditions

B-double overtaking car	
90 ->100	
Time (seconds)	0
Distance (m)	0
Distance of car (m)	55
Gap between (=75) (m)	-55
95 ->100	
Time (seconds)	0
Distance (m)	0
Distance of car (m)	57.7782
Gap between (=78)(m)	-57.7782

B-double overtaking Car towing	
90 ->100	
Time (seconds)	0
Distance (m)	0
Distance of car (m)	69
Gap between (=75) (m)	-69
95 ->100	0
Distance (m)	0
Distance of car (m)	71.7782
Gap between (=78) (m)	-71.7782

B-double overtaking B-double	
90 ->100	
Time (seconds)	0
Distance (m)	0
Distance of B-double (m)	75
Gap between (=75) (m)	-75
95 ->100	0
Distance (m)	0
Distance of B-double (m)	77.7782
Gap between (=78) (m)	-77.7782

Road Train Test Scenario Conditions

Road train overtaking car	
90 ->100	
Time (seconds)	0
Distance (m)	0
Distance of car (m)	55
Gap between (=86.5) (m)	-55
95 ->100	
	0
Distance (m)	0
Distance of car (m)	57.7782
Gap between (=90) (m)	-57.7782

Road train overtaking car towing	
90 ->100	
Time (seconds)	0
Distance (m)	0
Distance of car (m)	69
Gap between (=86.5) (m)	-69
95 ->100	
	0
Distance (m)	0
Distance of car (m)	71.7782
Gap between (=90) (m)	-71.7782

Road train overtaking Road train	
90 ->100	
Time (seconds)	0
Distance (m)	0
Distance of car (m)	86.5
Gap between (=86.5) (m)	-86.5
95 ->100	
	0
Distance (m)	0
Distance of car (m)	89.2782
Gap between (=90) (m)	-89.2782

HV Overtaking Model Lengths

B-double		
Test	Speed	Distance (m)
1	90 ->100	1387
	95 ->100	2761
2	90 ->100	1527
	95 ->100	3041
3	90 ->100	1587
	95 ->100	3161

Road Train		
Test	Speed	Distance (m)
1	90 ->100	1511
	95 ->100	3001
2	90 ->100	1651
	95 ->100	3281
3	90 ->100	1826
	95 ->100	3631