University of Southern Queensland

Faculty of Engineering & Surveying

The Safety Benefit of Continuous Narrow Painted Median Strips

A dissertation submitted by

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Abstract

Rural highways are typically undivided, have high operating speeds, carry high traffic volumes and are often designed to minimum geometric standards. Head-on and cross-over-the-centreline crashes are of the most severe crash types that occur on rural highways. They are disproportionally represented in crashes resulting in fatalities, yet undivided rural highways provide no separation between opposing traffic lanes. One possible countermeasure to these crash types is a continuous narrow painted median strip.

Narrow painted median strips are a relatively new and innovative road safety treatment aimed at reducing the incidence and severity of head-on and cross-over-the-centreline crashes on undivided roads. This is achieved by increasing the separation between vehicles travelling in opposite directions and warning drivers that have strayed from their lane with noise and vibration inside the vehicle. Previous research suggests audio-tactile centreline-marking to be an effective countermeasure to these crash types however, the added benefit of combining audio-tactile line-marking with a narrow painted median has not been thoroughly evaluated.

This research quantifies the safety benefit following installation of a 1.0 m wide continuous painted median strip utilising audio-tactile line-marking on the Bruce Highway in Queensland, Australia. Data was analysed for a 56 km section of the highway before and after installation of the painted median. An Empirical Bayes statistical analysis procedure was used for evaluation due to the short period of before and after data available. This method accounts for the regression to the mean bias that is prevalent when short data collection periods are available or when sites with a higher than normal crash history are being analysed.

Findings indicate significant reductions for all crash types that were analysed in this study. Head-on crashes were reduced by 75% (SD = 7.0%), Run-off-road-left crashes were reduced by 59% (SD = 14.5%) and Total crashes were reduced by 59% (SD = 8.8%). The results of this study add to the limited body of knowledge that is published on narrow painted median strips as a road safety treatment. The narrow painted median strip provides significant safety benefits, by means of crash reduction, and has relatively low installation costs. These preliminary yet encouraging results give justification to the future consideration or implementation of a continuous narrow painted median strip as a road safety countermeasure.

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Chapter 1

Introduction

1.1. Background

Head-on and cross-over-the-centreline crashes are of the most severe crash types that can occur on rural roads. These crash types are disproportionally represented in crashes resulting in Fatalities. In Queensland during the period from 1 January 2006 to 31 December 2010 there were 1603 fatalities of which 17.3% were head-on type crashes (Department of Transport and Main Roads 2011*a*). Results of a study in Maine in the United States of America (USA) covering the period from 2000 - 2002 show head-on crashes accounted for less than 5% of all crashes yet they were responsible for almost half of all fatalities (Gårder 2006). Typically it is economically prohibitive to provide barriers or wide median separation between opposing traffic lanes on rural highways. Continuous narrow painted median strips, also known as wide centreline marking in other states of Australia, have been identified as a potential low cost countermeasure to this road safety problem.

In early 2011, the Queensland Department of Transport and Main Roads (TMR) installed a 1.0 m wide continuous narrow painted median strip to improve safety on a 56 km section of the Bruce Highway in South East Queensland where a high number of fatal head-on crashes were occurring. The speed limit on the section of road had been reduced from 100 km/h to 90 km/h in December 2008 as part of a state-wide initiative developed between TMR and the Queensland Police Service to improve safety on blackspot segments of road. Despite the speed limit reduction a high number of severe and fatal crashes continued to occur. The installation of the median strip complemented the earlier speed reduction initiative and aimed to further improve safety on the section of road.

Continuous narrow painted median strips utilising Audio-tactile line-marking (ATLM) are a relatively new engineering treatment aimed at reducing the incidence and severity of head-on and cross-over-the-centreline crashes on undivided roads. This is achieved by increasing the separation between vehicles travelling in opposite directions and warning drivers that have strayed from their lane with noise and vibration inside the vehicle. The hypothesis behind the treatment is that the ATLM alerts a driver that they have deviated from their lane and the painted median provides a buffer zone for the driver to take corrective action before encroaching into the opposing traffic lanes.

1.2. Treatment Site Details

The treatment site is a 56 km section of the Bruce Highway between Cooroy and Curra in South East Queensland. A total length of 35.2 km of median was installed at the site, as existing channelised intersections and some segments that did not meet the project specific criteria were not treated. A map of the treatment site is shown in Figure 1.1

The section of the Bruce Highway is typically a two lane two way road with the exception of overtaking lanes. Opposing traffic Lanes were separated by conventional linemarking only. It had two 3.5 m lanes and generally 2 m wide sealed shoulders. The roadside environment is relatively forgiving and generally has sufficient clear zones. Figure 1.2 shows a typical section of the highway prior to the median installation.

The section of road has a high traffic volume for a two lane two way road with an Annual Average Daily Traffic volume (AADT) ranging from 12,000 to 17,000 vehicles per day with an average of 14,600. The section also carries up to 21% commercial vehicles.

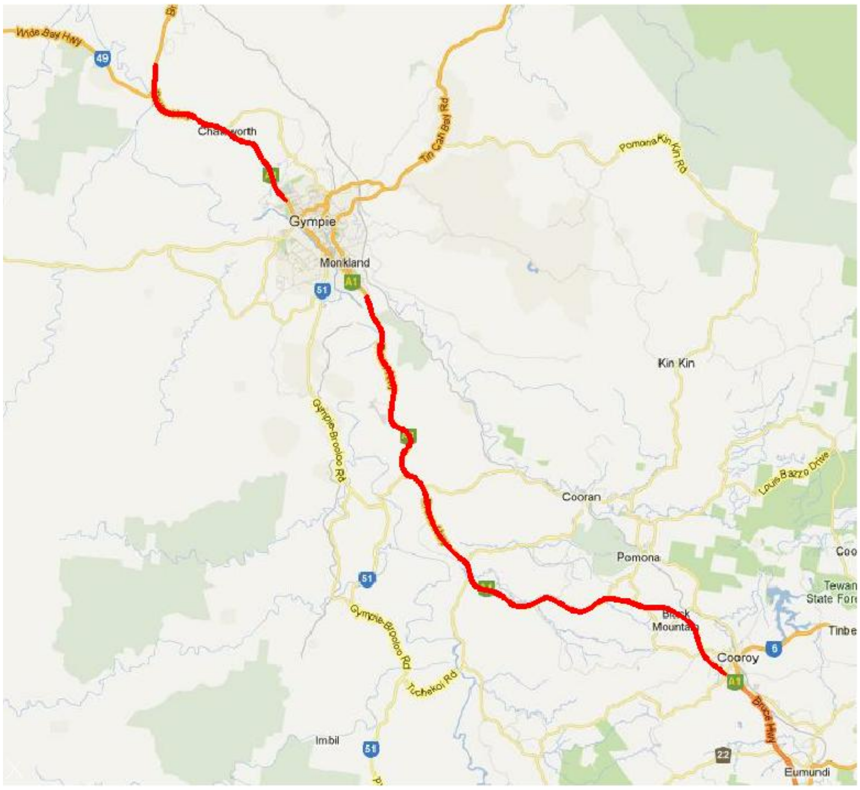

Figure 1.1: Treatment Site Location

(Median Location Shown in Red)

Figure 1.2: Typical Section of the Treatment Site

There are limited overtaking opportunities on the section with only 10 dedicated overtaking lanes, which equates to an average separation of 10 km. This is much greater than the spacing recommended in Austroads (2010c) to provide an acceptable level of service. Overtaking opportunities on the opposite side of the road were virtually non-existent due to the high traffic volumes.

In the 2008 Australian Road Assessment Plan (AusRap) report on the national road network, the Bruce Highway from Cooroy to Gympie was found to be one of the most dangerous sections of road in Australia and was the worst section of the Bruce Highway.

In the 5 year period from 2006 to 2010 inclusive the section of road recorded a total of 18 fatal crashes and 101 hospitalisation crashes. These crashes are shown by year in Figure 1.3. When considering all severe crashes, head-ons contributed only 19% to the crash total yet they accounted for 56% of fatal crashes. The head-on crashes occurring were predominantly attributed to fatigue and/or inattention.

As can be seen in Figure 1.3 showing crashes for the 2006 to 2010 period, total crashes were on a declining trend but fatal and head on crashes were steady or even on the rise. It should be noted that the vertical black line represents the period when the speed limit was reduced from 100 km/h to 90 km/h. It can be seen that fatal and head-on crashes were continuing to occur at a similar rate after the reduction in the posted speed limit.

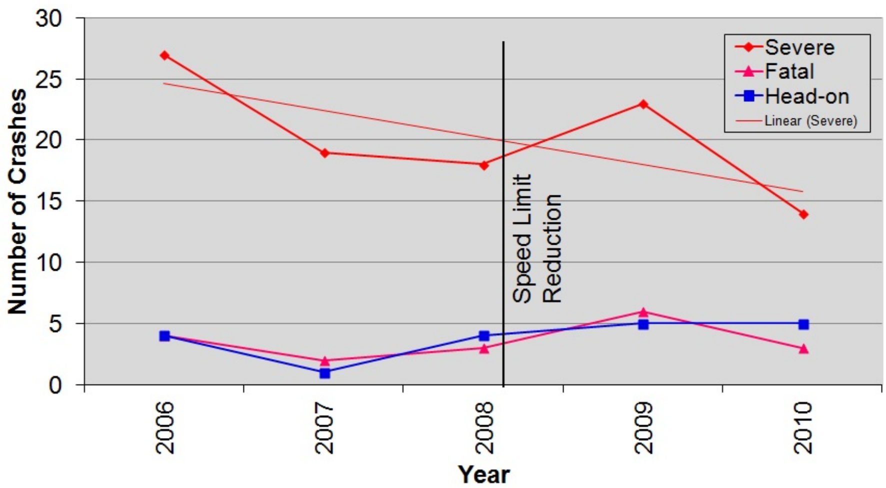

Figure 1.3: Severe Crashes at Treatment Site, by Year

Fatigue and inattention was a contributing factor to a number of the head-ons with witnesses to these accidents consistently reporting vehicles slowly drifting into the on-coming traffic lane. With the continually rising traffic volumes on the highway, the occurrence of vehicles crossing the centreline were increasingly becoming head-on crashes.

1.3. Painted Median Strip Details

The continuous painted median strip implemented by TMR has an overall dimension of 1.0 m. The outline consists of two 100 mm lane lines. Inside each of the outlines is a row of 150 mm wide raised ribs, in the same configuration that is used in conventional Audio-tactile edge line marking (see Figure 2.1 in chapter 2).

The median strip has painted white diagonal chevrons and rows of yellow reflective pavement markers inside the outline at intermittent spacing to further enhance the visual perception. The diagonal chevrons are 2.0 m in length and are placed at 72.0 m spacings. The rows of yellow raised reflective pavement markers are placed at the 24 m spacing that is standard for conventional centreline marking in Australia. The median configuration is shown in Figure 1.4.

The project was performed as a retrofit installation and no additional civil works were undertaken. The existing edge lines were not altered as part of the project which resulted in the lane widths being reduced from 3.5 m to 3.0 m. Although the same physical width of asphalt surface is still available.

Narrow lane widths are thought to make drivers feel more constrained and they drive at lower speeds to compensate. This complimented the earlier speed limit reduction initiative, therefore these narrow lanes were deemed to be acceptable for this section of the National highway where 3.5 m lanes are the traditional minimum.

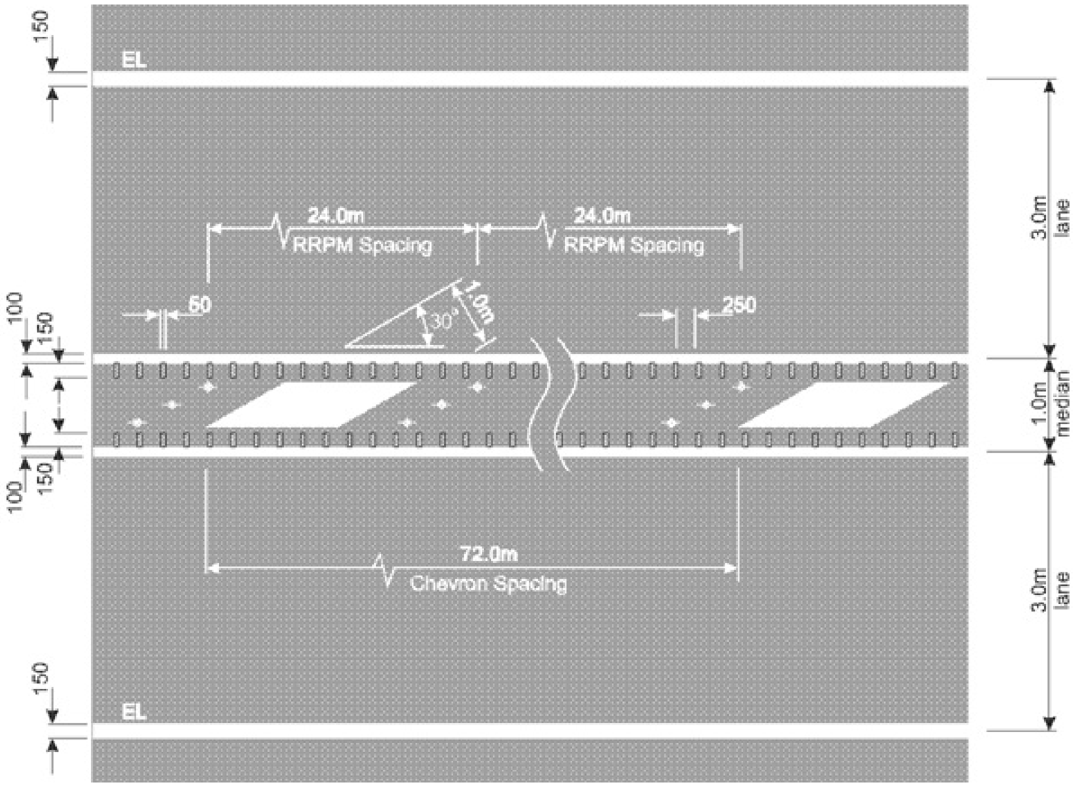

Figure 1.4: Layout Details of Continuous Painted Median Strip

All opportunities for overtaking on the opposite side of the road were removed with the installation of the median as it was considered that these manoeuvres were becoming increasingly risky given the high traffic volumes. An image of the installed treatment is shown in Figure 1.5.

1.4. Project Aim

The aim of this research is to quantify the safety benefit following installation of the 1.0 m wide painted median strip utilising ATLM. This treatment targets cross-over-the-centreline crashes which in this study includes head-on, side-swipe and run-off-the-road-right crash types. Since this study required recent crash data only fatal and hospitalisation crashes could be considered as minor severity crash data is not currently validated. The data was anal-

Figure 1.5: Continuous Painted Median Strip Installation

ysed separately for target crashes, run-off-the-road-left and total number of crashes. Previous literature has identified that run-off-the-road-left crashes may increase as the result of centreline ATLM being installed. This evaluation builds on the limited amount of existing knowledge of narrow painted median strips within the road safety industry and provides practitioners with sound evidence that painted median strips utilising ATLM are effective in reducing cross-over-the-centreline crashes. The results of this study are defined as percent reduction in crashes for each of the crash types mentioned previously.

1.5. Project Objective

The key objectives of the project are:

1. Research and become familiar with world best practice in regard to ATLM, narrow painted median strips, factors contributing to rural crashes and analysis methods used in previous studies. This is presented in the form of a literature review.

2. Determine where this research fits in relation to previous evaluations and

where it can bridge gaps and build on existing knowledge.

3. Obtain all crash data and traffic volume data for the treated sections of road and for the selected reference group of sites. This includes validated data from TMR's road crash database and some data from Queensland Police service QPrime database that will require validating.

4. Perform an Empirical Bayes statistical analysis to analyse the before and after crash data using the statistical software package SPSS Version 20.

5. Provide the results and recommendations from the analysis to quantify the safety benefit provided by the continuous narrow painted median strip.

Chapter 2

Literature Review

2.1. Introduction

The literature review presented in this report provides a summary of relevant literature available at the time of the review. Narrow painted median strips combined with ATLM are a relatively new countermeasure to cross-over-the-centreline crashes. During the literature review only two published road safety evaluations were found analysing these two treatments being used simultaneously (See Levett et al. 2009, Sagberg 2006). To gain a sound knowledge of the effects each component of this treatment has on safety the review analyses studies undertaken on centreline ATLM and narrow painted median strips both combined and as individual treatments. The review also covers, to lesser detail, factors influencing crashes on rural roads. The aim of the review is to examine findings of recent investigations, with particular consideration given to Australian conditions, and determine where this research can bridge gaps and build on existing knowledge. It analyses the methodologies and techniques that have been applied in prior research and identifies any shortfalls in these evaluations. This research adopts the most suitable evaluation method from the methods found in previous studies to maximise the validity of the analysis performed in this report.

2.2. Audio-Tactile Line-Marking

Audio-Tactile Line-Marking is the term given to the rumble strips typically used in Australia. These rumble strips are raised ribs formed from the thermoplastic paint that is commonly used to mark lane lines. The dimensions of the raised ribs used in Queensland and most parts of Australia are shown in Figure 2.1.

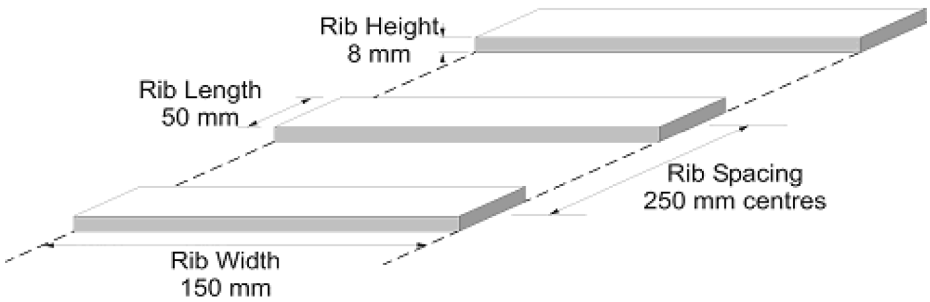

Figure 2.1: Typical Dimensions and Spacing of ATLM

Source: Department of Transport and Main Roads, Queensland, MRTS45

In the USA there are four different types of rumble strips that have been used; they are milled, rolled, raised and formed. The most common types that have been analysed are milled and rolled, both types are an indentation in the pavement surface. Milled rumble strips are made by grinding into the pavement surface while rolled rumble strips are pressed into the hot asphalt at the time of construction.

The rumble strip dimensions commonly used in the USA using the same terminology as in Figure 2.1 are a width of 406 mm, length of 178 mm, depth of 12.7 mm and a spacing of 305 mm centres (Karkle et al. 2009). The milled or pressed rumble strips used in the USA provide a greater audio and tactile response than the raised type employed in Australia (Anund, Hjlmdahl & Peters 2005). Despite this Dravitzki & Thomas (2011) reported that raised ribs with a height of 5 mm were detected by all drivers who participated in a study that evaluated human response to ATLM and Anund et al. (2008) found that the configuration and dimensions had little influence on the alerting effects of hitting a rumble strip.

The function of ATLM is to alert drivers that have deviated from their lane by causing noise and vibration inside the vehicle when the tires contact the raised ribs. The use of ATLM on both edgelines and centrelines, used independently or in combination, has been reported to provide a significant reduction in both target crashes and total crashes. Recent studies show that reductions in target crashes are not undermined by increases in non-target crashes (Hatfield et al. 2009).

In a USA study covering seven states and 350 km of treated roads an Empirical Bayes before and after analysis was conducted (Persaud, Retting & Lyon 2004). Overall crashes at sites treated with centreline rumble strips were reduced by 12%. Injury crashes were reduced by an estimated 14%. Head-on and sideswipe crashes, which are the primary target of centreline rumble strips, were reduced by 25%. The percent reduction was greater at night than during the day, this is supportive of the belief that rumble strips provide improved delineation under reduced visibility conditions.

Hatfield et al. (2009) conducted a study in Australia that evaluated 58.5 km of road at 10 locations in New South Wales. The Empirical Bayes method of analysis was used to evaluate for all crashes, target crashes, non-target crashes and out of control crashes for cars and heavy vehicles. The results show for roads with centreline only or centreline and edgeline ATLM a 44% crash reduction for cars and an 88% crash reduction for heavy vehicles when considering target crashes. When only edgeline ATLM was considered a 44% reduction in crashes for cars and a 61% reduction in crashes for heavy vehicles was observed.

In one of the most thorough and comprehensive before and after studies the impact of rumble strips on collision reduction on highways was evaluated (Sayed, Deleur & Pump 2010). There were 34 treatment sites on two lane rural roads chosen for the study, 18 of these had centreline rumble strips. The results of an Empirical Bayes statistical analysis found centreline rumble strips had a reduction of 29.3% for target crashes. This is higher than the results obtained for edgeline only and for combined edgeline and centreline which showed reductions of 26.1% and 21.4% respectively.

Karkle, Rys & Russell (2009) investigated the effectiveness of milled centreline rumble strips in reducing crossover accidents in a before and after study that applied both the Empirical Bayes and Naïve methods. The study used nine years of crash data for 43 km of two lane rural highway in Kansas. Considering total crashes the Empirical Bayes and the Naïve methods showed a reduction of 49.38% and 50.69% respectively. For cross-over-the-centreline crashes only, a reduction of 89.18% and 92.07% was found for the Empirical Bayes and the and the Naïve methods respectively. These results confirm the belief that the Naïve method often over-estimates the safety benefit reported from a road safety treatment.

The results of the reviewed literature suggest an overall benefit of rumble strips and report it to be an effective countermeasure against head-on and cross-over-the centreline crashes. Several studies indicate that rumble strips result in drivers contacting the centreline less, maintaining a more consistent lateral position and keeping a lateral position that is farther from the centreline, all which contribute to reduced incidence of target crashes. The wide range of road sections that have been analysed in various studies, mostly with very positive results, indicate that centreline rumble strips are effective under variety of geometric environment conditions.

The most common concerns with rumble strips in the literature are the impact of external noise produced by a vehicle contacting the rumble strips on roadside residents and inattentive or drowsy drivers making an initial “wrong” correction and swerving into the opposing traffic lane. It could be said that the alerting effects and eventual proper correction may still prevent a head-on collision. Noyce & Elango (2004) reported that drivers reacted to and corrected the vehicle trajectory more quickly with centreline rumble strip encounters than with shoulder encounters. This supports using a combination of ATLM and painted median strips, where the ATLM alerts a driver that they have deviated from their lane and the painted median provides a buffer zone for the driver to take corrective action.

2.3. Narrow Painted Median Strips

Rural roads as defined by Austroads are main roads carrying mostly long-distance traffic, as distinct from local traffic (Austroads 2010a). They are typically single carriageway, have a high operating speeds, carry high volumes of traffic and are designed to minimum geometric standards. All these factors contribute to their over-representation in severe and fatal crashes. Head-on and cross-over-the-centreline crashes on rural roads often have serious consequences due to the impact involved being up to two times that of a single vehicle run-off-the-road crash.

Typical cross section of an undivided rural road in Australia provides for no physical separation between opposing traffic lanes, the only separation is a painted barrier line. A typical rural two lane two way road is shown in Figure 2.2.

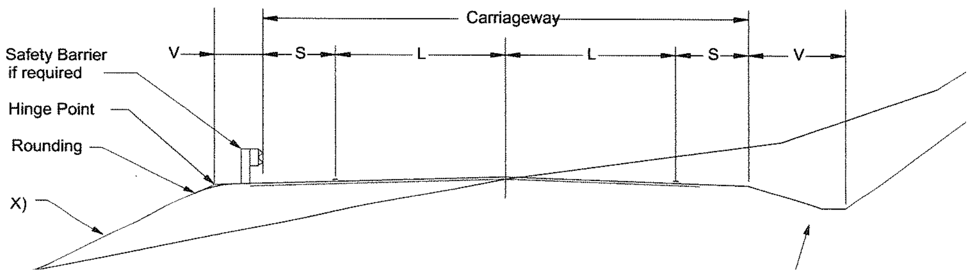

Figure 2.2: Typical Rural Road Cross-Section

Source: Queensland Department of Transport and Main Roads, Road Planning and Design Manual

The standard barrier line used in Australia, as shown in Figure 2.3, consists of two 80 mm white painted lines with an 80 mm spacing between them, providing only 240 mm of separation between vehicles travelling in opposite directions. This centreline configuration provides no room for driver error and only the smallest lapse in concentration, distraction or fatigue can result in serious consequences.

Sealed shoulders provide an initial area for drivers that have deviated from their lane to take corrective action, similar to painted median strips. Many studies on rural road crashes have found that a greater sealed shoulders width is associated with a reduction in run-off-the-road crashes. A considerable emphasis is placed on providing sealed shoulders in best practice road design. However, consideration is rarely given to providing separation between opposing traffic lanes on rural roads when the benefits could be equal to or greater than that of providing a shoulder.

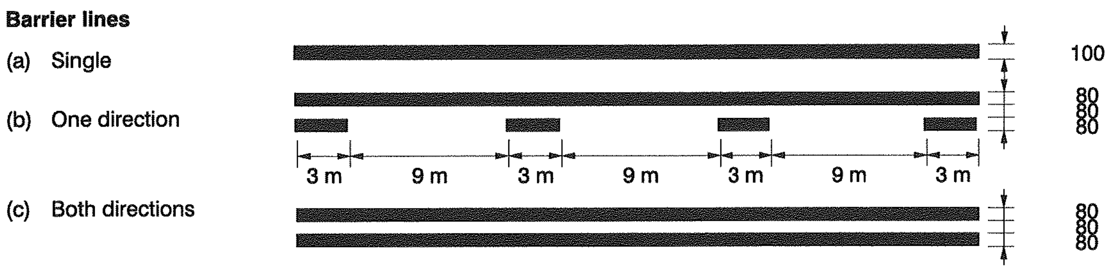

Figure 2.3: Typical Barrier Line Configuration

Source: Manual of Uniform Traffic Control Devices (Queensland)

Levett, Job & Trang (2009) analysed centreline treatment countermeasures to address crossover crashes where several wide centreline configurations were trialled. These ranged from 0.5 m painted medians to 2.0 m wide medians with wire rope safety barrier. The results indicate that crash incidence and severity were reduced following the installation of a 1.0 m wide painted median strip. Total crashes were reduced by 61.5% and target crashes were reduced by 60%. They reported a positive effect from the narrow median and that fatigue, distraction and maybe speed related crashes could be expected to be reduced.

Findings also indicated that to maximise the safety benefit ATLM should be incorperated into the 1.0 m wide median. This study concluded that head-on and cross-over-the-centreline crashes can be addressed in a similar fashion to run-off-the-road crashes.

Sagberg (2006) investigated the effects of a 1.0 m wide painted median on driver behaviour. The study included two sections of road totalling 26.4 km. Speed data was recorded from permanent speed counters and vehicle lateral position was measured on the basis of digital video recordings. The results indicate that providing a 1.0 m wide painted median the average speed was reduced by 2.7 km/h and the average distance from the centre of the road to the vehicles side mirror increased by 30 - 35 cm. One of the conclusions from this study was that purely visual measures are effective in order to influence driver behaviour both in terms of speed and lateral position.

Burdett (2011) conducted another wide centreline trial evaluation where four sites were evaluated for change in vehicle lateral position following installation of a 1.0 m wide painted median. Findings indicated a significant increase in distance from the centre of the road from 1.2 m to 1.5 m. In a similar study Connell et al. (2011) reported large reductions in the proportion of vehicles crossing the centreline and edgeline. When considering both day and night conditions there was a reduction of 84% in vehicles crossing onto or over the centreline. It was concluded that providing a 1.2 m wide painted median significantly improved the likelihood of a driver to keep wholly within their lane.

Austroads (2010b) acknowledged that work on enhanced road markings to increase the level of separation between opposing traffic flows seems promising and in Australia work on perceptual countermeasures also looks to have merit. It was concluded that to support these findings further on road trials need to be evaluated.

2.4. Factors Influencing Crashes on Rural Roads

During the twelve month period ending February 2012 there were 1305 fatalities on Australian roads. Figures indicate that 39.0% involved more than one vehicle and 35.2% occurred on roads with posted speed limits of 100 km/h, typical of undivided rural roads (Department of Infrastructure and Transport 2012). A difficulty in reviewing rural crash data and analysis from different states is that there is no consistent definition of 'rural'. In Queensland rural is defined as a crash occurring on a road with a posted speed limit of 90 km/h or greater, other states use a given distance from a town centre of a given size. Fatality rates in rural crashes have been shown in many studies to be two to six times higher than that of urban crashes.

In a study of rural and remote crashes with respect to their environment vehicle and operator factors Siskind et al. (2011) found that over 80% of crashes occurred where there was no road features present, such as intersections or traffic controls, and over 70% of fatal crashes occurred on open road where the speed limit was at or over 100 km/h. Alcohol was considered a contributing factor by police in nearly 30% of fatal crashes and only 18% in non fatal crashes. Fatigue was a contributing factor in 16.1% of fatal crashes and 11.5% of injury crashes, while distraction and inattention was higher in the non fatal group than in the fatal group being 25.5% and 20.0% respectively. The factors making the major contribution were shown to be travel speed and alcohol use, with alcohol use having a strong influence on the severity of the crash.

A review of road crashes in Queensland during the period from 1 January 2006 to 31 December 2010 reported that in fatal crashes 19.8% were alcohol or drug related, 16.7% were drink driving, 11.5% were performing illegal manoeuvres and 10.1% were fatigue related. In 80% of fatal crashes the drivers intention was to continue straight along the road. 34.8% were hit object crashes and 17.3% were head-on type crashes, 58.6% occurred on state controlled roads, typically high speed rural roads, and 78.4% occurred away from intersections (Department of Transport and Main Roads 2011*a*).

A USA study by the National Highway Traffic Safety Administration (NHTSA) showed that 56.0% of fatal crashes occur on rural roads with 65.5% of those being in 90 km/h or higher speed zones. Only 28.0% of all crashes were on undivided two lane roads however they accounted for 58.0% of fatalities. In 10% of total crashes head-on and sideswipe were reported to be the first harmful event (NHTSA 2011).

Gårder (2006) analysed crash data for head-on crashes in Maine, US, covering the period from 2000 - 2002. Alarmingly, head-on crashes accounted for less than 5% of all crashes yet they were responsible for almost half of all fatalities. The results show illegal or unsafe speed was a factor in 32% of the crashes, driver inattention or distraction was a primary factor in 28%, fatigue was responsible for only 2.5% of all crashes but was a factor in 8.3% of fatalities. Less than 8% involved a driver performing an overtaking manoeuvre, 66% occurred on straight segments and 67% of these happened on dry pavement. It was summarised that there were two main reasons why drivers crossover the centreline and have head-on collisions, they are driving too fast for the roadway conditions and inattentive drivers crossing the centreline more or less without even knowing it.

In a publication by Austroads (2010b) on rural head-on crashes it was summarised that head-on crashes are one of the most severe type of crash that may occur in rural environments. It is therefore important that gaps in knowledge of the factors that contribute to head-on crashes and that methods that may be used to prevent them from occurring be determined. It was also reported that contributory factors were identified as straying into the opposing lane without knowing it, driver inattention or impairment, over-correcting after straying onto the shoulder excessive speed, particularly on bends, and overtaking. The review also found that road features may also be a factor such as geometry of curves, shoulder condition, whether a road is single or dual carriageway, poor delineation and insufficient overtaking opportunities.

The common factors that influence rural road crashes were found to be driving with a speed in excess of that appropriate for the roadway conditions not necessarily above the speed limit, driving impaired by either alcohol or drugs, driver not paying attention or being distracted and fatigue. It was shown in most studies that driver error or misjudgement was a far greater contributing factor than were road conditions and environment.

These results indicate that to reduce the incidence of serious rural crashes actions should target improving measures to keep vehicles within their lane and that continuous treatments over larger sections of road could provide the greatest benefits.

2.5. Analysis Methods

Of the studies on ATLM and painted median strips that were evaluated in this research it was found that there are a number of methods used and that these differing methods may influence the validity of the results. The factors of most influence to the results were assessed as being the method of statistical analysis, naïve or Emperical Bayes, suitability of reference group sites, types of crashes evaluated, duration of data collection period and type of treatment assessed eg. milled or raised rumble strips. These are discussed below.

The naïve before and after study is the simplest method for this type of observational study. In this approach, the change in accident counts between the before and the after period is considered the treatment effect. The effect of the passage of time on the safety of a facility is ignored. This method is unable to separate the treatment effect from the exposure, trend and random effects that are present in road crash data. The application of this method is not recommended however, some comparison studies show that the results from the naïve method are similar to an Empirical Bayes method when considering a longer duration of crash data.

As sites selected for before and after studies often have higher than average crash rates before application of a treatment, a lower accident rate would be expected in the after period even if no treatment had been implemented. This effect is known as regression to the mean. To properly account for the effect of regression to the mean, the Empirical Bayes method is used. The Empirical Bayes method is a statistical approach to determine the appropriate weighting to place on each relevant factor to estimate accident outcomes for a treatment group. The Empirical Bayes method determines a smoothed value for expected accidents and eliminates the randomness element of accidents. Safety performance functions (SPFs) are used to estimate accident frequencies had the treatment not been applied. SPFs are regression models that explain the relationship between accident frequency and some explanatory variables such as traffic volume (Institute of Transportation Engineers 2009). SPFs are created using a comparison group of untreated sites with similar characteristics to that of the treatment site.

Results of naïve before and after studies are often considered unreliable and non valid. There is a clear acceptance in the road safety industry that the Empirical Bayes before and after method produces statistically defendable results and is the prefered method (Institute of Transportation Engineers 2009).

In many before and after studies the suitability of the comparison or reference group is often not documented. This presents a problem when determining how valid the results are and whether or not they can be used with any certainty. Persaud & Lyon (2007) report that the reference group must be representative of the treatment site that is, similar in terms of geometry, traffic volumes, types of vehicles and so on. For the analysis to be useful to practitioners the suitability of the comparison group must be presented in the report.

Consideration must be given to the types of crashes being analysed especially when creating the SPFs for use in the Empirical Bayes method. An SPF for one type of crash may not have the same parameters as an SPF for another crash type and incorrect use can reduce the validity of results. Attention should also be given to negative effects of a treatment not just the improvement in target crashes. The data collection period should be of considerable length to allow greater confidence in the results. This is typically three years minimum however, the Empirical Bayes method allows the use of some shorter periods.

Chapter 3

Method

3.1. Introduction

The evaluation of the effectiveness of road safety countermeasures is done by performing a before and after study. To become familiar with best practice in before and after studies an exhaustive literature review was undertaken. All literature was assessed for its relevance to narrow painted median strips utilising ATLM and crash types that are the target of this treatment. Due to the use of ATLM and narrow median strips being relatively new, advances in engineering practices and improved vehicle handling characteristics early literature was not included in the review. While the main search was performed in March, 2012, any relevant literature that was made available during the study period was also included.

Currently there is limited research into the effectiveness of narrow painted median strips utilising ATLM in Australian conditions. With only one study undertaken by Levett et al. (2009) using the naïve method having been published. Even with the lack of statistical evidence there is plans for the treatment to be employed extensively throughout Australia. The results of this research provide practitioners with reliable evidence that this treatment does in fact improve road safety and gives support to future implementation.

The simplest method of road safety evaluation is the naïve before and after study. This method though, has been shown to be flawed in that it does not account for the regression to the mean bias and it assumes a linear relationship between included factors, which is rarely the case. To overcome these shortfalls in the naïve method it is recommended by road safety experts that the

Empirical Bayes method be employed.

The Empirical Bayes statistical analysis method as proposed by Hauer (1997) overcomes the limitations of simpler methods by accounting for regression to the mean, changes in traffic volume, variation in segment lengths and for time trends, such as weather and driving habits. This is achieved by means of a calibrated safety performance function which is discussed in Section 3.3. The method is now well established in road safety analysis and has become the "gold standard" for road safety evaluations. The Empirical Bayes statistical analysis method as derived by Persaud et al. (2004) is used in this study.

3.2. Empirical Bayes Methodology

The effect a treatment has had on safety is given by $B - A$, where B is the predicted number of crashes for the after period had the treatment not been implemented and A is the sum of the number of crashes recorded in the after period.

The Empirical Bayes method determines a statistically valid estimate of the number of crashes expected in the after period had the treatment not been implemented. First, the number of crashes expected in the before period is estimated by combining two sources of information. These are,

1. the number of crashes recorded at the treatment site in the before period and
2. the number of crashes that would be expected at similar sites predicted by the SPF.

These two clues are then combined using a weighted average, given by:

$$m = w_1(x) + w_2(P) \tag{3.1}$$

where m is the estimate of the expected crashes, w_1 and w_2 are the weighting factors, (x) is the number of crashes recorded at the treatment site in the before period and (P) is the sum of the number of crashes predicted by the SPF. The number of crashes predicted by the SPF is calculated for each segment individually using the characteristics of that segment and then summed to perform the remaining calculations.

The parameters w_1 and w_2 determine the weight given to the number of crashes predicted by the SPF when combining it with the recorded number of crashes at the treatment site.
The parameters w_1 and w_2 are estimated as:

$$w_1 = \frac{P}{P + 1/k} \tag{3.2}$$

and

$$w_2 = \frac{1}{k(P + 1/k)} \tag{3.3}$$

where k is a constant for a given model and is estimated from the SPF calibration process with the use of a maximum likelihood procedure. In the calibration process a negative binomial distributed error structure is assumed with k being the dispersion parameter of the distribution.

A factor is then applied to the estimate m to account for variation in the before and after period and for changes in traffic volume. This factor is determined by dividing the sum of the SPF estimates for the after period, P_A by the sum of the SPF estimates for the before period, P_B. This accounts for the increase in traffic volume and other non defined time related variables in a non linear fashion, as changes in these parameters have been shown to rarely be linear. The estimated number of crashes in the before period, m is multiplied by that factor to obtain the predicted number of crashes in the after period, B had the treatment not been implemented.

The effectiveness of the treatment could be obtained from the ratio of the sum of the crashes recorded in the before period, x to the sum of the predicted number of crashes, B. However, Hauer (1997) claims this estimate biased and a more reliable estimate of the effectiveness is obtained from equation 3.4.

$$\theta = \frac{A/B}{1 + \left[\frac{Var(B)}{B^2}\right]} \tag{3.4}$$

The Standard deviation of θ is given by equation 3.5.

$$SD.\theta = \left[\frac{\theta^2 \left\{\left[\frac{Var(A)}{A^2}\right] + \left[\frac{Var(B)}{B^2}\right]\right\}}{1 + \left[\frac{Var(B)}{B^2}\right]}\right]^{0.5} \tag{3.5}$$

The percent reduction in crashes is then given by 100 $(1 - \theta)$ with a standard deviation of 100 $(SD.\theta)$.

3.3. Safety Performance Functions

The first task in performing a before and after study using the Empirical Bayes method is to develop unique SPF's for the road type and geographic conditions under evaluation. The SPF is a mathematical model that predicts the number of crashes that would be expected to occur on a road segment, based on data from a large reference group of sites that are similar to the treatment sites. The models use input variables such as segment length and AADT to predict the number of crashes. The equations are modelled using a generalised linear equation and are fit to the data using a Negative Binomial regression analysis with the natural logarithm as the link function. Therefore the models take the form shown in Eq. 3.6 where the variables are exponential.

$$P = exp^{[\alpha + (segmentlength \times \beta_1) + (AADT \times \beta_2)]} \tag{3.6}$$

where P is the estimated number of crashes per year and α, β_1 and β_2 are parameters determined in the model calibration process. The model is calibrated with data obtained from a reference group of sites using a regression analysis package. The control sites have similar characteristics to the treatment sites, but need not be exact.

3.4. Data Collection and Reference Site Selection

The continuous narrow painted median strip being analysed in this study is a mid block treatment only. That is, the treatment is not applied through major intersections that are already channelised with either a painted or raised island. Segments were created for each length of road between major intersections. Crashes occurring within 100 m of a major intersection were excluded from the final data files.

The data that was used in this study was extracted from four different databases. The segments and segment lengths for the treatment sites were taken from the project design drawings while for the reference group the segments and lengths were obtained by using TMRs Digital Video Roads (DVR) application and the TMR North Coast Region Traffic Census (2011). The AADT data was obtained from the TMR Traffic Analysis and Reporting System (TARS).

The crash data was extracted from the TMR Road Crash 2 database by TMR data analysis branch. Road crash 2 is the database maintained by TMR with raw data from from the Queensland Police Service QPrime database. The Qprime data is checked for its accuracy, validity, additional information such as the Definition for Coding Accidents (DCA) is added and the crash is accurately located before being added to the Road Crash 2 database. Crash data was also obtained from the Queensland Police Service QPrime database for the after period to ensure all crash occurrences were considered.

Due to this being a preliminary study up to date data was required. There is generally a lag period with crashes of minor severity being entered into crash databases due to the validation process. For this reason only high severity crashes have been analysed in this study. These include hospitalisations and fatalities.

The data periods used to determine the crash reduction attributed to the painted median strip were, for the before period 2009 & 2010 and for the after period June 2011 to June 2012. A summary of the treatment site data is given in Table 3.1.

Table 3.1: Summary of Treatment Site Data

Road	**Length (km)**	**Segments**	**Before (2 years)**				**After (1 year)**			
			Average AADT	**Crash count**			**AADT**	**Crash count**		
				HO	**RORL**	**Total**		**HO**	**RORL**	**Total**
10A	27.27	12	15236	7	3	12	15705	0	1	1
10B	7.93	9	12655	2	1	6	12659	1	0	3
Total	35.2	21	13946	9	4	18	14182	1	1	4

1. HO = Head-on and Run-off-road-right
2. RORL = Run-off-road-left
3. Total = The total number of severe crashes (hospitalisation and fatal)

Five years of data was also obtained for 49 sites for the reference group to enable the SPF model calibration process. The reference group sites total 155 km in length. The reference sites have similar characteristics to the treatment sites, but need not be exact. Typical sections of the reference sites are shown in Figures 3.1 and 3.2. The reference sites were selected based on the following criteria,

1. State/National highway in similar geographic location.
2. Similar AADT to the treatment sites (Minimum AADT was 3200).
3. Horizontal and vertical geometry similar to treatment sites.
4. Typical cross-section similar to treatment site.

Each reference site is a segment between major intersections and may contain minor intersections. Major intersection related crashes were excluded from the data set based on Definitions for Coding Accidents (DCA) coding and location, the Queensland DCA coding Table is included in Appendix C. These crash types were excluded as they were not likely to be affected by the median installation. A summary of the reference group data is shown in Table 3.2

Figure 3.1: Typical Section - D'Aguilar Highway

Source: Department of Transport and Main Roads

Figure 3.2: Typical Section - Brisbane Valley Highway

Source: Department of Transport and Main Roads

Table 3.2: Summary of Reference Group Data

Road	**Length (km)**	**Segments**	**Average AADT**	**Crash count**			
				HO	**RORL**	**Fatal**	**Total**
Bruce Hwy	69.99	32	11474	27	15	11	72
D'Aguilar Hwy	39.53	7	8579	20	5	7	64
Warrigo Hwy	11.85	5	11339	6	2	4	16
Cunningham Hwy	12.84	9	6220	2	2	1	12
New England Hwy	9.44	4	4253	0	0	0	1
Brisbane Valley Hwy	11.67	3	8262	5	0	2	12
Total	155.32	60	8355	60	24	25	177

1. HO = Head-on and Run-off-road-right
2. RORL = Run-off-road-left
3. Total = The total number of severe crashes (hospitalisation and fatal)

Chapter 4

Analysis

4.1. Introduction

The analysis performed in this study follows the methodology set out in the previous Chapter. This Chapter describes the process undertaken in performing the statistical analysis for this study and provides all the relevant data, models and statistical results.

The analysis was performed on three different crash types to not only give an understanding of the effect on crashes which are the target of this treatment but also the effects on crashes which may be negatively affected by the treatment. The data was analysed for the following crash types;

1. Head-on and cross-centreline crashes (The target of this treatment)
2. Run-off-the-road-left crashes (possibly negatively affected)
3. Total crashes, which includes all crash types

This chapter is divided into four sections which describe in detail the main parts of the analysis which are; Collection and Sorting of Data, Development of Safety Performance Functions, the Empirical Bayes Analysis and a Cost Benefit analysis.

4.2. Collection and Sorting of Data

As mentioned in Chapter 3 it was required for the treatment site and reference group sites to be divided into individual mid block segments. To determine the segments for the treatment site the design drawings were used and the exact road through distances (Chainages) for the start and end of each segment of the painted median were recorded.

For sites in the reference group the highways were first assessed based on traffic volumes, as AADT has been documented in many studies as being the factor that has the greatest influence on the crash rate. The AADT for all the highways were obtained from the TMR Traffic Analysis and Reporting System. Sections of the highways which had traffic volumes similar to the treatment sites were included for further investigation.

The next criteria for the reference group were cross section and geometry. The road cross section is also known to have a significant effect on the number of crashes particularly the shoulder width and the overall carriageway width. The road alignment is also a factor that can have an effect on the crash rate. To be included the road had to be two-lane two-way with a cross section of two 3.5 m lanes and a 1.5 - 2.0 m sealed shoulder. The cross section and geometry were predominately assessed using the TMR Digital Video Roads (DVR) application. DVR is a database recorded from a vehicle that moves along the road and takes photographs and records other information every 10 m based on GPS tracking. The application then enables virtual driving of the road.

The sections of highway that met all of the above criteria were then divided into mid block segments that run between major intersections.

The crash data used in this study was provided by TMR Data Analysis Branch from the Road Crash 2 database. The file supplied was a comma separated text file containing fatal and hospitalisation crashes for the period from January 2006 to June 2012. This file contained crashes that occurred on the entire length of all the highways listed in Table 3.2. The supplied crash data file contained 1247 crashes.

Since only some segments of the highways met the criteria to enable inclusion in the reference group this data file had to be filtered to include only crashes that occurred in the appropriate segments. This filtered crash data file contains 213 crashes. An extract of the filtered data file is shown in Table 4.1 and the complete data file is included in Appendix E.

Table 4.1: Extract from Crash Data File

CRASH NUMBER	CRASH SEVERITY	CRASH YEAR	CRASH MONTH	CRASH ROAD ID	CRASH ROAD TDIST	CRASH NATURE CODE	CRASH NATURE DESCRIPTION	CRASH DCA	CRASH DCA DESCRIPTION	CRASH DCA GROUP	CRASH DCA GROUP DESCRIPTION	CAS FATALITY	CAS HOSPITALISED	CAS TOTAL
20100231999	Hospitalisation	2010	February	150B	20.89	4	Head-on	201	VEH'S OPPOSITE APPROACH: HEAD ON	2	Head-on	0	3	3
20100254008	Hospitalisation	2010	February	134	9.66	6	Hit fixed obstruction or temporary object	704	OFF PATH-STRAIGHT:RIGHT OFF CWAY HIT OBJ	16	Off carriageway on straight hit object	0	1	1
20100269910	Hospitalisation	2010	February	10A	72.3	6	Hit fixed obstruction or temporary object	607	VEH'S ON PATH: TEMPORARY OBJECT ON C'WAY	21	Other	0	1	1
20100270037	Hospitalisation	2010	February	10A	104.21	6	Hit fixed obstruction or temporary object	704	OFF PATH-STRAIGHT:RIGHT OFF CWAY HIT OBJ	16	Off carriageway on straight hit object	0	1	1

The filtered crash data file was still not in a format that could be utilised by the Statistical analysis software so the file was modified into a suitable structure. This was again a comma separated text file where each row has the number of the various crash types that occurred in that segment in a year. Each row also has the length of the segment and the AADT of the segment for the given year.

The crashes were sorted from the filtered crash data file into the three groups of crash types based on DCA coding, the Queensland DCA coding Table is included in Appendix C. The DCA codes that were included in the Head-on and cross-centreline crashes were 201, 702 and 704. The DCA codes used to determine Run-off-the-road-left crashes were 701 and 703.

An extract from this modified data file is shown in Table 4.2 and the complete data file is included in Appendix D

Table 4.2: Extract from the Modified Data File

Road	Section ID	Start Chainage	End Chainage	Length (km)	AADT	Head-on	RORL	Other	Total
10A	1	102.24	108.27	6.03	13991	1	0	1	2
2006	2	108.27	108.93	0.66	15246	0	0	0	0
	3	112.18	117.1	4.92	14258	1	2	0	3
	4	118.5	119.33	0.83	14258	0	0	0	0
	5	119.79	120.86	1.07	14258	0	0	0	0
	6	121.43	121.69	0.26	13366	0	0	0	0
	7	122.06	124.52	2.46	13366	0	0	0	0
	8	124.99	125.32	0.33	13366	0	0	0	0
	9	127.18	128.04	0.86	14252	1	0	2	3
	10	128.52	130.27	1.75	14252	0	0	2	2
	11	130.9	135.86	4.96	14252	0	0	1	1
	12	136.24	139.38	3.14	14252	1	0	2	3
10A	13	102.24	108.27	6.03	14558	0	0	0	0
2007	14	108.27	108.93	0.66	15852	0	0	0	0
	15	112.18	117.1	4.92	14934	0	0	1	1
	16	118.5	119.33	0.83	14934	0	0	0	0
	17	119.79	120.86	1.07	14934	0	2	0	2
	18	121.43	121.69	0.26	13997	1	0	0	1

4.3. Development of Safety Performance Functions

With the data now in a format that can be input into the statistical analysis package the next step in the analysis is to develop the unique SPF's. As discussed in Chapter 3 the SPF's are mathematical models that predict the number of crashes that would be expected to occur on a segment of road. The models use the input variables AADT and segment length to enable the prediction.

The statistical analysis package used in this study was SPSS Version 20. SPSS was chosen for this analysis as it has all the functionality required and has a very user friendly graphical interface. The modified data file is input into SPSS using the Open Data command where the modified comma separated text file is selected. The Text Import Wizard is then used to configure parameters such as the delimiter type and the line number that contains the first line of data etc. The code used to import the data is shown in Figure 4.1.

```
GET DATA
  /TYPE=TXT
  /FILE="C:\Users\Adam\Documents\Uni Work\Final Project\Data
     and Analysis\_Final data\Input for "+
    "SPSS.csv"
  /DELCASE=LINE
  /DELIMITERS=","
  /ARRANGEMENT=DELIMITED
  /FIRSTCASE=2
  /IMPORTCASE=ALL
  /VARIABLES=
  Road A4
  SectionID F3.0
  StartChainagekm F6.2
  EndChainagekm F6.2
  Lengthkm F4.2
  AADT F5.0
  Headon F1.0
  RORL F1.0
  Other F1.0
  Total F1.0.
CACHE.
EXECUTE.
DATASET NAME DataSet1 WINDOW=FRONT.
```

Figure 4.1: SPSS Code for Data Import

With the data now in the SPSS data editor an analysis can be set up and run. The equations are modelled using a generalised linear equation which in SPSS uses the generalised linear models function, GENLIN. The models are fit to the data with a Negative Binomial probability distribution employing a maximum likelihood error structure and using the natural logarithm as the link function. The dependant variables are selected as appropriate for the model being constructed, these are either Head-on, run-off-the-road-left (RORL) or

Total. Next the independent variables are selected as covariates, these are AADT and Segment Length. The remaining statistical parameters are chosen and the model is then run. The code used to create the calibrated model for Total crashes is shown in Figure 4.2.

```
* Generalized Linear Models.
GENLIN Total WITH AADT Lengthkm
  /MODEL AADT Lengthkm INTERCEPT=YES
 DISTRIBUTION=NEGBIN(MLE) LINK=LOG
  /CRITERIA METHOD=FISHER(1) SCALE=1 COVB=MODEL MAXITERATIONS
     =100 MAXSTEPHALVING=5
    PCONVERGE=1E-006(ABSOLUTE) SINGULAR=1E-012 ANALYSISTYPE=3(
       WALD) CILEVEL=95 CITYPE=WALD
    LIKELIHOOD=FULL
  /MISSING CLASSMISSING=EXCLUDE
  /PRINT CPS DESCRIPTIVES MODELINFO FIT SUMMARY SOLUTION.
```

Figure 4.2: SPSS Code for Creating Models

From the Statistics tab of the Generalised Linear Models function the following parameters were selected to be plotted to the output window;

- Case Processing Summary
- Descriptive Statistics
- Model Information
- Goodness of Fit Statistics
- Model Summary Statistics
- Parameter Estimates

The output obtained from the model for Total crashes is shown below and a short description of each of the output tables is also given. The model parameters for Head-on and RORL crashes are shown in Appendix B.

The Model Information Table, Figure 4.3, displays the data and method that was used to construct the models. This table shows that the model was constructed for Total crashes, the Negative Binomial distribution was used with the maximum likelihood error structure and the link function was the natural logarithm.

Model Information

Dependent Variable	Total
Probability Distribution	Negative binomial (MLE)
Link Function	Log

Figure 4.3: Model Information (Total Crashes)

The Case Processing Summary, Figure 4.4, displays the number and percentage of cases included and excluded from the analysis. This shows that none of the cases were missing data and 100% of cases were included in the model calibration.

Case Processing Summary

	N	Percent
Included	339	100.0%
Excluded	0	0.0%
Total	339	100.0%

Figure 4.4: Case Processing Summary (Total Crashes)

The Continuous Variable Information Table, Figure 4.5, shows details of the dependant and independent variables included in the model. The key information in this table is that the standard deviation is greater than the mean for the dependant variable which confirms that the data does not comply with the rules of the poisson distribution and the negative binomial distribution was appropriately chosen.

The Goodness of Fit Table, Figure 4.6 displays deviance and scaled deviance,

Continuous Variable Information

		N	Minimum	Maximum	Mean	Std. Deviation
Dependent Variable	Total	339	0	6	.59	1.043
Covariate	AADT	339	3117	16445	9733.94	3411.276
	Lengthkm	339	.13	19.25	2.6452	3.11878

Figure 4.5: Continuous Variable Information (Total Crashes)

Pearson chi-square and scaled Pearson chi-square, log-likelihood, Akaike's information criterion (AIC), finite sample corrected AIC (AICC), Bayesian information criterion (BIC) and consistent AIC (CAIC). The values contained in this table are useful for comparing models when trying different model types. The two most useful values in this table are the deviance and Pearson chi-square values divided by the degrees of freedom where a value of 1 means the model fits the data perfectly.

Goodness of Fit[a]

	Value	df	Value/df
Deviance	279.602	335	.835
Scaled Deviance	279.602	335	
Pearson Chi-Square	380.198	335	1.135
Scaled Pearson Chi-Square	380.198	335	
Log Likelihood[b]	-314.381		
Akaike's Information Criterion (AIC)	636.763		
Finite Sample Corrected AIC (AICC)	636.882		
Bayesian Information Criterion (BIC)	652.067		
Consistent AIC (CAIC)	656.067		

Dependent Variable: Total
Model: (Intercept), AADT, Lengthkm

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Figure 4.6: Goodness of Fit (Total Crashes)

The Omnibus Test Table, Figure 4.7 shows the significance of the fitted model against the intercept only model to confirm that the independent variables are having a positive impact on the model estimates.

Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
78.503	2	.000

Dependent Variable: Total
Model: (Intercept), AADT, Lengthkm

a. Compares the fitted model against the intercept-only model.

Figure 4.7: Omnibus Test (Total Crashes)

The Test of Model Effects Table, Figure 4.8, displays the significance of each of the model parameters. To be significant at the 95% confidence interval the significance value must be below 0.05. All of the model parameters in this case are significant.

Tests of Model Effects

	Type III		
Source	Wald Chi-Square	df	Sig.
(Intercept)	46.945	1	.000
AADT	13.677	1	.000
Lengthkm	67.083	1	.000

Dependent Variable: Total
Model: (Intercept), AADT, Lengthkm

Figure 4.8: Test of Model Effects (Total Crashes)

The Parameter Estimates Table, Figure 4.9, displays parameter estimates and corresponding test statistics and confidence intervals. It also gives the negative binomial over-dispersion parameter k. The table gives the log of the parameter estimates and the and the associated standard errors.

The reference group is made up of major highways within the same geographic location as the treatment site. For this road type the posted speed limit is

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-2.305	.3364	-2.965	-1.646	46.945	1	.000
AADT	.0001028	2.7792E-005	4.831E-005	.000	13.677	1	.000
Lengthkm	.194	.0237	.148	.241	67.083	1	.000
(Scale)	1[a]						
(Negative binomial)	.552	.1852	.286	1.065			

Dependent Variable: Total
Model: (Intercept), AADT, Lengthkm

a. Fixed at the displayed value.

Figure 4.9: Parameter Estimates (Total Crashes)

typically 100 km/h, hence all of the reference group sites had a speed limit of 100 km/h. The treatment site however had the speed limit reduced from 100 km/h to 90 km/h in December 2008 which leaves a two year period before the implementation of the painted median where the speed limit was 90 km/h. To overcome the difference in the speed limit between the treatment site and the reference group sites an Accident Modification Factor (AMF) was applied to the SPF estimates that are calibrated using the reference group.

AMF's provide a quick way of estimating crash reductions associated with highway safety improvements. AMFs are used extensively in the USA to make decisions concerning whether to implement a specific treatment and/or to quickly determine the costs and benefits of selected alternatives. AMFs are also key components of the latest safety-estimation tools and procedures.

The AMF used in this study for the difference in posted speed limits was taken from the USA National Cooperative Highway Research Program (NCHRP) report number 617, Accident Modification Factors for Traffic Engineering and ITS Improvements. The AMF for Reduced Mean Travel Speed presents two tables with values based on the original mean speed and the reduction in mean speed. The first table is for Non-fatal injury crashes and the second is for fatal crashes. For a 100 km/h original speed limit and a reduction of 8 km/h (average observed speed reduction at treatment site) the AMF is 0.75 for non fatal crashes and 0.58 for fatal crashes (NCHRP 2008). Given that only hospitalisation and fatal crashes were analysed in this study and there was a high percentage of fatal crashes in those an AMF of 0.6 has been adopted for this analysis.

The AMF is then incorporated into the model for the SPF estimates. Given that the model fitting procedure uses the natural logarithm as the link function the parameters in the model are exponential. The SPF's used in this study therefore take the following form:

$$P = AMF \times exp^{[\alpha + (AADT \times \beta_1) + (segmentlength \times \beta_2)]} \tag{4.1}$$

where P is the estimated number of crashes per year, AMF is the Accident Modification Factor, α is the intercept term, β_1 is the fitted model parameter estimate for AADT and β_2 is the fitted model parameter estimate for Segment Length. The intercept term and parameters estimates are determined in the previously mentioned model calibration process.

After running the model for Total crashes and using the parameter values shown in Figure 4.9, The SPF for Total crashes is then given by Equation 4.2 shown below.

$$P = 0.6 \times exp^{[-2.305 + (AADT \times 0.000103) + (segmentlength \times 0.194)]} \tag{4.2}$$

To give an understanding of the output from Equation 4.2 the Equation was modelled in Matlab and a plot produced for visual representation of the equation. The Matlab model was set up to determine the expected number of crashes for a 1.0 km long segment and for AADT ranging from 2000 to 20000. The results from the Matlab model are shown on the plot in Figure 4.10. The results are also plotted for the SPF estimate without the AMF to show the observed change produced by the AMF. The SPF equations were also modelled in Matlab for Head-on crashes and RORL crashes and the plots from these Matlab models are shown in Appendix B.

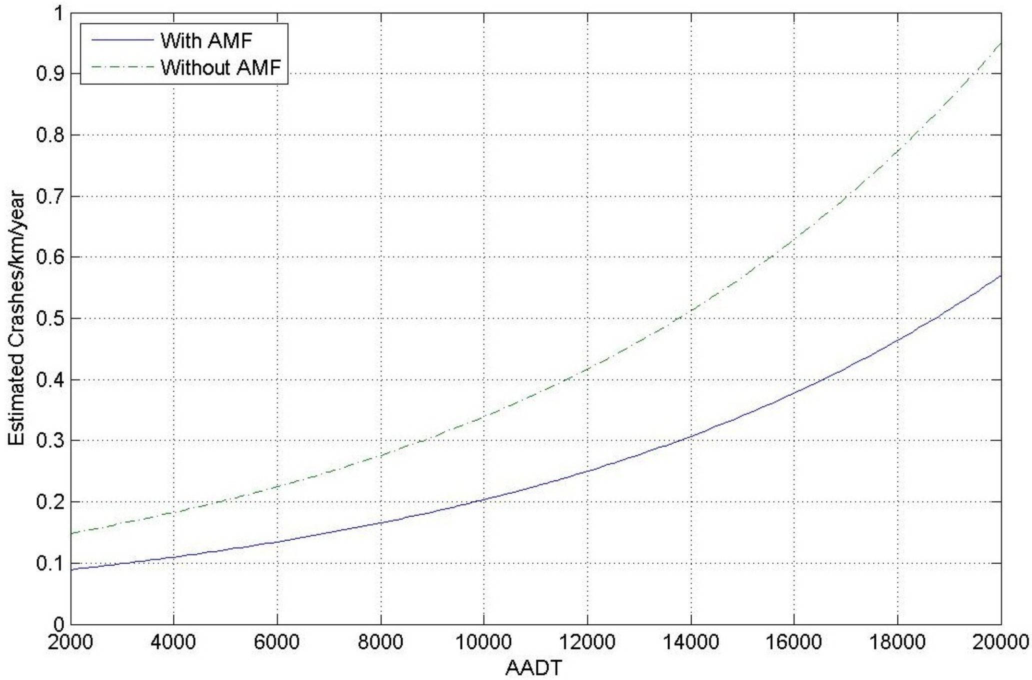

Figure 4.10: SPF Predicted Crashes/km/year (Total Crashes)

The SPF calibration procedure described above was carried out three times to obtain the SPF models for the three crash types being analysed, Head-on and cross-centreline crashes, Run-off-the-road-left crashes and Total crashes. The model calibration statistics for the other two crash types are given in Appendix B. A summary of the calibrated model parameters for all crash types is shown in Table 4.3.

Table 4.3: Calibrated SPF Models

Parameter	**HO**	**RORL**	**Total**
α (S.E.)	-3.198 (0.49)	-5.550 (0.89)	-2.305 (0.336)
β_1 (S.E.)	0.00010013 (0.00004)	0.0002227 (0.000065)	0.0001028 (0.000028)
β_2 (S.E.)	0.156 (0.026)	0.196 (0.039)	0.194 (0.024)
k^1	0.116	0.184	0.552

1. The parameter k is the dispersion parameter obtained from the model calibration process.

2. (S.E.) is the parameter Standard Error.

4.4. Empirical Bayes Analysis

As mentioned in Chapter 3 the Empirical Bayes method estimates the number of crashes expected in the after period had the treatment not been implemented by combining two sources of information which are are,

1. the number of crashes recorded at the treatment site in the before period.
2. the number of crashes that would be expected at similar sites predicted by the SPF.

In the previous Section Safety Performance Functions were developed for each of the crash types being analysed in this study. The SPF's are mathematical models that predict the number of crashes expected to occur on a segment of road given the input variables AADT and Segment Length. A spreadsheet was created to perform the calculations required to determine the safety benefit attributed to the painted median by the Empirical Bayes statistical method. The details of the spreadsheet and associated calculations are given below.

The spreadsheet utilises the modified data file used in Section 4.3 for the basis of the Empirical Bayes calculations. In addition to the modified data file, columns are added for the SPF estimates for the three crash types. The mathematical equations, that are the SPF's, were included in the appropriate columns to determine the estimated number of crashes for each individual segment and are summed at the bottom. The results from the spreadsheet for the before period are shown in Table 4.4 and the results for the after period are shown in Table 4.5.

The SPF equations used in the spreadsheet are;

For Head-on crashes

$$P = 0.6 \times exp^{[-3.198+(AADT \times 0.00010013)+(segmentlength \times 0.156)]} \tag{4.3}$$

Table 4.4: SPF Estimates for Each Segment (Before Period)

Road	Start Chainage	End Chainage	Length (km)	AADT	Head-on	RORL	Other	Total	SPF Estimates Head-on	SPF Estimates RORL	SPF Estimates Total
10A	102.24	108.27	6.03	15123	1	0	0	1	0.285	0.221	0.913
2009	108.27	108.93	0.66	16292	0	0	0	0	0.139	0.100	0.363
	112.18	117.1	4.92	15192	1	0	0	1	0.242	0.180	0.741
	118.5	119.33	0.83	15192	0	1	0	1	0.128	0.081	0.335
	119.79	120.86	1.07	15192	0	1	0	1	0.133	0.085	0.351
	121.43	121.69	0.26	14313	0	0	0	0	0.107	0.059	0.274
	122.06	124.52	2.46	14313	0	0	0	0	0.151	0.092	0.420
	124.99	125.32	0.33	14313	0	0	0	0	0.108	0.060	0.278
	127.18	128.04	0.86	15364	0	0	0	0	0.131	0.085	0.343
	128.52	130.27	1.75	15364	0	0	0	0	0.150	0.101	0.408
	130.9	135.86	4.96	15364	1	0	1	2	0.247	0.189	0.760
	136.24	139.38	3.14	15364	1	0	1	2	0.186	0.132	0.534
10A	102.24	108.27	6.03	15161	1	0	0	1	0.286	0.223	0.916
2010	108.27	108.93	0.66	16445	0	0	0	0	0.141	0.103	0.369
	112.18	117.1	4.92	15602	0	0	0	0	0.252	0.198	0.773
	118.5	119.33	0.83	15602	0	0	0	0	0.133	0.089	0.350
	119.79	120.86	1.07	15602	0	0	0	0	0.138	0.093	0.366
	121.43	121.69	0.26	14690	0	0	0	0	0.111	0.065	0.285
	122.06	124.52	2.46	14690	1	0	0	1	0.157	0.100	0.437
	124.99	125.32	0.33	14690	0	0	0	0	0.112	0.066	0.289
	127.18	128.04	0.86	15451	0	0	0	0	0.132	0.086	0.346
	128.52	130.27	1.75	15451	1	0	0	1	0.151	0.103	0.411
	130.9	135.86	4.96	15451	0	1	0	1	0.250	0.192	0.767
	136.24	139.38	3.14	15451	0	0	0	0	0.188	0.135	0.539
10B	3.05	3.63	0.58	14032	0	0	0	0	0.109	0.059	0.283
2009	3.85	5.11	1.26	14032	0	0	0	0	0.122	0.068	0.323
	5.45	5.76	0.31	14032	0	0	0	0	0.105	0.056	0.269
	6.02	6.85	0.83	14032	0	0	0	0	0.114	0.062	0.298
	7.3	9.09	1.79	12360	0	0	1	1	0.112	0.052	0.302
	9.58	10.46	0.88	12360	0	0	0	0	0.097	0.043	0.253
	10.58	12.1	1.52	12360	0	0	0	0	0.107	0.049	0.286
	12.41	12.8	0.39	10426	1	0	0	1	0.074	0.026	0.189
	12.8	13.17	0.37	10426	0	0	0	0	0.074	0.026	0.188
10B	3.05	3.63	0.58	13932	0	0	0	0	0.108	0.058	0.281
2010	3.85	5.11	1.26	13932	0	0	1	1	0.120	0.066	0.320
	5.45	5.76	0.31	13932	0	0	0	0	0.104	0.055	0.266
	6.02	6.85	0.83	13932	0	0	0	0	0.113	0.061	0.294
	7.3	9.09	1.79	12360	1	1	1	3	0.112	0.052	0.302
	9.58	10.46	0.88	12360	0	0	0	0	0.097	0.043	0.253
	10.58	12.1	1.52	12360	0	0	0	0	0.107	0.049	0.286
	12.41	12.8	0.39	10461	0	0	0	0	0.074	0.026	0.189
	12.8	13.17	0.37	10461	0	0	0	0	0.074	0.026	0.189
			Total 10A		7	3	2	12	4.057	2.835	11.569
			Total 10B		2	1	3	6	1.822	0.879	4.771

For Run-off-road-left crashes

$$P = 0.6 \times exp^{[-5.50+(AADT \times 0.0002227)+(segmentlength \times 0.196)]} \tag{4.4}$$

and for Total crashes

$$P = 0.6 \times exp^{[-2.305+(AADT \times 0.000103)+(segmentlength \times 0.194)]} \tag{4.5}$$

Table 4.5: SPF Estimates for Each Segment (After Period)

Road	Start Chainage	End Chainage	Length (km)	AADT	Head-on	RORL	Other	Total	SPF Estimates Head-on	RORL	Total
10A	102.24	108.27	6.03	15784	0	0	0	0	0.305	0.256	0.977
2011/12	108.27	108.93	0.66	16981	0	0	0	0	0.149	0.117	0.390
	112.18	117.1	4.92	15899	0	0	0	0	0.259	0.211	0.797
	118.5	119.33	0.83	15899	0	0	0	0	0.137	0.095	0.360
	119.79	120.86	1.07	15899	0	0	0	0	0.142	0.099	0.378
	121.43	121.69	0.26	14906	0	0	0	0	0.114	0.068	0.291
	122.06	124.52	2.46	14906	0	0	0	0	0.160	0.104	0.447
	124.99	125.32	0.33	14906	0	0	0	0	0.115	0.069	0.295
	127.18	128.04	0.86	15821	0	0	0	0	0.137	0.094	0.360
	128.52	130.27	1.75	15821	0	0	0	0	0.157	0.111	0.427
	130.9	135.86	4.96	15821	0	1	0	1	0.259	0.209	0.797
	136.24	139.38	3.14	15821	0	0	0	0	0.195	0.146	0.560
10B	3.05	3.63	0.58	13626	0	0	0	0	0.105	0.054	0.272
2011/12	3.85	5.11	1.26	13626	0	0	0	0	0.117	0.062	0.310
	5.45	5.76	0.31	13626	0	0	0	0	0.101	0.052	0.258
	6.02	6.85	0.83	13626	0	0	0	0	0.109	0.057	0.285
	7.3	9.09	1.79	12781	0	0	2	2	0.117	0.057	0.315
	9.58	10.46	0.88	12781	0	0	0	0	0.101	0.048	0.264
	10.58	12.1	1.52	12781	1	0	0	1	0.112	0.054	0.299
	12.41	12.8	0.39	10540	0	0	0	0	0.075	0.026	0.191
	12.8	13.17	0.37	10540	0	0	0	0	0.075	0.026	0.190
			Total 10A		0	1	0	1	2.128	1.579	6.079
			Total 10B		1	0	2	3	0.910	0.436	2.385

With the SPF estimates of the number of crashes, for each segment in the treatment site, and the sums of these crashes now calculated the next step in the analysis is to determine the weighting factors used to combine the recorded number of crashes in the before period with the predicted number of crashes, in Equation 4.6.

These two clues are combined using a weighted average, given by:

$$m = w_1(x) + w_2(P) \tag{4.6}$$

The weighting factors w_1 and w_2 are given by:

$$w_1 = \frac{P}{P + 1/k} \tag{4.7}$$

and

$$w_2 = \frac{1}{k(P + 1/k)} \tag{4.8}$$

where k is the dispersion parameter of the distribution and is estimated from the SPF calibration process. The values of k are given in Table 4.3. The results obtained from the spreadsheet for Equations 4.7 and 4.8 are shown in Table 4.6.

Table 4.6: Weighting Factors w_1 and w_2

	Head-on	**RORL**	**Total**
w_1	0.405	0.406	0.900
w_2	0.595	0.594	0.100

With the values for the weighting factors determined they are then used in Equation 4.6 to determine an unbiased estimate of the number of crashes in the before period. The results obtained from the spreadsheet for Equation 4.6 are shown in Table 4.7.

Table 4.7: Estimate of crashes and Standard Deviation

	Head-on	**RORL**	**Total**
Weighted Estimate, m	7.144	3.830	17.834
Standard Deviation	2.254	1.584	3.978

A factor is then applied to the estimate m to account for variation in the before and after period and for changes in traffic volume. This factor is determined by dividing the sum of the SPF estimates for the after period, P_A by the sum of the SPF estimates for the before period, P_B. The factors used for each crash type are given in Table 4.8.

Table 4.8: Factors for Time Related Variance

	Head-on	**RORL**	**Total**
Factor	0.517	0.543	0.518

The estimated number of crashes in the before period, m is then multiplied by that factor to obtain the predicted number of crashes in the after period, B had the treatment not been implemented. This is performed on each crash type and the results are shown in Table 4.9.

Table 4.9: Predicted Number of Crashes (After Period)

	Head-on	**RORL**	**Total**
B	3.693	2.078	9.237
Variance	1.357	0.739	4.245

The effectiveness of the treatment is then obtained from equation 4.9.

$$\theta = \frac{A/B}{1 + \left[\frac{Var(B)}{B^2}\right]} \tag{4.9}$$

The Standard deviation of θ is given by equation 4.10.

$$SD.\theta = \left[\frac{\theta^2 \left\{\left[\frac{Var(A)}{A^2}\right] + \left[\frac{Var(B)}{B^2}\right]\right\}}{1 + \left[\frac{Var(B)}{B^2}\right]}\right]^{0.5} \tag{4.10}$$

The percent reduction in crashes is then given by 100 $(1 - \theta)$ with a standard deviation of 100 $(SD.\theta)$. The results for Equations 4.9 and 4.10 are given in Table 4.10.

Table 4.10: Effectiveness and Standard Deviation

	Head-on	**RORL**	**Total**
θ	0.246	0.411	0.413
SD. θ	0.071	0.145	0.088
% Change	75.370	58.908	58.749
SD.	7.067	14.515	8.765

4.5. Cost Benefit Analysis

Given the current economic environment the benefit a road / transport authority will receive from a road safety treatment or in fact any treatment at all is a major consideration in a project making it from concept to implementation. A cost benefit analysis is a means of analytically comparing cash investment to social / economic returns. The technique assigns a dollar value to each input and each output resulting from the project and compares the values.

The cost benefit analysis procedure commonly used in TMR is known as a Benefit Cost Ratio (BCR) and will be the method adopted in this study. This section outlines a simplified BCR analysis on the continuous narrow painted median strip utilising audio-tactile line-marking installed on 35.2 km of the Bruce Highway in South East Queensland, Australia. Costs are defined as those costs incurred by TMR during the planning, design and implementation of the project. The only defined benefits considered are community benefits including reduced crash incidence and severity.

The total cost of planning, designing and implementing the treatment for this initial trial was approximately $1,162,000. There will be a cost associated with maintenance of the treatment however this will not be considered in this analysis. The life of audio-tactile raised ribs is between 5 and 7 years and the line-marking is generally maintained annually.

The dollar values associated with the two crash severities in this study were taken from Main Roads RISC Crash Costs Update (2008) and are shown in Table 4.11. The dollar values are determined by associating all of the costs involved in a crash including Medical/Ambulance/Rehabilitation, insurance, legal costs, vehicle repairs, travel delays, loss of labour in the workforce, labour at home, quality of life, correctional services, workplace disruption etc. The latest crash cost data available from TMR estimates the cost of a crash resulting in fatality to be $2,144,096 and estimates the cost of a crash resulting in hospitalisation at $529,203.

Table 4.11: Cost of Crashes by Severity

Crash Severity	**Average Cost per Crash**
Fatality	$2,144,096
Hospitalisation	$529,203

During the one year after period it is estimated by the statistical analysis that had the treatment not been implemented there would have been 9.24 crashes in total. In the before period 22% of the high severity crashes analysed in this study resulted in fatality. Given the prediction of 9.24 crashes in the after period it could be expected that there would be 2.04 fatal crashes occur in the after period and 7.20 hospitalisation crashes.

In the one year after period there have been 4 crashes in total of which none resulted in fatality. It would be unrealistic to assume there will be zero fatalities on the section in the future based on zero fatalities occurring in the one year after period. Therefore the future fatality rate will be assumed to have reduced at the rate of total crash reduction being 59%. Given that there were an average of two fatalities per year in the before period it is forecast that there should be 0.82 fatalities per year in the after period.

Taking the life of the treatment to be 5 years (the time before major maintenance required) there would be expected to be 10.2 fatal crashes and 36 hospitalisation crashes. Using a linear projection of crashes observed in the after period it is forecast that there should be 4.1 fatalities and 20 hospitalisation crashes. The dollar values are shown in Table 4.12

Given the five year estimated benefit of $21,546,233 and the cost of implementing the treatment of $1,162,000 the resulting BCR is 18.5. A BCR greater than

Table 4.12: Benefit Cost Ratio (Five Year Life)

Crash Severity	After (Expected)	After (Forecast)	Saving
Fatality	\$21,869,779	\$8,790,794	\$13,078,985
Hospitalisation	\$19,051,308	\$10,584,060	\$8,467,248
Totals	\$40,921,087	\$19,374,854	\$21,546,233

one represents a nett benefit from a treatment. The BCR obtained from the painted median treatment is extremely high.

Chapter 5

results

One of the main advantages of performing a before and after study using the Empirical Bayes method is accounting for the regression to the mean phenomenon. This is achieved in the process of combining the recorded number of crashes with the number of crashes that would be expected at similar sites. Regression to the mean is most prevalent when the site is being analysed due to a high crash rate or short data collection periods are available. Table 5.1 shows the comparison of the recorded number of crashes to the SPF estimates, gives the weighted average and the percent change from the recorded crashes.

Table 5.1: Comparison of Recorded Crashes to SPF Estimates

	Head-on	**RORL**	**Total**
Recorded Crashes	9	4	18
SPF Estimate	5.879	3.714	16.340
Weighted Estimate	7.144	3.830	17.834
% Change	20.619	4.246	0.920

The estimated number of crashes obtained from the SPF's are close to the number of crashes recorded in the before period for RORL and Total crashes suggesting that the crash rate at the treatment site was only marginally higher than should be expected for the site and the Empirical Bayes procedure only pulled the predicted number of crashes down slightly. For Head-on crashes however the number of crashes recorded in the before period at the treatment site was significantly higher, 21%, than what should be expected for the site. This data confirms that there was a head-on crash problem being experienced at the site. Figure 5.1 is a plot of the recorded number of crashes, the SPF estimates and the weighted averages for the two year before period.

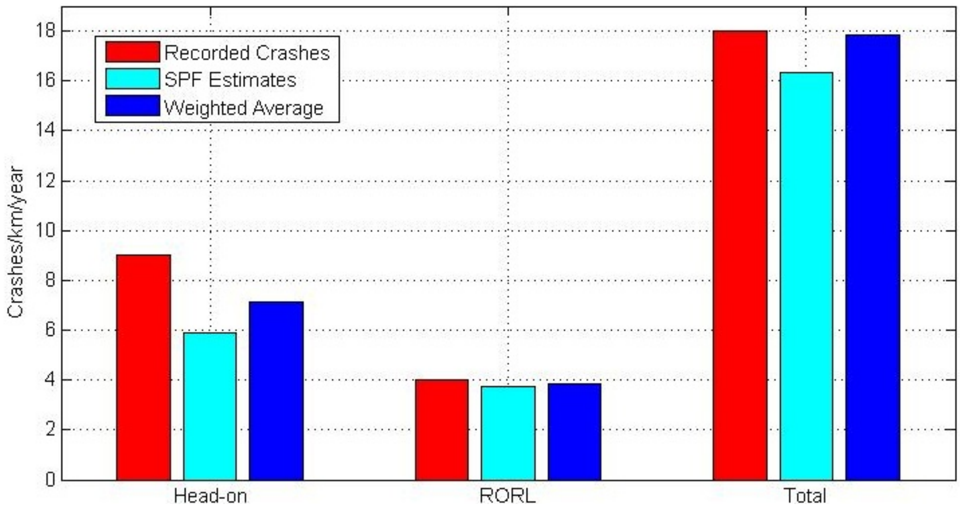

Figure 5.1: Recorded and Estimated Crashes (2 Year Before Period)

Figure 5.2 is a plot of the recorded number of crashes, the SPF estimates and the Empirical Bayes predicted number of crashes for the one year after period. In Figure 5.1 it can be seen how well the SPF estimates represent the actual recorded number of crashes. It is then obvious that had the treatment not been implemented the crash rate, as predicted by the SPF and Empirical Bayes analysis, would have been much greater than the observed crash rate. This plot gives a visual representation of how significant the crash reductions experienced at the treatment site are.

During the two year period before the painted median was implemented there were 9 head-on/cross-over-the-centreline crashes and during the one year after period there was only one such crash. For run-off-road-left crashes, in the before period there were 4 crashes of this type and during the after period there was again only one. Considering total crashes there were 18 in the two year before period and only 4 crashes of this type occurring in the after period.

Another notable and encouraging effect observed from the installation of the painted median is during the two year before period there were 4 crashes resulting in fatality at the treatment site and to date (16 months post imple-

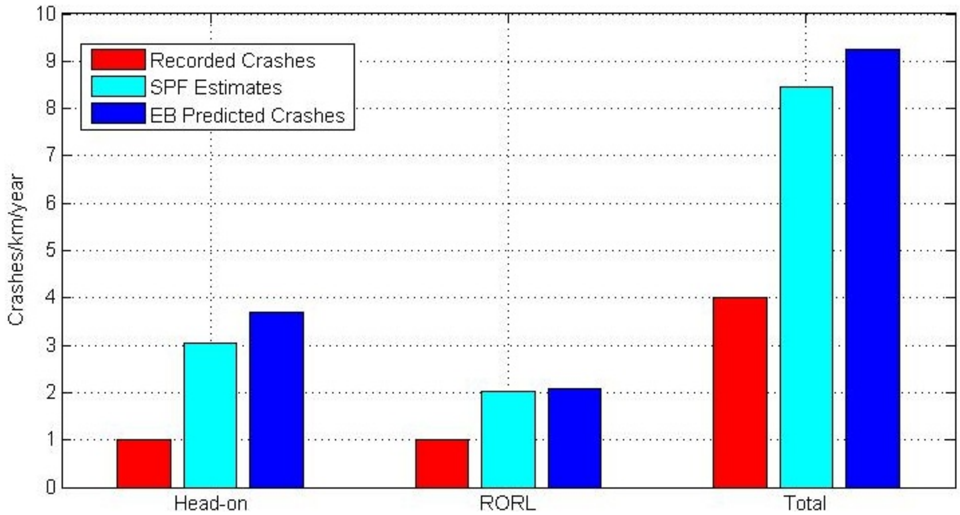

Figure 5.2: Recorded and Estimated Crashes (1 Year After Period)

mentation) there have been no fatal crashes occur.

The results of the Empirical Bayes analysis present significant reductions in crashes attributed to the continuous narrow painted median estimated as 75% for head-on/cross-over-the-centreline crashes, 59% for run-off-the-road-left crashes and 59% for total crashes. The Empirical Bayes results show that the treatment is effective in reducing the number of crashes for all crash types. A summary of the statistical analysis results is presented in Table 5.2.

Table 5.2: Summary of Safety benefit

Crash Count in After Period			**Empirical Bayes Estimate of Crashes in After Period Without Treatment. (standard Error)**			**Crash Reduction (standard Deviation)**		
HO	**RORL**	**Total**	**HO**	**RORL**	**Total**	**HO**	**RORL**	**Total**
1	1	4	3.69 (1.36)	2.08 (0.74)	9.24 (4.25)	75% (7.07)	59% (14.5)	59% (8.77)

1. HO = Head-on and Run-off-road-right
2. RORL = Run-off-road-left
3. Total = The total number of severe crashes (hospitalisation and fatal)

Chapter 6

Conclusions and Further Work

6.1. Conclusion

The results of this study indicate that installing the continuous narrow painted median strip utilising audio-tactile line-marking is effective in reducing head-on and cross-over-the-centreline crashes at the sites treated by 75%. Although head-on and cross-over-the-centreline crashes are the target of this treatment the results also indicate a reduction in both run-off-road-left and total crashes of 59%.

A reduction in the severity of the accidents reported was also observed. In the one year after period it could be expected that there would be 2.04 fatal crashes and 7.20 hospitalisation crashes. There was a total of 4 crashes reported in the after period of which none resulted in fatality. This statistic represents a reduction in crash severity, which was also observed when reading the comments provided in the detailed crash reports.

The cost of installing the treatment for this initial trial was approximately $33,000 per km. The results of the cost benefit analysis show for a five year life there is a nett cost benefit of $21,546,233 resulting in a BCR of 18.5. This is an extremely low cost countermeasure given the social / economic benefit observed.

It should be noted that although all possible measures were taken to account for the effects of other safety measures implemented at the treatment sites this may not be completely possible. Other safety treatments include the reduced speed limit, variable message signs and enhanced signage. All of these treatments were implemented prior to the two year before period but may not be accounted for entirely in the calibrated SPF estimates, therefore the safety benefit attributed to the painted median may be marginally overestimated.

Given the significant crash reductions shown for all crash types, the low installation cost and the ease of installation, consideration should be given to implementing this treatment on undivided rural roads that are experiencing a high number of cross-centreline type crashes or a high number of crashes in general.

6.2. Further Work

It is recommended that a follow up study be undertaken to support these preliminary results once more post implementation crash data is available. It would also be useful to assess the effect on all crash severities rather than only fatalities and hospitalisations.

It would also be valuable to assess the treatment site for the effect that the median has had on the behaviour of the traffic stream. High vehicle speeds on rural roads are a major road safety problem and this treatment may have had a positive effect on vehicle speeds due to the perceptual lane narrowing.

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Appendix A

Project Specification

University of Southern Queensland
Faculty of Engineering and Surveying

ENG 4111/2 Research Project

Project Specification

For:	**Adam Whittaker**
Topic:	Effectiveness of Narrow Painted Median utilising Audio-Tactile Line Marking on Undivided Rural Roads
Supervisor:	Dr Soma Somasundaraswaran
Sponsorship:	Faculty of Engineering & Surveying and the Department of Transport and Main Roads
Project Aim:	This research seeks to investigate the effectiveness of a retrofit painted median treatment installed in a "blackspot" section of the Bruce Highway between Cooroy and Curra in south east Queensland. The narrow painted median utilises Audio-Tactile Line Marking to help reduce the incidence of cross-over (vehicles in opposing direction) crashes. A before and after study using the Empirical Bayes method will analyse crash data for overall crashes, cross-over crashes (the target of this treatment) and increases in crashes (negative effects of this treatment) as well as the effect on vehicle operating speeds

Program:

1. Research and become familiar with world practices in regard to Audio-Tactile Line marking, narrow median strips, factors contributing to crashes and vehicle operating speeds on rural roads.
2. Obtain relevant data for the control section of road including crash data, traffic & speed counts and road characteristics such as geometry and environment. This will include validated data from TMR's road crash database and some data from Queensland Police service records that will require validation.
3. Analyse the data as mentioned above in Project Aim.
4. Provide the results of the analysis in the form of a written dissertation and an oral presentation

As time and resources permit:

1. Analyse the data with respect to vehicle operating speed.
2. Compare this median layout to other treatments targeting the same crash types.

Agreed:

Adam Whittaker (Student)	Date
Dr Soma Somasundaraswaran (Supervisor)	Date
Chris Snook/Dr Soma Somasundaraswaran (Examiner/Co-Examiner)	Date

Appendix B

Calibrated Model Statistics

B.1. Head-on Crashes

```
* Generalized Linear Models.
GENLIN Headon WITH AADT Lengthkm
  /MODEL AADT Lengthkm INTERCEPT=YES
 DISTRIBUTION=NEGBIN(MLE) LINK=LOG
  /CRITERIA METHOD=FISHER(1) SCALE=1 COVB=MODEL MAXITERATIONS
     =100 MAXSTEPHALVING=5
    PCONVERGE=1E-006(ABSOLUTE) SINGULAR=1E-012 ANALYSISTYPE=3(
       WALD) CILEVEL=95 CITYPE=WALD
    LIKELIHOOD=FULL
  /MISSING CLASSMISSING=EXCLUDE
  /PRINT CPS DESCRIPTIVES MODELINFO FIT SUMMARY SOLUTION.
```

Figure B.1: SPSS Code for Creating Models

Model Information

Dependent Variable	Headon
Probability Distribution	Negative binomial (MLE)
Link Function	Log

Figure B.2: Model Information (Head-on Crashes)

Case Processing Summary

	N	Percent
Included	339	100.0%
Excluded	0	0.0%
Total	339	100.0%

Figure B.3: Case Processing Summary (Head-on Crashes)

Continuous Variable Information

		N	Minimum	Maximum	Mean	Std. Deviation
Dependent Variable	Headon	339	0	3	.20	.475
Covariate	AADT	339	3117	16445	9733.94	3411.276
	Lengthkm	339	.13	19.25	2.6452	3.11878

Figure B.4: Continuous Variable Information (Head-on Crashes)

Goodness of Fit[a]

	Value	df	Value/df
Deviance	203.535	335	.608
Scaled Deviance	203.535	335	
Pearson Chi-Square	322.866	335	.964
Scaled Pearson Chi-Square	322.866	335	
Log Likelihood[b]	-166.451		
Akaike's Information Criterion (AIC)	340.902		
Finite Sample Corrected AIC (AICC)	341.022		
Bayesian Information Criterion (BIC)	356.206		
Consistent AIC (CAIC)	360.206		

Dependent Variable: Headon
Model: (Intercept), AADT, Lengthkm

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Figure B.5: Goodness of Fit (Head-on Crashes)

Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
34.078	2	.000

Dependent Variable: Headon
Model: (Intercept), AADT, Lengthkm

a. Compares the fitted model against the intercept-only model.

Figure B.6: Omnibus Test (Head-on Crashes)

Tests of Model Effects

Source	Type III Wald Chi-Square	df	Sig.
(Intercept)	42.020	1	.000
AADT	6.235	1	.013
Lengthkm	36.895	1	.000

Dependent Variable: Headon
Model: (Intercept), AADT, Lengthkm

Figure B.7: Test of Model Effects (Head-on Crashes)

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval Lower	Upper	Hypothesis Test Wald Chi-Square	df	Sig.
(Intercept)	-3.198	.4933	-4.165	-2.231	42.020	1	.000
AADT	.00010013	4.0101E-005	2.153E-005	.000	6.235	1	.013
Lengthkm	.156	.0257	.106	.207	36.895	1	.000
(Scale)	1[a]						
(Negative binomial)	.116	.3185	.001	25.386			

Dependent Variable: Headon
Model: (Intercept), AADT, Lengthkm

a. Fixed at the displayed value.

Figure B.8: Parameter Estimates (Head-on Crashes)

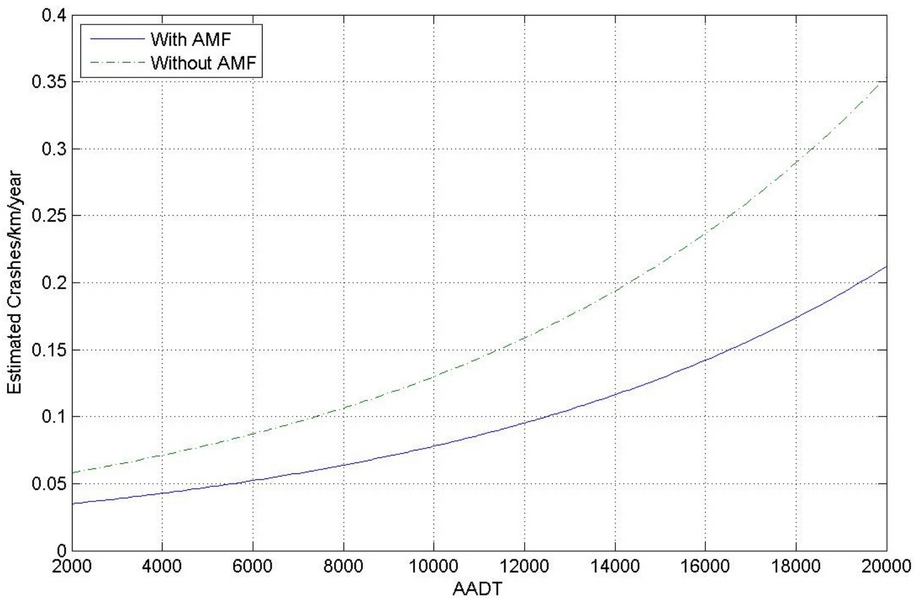


Figure B.9: SPF Predicted Crashes/km/year (Head-on Crashes)

B.2. RORL Crashes

```
* Generalized Linear Models.
GENLIN RORL WITH AADT Lengthkm
  /MODEL AADT Lengthkm INTERCEPT=YES
 DISTRIBUTION=NEGBIN(MLE) LINK=LOG
  /CRITERIA METHOD=FISHER(1) SCALE=1 COVB=MODEL MAXITERATIONS
     =100 MAXSTEPHALVING=5
    PCONVERGE=1E-006(ABSOLUTE) SINGULAR=1E-012 ANALYSISTYPE=3(
       WALD) CILEVEL=95 CITYPE=WALD
    LIKELIHOOD=FULL
  /MISSING CLASSMISSING=EXCLUDE
  /PRINT CPS DESCRIPTIVES MODELINFO FIT SUMMARY SOLUTION.
```

Figure B.10: SPSS Code for Creating Models

Model Information

Dependent Variable	RORL
Probability Distribution	Negative binomial (MLE)
Link Function	Log

Figure B.11: Model Information (RORL Crashes)

Case Processing Summary

	N	Percent
Included	339	100.0%
Excluded	0	0.0%
Total	339	100.0%

Figure B.12: Case Processing Summary (RORL Crashes)

Continuous Variable Information

		N	Minimum	Maximum	Mean	Std. Deviation
Dependent Variable	RORL	339	0	2	.09	.314
Covariate	AADT	339	3117	16445	9733.94	3411.276
	Lengthkm	339	.13	19.25	2.6452	3.11878

Figure B.13: Continuous Variable Information (RORL Crashes)

Goodness of Fit[a]

	Value	df	Value/df
Deviance	121.232	335	.362
Scaled Deviance	121.232	335	
Pearson Chi-Square	306.015	335	.913
Scaled Pearson Chi-Square	306.015	335	
Log Likelihood[b]	-91.104		
Akaike's Information Criterion (AIC)	190.209		
Finite Sample Corrected AIC (AICC)	190.329		
Bayesian Information Criterion (BIC)	205.513		
Consistent AIC (CAIC)	209.513		

Dependent Variable: RORL
Model: (Intercept), AADT, Lengthkm

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Figure B.14: Goodness of Fit (RORL Crashes)

Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
25.756	2	.000

Dependent Variable: RORL
Model: (Intercept), AADT, Lengthkm

a. Compares the fitted model against the intercept-only model.

Figure B.15: Omnibus Test (RORL Crashes)

Tests of Model Effects

Source	Type III Wald Chi-Square	df	Sig.
(Intercept)	38.922	1	.000
AADT	11.614	1	.001
Lengthkm	24.929	1	.000

Dependent Variable: RORL
Model: (Intercept), AADT, Lengthkm

Figure B.16: Test of Model Effects (RORL Crashes)

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-5.550	.8897	-7.294	-3.807	38.922	1	.000
AADT	.0002227	6.5344E-005	9.461E-005	.000	11.614	1	.001
Lengthkm	.196	.0393	.119	.273	24.929	1	.000
(Scale)	1[a]						
(Negative binomial)	.184	.7153	9.094E-005	372.857			

Dependent Variable: RORL
Model: (Intercept), AADT, Lengthkm

a. Fixed at the displayed value.

Figure B.17: Parameter Estimates (RORL Crashes)

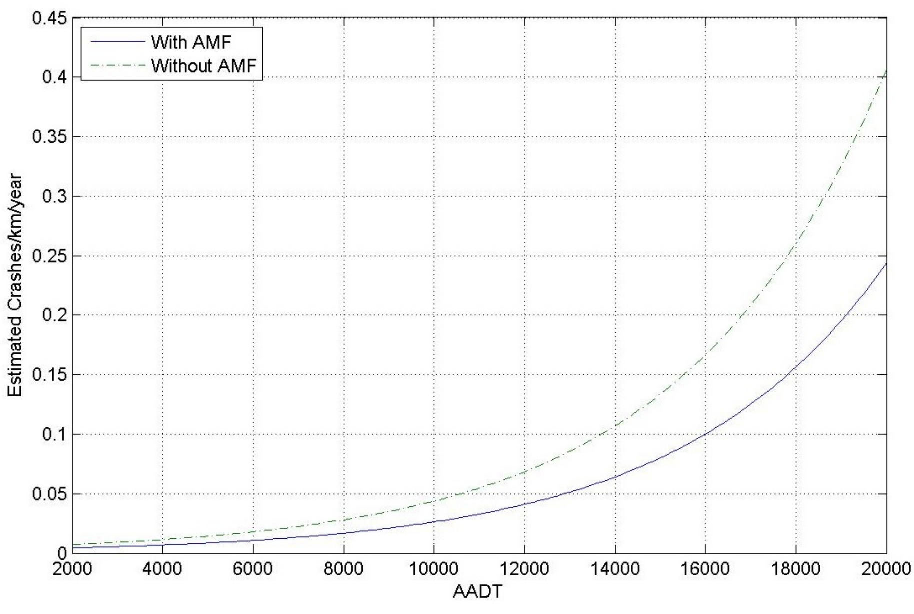
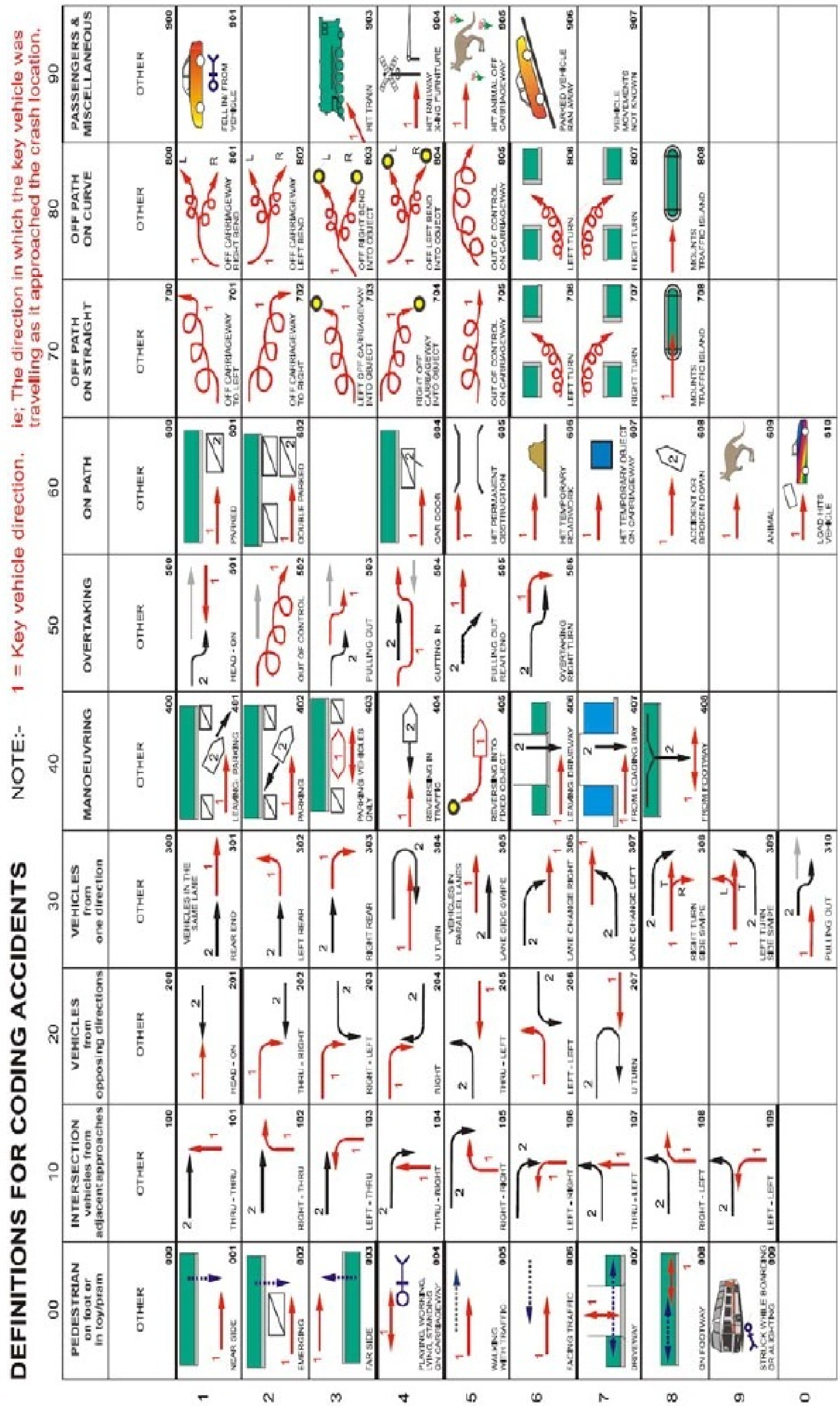


Figure B.18: SPF Predicted Crashes/km/year (RORL Crashes)

Appendix C

Definitions for Coding Accidents (DCA) Table


DEFINITIONS FOR CODING ACCIDENTS
NOTE:- 1 = Key vehicle direction. ie; The direction in which the key vehicle was travelling as it approached the crash location.
00 PEDESTRIAN on foot or in toy/pram
10 INTERSECTION vehicles from adjacent approaches
20 VEHICLES from opposing directions
30 VEHICLES from one direction
40 MANOEUVRING
50 OVERTAKING
60 ON PATH
70 OFF PATH ON STRAIGHT
80 OFF PATH ON CURVE
90 PASSENGERS & MISCELLANEOUS

Appendix D

Modified Data Files

Treatment Site Data

```
Road,Section ID,Start Chainage (km),End Chainage (km),Length (km),AADT,Head-on,RORL,other,Total
10A,1,102.24,108.27,6.03,15123,1,0,0,1
2009,2,108.27,108.93,0.66,16292,0,0,0,0
,3,112.18,117.1,4.92,15192,1,0,0,1
,4,118.5,119.33,0.83,15192,0,1,0,1
,5,119.79,120.86,1.07,15192,0,1,0,1
,6,121.43,121.69,0.26,14313,0,0,0,0
,7,122.06,124.52,2.46,14313,0,0,0,0
,8,124.99,125.32,0.33,14313,0,0,0,0
,9,127.18,128.04,0.86,15364,0,0,0,0
,10,128.52,130.27,1.75,15364,0,0,0,0
,11,130.9,135.86,4.96,15364,1,0,1,2
,12,136.24,139.38,3.14,15364,1,0,1,2
10A,13,102.24,108.27,6.03,15161,1,0,0,1
2010,14,108.27,108.93,0.66,16445,0,0,0,0
,15,112.18,117.1,4.92,15602,0,0,0,0
,16,118.5,119.33,0.83,15602,0,0,0,0
,17,119.79,120.86,1.07,15602,0,0,0,0
,18,121.43,121.69,0.26,14690,0,0,0,0
,19,122.06,124.52,2.46,14690,1,0,0,1
,20,124.99,125.32,0.33,14690,0,0,0,0
,21,127.18,128.04,0.86,15451,0,0,0,0
,22,128.52,130.27,1.75,15451,1,0,0,1
,23,130.9,135.86,4.96,15451,0,1,0,1
,24,136.24,139.38,3.14,15451,0,0,0,0
10A,13,102.24,108.27,6.03,15784,0,0,0,0
2011,14,108.27,108.93,0.66,16981,0,0,0,0
,15,112.18,117.1,4.92,15899,0,0,0,0
,16,118.5,119.33,0.83,15899,0,0,0,0
,17,119.79,120.86,1.07,15899,0,0,0,0
,18,121.43,121.69,0.26,14906,0,0,0,0
,19,122.06,124.52,2.46,14906,0,0,0,0
,20,124.99,125.32,0.33,14906,0,0,0,0
,21,127.18,128.04,0.86,15821,0,0,0,0
```

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,22,128.52,130.27,1.75,15821,0,0,0,0
,23,130.9,135.86,4.96,15821,0,1,2,3
,24,136.24,139.38,3.14,15821,0,0,1,1
10B,25,3.05,3.63,0.58,14032,0,0,0,0
2009,26,3.85,5.11,1.26,14032,0,0,0,0
,27,5.45,5.76,0.31,14032,0,0,0,0
,28,6.02,6.85,0.83,14032,0,0,0,0
,29,7.3,9.09,1.79,12360,0,0,1,1
,30,9.58,10.46,0.88,12360,0,0,0,0
,31,10.58,12.1,1.52,12360,0,0,0,0
,32,12.41,12.8,0.39,10426,1,0,0,1
,33,12.8,13.17,0.37,10426,0,0,0,0
10B,45,3.05,3.63,0.58,13932,0,0,0,0
2010,46,3.85,5.11,1.26,13932,0,0,1,1
,47,5.45,5.76,0.31,13932,0,0,0,0
,48,6.02,6.85,0.83,13932,0,0,0,0
,49,7.3,9.09,1.79,12360,1,1,1,3
,50,9.58,10.46,0.88,12360,0,0,0,0
,51,10.58,12.1,1.52,12360,0,0,0,0
,52,12.41,12.8,0.39,10461,0,0,0,0
,53,12.8,13.17,0.37,10461,0,0,0,0
10B,45,3.05,3.63,0.58,13626,0,0,0,0
2011,46,3.85,5.11,1.26,13626,0,0,1,1
,47,5.45,5.76,0.31,13626,0,0,0,0
,48,6.02,6.85,0.83,13626,0,0,0,0
,49,7.3,9.09,1.79,12781,0,0,0,0
,50,9.58,10.46,0.88,12781,0,0,0,0
,51,10.58,12.1,1.52,12781,1,0,0,1
,52,12.41,12.8,0.39,10540,0,0,0,0
,53,12.8,13.17,0.37,10540,0,0,0,0
```

Reference Group Data

```
Road,Section ID,Start Chainage (km),End Chainage (km),
    Length (km),AADT,Head-on,RORL,Other,Total
10A,1,102.24,108.27,6.03,13991,1,0,1,2
2006,2,108.27,108.93,0.66,15246,0,0,0,0
```

```
,3,112.18,117.1,4.92,14258,1,2,0,3
,4,118.5,119.33,0.83,14258,0,0,0,0
,5,119.79,120.86,1.07,14258,0,0,0,0
,6,121.43,121.69,0.26,13366,0,0,0,0
,7,122.06,124.52,2.46,13366,0,0,0,0
,8,124.99,125.32,0.33,13366,0,0,0,0
,9,127.18,128.04,0.86,14252,1,0,2,3
,10,128.52,130.27,1.75,14252,0,0,2,2
,11,130.9,135.86,4.96,14252,0,0,1,1
,12,136.24,139.38,3.14,14252,1,0,2,3
10A,13,102.24,108.27,6.03,14558,0,0,0,0
2007,14,108.27,108.93,0.66,15852,0,0,0,0
,15,112.18,117.1,4.92,14934,0,0,1,1
,16,118.5,119.33,0.83,14934,0,0,0,0
,17,119.79,120.86,1.07,14934,0,2,0,2
,18,121.43,121.69,0.26,13997,1,0,0,1
,19,122.06,124.52,2.46,13997,0,0,0,0
,20,124.99,125.32,0.33,13997,0,0,0,0
,21,127.18,128.04,0.86,14943,0,0,0,0
,22,128.52,130.27,1.75,14943,0,0,0,0
,23,130.9,135.86,4.96,14943,1,0,1,2
,24,136.24,139.38,3.14,14943,0,1,0,1
10A,25,102.24,108.27,6.03,14811,0,1,1,2
2008,26,108.27,108.93,0.66,15976,0,0,0,0
,27,112.18,117.1,4.92,15127,0,0,1,1
,28,118.5,119.33,0.83,15127,0,0,0,0
,29,119.79,120.86,1.07,15127,0,0,0,0
,30,121.43,121.69,0.26,14255,2,0,0,2
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,32,124.99,125.32,0.33,14255,1,0,0,1
,33,127.18,128.04,0.86,15008,0,0,1,1
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2006,62,3.85,5.11,1.26,12703,0,0,0,0
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```
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,68,12.41,12.8,0.39,9432,0,0,0,0
,69,12.8,13.17,0.37,9432,0,0,0,0
,70,13.59,14.02,0.43,9432,0,0,0,0
,71,14.02,16.6,2.58,8250,0,0,0,0
,72,17.32,20,2.68,8250,0,0,1,1
,73,20.68,23.81,3.13,8250,0,0,1,1
,74,24.76,27.04,2.28,8250,0,0,1,1
,75,28.75,28.88,0.13,7472,0,0,0,0
,76,29.37,30.25,0.88,7472,0,0,0,0
,77,34.66,36.25,1.59,7472,1,0,0,1
,78,36.77,39.86,3.09,7472,0,0,0,0
,79,40.75,46.35,5.6,7472,0,0,0,0
,80,46.9,59.3,12.4,8478,1,1,0,2
10B,81,3.05,3.63,0.58,13293,0,0,0,0
2007,82,3.85,5.11,1.26,13293,1,0,0,1
,83,5.45,5.76,0.31,13293,0,1,0,1
,84,6.02,6.85,0.83,13293,0,0,1,1
,85,7.3,9.09,1.79,11684,0,1,0,1
,86,9.58,10.46,0.88,11684,0,0,0,0
,87,10.58,12.1,1.52,11684,0,0,0,0
,88,12.41,12.8,0.39,10112,0,0,0,0
,89,12.8,13.17,0.37,10112,0,0,0,0
,90,13.59,14.02,0.43,10112,0,0,0,0
,91,14.02,16.6,2.58,8688,0,0,0,0
,92,17.32,20,2.68,8688,1,0,0,1
,93,20.68,23.81,3.13,8688,0,0,0,0
,94,24.76,27.04,2.28,8688,0,0,0,0
,95,28.75,28.88,0.13,7790,0,0,0,0
,96,29.37,30.25,0.88,7790,0,0,0,0
,97,34.66,36.25,1.59,7790,0,0,1,1
,98,36.77,39.86,3.09,7790,0,0,0,0
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,99,40.75,46.35,5.6,7790,0,0,0,0
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2008,102,3.85,5.11,1.26,13634,0,0,1,1
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,108,12.41,12.8,0.39,10067,0,0,0,0
,109,12.8,13.17,0.37,10067,0,0,0,0
,110,13.59,14.02,0.43,10067,0,0,0,0
,111,14.02,16.6,2.58,9679,0,0,0,0
,112,17.32,20,2.68,9679,0,0,1,1
,113,20.68,23.81,3.13,9679,0,0,2,2
,114,24.76,27.04,2.28,9679,0,0,0,0
,115,28.75,28.88,0.13,7592,0,0,0,0
,116,29.37,30.25,0.88,7592,0,0,0,0
,117,34.66,36.25,1.59,7592,0,0,0,0
,118,36.77,39.86,3.09,7592,0,0,0,0
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,120,46.9,59.3,12.4,8789,2,2,1,5
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2009,131,14.02,16.6,2.58,8978,0,0,0,0
,132,17.32,20,2.68,8978,1,0,1,2
,133,20.68,23.81,3.13,8978,0,0,0,0
,134,24.76,27.04,2.28,8978,0,0,0,0
,135,28.75,28.88,0.13,7726,0,0,0,0
,136,29.37,30.25,0.88,7726,0,0,0,0
,137,34.66,36.25,1.59,7726,0,0,1,1
,138,36.77,39.86,3.09,7726,1,0,0,1
,139,40.75,46.35,5.6,7726,0,0,1,1
,140,46.9,59.3,12.4,8824,1,0,0,1
10B,150,13.59,14.02,0.43,10461,0,0,0,0
2010,151,14.02,16.6,2.58,9811,0,0,0,0
,152,17.32,20,2.68,9811,0,0,0,0
```

```
,153,20.68,23.81,3.13,9811,0,0,0,0
,154,24.76,27.04,2.28,9811,0,0,0,0
,155,28.75,28.88,0.13,8598,0,0,0,0
,156,29.37,30.25,0.88,8598,0,0,0,0
,157,34.66,36.25,1.59,8598,1,0,0,1
,158,36.77,39.86,3.09,8598,0,1,0,1
,159,40.75,46.35,5.6,8598,1,0,0,1
,160,46.9,59.3,12.4,9672,0,0,2,2
10B,170,13.59,14.02,0.43,10540,0,0,0,0
2011,171,14.02,16.6,2.58,9483,0,0,0,0
,172,17.32,20,2.68,9483,0,0,1,1
,173,20.68,23.81,3.13,9483,0,0,0,0
,174,24.76,27.04,2.28,9483,0,0,0,0
,175,28.75,28.88,0.13,8345,0,0,0,0
,176,29.37,30.25,0.88,8345,0,0,0,0
,177,34.66,36.25,1.59,8345,0,0,0,0
,178,36.77,39.86,3.09,8345,0,0,0,0
,179,40.75,46.35,5.6,8345,1,1,2,4
,180,46.9,59.3,12.4,9379,2,1,0,3
17B,181,23.3,23.6,0.3,5537,0,0,0,0
2006,182,24.07,27.56,3.49,5537,0,0,0,0
,183,27.97,30.14,2.17,5537,1,0,0,1
,184,30.56,32.13,1.57,5537,0,0,0,0
,185,115.62,115.92,0.3,6897,0,0,0,0
,186,116.17,118.28,2.11,6897,0,0,0,0
,187,119.4,120,0.6,6897,0,0,5,5
,188,120.32,122.27,1.95,6897,0,0,0,0
,189,122.7,123.05,0.35,6897,0,0,0,0
17B,190,23.3,23.6,0.3,6766,0,0,0,0
2007,191,24.07,27.56,3.49,6766,0,0,0,0
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,193,30.56,32.13,1.57,6766,0,0,0,0
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,195,116.17,118.28,2.11,6515,0,1,0,1
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,205,119.4,120,0.6,5942,0,0,0,0
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17B,208,23.3,23.6,0.3,6684,0,0,0,0
2009,209,24.07,27.56,3.49,6684,0,0,0,0
,210,27.97,30.14,2.17,6684,0,0,0,0
,211,30.56,32.13,1.57,6684,0,0,0,0
,212,115.62,115.92,0.3,6392,0,0,0,0
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,214,119.4,120,0.6,6392,0,0,0,0
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,219,27.97,30.14,2.17,5009,0,0,0,0
,220,30.56,32.13,1.57,5009,0,0,0,0
,221,115.62,115.92,0.3,6494,0,0,0,0
,222,116.17,118.28,2.11,6494,0,0,0,0
,223,119.4,120,0.6,6494,0,0,0,0
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,225,122.7,123.05,0.35,6494,0,0,0,0
17B,226,23.3,23.6,0.3,5580,0,0,0,0
2011,227,24.07,27.56,3.49,5580,0,0,0,0
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,229,30.56,32.13,1.57,5580,0,0,0,0
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,231,116.17,118.28,2.11,6568,0,0,0,0
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,253,18.35,20.49,2.14,12041,1,1,1,3
,254,21.74,26.74,5,12041,0,1,2,3
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22B,269,14.58,18.2,3.62,5751,0,0,0,0
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22B,281,14.58,18.2,3.62,6256,0,0,0,0
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40A,289,0.89,2.14,1.25,6753,0,0,0,0
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,292,13.5,21.4,7.9,8098,2,0,2,4
,293,22.7,25,2.3,8000,0,0,0,0
,294,27.4,29.9,2.5,5252,1,0,0,1
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40A,296,0.89,2.14,1.25,7022,0,0,0,0
2007,297,4.23,7.2,2.97,7022,0,0,0,0
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,302,30,49.25,19.25,5689,0,0,2,2
40A,303,0.89,2.14,1.25,9394,0,0,0,0
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,309,30,49.25,19.25,6063,2,0,2,4
40A,310,0.89,2.14,1.25,12182,0,0,0,0
2009,311,4.23,7.2,2.97,9317,0,0,0,0
,312,7.6,10.96,3.36,11871,1,0,1,2
,313,13.5,21.4,7.9,9303,0,0,2,2
,314,22.7,25,2.3,9183,0,0,0,0
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,316,30,49.25,19.25,6311,1,0,2,3
40A,317,0.89,2.14,1.25,12763,0,0,0,0
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,323,30,49.25,19.25,6531,0,1,2,3
40A,324,0.89,2.14,1.25,13397,0,0,0,0
2011,325,4.23,7.2,2.97,10058,0,0,2,2
,326,7.6,10.96,3.36,11384,0,0,2,2
,327,13.5,21.4,7.9,9724,1,1,3,5
,328,22.7,25,2.3,9163,1,0,1,2
,329,27.4,29.9,2.5,7460,0,0,0,0
,330,30,49.25,19.25,6563,1,0,3,4
42A,331,0.5,3.27,2.77,8122,0,0,2,2
2006,332,3.8,5.73,1.93,8122,0,0,0,0
,333,5.98,12.95,6.97,6551,1,0,0,1
42A,334,0.5,3.27,2.77,8788,0,0,0,0
2007,335,3.8,5.73,1.93,8788,0,0,0,0
,336,5.98,12.95,6.97,7195,1,0,0,1
42A,337,0.5,3.27,2.77,9154,0,0,0,0
2008,338,3.8,5.73,1.93,9154,0,0,0,0
,339,5.98,12.95,6.97,7141,3,0,0,3
42A,340,0.5,3.27,2.77,8580,0,0,0,0
2009,341,3.8,5.73,1.93,8580,0,0,1,1
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42A,343,0.5,3.27,2.77,8653,0,0,0,0
2010,344,3.8,5.73,1.93,8653,0,0,0,0
,345,5.98,12.95,6.97,7575,0,0,2,2
42A,346,0.5,3.27,2.77,8616,0,0,0,0
2011,347,3.8,5.73,1.93,8616,0,0,0,0
,348,5.98,12.95,6.97,8829,0,0,2,2
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Appendix E

Crash Data File

Filtered Crash Data File

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"Serious crashes along Bruce Highway (10A,10B), Sunshine Motorway (150B), D'Aguilar Highway (40A), Warrigo Highway (18B), Cunningham Highway (17B), New England Highway (22B), Brisbane Valley Highway (42A) ",,,,,,,,,,,,,,,,,,,
Fatal crashes: 01-Jan-2006 to 30-Jun-2012,,,,,,,,,,,,,,,,,,,
Hospitalisation crashes: 01-Jan-2006 to 30-Jun-2012,,,,,,,,,,,,,,,,,,,
,,,,,,,,,,,,,,,,,,,
CRASH_NUMBER,CRASH_SEVERITY,CRASH_YEAR,CRASH_MONTH,CRASH_ROADSECTION_ID,CRASH_ROADSECTION_TDIST,CRASH_NATURE_CODE,CRASH_NATURE_DESCRIPTION,CRASH_DCA,CRASH_DCA_DESCRIPTION,CRASH_DCA_GROUP,CRASH_DCA_GROUP_DESCRIPTION,CAS_FATALITY,CAS_HOSPITALISED,CAS_MEDICALLY_TREATED,CAS_MINOR_INJURY,CAS_TOTAL,,,CRASH_ROADSECTION_TDIST
20060016519,Hospitalisation,2006,July,10A,102.35,6,Hit fixed obstruction or temporary object,804,OFF PATH-CURVE: OFF CWAY LT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,102.35
20600082505,Fatal,2006,October,10A,105.04,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,1,0,0,2,,1,105.04
20060011798,Hospitalisation,2006,May,10A,112.87,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,2,0,0,2,,4,112.87
2006020,Hospitalisation,2006,May,10A,116.45,1,Hit parked vehicle,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,116.45
20060010838,Hospitalisation,2006,May,10A,116.45,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,116.45
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20060007143,Fatal,2006,March,10A,128.13,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,0,0,0,1,,1,128.13
20600012823,Hospitalisation,2006,June,10A,128.53,7,Overturned,805,OFF PATH-CURVE: OUT OF CONTROL ON CWAY,20,Out of control on curve,0,1,0,0,1,,5,128.53
20600033800,Hospitalisation,2006,July,10A,129,7,Overturned,801,OFF PATH-CURVE: OFF CWAY RIGHT BEND,18,Off carriageway on curve,0,2,0,0,2,,5,129
20060017112,Hospitalisation,2006,July,10A,135.48,6,Hit fixed obstruction or temporary object,803,OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,135.48
20060014684,Hospitalisation,2006,June,10A,137.39,6,Hit fixed obstruction or temporary object,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,2,3,,3,137.39
20060003880,Fatal,2006,February,10A,138.74,3,Rear-end,303,VEH'S SAME DIRECTION: RIGHT REAR,4,Rear-end,1,2,0,0,3,,5,138.74
20600064758,Hospitalisation,2006,September,10A,138.89,2,Angle,104,VEH'S ADJACENT APPROACH: THRU-RIGHT,1,Intersection from adjacent approaches,0,1,0,0,1,,5,138.89
20700218765,Hospitalisation,2007,August,10A,115.85,7,Overturned,805,OFF PATH-CURVE: OUT OF CONTROL ON CWAY,20,Out of control on curve,0,1,0,0,1,,5,115.85
20700168020,Hospitalisation,2007,July,10A,119.77,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,1,0,2,,4,119.77
20700111476,Hospitalisation,2007,June,10A,120.43,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,120.43
20700018686,Hospitalisation,2007,January,10A,121.56,6,Hit fixed obstruction or temporary object,704,OFF PATH-
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      STRAIGHT:RIGHT OFF CWAY HIT OBJ,16,Off carriageway on
      straight hit object,0,1,0,0,1,,3,121.56
22  20700462773,Hospitalisation,2007,November,10A,131.53,5,
      Sideswipe,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on
      ,0,1,0,0,1,,3,131.53
23  20700297633,Fatal,2007,September,10A,135.87,6,Hit fixed
      obstruction or temporary object,804,OFF PATH-CURVE: OFF
      CWAY LT BEND HIT OBJ,19,Off carriageway on curve hit
      object,1,2,0,2,5,,5,135.87
24  20700377749,Hospitalisation,2007,October,10A,136.86,6,Hit
      fixed obstruction or temporary object,703,OFF PATH-
      STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on
      straight hit object,0,1,1,0,2,,4,136.86
25  20800483307,Hospitalisation,2008,August,10A,106.45,9,"Motor
       cycle or pedal cycle overturn, fall or drop",805,OFF
      PATH-CURVE: OUT OF CONTROL ON CWAY,20,Out of control on
      curve,0,1,0,0,1,,5,106.45
26  20800245634,Hospitalisation,2008,April,10A,107.92,7,
      Overturned,701,OFF PATH-STRAIGHT: LEFT OFF CWAY,15,Off
      carriageway on straight,0,1,0,0,1,,4,107.92
27  20800025939,Hospitalisation,2008,January,10A,115.7,9,"Motor
       cycle or pedal cycle overturn, fall or drop",802,OFF
      PATH-CURVE: OFF CWAY LEFT BEND,18,Off carriageway on
      curve,0,1,0,0,1,,5,115.7
28  20800345912,Hospitalisation,2008,May,10A,121.73,4,Head-on
      ,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on
      ,0,2,1,0,3,,3,121.73
29  20800065767,Fatal,2008,January,10A,121.86,4,Head-on,201,VEH
      'S OPPOSITE APPROACH: HEAD ON,2,Head-on
      ,2,0,1,0,3,,1,121.86
30  20800559522,Fatal,2008,September,10A,125.03,4,Head-on,201,
      VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on
      ,3,1,1,0,5,,1,125.03
31  20800560838,Hospitalisation,2008,September,10A,127.43,3,
      Rear-end,301,VEH'S SAME DIRECTION: REAR END,4,Rear-end
      ,0,1,0,0,1,,5,127.43
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20800105882,Hospitalisation,2008,February,10A,133.52,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,133.52
20900954602,Hospitalisation,2009,December,10A,105.15,5,Sideswipe,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,105.15
20900129376,Fatal,2009,February,10A,113.82,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,3,0,0,4,,1,113.82
20901000425,Hospitalisation,2009,December,10A,118.43,7,Overturned,802,OFF PATH-CURVE: OFF CWAY LEFT BEND,18,Off carriageway on curve,0,1,0,0,1,,5,118.43
20900464864,Hospitalisation,2009,June,10A,119.79,7,Overturned,805,OFF PATH-CURVE: OUT OF CONTROL ON CWAY,20,Out of control on curve,0,1,0,0,1,,5,119.79
20900174643,Fatal,2009,March,10A,132.2,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,2,0,0,3,,1,132.2
20900395708,Hospitalisation,2009,May,10A,133.37,3,Rear-end,302,VEH'S SAME DIRECTION: LEFT REAR,4,Rear-end,0,1,2,0,3,,5,133.37
20900679390,Hospitalisation,2009,September,10A,136.27,6,Hit fixed obstruction or temporary object,803,OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,136.27
20900065403,Fatal,2009,January,10A,136.28,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,2,0,0,3,,1,136.28
20100270037,Hospitalisation,2010,February,10A,104.21,6,Hit fixed obstruction or temporary object,704,OFF PATH-STRAIGHT:RIGHT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,3,104.21
20101015334,Hospitalisation,2010,November,10A,123.43,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,2,1,0,3,,3,123.43
20101156592,Hospitalisation,2010,December,10A,129.06,6,Hit
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    fixed obstruction or temporary object,201,VEH'S OPPOSITE
     APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,129.06
20101120672,Hospitalisation,2010,December,10A,134.45,6,Hit
    fixed obstruction or temporary object,703,OFF PATH-
    STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on
    straight hit object,0,1,0,0,1,,4,134.45
20110363621,Hospitalisation,2011,April,10A,132.213,6,Hit
    fixed obstruction or temporary object,804,OFF PATH-CURVE
    : OFF CWAY LT BEND HIT OBJ,19,Off carriageway on curve
    hit object,0,1,0,0,1,,5,132.213
20110460381,Hospitalisation,2011,May,10A,132.447,9,"Motor
    cycle or pedal cycle overturn, fall or drop",301,VEH'S
    SAME DIRECTION: REAR END,4,Rear-end,0,1,0,0,1,,5,132.447
20110695510,Hospitalisation,2011,August,10A,135.46,6,Hit
    fixed obstruction or temporary object,703,OFF PATH-
    STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on
    straight hit object,0,1,0,0,1,,4,135.46
20110202165,Hospitalisation,2011,March,10A,138.864,3,Rear-
    end,301,VEH'S SAME DIRECTION: REAR END,4,Rear-end
    ,0,1,1,0,2,,5,138.864
20060012308,Hospitalisation,2006,May,10B,11.2,6,Hit fixed
    obstruction or temporary object,804,OFF PATH-CURVE: OFF
    CWAY LT BEND HIT OBJ,19,Off carriageway on curve hit
    object,0,1,0,0,1,,5,11.2
20060003823,Fatal,2006,February,10B,18.129,10,Hit
    pedestrian,4,PED'N: PLAY; WORK; STAND; LIE ON C'WAY,12,
    Pedestrian,1,0,0,0,1,,5,18.129
20600079388,Hospitalisation,2006,October,10B,20.77,11,Hit
    animal incl. ridden horse or carriage,609,PASS & MISC:
    HIT ANIMAL,14,Hit animal,0,1,0,0,1,,5,20.77
20060009913,Hospitalisation,2006,April,10B,26.63,3,Rear-end
    ,301,VEH'S SAME DIRECTION: REAR END,4,Rear-end
    ,0,1,1,1,3,,5,26.63
20060008603,Hospitalisation,2006,April,10B,35.19,4,Head-on
    ,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on
    ,0,2,0,0,2,,3,35.19
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20060014940,Hospitalisation,2006,June,10B,47.628,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,47.628
20060009867,Fatal,2006,April,10B,51.554,4,Head-on,501,VEH'S OVERTAKING: HEAD ON,2,Head-on,1,3,0,0,4,,5,51.554
20700338191,Hospitalisation,2007,October,10B,3.86,6,Hit fixed obstruction or temporary object,704,OFF PATH-STRAIGHT:RIGHT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,3,3.86
20700415189,Hospitalisation,2007,November,10B,5.7,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,5.7
20700243506,Hospitalisation,2007,August,10B,6.31,7,Overturned,502,VEH'S OVERTAKING: OUT OF CONTROL,15,Off carriageway on straight,0,1,1,0,2,,5,6.31
20700071684,Hospitalisation,2007,April,10B,8.13,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,8.13
20700490074,Hospitalisation,2007,December,10B,19.244,4,Head-on,501,VEH'S OVERTAKING: HEAD ON,2,Head-on,0,1,0,0,1,,5,19.244
20700279648,Fatal,2007,September,10B,35.412,6,Hit fixed obstruction or temporary object,803,OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit object,1,0,0,0,1,,5,35.412
20700504706,Hospitalisation,2007,December,10B,56.02,7,Overturned,800,OFF PATH-CURVE: OTHER,21,Other,0,1,0,0,1,,5,56.02
20800015749,Hospitalisation,2008,January,10B,4.58,2,Angle,503,VEH'S OVERTAKING: PULLING OUT,9,Overtaking same direction,0,1,2,0,3,,5,4.58
20800563242,Hospitalisation,2008,September,10B,7.45,6,Hit fixed obstruction or temporary object,704,OFF PATH-
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STRAIGHT:RIGHT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,3,7.45
20800430185,Hospitalisation,2008,July,10B,7.48,6,Hit fixed obstruction or temporary object,704,OFF PATH-STRAIGHT: RIGHT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,1,0,2,,3,7.48
20800019688,Fatal,2008,January,10B,7.58,3,Rear-end,303,VEH'S SAME DIRECTION: RIGHT REAR,4,Rear-end,1,1,1,0,3,,5,7.58
20800108047,Hospitalisation,2008,February,10B,8.43,7,Overturned,701,OFF PATH-STRAIGHT: LEFT OFF CWAY,15,Off carriageway on straight,0,2,0,0,2,,4,8.43
20800247909,Hospitalisation,2008,April,10B,11.94,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,4,0,0,4,,3,11.94
20800438741,Hospitalisation,2008,July,10B,19.105,7,Overturned,705,OFF PATH-STRAIGHT:OUT OF CONTROL ON CWAY,17,Out of control on straight,0,1,0,0,1,,5,19.105
20800325180,Hospitalisation,2008,May,10B,21.2,3,Rear-end,301,VEH'S SAME DIRECTION: REAR END,4,Rear-end,0,2,0,0,2,,5,21.2
20800720160,Hospitalisation,2008,November,10B,23.67,6,Hit fixed obstruction or temporary object,700,OFF PATH-STRAIGHT: OTHER,21,Other,0,1,0,0,1,,5,23.67
20800226470,Hospitalisation,2008,April,10B,43.793,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,2,0,0,2,,4,43.793
20800325894,Hospitalisation,2008,May,10B,50.199,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,50.199
20800155893,Fatal,2008,March,10B,50.271,7,Overturned,702,OFF PATH-STRAIGHT: RIGHT OFF CWAY,15,Off carriageway on straight,1,0,0,0,1,,1,50.271
20800109727,Fatal,2008,February,10B,53.389,6,Hit fixed
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    obstruction or temporary object,703,OFF PATH-STRAIGHT:
    LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit
     object,1,0,0,0,1,,2,53.389
20800625717,Fatal,2008,October,10B,53.65,7,Overturned,502,
    VEH'S OVERTAKING: OUT OF CONTROL,15,Off carriageway on
    straight,1,1,1,0,3,,5,53.65
20800489001,Hospitalisation,2008,August,10B,58.683,6,Hit
    fixed obstruction or temporary object,607,VEH'S ON PATH:
     TEMPORARY OBJECT ON C'WAY,21,Other,0,1,0,0,1,,5,58.683
20900389973,Hospitalisation,2009,May,10B,8.7,12,Struck by
    external load,610,PASS & MISC: LOAD HIT VEHICLE,21,Other
    ,0,1,0,0,1,,5,8.7
20900273751,Hospitalisation,2009,April,10B,12.41,6,Hit
    fixed obstruction or temporary object,804,OFF PATH-CURVE
    : OFF CWAY LT BEND HIT OBJ,19,Off carriageway on curve
    hit object,0,1,1,0,2,,5,12.41
20900610293,Fatal,2009,August,10B,19.293,6,Hit fixed
    obstruction or temporary object,704,OFF PATH-STRAIGHT:
    RIGHT OFF CWAY HIT OBJ,16,Off carriageway on straight
    hit object,1,0,0,0,1,,1,19.293
20900147348,Fatal,2009,February,10B,19.74,6,Hit fixed
    obstruction or temporary object,803,OFF PATH-CURVE: OFF
    CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit
    object,1,0,0,0,1,,5,19.74
20900498901,Hospitalisation,2009,June,10B,35.294,6,Hit
    fixed obstruction or temporary object,803,OFF PATH-CURVE
    : OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve
    hit object,0,2,2,0,4,,5,35.294
20900503614,Hospitalisation,2009,July,10B,38.3,5,Sideswipe
    ,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on
    ,0,1,0,0,1,,3,38.3
20900174311,Hospitalisation,2009,March,10B,45.239,6,Hit
    fixed obstruction or temporary object,705,OFF PATH-
    STRAIGHT:OUT OF CONTROL ON CWAY,17,Out of control on
    straight,0,2,0,0,2,,5,45.239
20901001152,Hospitalisation,2009,December,10B,56.355,2,
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Angle,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,56.355
20100754409,Hospitalisation,2010,August,10B,5.01,3,Rear-end,303,VEH'S SAME DIRECTION: RIGHT REAR,4,Rear-end,0,1,1,0,2,,5,5.01
20100892091,Hospitalisation,2010,September,10B,7.579,6,Hit fixed obstruction or temporary object,607,VEH'S ON PATH: TEMPORARY OBJECT ON C'WAY,21,Other,0,2,0,0,2,,5,7.579
20100277043,Hospitalisation,2010,March,10B,8.76,6,Hit fixed obstruction or temporary object,804,OFF PATH-CURVE: OFF CWAY LT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,8.76
20100590350,Fatal,2010,June,10B,9.07,4,Head-on,501,VEH'S OVERTAKING: HEAD ON,2,Head-on,1,0,0,0,1,,5,9.07
20100825739,Fatal,2010,September,10B,34.68,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,2,2,0,0,4,,1,34.68
20100638245,Hospitalisation,2010,July,10B,39.759,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,2,0,0,2,,4,39.759
20101107277,Hospitalisation,2010,December,10B,45.779,5,Sideswipe,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,4,0,0,4,,3,45.779
20100190750,Hospitalisation,2010,January,10B,57.909,6,Hit fixed obstruction or temporary object,804,OFF PATH-CURVE: OFF CWAY LT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,57.909
20100718338,Hospitalisation,2010,August,10B,58.818,5,Sideswipe,305,VEH'S SAME DIRECTION: LANE SIDE SWIPE,5,Lane changes,0,1,0,1,2,,5,58.818
20110109347,Hospitalisation,2011,February,10B,3.994,2,Angle,202,VEH'S OPPOSITE APPROACH: THRU-RIGHT,3,Opposing vehicles turning,0,2,0,0,2,,5,3.994
20111179468,Hospitalisation,2011,December,10B,11.42,6,Hit fixed obstruction or temporary object,502,VEH'S
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OVERTAKING: OUT OF CONTROL,15,Off carriageway on straight,0,3,0,0,3,,5,11.42
20110212895,Hospitalisation,2011,March,10B,17.699,7,Overturned,705,OFF PATH-STRAIGHT:OUT OF CONTROL ON CWAY,17,Out of control on straight,0,1,1,0,2,,5,17.699
20110134576,Hospitalisation,2011,February,10B,41.231,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,1,2,,3,41.231
20110713122,Hospitalisation,2011,August,10B,45.239,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,45.239
20110214403,Hospitalisation,2011,March,10B,45.343,12,Struck by external load,610,PASS & MISC: LOAD HIT VEHICLE,21,Other,0,1,0,0,1,,5,45.343
20110719143,Hospitalisation,2011,August,10B,45.839,6,Hit fixed obstruction or temporary object,803,OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,45.839
20110172245,Hospitalisation,2011,February,10B,54.351,7,Overturned,701,OFF PATH-STRAIGHT: LEFT OFF CWAY,15,Off carriageway on straight,0,1,0,0,1,,4,54.351
20110361846,Fatal,2011,April,10B,55.76,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,2,7,0,0,9,,1,55.76
20110005128,Hospitalisation,2011,January,10B,57.322,5,Sideswipe,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,57.322
20060008652,Hospitalisation,2006,April,150B,19.11,7,Overturned,704,OFF PATH-STRAIGHT:RIGHT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,3,19.11
20060001071,Hospitalisation,2006,January,150B,21.33,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,21.33
20060007399,Fatal,2006,March,150B,25.5,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT:
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LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,1,0,0,0,1,,2,25.5
20600058326,Hospitalisation,2006,September,150B,25.69,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,25.69
20700032538,Hospitalisation,2007,February,150B,14.4,6,Hit fixed obstruction or temporary object,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,14.4
20700465865,Fatal,2007,December,150B,18.19,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,1,0,0,2,,1,18.19
20800013003,Hospitalisation,2008,January,150B,20.45,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,5,0,0,5,,3,20.45
20900808687,Hospitalisation,2009,October,150B,18.1,5,Sideswipe,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,1,1,3,,3,18.1
20900297594,Hospitalisation,2009,April,150B,25.68,9,"Motor cycle or pedal cycle overturn, fall or drop",805,OFF PATH-CURVE: OUT OF CONTROL ON CWAY,20,Out of control on curve,0,1,0,0,1,,5,25.68
20100994189,Hospitalisation,2010,November,150B,13.4,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,3,0,0,3,,3,13.4
20100676457,Fatal,2010,July,150B,15.96,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,1,0,0,2,,1,15.96
20100381028,Hospitalisation,2010,April,150B,16.37,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,2,0,1,3,,3,16.37
20100231999,Hospitalisation,2010,February,150B,20.89,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,3,0,0,3,,3,20.89
20110215302,Fatal,2011,March,150B,18.1,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,2,1,0,0,3,,1,18.1
20600114794,Hospitalisation,2006,December,17B,28.18,7,
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    Overturned,702,OFF PATH-STRAIGHT: RIGHT OFF CWAY,15,Off
    carriageway on straight,0,1,0,0,1,,3,28.18
20600055445,Hospitalisation,2006,August,17B,119.325,6,Hit
    fixed obstruction or temporary object,804,OFF PATH-CURVE
    : OFF CWAY LT BEND HIT OBJ,19,Off carriageway on curve
    hit object,0,1,0,0,1,,5,119.325
20700144474,Hospitalisation,2007,July,17B,117.03,7,
    Overturned,701,OFF PATH-STRAIGHT: LEFT OFF CWAY,15,Off
    carriageway on straight,0,1,0,0,1,,4,117.03
20800454307,Hospitalisation,2008,July,17B,29.73,6,Hit fixed
     obstruction or temporary object,703,OFF PATH-STRAIGHT:
    LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit
     object,0,1,0,0,1,,4,29.73
20800603250,Hospitalisation,2008,September,17B,117.84,10,
    Hit pedestrian,5,PED'N: HIT WALKING WITH TRAFFIC,12,
    Pedestrian,0,1,0,0,1,,5,117.84
20100410414,Hospitalisation,2010,April,17B,24.33,7,
    Overturned,805,OFF PATH-CURVE: OUT OF CONTROL ON CWAY
    ,20,Out of control on curve,0,1,0,0,1,,5,24.33
20111122135,Fatal,2011,December,17B,119.54,4,Head-on,201,
    VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on
    ,1,2,0,0,3,,1,119.54
20110470675,Hospitalisation,2011,May,17B,122.42,6,Hit fixed
     obstruction or temporary object,705,OFF PATH-STRAIGHT:
    OUT OF CONTROL ON CWAY,17,Out of control on straight
    ,0,1,0,0,1,,5,122.42
20600063788,Fatal,2006,September,18B,22.79,4,Head-on,201,
    VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on
    ,2,1,0,0,3,,1,22.79
20700096064,Fatal,2007,May,18B,11.92,4,Head-on,201,VEH'S
    OPPOSITE APPROACH: HEAD ON,2,Head-on,1,1,0,0,2,,1,11.92
20700094807,Hospitalisation,2007,May,18B,16.98,7,Overturned
    ,705,OFF PATH-STRAIGHT:OUT OF CONTROL ON CWAY,17,Out of
    control on straight,0,1,0,0,1,,5,16.98
20700003324,Hospitalisation,2007,January,18B,24.16,3,Rear-
    end,303,VEH'S SAME DIRECTION: RIGHT REAR,4,Rear-end
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,0,1,0,0,1,,5,24.16
20800122835,Fatal,2008,February,18B,12.5,6,Hit fixed obstruction or temporary object,803,OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit object,1,0,0,0,1,,5,12.5
20800411896,Fatal,2008,June,18B,15.8,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,2,0,0,0,2,,1,15.8
20900191950,Hospitalisation,2009,March,18B,15.772,3,Rear-end,303,VEH'S SAME DIRECTION: RIGHT REAR,4,Rear-end,0,1,0,0,1,,5,15.772
20900703147,Fatal,2009,September,18B,19.05,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,2,0,0,3,,1,19.05
20900417035,Hospitalisation,2009,June,18B,20.315,7,Overturned,701,OFF PATH-STRAIGHT: LEFT OFF CWAY,15,Off carriageway on straight,0,3,0,0,3,,4,20.315
20900542069,Hospitalisation,2009,July,18B,20.38,3,Rear-end,301,VEH'S SAME DIRECTION: REAR END,4,Rear-end,0,1,0,0,1,,5,20.38
20900741156,Hospitalisation,2009,September,18B,23.367,3,Rear-end,505,VEH'S OVERTAKING: PULLING OUT REAR END,9,Overtaking same direction,0,1,0,0,1,,5,23.367
20900302173,Hospitalisation,2009,April,18B,25.17,3,Rear-end,303,VEH'S SAME DIRECTION: RIGHT REAR,4,Rear-end,0,1,0,1,2,,5,25.17
20900454271,Hospitalisation,2009,June,18B,26.73,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,26.73
20100667734,Hospitalisation,2010,July,18B,20.32,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,20.32
20110170979,Hospitalisation,2011,February,18B,11.623,2,Angle,408,VEH'S MANOEUVRING: ENTERING FROM FOOTWAY,8,Vehicle leaving driveway,0,1,2,0,3,,5,11.623
20110185326,Hospitalisation,2011,March,18B,11.966,4,Head-on
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,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,11.966
20120614899,Fatal,2012,June,18B,17.35,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,1,0,0,2,,1,17.35
20700447192,Hospitalisation,2007,November,22B,19.7,7,Overturned,502,VEH'S OVERTAKING: OUT OF CONTROL,15,Off carriageway on straight,0,1,0,0,1,,5,19.7
20600062531,Fatal,2006,September,40A,14.11,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,3,4,0,8,,1,14.11
20600109786,Fatal,2006,December,40A,16.2,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,0,0,2,3,,1,16.2
20600041352,Hospitalisation,2006,July,40A,19.45,5,Sideswipe,307,VEH'S SAME DIRECTION: LANE CHANGE LEFT,5,Lane changes,0,1,0,0,1,,5,19.45
20600073501,Hospitalisation,2006,September,40A,19.95,6,Hit fixed obstruction or temporary object,607,VEH'S ON PATH: TEMPORARY OBJECT ON C'WAY,21,Other,0,1,0,0,1,,5,19.95
20060009356,Hospitalisation,2006,April,40A,28.9,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,28.9
20060004712,Hospitalisation,2006,February,40A,35.56,9,"Motor cycle or pedal cycle overturn, fall or drop",805,OFF PATH-CURVE: OUT OF CONTROL ON CWAY,20,Out of control on curve,0,1,0,0,1,,5,35.56
20600106805,Hospitalisation,2006,November,40A,46.52,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,46.52
20700295615,Hospitalisation,2007,September,40A,8.72,6,Hit fixed obstruction or temporary object,502,VEH'S OVERTAKING: OUT OF CONTROL,15,Off carriageway on straight,0,1,0,0,1,,5,8.72
20700089360,Hospitalisation,2007,May,40A,9.07,5,Sideswipe,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,9.07
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20700059137,Hospitalisation,2007,March,40A,15.36,7,Overturned,803,OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,15.36
20700229853,Fatal,2007,August,40A,18.88,6,Hit fixed obstruction or temporary object,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,0,1,0,2,,1,18.88
20700127197,Hospitalisation,2007,June,40A,19.57,6,Hit fixed obstruction or temporary object,607,VEH'S ON PATH: TEMPORARY OBJECT ON C'WAY,21,Other,0,1,0,0,1,,5,19.57
20700001245,Hospitalisation,2007,January,40A,20.45,6,Hit fixed obstruction or temporary object,607,VEH'S ON PATH: TEMPORARY OBJECT ON C'WAY,21,Other,0,1,0,0,1,,5,20.45
20700034715,Fatal,2007,February,40A,20.606,6,Hit fixed obstruction or temporary object,803,OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit object,1,0,0,0,1,,5,20.606
20700032266,Hospitalisation,2007,February,40A,20.65,6,Hit fixed obstruction or temporary object,804,OFF PATH-CURVE: OFF CWAY LT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,20.65
20700027351,Hospitalisation,2007,February,40A,20.85,6,Hit fixed obstruction or temporary object,607,VEH'S ON PATH: TEMPORARY OBJECT ON C'WAY,21,Other,0,1,0,0,1,,5,20.85
20700112517,Hospitalisation,2007,June,40A,24.2,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,24.2
20700042238,Hospitalisation,2007,March,40A,27.7,7,Overturned,502,VEH'S OVERTAKING: OUT OF CONTROL,15,Off carriageway on straight,0,1,0,0,1,,5,27.7
20700081068,Hospitalisation,2007,April,40A,29.16,6,Hit fixed obstruction or temporary object,502,VEH'S OVERTAKING: OUT OF CONTROL,15,Off carriageway on straight,0,1,0,0,1,,5,29.16
20700466964,Hospitalisation,2007,November,40A,35.13,2,Angle
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    ,207,VEH'S OPPOSITE APPROACH: U-TURN,7,U-turn
    ,0,1,0,1,2,,5,35.13
20700260636,Hospitalisation,2007,August,40A,42.12,5,
    Sideswipe,503,VEH'S OVERTAKING: PULLING OUT,9,Overtaking
     same direction,0,1,0,0,1,,5,42.12
20800175281,Hospitalisation,2008,March,40A,4.8,6,Hit fixed
    obstruction or temporary object,804,OFF PATH-CURVE: OFF
    CWAY LT BEND HIT OBJ,19,Off carriageway on curve hit
    object,0,1,0,0,1,,5,4.8
20800434326,Hospitalisation,2008,July,40A,6.7,5,Sideswipe
    ,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on
    ,0,1,0,0,1,,3,6.7
20800645398,Fatal,2008,October,40A,8.82,4,Head-on,201,VEH'S
     OPPOSITE APPROACH: HEAD ON,2,Head-on,2,1,0,0,3,,1,8.82
20800664143,Hospitalisation,2008,October,40A,8.96,2,Angle
    ,408,VEH'S MANOEUVRING: ENTERING FROM FOOTWAY,8,Vehicle
    leaving driveway,0,1,0,0,1,,5,8.96
20800555416,Hospitalisation,2008,September,40A,10.1,6,Hit
    fixed obstruction or temporary object,805,OFF PATH-CURVE
    : OUT OF CONTROL ON CWAY,20,Out of control on curve
    ,0,1,0,0,1,,5,10.1
20800064085,Fatal,2008,January,40A,17.47,4,Head-on,201,VEH'
    S OPPOSITE APPROACH: HEAD ON,2,Head-on
    ,1,0,1,0,2,,1,17.47
20800119054,Hospitalisation,2008,February,40A,17.56,4,Head-
    on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on
    ,0,2,0,0,2,,3,17.56
20800338822,Hospitalisation,2008,May,40A,19.2,2,Angle,306,
    VEH'S SAME DIRECTION: LANE CHANGE RIGHT,5,Lane changes
    ,0,1,0,1,2,,5,19.2
20800220997,Hospitalisation,2008,April,40A,20.85,7,
    Overturned,804,OFF PATH-CURVE: OFF CWAY LT BEND HIT OBJ
    ,19,Off carriageway on curve hit object
    ,0,2,0,1,3,,5,20.85
20800424178,Fatal,2008,July,40A,29.12,4,Head-on,201,VEH'S
    OPPOSITE APPROACH: HEAD ON,2,Head-on,1,1,0,0,2,,1,29.12
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176 20800790777,Hospitalisation,2008,December,40A,34.28,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,1,2,,3,34.28
177 20800692631,Hospitalisation,2008,October,40A,36.83,3,Rear-end,303,VEH'S SAME DIRECTION: RIGHT REAR,4,Rear-end,0,1,0,0,1,,5,36.83
178 20800492554,Hospitalisation,2008,August,40A,41.85,6,Hit fixed obstruction or temporary object,502,VEH'S OVERTAKING: OUT OF CONTROL,15,Off carriageway on straight,0,2,0,0,2,,5,41.85
179 20800424144,Hospitalisation,2008,July,40A,44.35,7,Overturned,802,OFF PATH-CURVE: OFF CWAY LEFT BEND,18,Off carriageway on curve,0,1,0,0,1,,5,44.35
180 20900900693,Hospitalisation,2009,November,40A,9.71,2,Angle,104,VEH'S ADJACENT APPROACH: THRU-RIGHT,1,Intersection from adjacent approaches,0,1,0,0,1,,5,9.71
181 20900842887,Hospitalisation,2009,October,40A,10.46,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,1,0,2,,3,10.46
182 20900380186,Fatal,2009,May,40A,18.9,6,Hit fixed obstruction or temporary object,804,OFF PATH-CURVE: OFF CWAY LT BEND HIT OBJ,19,Off carriageway on curve hit object,1,0,2,0,3,,5,18.9
183 20900917073,Hospitalisation,2009,November,40A,19.68,7,Overturned,805,OFF PATH-CURVE: OUT OF CONTROL ON CWAY,20,Out of control on curve,0,1,0,0,1,,5,19.68
184 20900030965,Hospitalisation,2009,January,40A,39.06,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,39.06
185 20900512383,Hospitalisation,2009,July,40A,43.13,7,Overturned,804,OFF PATH-CURVE: OFF CWAY LT BEND HIT OBJ,19,Off carriageway on curve hit object,0,2,0,0,2,,5,43.13
186 20900509789,Hospitalisation,2009,July,40A,45.8,6,Hit fixed obstruction or temporary object,800,OFF PATH-CURVE: OTHER,21,Other,0,1,0,0,1,,5,45.8
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187 20100787942,Hospitalisation,2010,August,40A,7.625,6,Hit fixed obstruction or temporary object,803,OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,7.625
188 20101134593,Hospitalisation,2010,December,40A,17.258,5,Sideswipe,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,0,0,1,,3,17.258
189 20101070823,Hospitalisation,2010,November,40A,17.59,7,Overturned,804,OFF PATH-CURVE: OFF CWAY LT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,17.59
190 20100548250,Hospitalisation,2010,June,40A,17.74,6,Hit fixed obstruction or temporary object,803,OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,17.74
191 20100569401,Hospitalisation,2010,June,40A,38.92,6,Hit fixed obstruction or temporary object,705,OFF PATH-STRAIGHT: OUT OF CONTROL ON CWAY,17,Out of control on straight,0,1,0,0,1,,5,38.92
192 20100271831,Hospitalisation,2010,February,40A,39.14,6,Hit fixed obstruction or temporary object,607,VEH'S ON PATH: TEMPORARY OBJECT ON C'WAY,21,Other,0,1,0,0,1,,5,39.14
193 20100313840,Hospitalisation,2010,March,40A,49.03,6,Hit fixed obstruction or temporary object,703,OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,4,49.03
194 20110293252,Hospitalisation,2011,April,40A,4.957,3,Rear-end,301,VEH'S SAME DIRECTION: REAR END,4,Rear-end,0,1,0,1,2,,5,4.957
195 20110475947,Hospitalisation,2011,May,40A,6.33,3,Rear-end,301,VEH'S SAME DIRECTION: REAR END,4,Rear-end,0,2,1,1,4,,5,6.33
196 20110910649,Hospitalisation,2011,October,40A,9.58,6,Hit fixed obstruction or temporary object,803,OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,1,0,2,,5,9.58
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20110168297,Hospitalisation,2011,February,40A,10.946,3,Rear-end,303,VEH'S SAME DIRECTION: RIGHT REAR,4,Rear-end,0,1,0,0,1,,5,10.946
20110637646,Fatal,2011,July,40A,15.61,6,Hit fixed obstruction or temporary object,804,OFF PATH-CURVE: OFF CWAY LT BEND HIT OBJ,19,Off carriageway on curve hit object,1,1,0,0,2,,5,15.61
20110679518,Hospitalisation,2011,August,40A,16.169,3,Rear-end,301,VEH'S SAME DIRECTION: REAR END,4,Rear-end,0,2,0,0,2,,5,16.169
20110060392,Fatal,2011,January,40A,17.35,6,Hit fixed obstruction or temporary object,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,0,1,0,2,,1,17.35
20110048327,Hospitalisation,2011,January,40A,19.253,7,Overturned,701,OFF PATH-STRAIGHT: LEFT OFF CWAY,15,Off carriageway on straight,0,1,0,0,1,,4,19.253
20110474291,Fatal,2011,May,40A,19.27,2,Angle,408,VEH'S MANOEUVRING: ENTERING FROM FOOTWAY,8,Vehicle leaving driveway,1,0,1,0,2,,5,19.27
20110347819,Hospitalisation,2011,April,40A,24.62,3,Rear-end,303,VEH'S SAME DIRECTION: RIGHT REAR,4,Rear-end,0,1,0,0,1,,5,24.62
20110447032,Hospitalisation,2011,May,40A,24.705,4,Head-on,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on,0,1,1,0,2,,3,24.705
20110835566,Hospitalisation,2011,September,40A,31.933,6,Hit fixed obstruction or temporary object,704,OFF PATH-STRAIGHT:RIGHT OFF CWAY HIT OBJ,16,Off carriageway on straight hit object,0,1,0,0,1,,3,31.933
20111101782,Hospitalisation,2011,December,40A,36.863,6,Hit fixed obstruction or temporary object,803,OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit object,0,1,0,0,1,,5,36.863
20111155054,Hospitalisation,2011,December,40A,39.06,3,Rear-end,303,VEH'S SAME DIRECTION: RIGHT REAR,4,Rear-end,0,1,0,1,2,,5,39.06
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20110675212,Hospitalisation,2011,August,40A,44.77,6,Hit
    fixed obstruction or temporary object,803,OFF PATH-CURVE
    : OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve
    hit object,0,1,1,0,2,,5,44.77
20060000883,Hospitalisation,2006,January,42A,1,7,Overturned
    ,800,OFF PATH-CURVE: OTHER,21,Other,0,1,0,0,1,,5,1
20060010018,Hospitalisation,2006,April,42A,2.35,6,Hit fixed
     obstruction or temporary object,803,OFF PATH-CURVE: OFF
     CWAY RT BEND HIT OBJ,19,Off carriageway on curve hit
    object,0,1,0,0,1,,5,2.35
20600010855,Fatal,2006,June,42A,10.26,4,Head-on,201,VEH'S
    OPPOSITE APPROACH: HEAD ON,2,Head-on,1,0,0,1,2,,1,10.26
20700445481,Fatal,2007,November,42A,12.2,4,Head-on,201,VEH'
    S OPPOSITE APPROACH: HEAD ON,2,Head-on,1,0,0,0,1,,1,12.2
20800464730,Hospitalisation,2008,July,42A,11.96,4,Head-on
    ,201,VEH'S OPPOSITE APPROACH: HEAD ON,2,Head-on
    ,0,2,0,1,3,,3,11.96
20900909089,Hospitalisation,2009,November,42A,6.47,6,Hit
    fixed obstruction or temporary object,803,OFF PATH-CURVE
    : OFF CWAY RT BEND HIT OBJ,19,Off carriageway on curve
    hit object,0,1,0,0,1,,5,6.47
20100792902,Fatal,2010,August,42A,6.199,2,Angle,406,VEH'S
    MANOEUVRING: LEAVING DRIVEWAY,8,Vehicle leaving driveway
    ,1,0,0,0,1,,5,6.199
20100130473,Hospitalisation,2010,January,42A,6.47,3,Rear-
    end,301,VEH'S SAME DIRECTION: REAR END,4,Rear-end
    ,0,1,0,0,1,,5,6.47
20110387111,Hospitalisation,2011,May,42A,7.96,2,Angle,101,
    VEH'S ADJACENT APPROACH: THRU-THRU,1,Intersection from
    adjacent approaches,0,1,0,0,1,,5,7.96
20110735409,Hospitalisation,2011,August,42A,8.74,6,Hit
    fixed obstruction or temporary object,607,VEH'S ON PATH:
     TEMPORARY OBJECT ON C'WAY,21,Other,0,1,0,0,1,,5,8.74
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