University of Southern Queensland
Faculty of Health, Engineering and Sciences

Comparative analysis of the effectiveness of current and innovative rural road safety countermeasures implemented in Far North Queensland

A dissertation by
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Abstract

The rural road network in Far North Queensland is vast, comprising of over 40,000 km of state-controlled roads and 2,000km of local government owned roads. This road network is essential to supporting the economic outcomes for Far North Queensland. This includes domestic and international farming exports and the mining industry. The road network is also essential for social outcomes with 6% of the population in this region living in areas that are classified as remote or very remote. However, the grim reality is that road trauma is a leading cause of death amongst society and over 80% of run-off-road fatalities are on Australian rural road networks. Crash fatality data shows an increase of fatalities by 27% from 2018 and 2022 and increase in hospitalised casualties by 8%.

Recognising the profound connection between road accidents and environmental factors, safety treatments should be selected in a way that will specifically target the root cause of these crashes. With advancements in road safety strategies and techniques, prioritising the reduction of road fatalities is paramount. The core objective of this research is to pinpoint problematic sections along the rural roads of Far North Queensland, known as chainages, and establish a correlation between the causative factors and the environmental conditions of these segments. Subsequently, innovative safety interventions are deployed in these identified chainages to draw a comparative analysis between current and innovative safety measures.

The research outcomes indicate that advancements in road safety can significantly enhance the overall safety of the targeted road sections. An assessment of the current state of these chainage sections revealed that most fell short of meeting the safe system objectives. However, after the implementation of advanced safety treatments, a substantial improvement was observed, particularly in reducing run-off-road type crashes. Furthermore, the findings derived from the Safe System matrix highlight that safety measures emphasising the geometric properties of the carriageway wielded a more substantial influence in enhancing safety compared to guidance treatments such as signage and linemarking. Additionally, this research underscores the existing gap in rural road safety treatments within Far North Queensland and underscores the imperative for further initiatives and projects aimed at enhancing road safety in these remote areas.

Keywords: Rural, Road Safety, Safe Systems, Austroads, Geometric, Environmental

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Limitations of Use

Certification

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

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

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Signature

15/10/2023

Date

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Chapter 1 – Introduction

1.1 Background

Rural road crashes in Far North Queensland have become a persistent concern within the community with crash fatalities increasing by 27% in the last 5 years and hospitalised casualties increasing by 8%. While human factors like alcohol, speeding, mobile phone use, and driver fatigue contribute substantially to vehicle accidents, there is also a notable proportion that can be directly attributed to the inadequate conditions of rural highways in the region with many Far North Queensland Towns isolated for over five months per year due to flooding. The impact of environmental disasters on road conditions is significant, likely resulting in an increase of fatalities. According to QLD Transport and Main Roads, road trauma is the primary cause of death among children and young adults (tmr.qld.gov.au, 2022). Despite efforts to prioritise the enhancement of rural road networks to create safer driving environments, limited resources and funding challenges have hindered the improvements of rural roads. The North Queensland rural road network is vast, comprising of over 4,000km of state-controlled roads and 2,000km of local government roads. Advanced engineering is required to develop low-cost safety options that are easily implemented and maintained in these remote locations.

Between the year 2012 and 2022, Far North Queensland experienced a total of 255 fatal road crashes vehicle collisions, out of which 85 are categorized in remote and very remote areas. To conduct a comprehensive analysis covering a period of 10 years, starting from 2012, the total number of crashes amounted to 9,190, with 1,150 of them taking place in remote Far North Queensland. To narrow these down further, 132 resulted in fatality. The Bureau of Infrastructure and Transport Research Economics provided data indicating that 250 crashes, which occurred during poor visibility conditions at dawn or dusk, led to hospitalisation or fatality. Among these casualties, 167 were directly attributed to factors such as road geometry, road conditions, and other visibility standards, as reported on data.qld.gov.au. These statistics portray the issue of the safety situation on rural roads in Far North Queensland, underscoring the need to consider implementing further safety measures to reduce the overall number of collisions in remote areas.
The percentage of car accidents that are caused by geometric and environmental factors can be scrutinised for being minimal and negligible, but it is essential to not overlook any

casualty or fatality in modern Engineering practices. While the fraction of fatalities that represent rural road crashes is small, disregarding them would be detrimental to moral practice.

Geometric factors which include curvature, superelevation, speed, and topography, play a crucial role in ensuring road safety. When designing roads, these factors are carefully considered and incorporated according to the Australian Standards for road design, as outlined in the Austroads Guide for sealed and unsealed roads. These standards are regularly updated to reflect advancements in Engineering practices and to improve upon previous designs.

Many rural roads in Far North Queensland have geometric features that fail to meet current design standards. These include steep vertical grades and sharp horizontal curvature on highways with high-speed limits (typically 100 km/hr). It is vital to address the deficiencies in this road network when revising design standards, as they should not be disregarded or overlooked.

The shortage of Government funding poses a significant barrier to improving rural roads, primarily due to being remote and isolated locations. The maintenance of roads in Far North Queensland faces many challenges relating to the limited supplies and labour. According to a report by the Australian Rural Road Group regarding the Rural and Local Road crisis, rural councils allocate approximately 82% of their average annual asset consumption to rural road management. In contrast, roads in regional areas account for only 66% of the total local council's asset consumption (infrastructureaustralia.gov.au, 2010). Consequently, it can be argued that the local Governments responsible for the rural road network, lack the financial resource stability to adequately maintain or replace these networks.

Given the alarming number of fatalities on rural roads, concerns arise regarding the safety of road design. Although it is impossible to eliminate human factors entirely, it is feasible (with the allocation of funding) to implement additional safety measures that reduce the impact of geometric factors on driving conditions.

1.2 Research Problem

The objective of this research is to highlight the necessity for upgrades to the rural road network in Far North Queensland. The project aims to compare the existing conditions of rural highways with the current standards for road design and safety, thereby identifying the deficiencies within the rural road network. The research will contribute to a better understanding of Australian Standards pertaining to road design and safety, as well as the minimum design guidelines required to ensure the safety of drivers on Australian roads. Additionally, the evidence gathered from the research will demonstrate the escalating issue of driver safety in rural and remote areas, while also proposing the implementation of new and innovative research for safety treatments.

The overarching issue that is seen throughout road design is the typically subjective opinion that road crashes are a result of human behaviours, which results in inefficient solutions caused by environmental factors affecting road use. Instead, road accidents are complex, and linked to the interaction of many factors, including the driver environment, road conditions, and human factors. Although several road safety measures are historically implemented, including speed limits, warning signs, and traffic control measures, the effectiveness of these in reducing fatal road crashes in rural Far North Queensland remains unclear given the substantial number of annual fatalities. Moreover, there is limited research that examines the impact of different combinations of these measures on RTAs. Therefore, this study aims to investigate the effectiveness of current road safety measures versus innovative safety measures in reducing the overall crash rate in rural areas and to identify the most effective combinations of measures for different rural settings. The findings of this study will communicate and inform of the most effective road safety measures for reducing road crashes in rural areas, and potentially contribute to the reduction of injuries and fatalities in these areas.

1.3 Research Objective

The aim of this research is to identify the safety standard of the rural road network in Far North Queensland, and provide recommendations as to low cost, treatment measures to increase safety. This will be met by conducting a Safe Systems Assessment in accordance with the Austroads Guidelines and a Geometrical analysis of the existing road alignment to compare with Australian Standards for road geometry – also in accordance with the Austroads Guidelines.

The following objectives can be expected to meet the aims for the project:

1. Obtain Road Crash data from Queensland Government certified websites to find Far North Queensland's most fatal highway road sections
2. Compare crash data to identify problematic Roads and crash causations
3. Diagnose the crash problem using road crash data (cause) and site investigations. Present data in graphical formats to demonstrate rural road factors

4. Assess the road geometry against the Austroad Guide for sections where geometrical or visual factors were present. Identify what treatments are currently in place
5. Conduct literature review on current innovations used in trials or previous trials for improved road safety. Literature review to consider road types, traffic type, and environmental factors differentiating between the trial sites and Far North Queensland
6. Conduct Safety Treatment selection and design process in accordance with the Austroads Guidelines and rank the safety treatments as a result of the Safety Systems Assessment Framework
7. Comparison between the results from the Safe Systems Framework
8. Final conclusions drawn from the comparison and final recommendations for future implementation of safety measures.

Chapter 2 – Literature Review

2.1 Current road safety applications

Currently, the application and development of road safety is in accordance with the Austroads Guidelines as a basis for design recommendations and restrictions. Historically, road design has taken the approach of 'how can the risk be eliminated' which resulted in biases towards human factors. As an Engineer, the assumption that a risk is mitigated from compliant design standards, is an inadequate form of safety understanding. This is evident in that human error contributes to as high as 90% of all fatal road crashes (Treat et al, 1977). The safety design procedure has recently developed into a more realistic approach, which is to expect the risk and mitigate it from preparation. Human behaviour is now a considerable factor in the design of road networks and risk mitigation, with the expectation that driver and pedestrian behaviours cannot be predicted 100% of the time.

As current road safety applications are implemented by designers and Engineers as a result of road crash modelling, it is crucial to highlight weaknesses in the initial modelling methods. As Zheng.L et al mentions in their report on *Modeling traffic conflicts for use in road safety analysis: A review of analytic methods and future directions,* there has been a substantial decrease in road crashes in current years as opposed to decades ago, however millions of people still lose their lives because of fatal road accidents. The report states that while road safety is ever progressing and evolving, limitations still exist in the methodology of modelling and representing crash data for optimal understanding of the nature of the crash. There seems to be a heavier focus or over-representation of abnormalities in driver behaviour that does not accurately represent the wider population of drivers (Zheng. L., 2021). This report discusses the relationship between traffic conflicts and road crashes. Zheng. L. et al argues that every passage of a road user on a traffic facility presents a finite probability of a collision, and every road user passage can be seen as a trial tested by some underlying probability of failure (Zheng.L., 2021). The review defines a traffic conflict as a situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged. Traffic conflicts are considered a broad definition that includes a range of safety measurements, including proximity and evasive actions, near-misses, near-crashes, and safety-critical events. A main argument present in Zheng. L. et al's research is that traffic conflicts can act as precursors for more catastrophic or fatal events; the crash-related outcome is a probabilistic function of both the initial conditions and the evasive actions. Involved road users choose the evasive actions according to initial conditions that reflect their proximity, and both "evasive actions" and "proximity" are fundamental components of traffic conflicts.

2.2 Previous studies on rural road safety

The issue of rural road safety is frequently discussed in Civil Engineering workplaces, but research specifically focussed on Far North Queensland rural road safety appears to be scarce. One notable study conducted by V. Siskind titles "Risk Factors for Fatal Crashes in Rural Australia" examines rural crash data across the country, considering factors such as age, gender, road conditions, and driver-related elements. The research suggests that driver behaviour plays a significant role in the overall outcome of crashes, outweighing the influence of environmental factors. While this finding is supported by evidence, it is important not to dismiss the impact of environmental factors on accidents occurring on rural highways as minor influences.

Throughout the research, alcohol and speed emerge as common factors strongly associated with the data, overshadowing other environmental and driving factors. The study highlights the importance of increased police monitoring on rural roads to address issues of speeding and driving under the influence of substances. However, it does not provide recommendations on how to mitigate the impact of other factors that are still prevalent in the data, nor is it feasible to implement a higher presence of police in rural locations.

Many research papers focus the attention of crash fatalities to human behaviours such as alcohol consumption and speeding (commonly seen to coincide) and the safety measures related to reducing the number of fatalities due to these factors. It is difficult to find research that directly relates outdated road design and safety devices to crash fatalities and the need to upgrade the rural road network. A New Zealand study *"A road safety risk prediction methodology for low volume rural roads"* by D. Harris uses the curve identification methodology to correlate poorly designed curvature of rural roads to loss-of-control car accidents on rural roads. Developing this methodology demonstrates the relationship between poor curvature design and the increased likelihood of an accident occurring. An argument by S.Othman et al states that large curve radius greater than 1000m are at least two times safer than sharp curves with radius less than 500m (S.Othman, 2009). The relationship between curve radius and speed plays a crucial role in the outcome of curve execution; it is shown in previous research that curves at lower radii and lower speeds have a smaller crash frequency than that of curves with a greater radii and higher speed limit. An indication of these figures suggests the data may have been collected in urban or residential areas where speed limits are lower and thus the desirable minimum standard for curve radius is also lower. The correlation between curvature and visibility, is that a higher crash rate is typically seen where sudden or sharp curvature is overlooked by poor visibility standards that may be from short site distances or from environmental obstructions. Regardless of the cause of poor visibility, there is an agreeance amongst research studies that 'dangerous' curves on rural roads were as a direct result of poor visibility standards when approaching the curve, correlating back to the idea that the design is not adequate for those conditions.

On behalf of the Australian Rural Roads Group, Juturna Consulting presented research based on the rural local road crisis in Australia. The research presents evidence to suggest why the support of the development and upgrades of Australia's rural road networks is minimal. The main concept within the report suggests that the rural road network is far too large to be maintained by the rural communities that are responsible for the upkeep of the networks. It is suggested this is due to the funding limitations provided to rural Council's to coincide with the great extent of the rural road network. As mentioned in the research, the initial construction of infrastructure accounts for 20% of the total lifetime costs with the remainder dedicated to operating, maintaining, and renewing. The argument directly correlates the limited funding available in rural and remote areas due to the funding gap that represents the financial debt sustained by local councils. Evidently, this funding gap is caused from the little attention gained to rural local roads prior to the end-of-lifecycle for renewal. The average New South Wales, unsealed, rural road maintenance cost is approximately $132 million per annum, while in 2008, $29 million was allocated to the maintenance of these roads (infrastructureaustralia.gov.au, 2010). The issue now is that restricted funding has meant the quality of maintenance and road redesigns have not been adequate and end-of-life conditions are fast approaching. Unfortunately, rural Council's simply do not have the funding allocations to complete road renewals. It is evident that there is a strong need for support of funding to local communities if the Queensland Government continues to allocate the responsibility of rural road upkeep to the local Councils.

As expected, majority of studies conducted in regard to road safety are based on speed being the number one causation of fatal road crashes. While the data presents this statement as evident, it is important to understand the other contributing factors that may be present amongst drivers to recognise the treatments that can minimise the impact of speed on a crash outcome.

A study conducted by Kristie L. Young for the Monash University Accident Research Centre, presents the findings on *What are Australian drivers doing behind the wheel?* A report which examines driver behaviour and patterns that are termed 'secondary tasks' to that of driving. Secondary tasks can be defined as adjusting vehicle devices; looking outside the vehicle; the use of a mobile phone (in a variety of manners); interacting with a passenger; eating; or singing to oneself to list some examples. The methodology used in this study, saw three-hundred and fifty-two vehicles fitted with Data Acquisition Systems over the period of four months to capture true timing of driver distraction (K.L. Young, 2018). The study shows that on average, drivers will engage in a secondary task every 1.6 minutes with most involving interactions of less than 5 second duration. This research highlights the significance of driver behaviour in distractions, as little as changing the volume, can have a significant time reduction in overall driver awareness. This is linked back to the ideology that driver behaviour can play a contributing factor in road crash causations and it is imperative that safety treatments are considered along with compliant design methodology.

2.3 Innovation Research

2.3.1 Bioluminescent materials

Australia wide is seeing the implementation of innovative technologies to further increase the level of Safety on the road networks. With continuous development in technology and study, these innovations are leading away from safe design techniques and instead focusing more on design additives. A method that has an increasing presence in trials around Australia is the implementation of luminescent materials in pavements. Western Australian Road Research and Innovation Program (WARRIP) conducted a review on the implementation of luminescent materials added to road paving materials with final recommendations produced in accordance with specified relevant criteria. These criterions addressed applicability/performance (considering lifecycle, maintainability, performance in different environmental conditions); availability/ cost; safety benefits; and compliance with the required standards (visibility, skid resistance value, reflectivity etc).

According to WARRIP, luminescent materials were developed by Daan Roosegaarde alongside the construction company Heijmans with the purpose of enhancing delineation of road markings to improve visibility and safety for motorists and pedestrians in poor visibility conditions. The luminescent line marking was a response for a more efficient safety measure where power grids are absent and hence conventional street lighting cannot be implemented (WARRIP, 2019). Initial trials of the line marking began in the Netherlands in April 2014, investigated by the Scottish Road Research Board (SRRB). WARRIP reports during the trials, a number of limitations became evident with the material used; excess moisture from rainfall reacted negatively with the luminescent which resulted in a dimmed ‘glow’; vehicle headlights tended to overpower the glow of the line marking once it was directly hit; the quality of modern strontium aluminate (fluorescent substance) does not allow for long hours of continual glow and may in fact only produce and hour of glow effect. Another negative outcome from the trial, WARRIP states that the Scottish Road Research Board identified that motorists would drive without headlights to experience the optimal glow effect, counteracting one safety measure for another.

2.3.2 Connected Roads Technology

Connected roads technology, often referred to as Intelligent Transportation Systems (ITS) or Smart Roads, is a cutting-edge infrastructure concept that aims to make our road networks more efficient, safe, and responsive to the needs of modern transportation. Here are some key aspects of connected roads technology:

1. **Communication Infrastructure:** Connected roads rely on advanced communication networks, such as 5G or dedicated short-range communication (DSRC), to enable real-time data exchange between vehicles, roadside infrastructure, and traffic management centers. This communication infrastructure forms the backbone of the system.

2. **Vehicle-to-Infrastructure (V2I) Communication:** Vehicles equipped with onboard sensors and communication devices can exchange data with roadside infrastructure elements, such as traffic lights, signs, and sensors embedded in the road surface. This data exchange allows vehicles to receive traffic updates, signal phasing information, and safety warnings.

3. **Vehicle-to-Vehicle (V2V) Communication:** V2V communication enables vehicles to exchange information with nearby vehicles. This helps in creating a dynamic and interconnected network of vehicles that can share real-time information about their speed, location, and intentions. This is particularly crucial for avoiding collisions and managing traffic flow.

4. **Traffic Management and Optimization:** Connected roads enable traffic management centers to monitor traffic conditions in real-time. By analyzing data from connected vehicles and roadside sensors, traffic managers can adjust signal timings, reroute traffic, and respond to incidents more effectively to reduce congestion and improve traffic flow.

5. **Enhanced Safety:** One of the primary goals of connected roads is to enhance road safety. Vehicles can receive alerts about potential hazards, such as accidents, construction zones, or slippery road conditions, and take appropriate action to avoid them. This technology can also be used for autonomous vehicles to navigate safely.

6. **Environmental Benefits:** By optimizing traffic flow and reducing congestion, connected roads technology can lead to reduced fuel consumption and lower emissions, contributing to environmental sustainability.

7. **Data Collection and Analysis:** Connected roads generate a vast amount of data that can be used for traffic modeling, urban planning, and future infrastructure improvements. This data can provide insights into traffic patterns, infrastructure performance, and safety trends.

8. **Challenges:** Implementing connected roads technology requires significant investment in infrastructure and vehicle upgrades. Privacy and security concerns related to data exchange also need to be addressed. Furthermore, ensuring compatibility between different vehicle brands and infrastructure providers is essential for the widespread adoption of this technology.

Connected roads technology is a critical component of the future of transportation, as it has the potential to transform how we move people and goods, making our road networks safer, more efficient, and environmentally sustainable.

Connected roads technology has the potential to revolutionize road safety in several ways:

1. **Real-time Hazard Warnings:** Connected vehicles can receive real-time hazard warnings from other vehicles and roadside infrastructure. For example, if a vehicle encounters slippery road conditions or a sudden traffic slowdown, it can relay this information to nearby vehicles, allowing them to take precautionary measures or adjust their speed accordingly. This collective awareness of road conditions significantly reduces the risk of accidents caused by unexpected hazards.

2. **Collision Avoidance:** V2V communication allows vehicles to exchange information about their speed, position, and direction. Advanced driver assistance systems (ADAS) can analyze this data to detect potential collision risks and issue warnings or even take autonomous actions, such as applying brakes or steering, to avoid accidents.

3. **Intersection Safety:** Connected roads can improve intersection safety by enabling V2I communication. Traffic signals can transmit their phase and timing information to approaching vehicles, helping drivers time their approach to reduce the likelihood of red-light violations and intersection collisions.

4. **Emergency Vehicle Alerts:** Connected technology can notify drivers when emergency vehicles, such as ambulances or fire trucks, are approaching. This ensures that drivers yield the right-of-way promptly, allowing emergency responders to reach their destinations quickly and safely.

5. **Work Zone Safety:** Construction zones often pose safety risks to both drivers and construction workers. Connected roads can provide real-time information about work zone locations, lane closures, and detours, helping drivers navigate these areas safely and reduce the risk of accidents.

6. **Fatigue and Distraction Monitoring:** Sensors and cameras in connected vehicles can monitor driver behavior for signs of fatigue or distraction. If a driver is detected as being drowsy or distracted, the system can issue warnings to alert the driver and reduce the risk of accidents caused by impaired attention.

7. **Adaptive Speed Limits:** Connected roads can adjust speed limits dynamically based on real-time traffic and weather conditions. This ensures that drivers are traveling at safe speeds, reducing the likelihood of accidents during adverse conditions.

8. **Data-Driven Safety Improvements:** The data collected from connected vehicles and infrastructure can be analyzed to identify accident-prone areas and patterns. This information can inform road safety improvements, such as better signage, road surface enhancements, or changes in road design.

9. **Autonomous Vehicles:** Connected roads are a critical component of the infrastructure needed for autonomous vehicles (self-driving cars) to operate safely. These vehicles rely on real-time data from other vehicles and infrastructure elements to make decisions, navigate complex situations, and avoid accidents.

10. **Reduced Traffic Congestion:** By optimizing traffic flow and minimizing stop-and-go situations, connected roads can reduce congestion, which is a common factor contributing to accidents.

In summary, connected roads technology enhances road safety by enabling vehicles to communicate with each other and with infrastructure elements, providing real-time information and warnings to drivers, and facilitating data-driven safety improvements. By addressing these aspects, connected roads have the potential to significantly reduce the number and severity of accidents on our roadways, ultimately saving lives and improving overall road safety.

2.3.3 OmniGrip

Omni Grip technology is a revolutionary advancement in road infrastructure that has redefined safety and performance on our highways. This innovative system employs a combination of specialized materials and intelligent design to enhance traction and control for vehicles in various weather conditions. Australia's first producer of Omni Grip, OmniGrip Direct, produces a variety of products specifically targeting road safety for road users. Product features include Omnigrip HF, Omnigrip CST, Linemarking, and various LED products for night use. Specifically, Omnigrip HF, or high-friction surface treatment, features a thin overlay of calcined-bauxite over asphalt roads to improve surface friction (omnigripdirect.com.au, 2023). By improving surface friction, lowers the risk of skidding and sliding for road users which enhances the driver's overall control of the vehicle. The Australian Road Research Board states that high-friction surface treatments can help stop a vehicle from skidding off roads and increase the ability to brake more affectively in critical moments (omnigripdirect.com.au, 2023). Furthermore, its durability and resistance to wear and tear make it a sustainable choice, reducing maintenance costs and the need for frequent road repairs.

2.3.4 Flexible Roadside and Centreline Barriers

The significance of run-off-road crashes remains high within Australia with the Bureau of Infrastructure and Transport Research Economics (BITRE) stating between 2016 and 2020, Australia averaged to 458 deaths (bitre.gov.au, 2022). A study by the Centre for Accident Research and Road Safety (CARRS) also found that most rural crashes were as a result of single vehicle run-off-road crashes (Centre for Accident Research and Road Safety, 2021).

One solution for mitigating these types of crashes is the implementation of flexible roadside barriers. Common roadside barriers are the rigid barriers, which serve as a higher safety method for heavier vehicles. However, the high level of containment present in a rigid barrier is not ideal for a light vehicle travelling at high speeds. Given that light vehicles account for 80 percent of run-off-road crashes, light vehicle protection is crucial. The flexible barrier, which are made from wired rope, can catch a fast-travelling vehicle with minimal impact to the driver by dissipating the energy exerted from the vehicle. These barriers have proven to reduce injury in a study by the Monash University Accident Research Centre, which evaluated 100 kilometres of flexible safety barriers implemented in Victoria. The evaluation concluded that the flexible barrier reduced fatal and serious run-off-road and head-on accidents by 80-90 percent (Monash University, 2018).

By establishing flexible roadside barriers, in rural Far North Queensland, there are hopes in reducing the amount of serious and fatal road crashes (resulting from run-off-road) by similar figures that Victoria saw in 2018.

2.3.5 Advanced Warning Systems

Rural Far North Queensland is densely populated with agricultural farming, particularly cattle, which is seen throughout all areas of Far North Queensland. A common hazard that is witnessed by drivers travelling through remote areas via State Controlled Roads is the presence of cattle. Due to the large number of cattle farmers, it is not uncommon to be halted due to cattle movements across a main road, which in these cases, are resolved by simply waiting for the cattle to move.

Rural Far North Queensland is also home to a high concentration of other larger wildlife species such as kangaroos, emus, spotted deer, and wild boars. These animals can behave unpredictably and can often find themselves trapped on the roadside of a boundary fence, enabling them to become a potential hazard for road users. To add to this issue, these animals are known to become more active during the night, increasing the hazard significantly in low visibility.

One solution to the wildlife-vehicle collision problem was analysed in the 1990's when the Roadside Animal Detection System (RADS) was introduced. The RADS technology works by infrared or motions sensors detecting animal movements and a signal is sent to a nearby sign; the sign will begin flashing to alert oncoming drivers (Molly K. Grace, 2017). Switzerland was the first to deploy the RADS technology in an attempt to decrease the number of animal deaths on roads. A study published by Gordon et al. upon the initial release of RADS technology, drivers reportedly reduced their speed by up to 7km/h in response to the warning system (Molly K. Grace, 2017).

One product which demonstrates the RADS concept is the ClearWay system founded in the United Kingdom. ClearWay is able to detect an animal that is within close proximity to the carriageway and alerts drivers by road-side electric signage. The theory is that road users will become more vigilant to real-time, known threats as opposed to permanent animal warning signage that is commonly seen throughout Australia.

Chapter 3 – Methodology

3.1 Road Crash Data

The first stage in the main component of the research project is to collect road crash data; analyse the crash data; and diagnose the crash problem. Collecting road crash data will be the first crucial stage in assembling the execution of this research. The data is required to extract the problematic rural highway zones in Far North Queensland and will navigate the base of the research. The relevant data will be sourced from Queensland Government recognised websites, with the primary data sourced from the Queensland Data Portal. Data sets can be downloaded from this portal in multiple formatting dependent on the focused topic. For this research topic, the data set which will be used is the 'Road crash locations' data set, which provides road location, crash outcome and crash nature. For relevancy, data will be filtered from 2012 – 2022 to provide recent and accurate analysis.

A series of frequency histograms will present the information in a simplistic form to represent crash locations per police division. Areas of the highest crash fatalities will be extracted for further analysis.

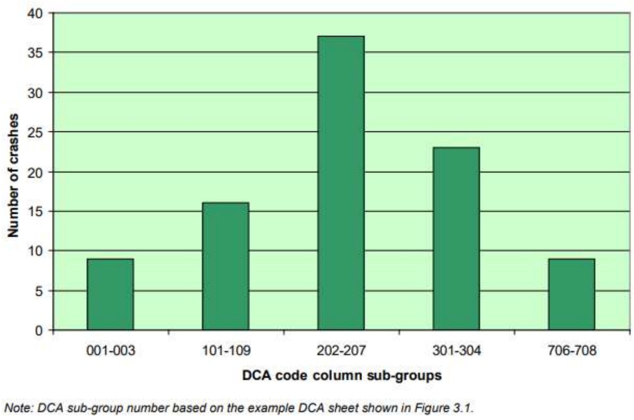


Figure 1:example crash frequency histogram, source: Austroads Guide to Road Safety

A separate crash frequency histogram will then be developed to portray each police division per road basis. This will give a representation of problematic roads and the cause of the road crashes. Problematic chainages will then be sourced by extracting the coordinates from the Queensland Data Portal and uploaded into Google Earth. From Google Earth, problematic road sections will be identified based on number of crashes per kilometre to determine if the section is a safety risk. Singular crashes with little relativity to other crashes will be excluded from the analysis.

3.2 Virtual Site Inspection

Establishing the geometric properties of the highway sections will identify faults in the geometric design, as a result, making the process of fault identification more efficient. Due to the limited accessibility of Rural Far North Queensland, aerial imagery and street view snippets will be used to capture a visual inspection for the purpose of this research.

Site inspections will include:

- measurements of cross-sectional properties (including lane width, shoulder width and any verges or V drains)
- steep vertical grades
- horizontal curvature concealed by view obstruction or vertical grades
- visibility standards – visual obstructions, poor alignment resulting in decreased line of site, implemented safety devices i.e., lighting, guideposts and/or signs, any other visibility hazards
- surrounding factors that may influence driver behavior or reaction time, such as wildlife or foliage.
- Assessment of speed limits

The objective of the site inspections will be to identify contributing factors to the car crash and to identify any implemented safety devices i.e. guide posts/signs and line marking. A crucial element to the site inspections is to ensure the site inspection is conducted with reference to the car crash; the time of day, weather, lighting etc. are all factors that influence the crash severity. The site inspection will be conducted with the assessment of all relevant factors.

3.3 Assessment of Safety Countermeasures

3.3.1 Investigation of current Safety Measures

Safety measures will be in accordance with the Austroads Guide to Road Safety. With the previous stages of the research project identifying the crash contributions by environmental and geometric factors, the applicable safety measures will then be assessed. The aim of the countermeasure as addressed by the Austraods Guide to Road Safety:

- countermeasure will have proven efficiency in reducing crash severity
- will not decrease traffic efficiency or have negative environmental impacts
- will be a cost-efficient solution that maximises the expenditure.

Assessment of countermeasures will use a combination of safety measures found within the Austroads Guide to Road Safety Part 2 and Austroads Guide to Road Design Part 6 and external literature sources from government publications of increase road safety measures. Safety measures for highway sections that are not in accordance with the current design standards, a suggested increase in geometric properties will be recommended as the first safety measure (if applicable). Using the Austroads Guide to Road Design Part 3, a minimum design requirement will be recommended using the formulas and tables from section 2.2.3 of this report. However, this option will not be the most cost-effective solution and thus the same methodology from the Guide to Road Safety Part 2 will also be applied to these highway sections.

3.3.2 Investigation of Innovative Design Methods

This stage of the research project will involve a large extent of literature review and will heavily rely of previously conducted research or experiments as accessibility retrains self-conducted analysis. Products that may be recognised Australian wide but not currently utilised largely will be considered. The innovative product will be directly related to the crash causation and will coincide with the Austroads requirements stated above:

- countermeasure will have proven efficiency in reducing crash severity
- will not decrease traffic efficiency or have negative environmental impacts
- will be a cost-efficient solution that maximises the expenditure.

3.3.3 Modelling of Countermeasures

Modelling of the effectiveness of the investigated countermeasures will be in accordance with Austroads Guide to Road Safety. The steps undertaken in the modelling stage of the project are detailed below:

Step 1: select most appropriate countermeasure

This step combines learnt knowledge through studies and professional experience to analyse the countermeasures within the guidelines and to select the most appropriate applicable for the accident cause.

Step 2: Apply CMFs

Crash Modification Factors, as defined in the Austroads Guidelines, provide an indication of the expected outcome of a crash once a safety countermeasure has been implemented. The total crash modification can be found using the below equation from the guidelines:

$CMF_x = CMF_1$

Or for multiple safety treatments:

$CMF_t = CMF_1 \text{ x } CMF_2 \text{ x } CMF_3$

Where CMF_t = the total crash medication.

The below example of CMF modelling has been extracted from the Austroad Guide to Road Safety:

As an example, if three treatments are being considered in one location, with respective CMFs of 0.6, 0.75 and 0.8, the results would be as follows.

CMF_t = 0.6 x 0.75 x 0.8

= 0.36, or 36% of crashes will remain (i.e. 64% of crashes will be eliminated).

Figure 2: example of crash modification factors, source: Austroads Guide to Road Safety: Part 2

Using Appendix D of the Austroads Guide to Road Safety (Part 2), the benefit/cost ratio can be used to draw recommendations for each of the safety countermeasures. However, this can only be established with the appropriate and relevant safety measure to the accident causation.

3.4 Safe Systems Assessment Framework

The results from this report will comprise of the conclusions derived from the Safe Systems assessment matrix. The Safe Systems Assessment Framework is a comprehensive approach to road safety aimed at reducing the severity of road crashes. The framework has been developed in accordance with the Austroads guide to provide a strategic tool for road engineers to assess and improve road safety measures that align with the Safe System approach. The key aspect to The Safe System approach is that it has been developed to recognise that people will make mistakes on the road, with the goal to mitigate the consequences of those mistakes as opposed to blaming individuals. The five key pillars that describe the Safe System Approach are:

1. **Safe Roads:** Designing and maintaining roads with safety in mind, including factors like road geometry, signage, and crash barriers.
2. **Safe Vehicles:** Promoting the use of vehicles equipped with advanced safety features and technologies.
3. **Safe Speeds:** Setting speed limits that are appropriate for road conditions and using technology to enforce these limits.
4. **Safe Road Users:** Encouraging responsible and law-abiding behavior among road users through education, enforcement, and awareness campaigns.
5. **Post-Crash Care:** Ensuring that emergency response and medical care systems are efficient and effective in providing timely care to crash victims.

Safe System Assessment Framework:

The Austroads Safe System Assessment Framework is a structured methodology for evaluating road safety initiatives and strategies. It serves as a guide to assess how well these initiatives align with the principles of the Safe System approach. The framework consists of several key elements:

1. **Safety Objectives:** Clearly defined safety objectives are established, focusing on reducing fatalities and severe injuries on the road network.
2. **Alignment with Safe System Principles:** Initiatives are assessed to determine their alignment with the five key principles of the Safe System approach, ensuring they contribute to creating a safer road environment.
3. **Risk Factors:** Identifying and analyzing the key risk factors that contribute to road crashes, such as speeding, impaired driving, and road design issues.
4. **Performance Metrics:** Developing and implementing performance metrics to measure the effectiveness of road safety initiatives in achieving their intended safety outcomes.
5. **Stakeholder Engagement:** Involving various stakeholders, including government agencies, law enforcement, and road users, in the assessment process to ensure a holistic and collaborative approach to road safety.

Safe System Assessment Matrix:

The Safe System Assessment Matrix is a tool developed within the framework that helps quantify and evaluate the effectiveness of specific road safety interventions. The purpose of the matrix is to assess different crash types derived from dominant causations from road fatalities or other serious injury outcomes against the crash risk, likelihood, and the severity of the crash (austroads.com.au, 2016).

The three pillars in which the matrix is structured by, can be defined as:

Road exposure: can be described as the quantity of road users and the duration of the time spent exposed to a potential road crash. This can be quantified by Annual Average Daily Traffic (AADT) and other methods of counting motorists, pedestrians, and cyclists.

Crash Likelihood: factors that influence the opportunity of road crash probability. This may include hazards, road driver behaviour, geometric and environmental properties, speed, and other conflict points encountered while driving.

Crash severity: the outcome of the crash caused by the factors influencing the probability.

An example Safe Systems Assessment Matrix, sourced from the Austroads Safe Systems Framework, is provided in Appendix E.

The Framework begins by establishing the context of the project – this section is used to outline the problem and describe the current road conditions. Following this is the assessment of the Safe System Matrix. This is done by scoring each heading in Figure 2 using the principles of the Safe System. The score will range from 0 to 4, with a score of 0 meaning the road section is completely aligned to the Safe System principles. The total score is then taken as the sum of the totals under the seven pillars in Figure 2 and will be out of 448.

Scoring of the Safe System Matrix is subjective and can vary from person to person based on industry exposure and experience. Comments should be added beneath the seven pillars in each of the exposure, likelihood, and severity rows to demonstrate or explain the reasoning for the scoring.

Two Safe System matrices will be conducted based on the baseline condition and the innovative treatment condition. The baseline condition will identify any safety treatments in place and the final score will be a product of the compliance to the Safe System objectives. The selected innovative treatments will then undergo the same matrix analysis with a final score which also indicates compliance to the Safe Systems objectives. The matrix outcomes will then be compared, and a conclusion will be drawn from which condition associates with the Safe System objectives.

Chapter 4 – Results and Discussion

4.1 Data Preparation

4.1.1 Crash Data Investigation

The data has been extracted with all Queensland Road crash data provided by the Queensland Data Portal. The data contains a large amount of information from the year 2001 through to June of 2022. Crash locations cover the extent between Southern Queensland to the Far Northern most town,

The below histogram illistrates the total crash casualties in Far North Queensland by police division (or by local district). Total crash casualties capture fatalities, hospitilsation, medical treatment, and minor injury sustained as a result of the crash. The histogram does not portray total crashes. The data includes outerregional areas including, Cairns, Innisfail, Mareeba, and Atherton for example. It is evident from the histogram that outerregional areas will see a higher number of crash casualties than that of remote or very remote areas such as Mount Garnett or Thursday Island.

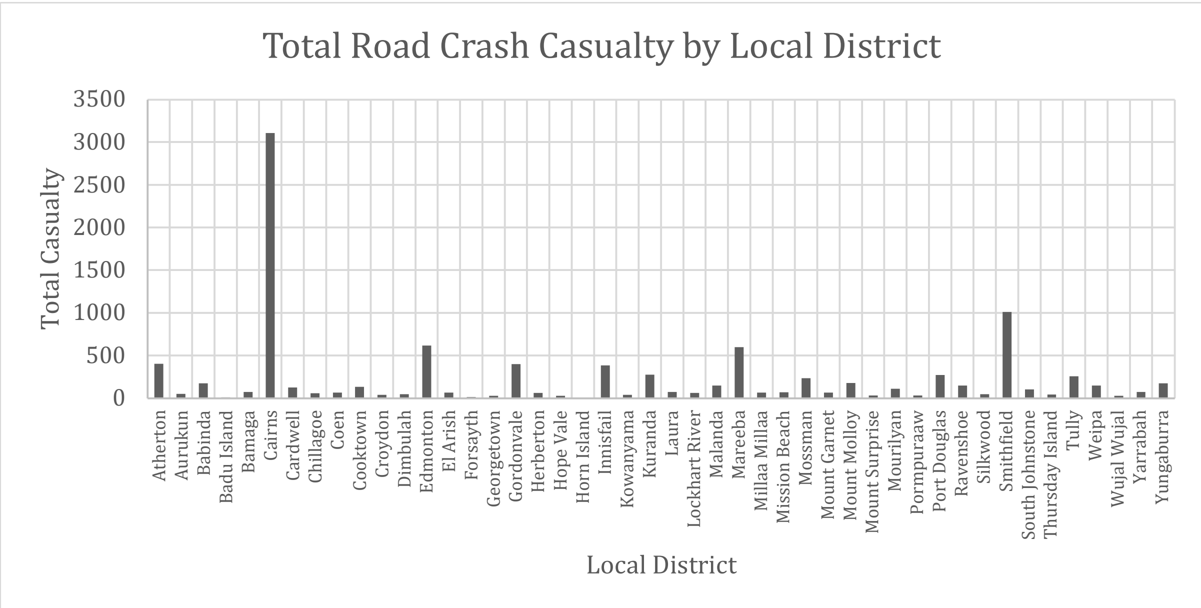


Figure 3: Total Crash Casualties per Police Division

A separate crash frequency histogram is needed to be developed to illustrate how rural Far North Queensland contribute to the overall casualties seen in Figure 3. With outer regional data included, it is difficult to see the nature and impact of remote and very remote casualties due to population and annual daily traffic counts far outweighing those of remote areas. Therefore, Figure 4 has been produced to filter out outer regional areas and to properly focus on the numbers seen throughout remote and very remote areas. Figure 4 shows a total of twelve localities that have reached over fifty casualties as a result of road crashes, in a yearly perspective, this equates to over five casualties per year for these twelve highest locations.

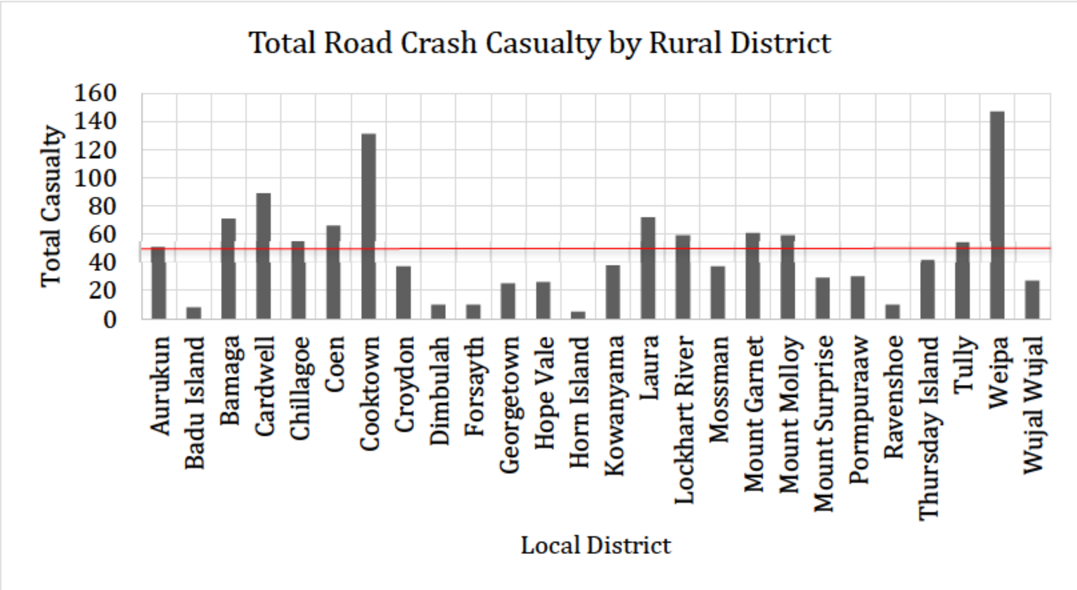


Figure 4: Total Crash Casualties per Remote Police Division

From the above histogram, locations that have seen a greater amount of crash casualties (greater than fifty) between the year 2012 and 2022 are sorted by highest to lowest:

1. Weipa
2. Cooktown
3. Cardwell
4. Bamaga
5. Laura
6. Coen
7. Mount Garnett
8. Lockhart River
9. Mount Molloy
10. Chillagoe

To analyse the data for road crash fatalities to compare trends with total casualties, the data has been filtered to only produce a histogram showing road crash fatalities from the year 2012 to 2022 in Figure 5.

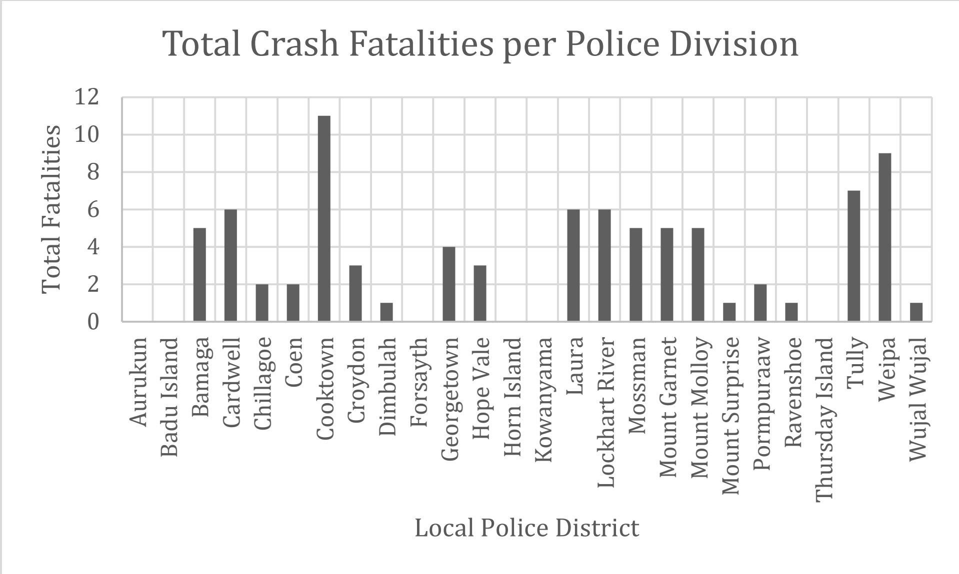


Figure 5: Total Crash Fatalities per remote Police Division

Now to rank the data for the highest ten locations which experience the greatest amounts of fatalities to compare the data from Figure 4:

1. Cooktown (11)
2. Weipa (9)
3. Tully (7)
4. Laura (6)
5. Lockhart River (6)
6. Cardwell (6)
7. Mount Garnett (5)
8. Mount Molloy (5)
9. Mossman (5)
10. Bamaga (5)

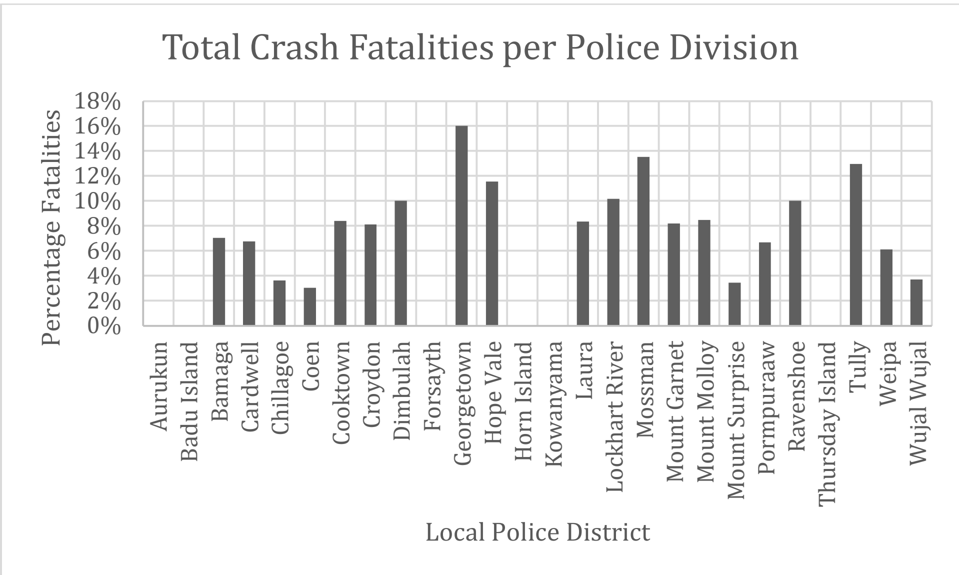


Figure 6: Percentage of Crashes resulting in fatality

Figure 6 indicates the percentage of road crash casualties that have resulted in fatality. Georgetown, for example, experienced twenty-five total road crash casualties between 2012 and 2022. Of these twenty-five casualties, five have resulted in a fatality, with statistics showing overall 15% of Georgetown's Road crashes have had a fatal outcome.

When using the previous highest ranking ten districts and converting their data into a percentage, the list now yields:

1. Cooktown (8%)
2. Weipa (6%)
3. Tully (13%)
4. Laura (8%)
5. Lockhart River (10%)
6. Cardwell (7%)
7. Mount Garnett (8%)
8. Mount Molloy (8%)
9. Mossman (14%)
10. Bamaga (7%)

From this data, it is evident that Mossman, on a statistical basis, is considered more likely to experience a fatal outcome from a road crash. Analysis using the Safe System Assessment Matrix will include road fatalities and serious injury outcomes only, to capture the seriousness of the crash and the factors that likely could have influenced the crash. Including hospitalisation outcomes into the data, the below histogram becomes apparent:

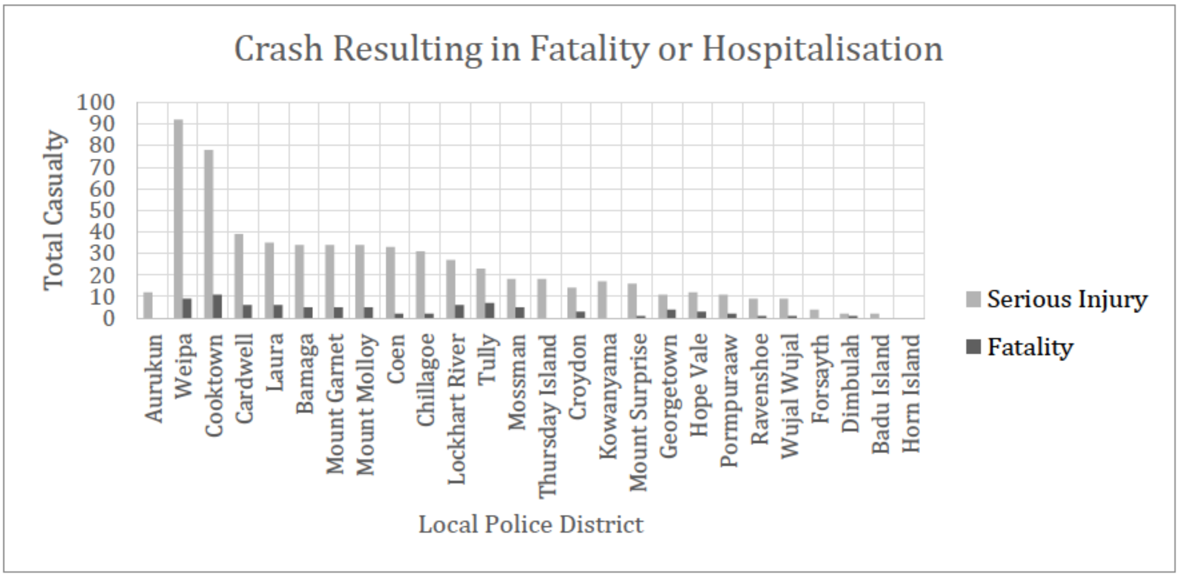


Figure 7: Total Road Crash Casualty (Fatal and Hospitalisation) per Rural Police District

Evidently, the top ten rural districts that experienced the highest amount of hospitalisation are the same districts that experienced the highest amounts of fatalities during the period of 2012 and 2022. However, a notable difference is Weipa and Cooktown experiencing a significantly higher hospitalisation rate than other districts. Two other districts that are varying from the fatality figures are Chillagoe and Coen, with two fatalities each but a significant hospitalisation figure. Mossman and Tully, which were considered a two highest fatality districts, have a lower hospitalisation figure than most districts. To evaluate the data based on roads that are evidently problematic, a total of the sum of fatality and hospitalisation will be used to determine the highest ten districts for evaluation.

From the Fatality and Hospitalisation histogram, the following ten districts will be used for further analysis:

- Weipa (101)
- Cooktown (89)
- Cardwell (45)
- Laura (41)
- Bamaga (39)
- Mount Garnet (39)
- Mount Molloy (39)
- Coen (35)
- Chillagoe (35)
- Lockhart River (33)

To gain an accurate understanding of which roads are consistently experiencing serious road crashes, the following section provides a series of histograms comparing road crash data across the ten identified districts in the previous section. Notably problematic roads and road sections will be used to undertake the Safe Systems Assessment following the analysis.

Chillagoe

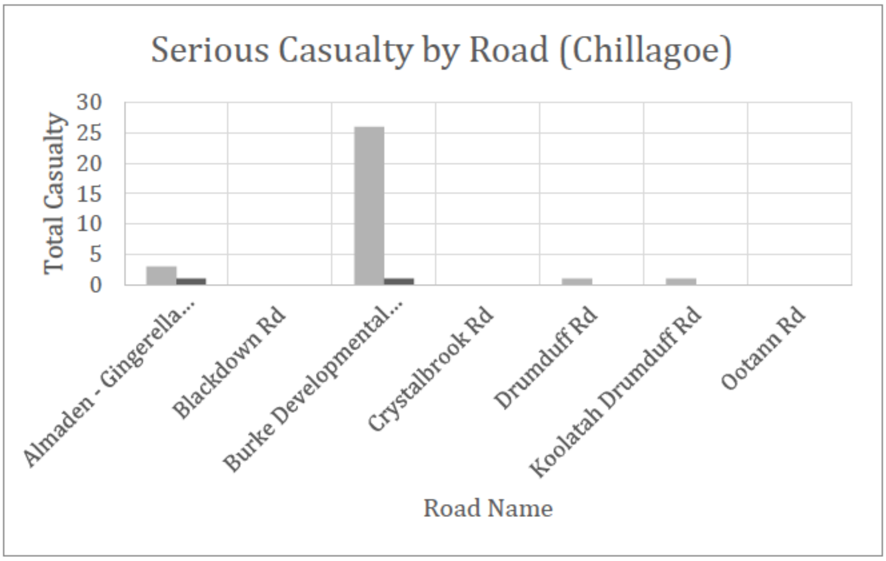


Figure 8: Road Crash Casualty Histogram (Chillagoe)

From the above figure 8, the Burke Developmental Road has experienced a total of two fatalities between 2012 and 2022 and twenty-six injury requiring hospitalisation. Therefore, it can be concluded that the Burke Developmental Road is deemed a problematic blackspot for the Chillagoe district when compared to the other road networks such as Drumduff Road and Koolatah Drumduff Road that have historic casualty but no reported fatalities.

Coen

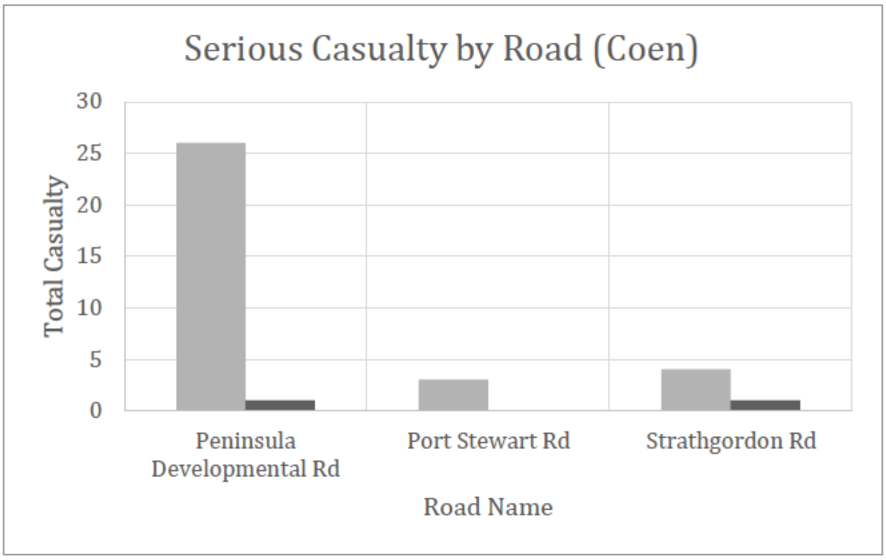


Figure 9:Road Crash Casualty Histogram (Coen)

Data gathered for Coen indicates that both Peninsula Developmental Road and Strathgordon Road have recorded a total of one fatality, however, Peninsula Developmental Road has also reported twenty-six serious injury requiring hospitalisation incidents. Therefore, the Peninsula Developmental Road far outweighs Strathgordon Road in comparison to serious road crash incidents.

Lockhart River

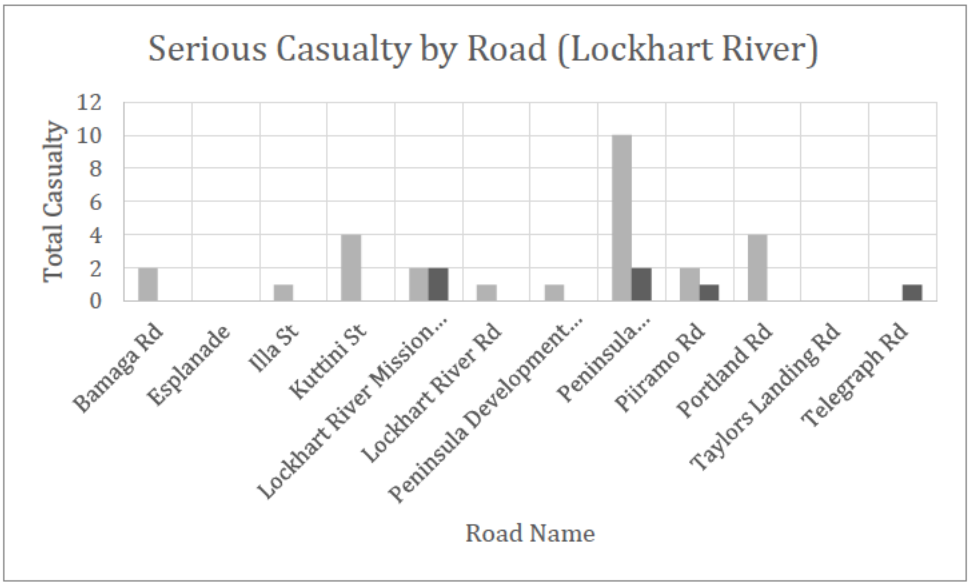


Figure 10: Road Crash Fatality Histogram (Lockhart River)

From the histogram above, two roads surrounding the Lockhart River area have a total of two fatalities each – Peninsula Developmental Road and Lockhart River Mission Road. While the fatality figures are lower than that of previously assessed road networks, the hospitalisation rate for the Peninsula Developmental Road has reached a total of eleven casualties (data registered in differing names).

Cooktown

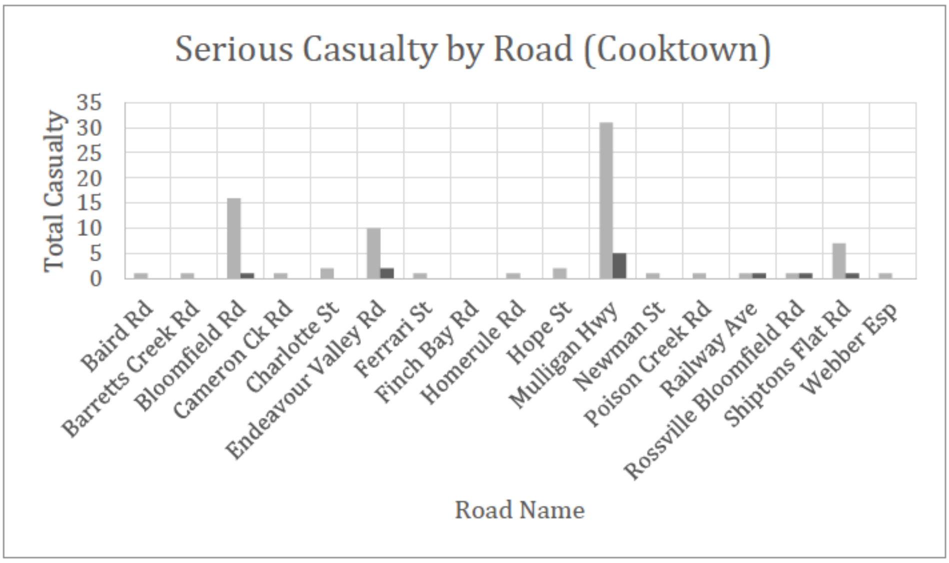


Figure 11: Road Crash Casualty Histogram (Cooktown)

The Mulligan Highway evidently stands out in the above histogram with a total of five fatalities, three more than that of the Endeavour Valley Road, and thirty-one hospitalisations. The Mulligan Highway shows a significant figure above other road networks in the Cooktown area.

Laura

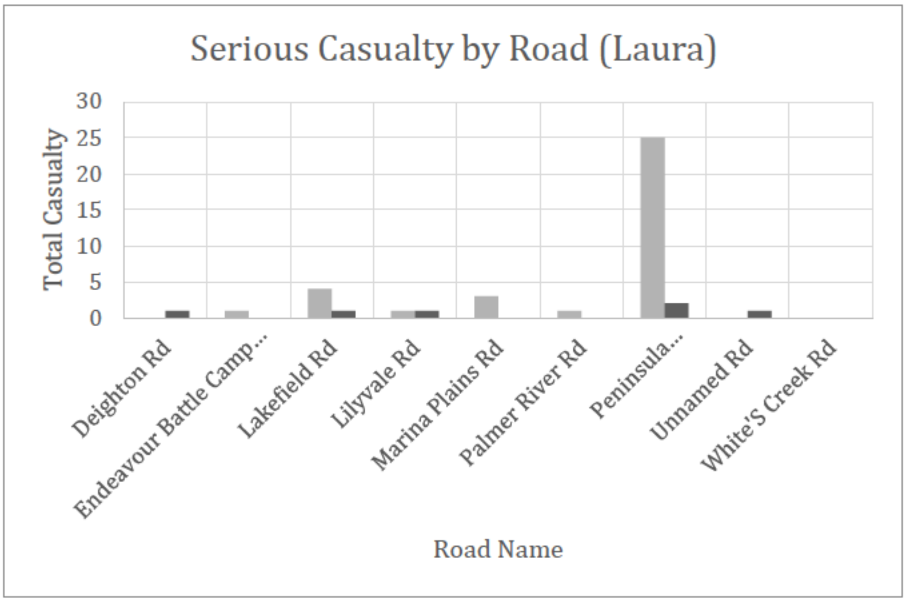


Figure 12: Road Crash Casualty Histogram (Laura)

For the Laura district, the Peninsula Development Road has 50% more fatalities than other roads with a total of two since 2012. While the figure is lower, it can be drawn from previous assessment that the Peninsula Development Road has three other fatalities in the Lockhart River and Coen region. This now takes the total of the Peninsula Development Road to five fatalities since 2012. The total of Hospitalisations in this histogram also highlights the serious extent of road crashes in this location.

Mount Garnett

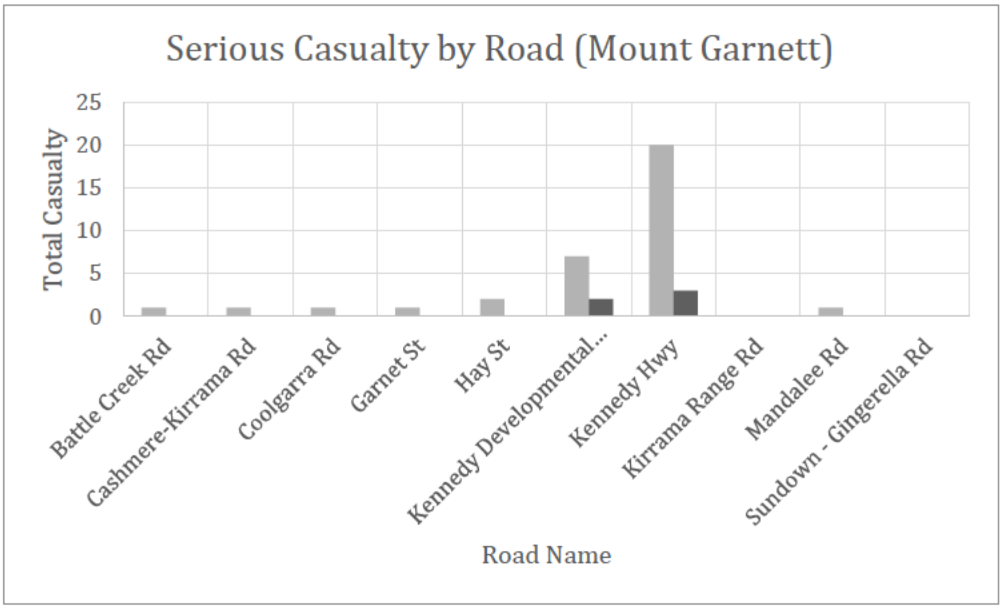


Figure 13: Road Crash Casualty Histogram (Mount Garnett)

The Kennedy Highway and the Kennedy Developmental Road, as per TMR road networks, is a vast network that covers the extent between Cairns and the Gulf Region. Specifically, the Kennedy Developmental Road is the coverage across the Mount Garnett region to the Gulf Developmental Road. The Kennedy Highway has one more fatality than that of the Kennedy Development Road, though within the same highway network, the roads will be considered separately in analysis.

Mount Molloy

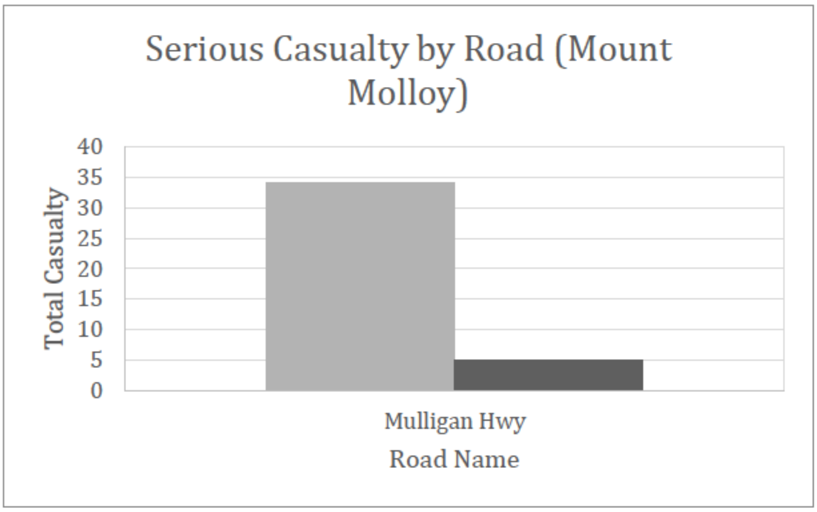


Figure 14: Road Crash Casualty Histogram (Mount Molloy)

The Mulligan Highway is the only road network surrounding the Mount Molloy region that has experienced fatalities in the last ten years between the year 2012 and 2022. A total of five fatalities and thirty-four hospitalisations have been recorded in the year period. The Mulligan Highway can be drawn to previous assessment of the Cooktown region, with a total of ten fatalities now recorded in the last ten years.

Cardwell

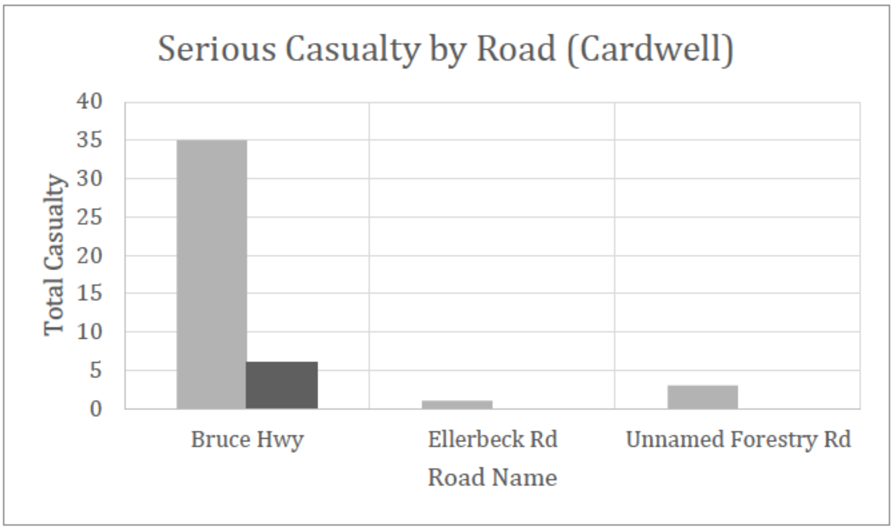


Figure 15: Road Crash Casualty Histogram (Cardwell)

From the Cardwell histogram, six fatalities and thirty-five hospitalisations have been reported on the Bruce Highway. With fatalities only recorded on the Bruce Highway and no other road networks surrounding Cardwell in the last ten years, the Bruce Highway can be deemed problematic for the Cardwell region.

Bamaga

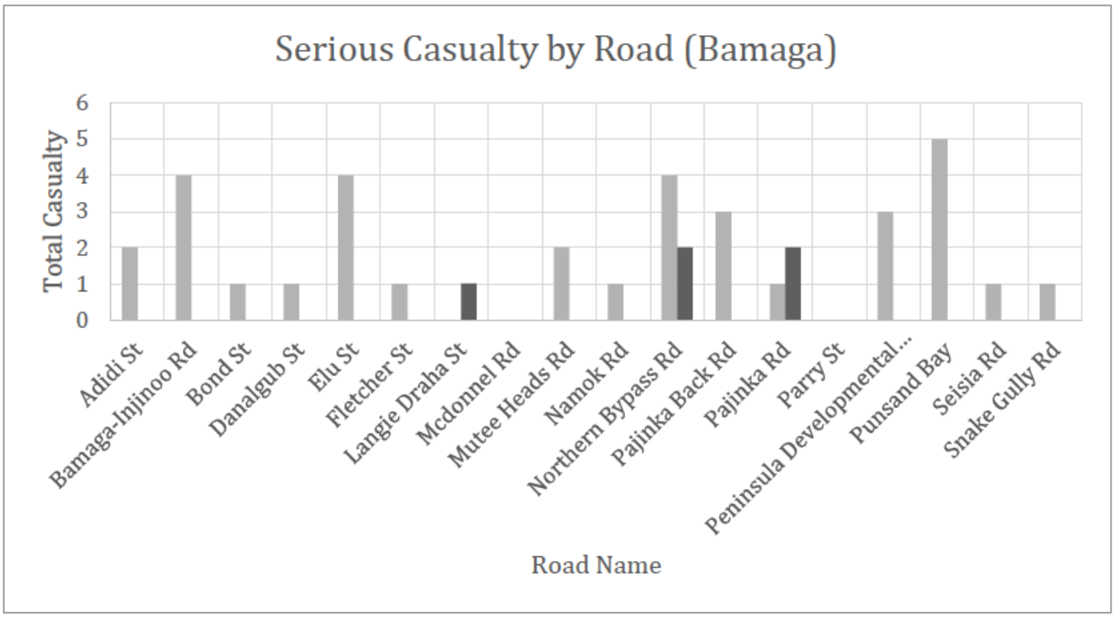


Figure 16: Road Crash Casualty Histogram (Bamaga)

Two roads can be identified in the Bamaga histogram to experience 50% more fatalities than other networks – Pajinka Road and the Northern Bypass Road. Sharing a total of four fatalities, two for each network, the fatal numbers are lower than that of previously assessed road networks. However, can be attributed for four fatalities between the two networks.

Weipa

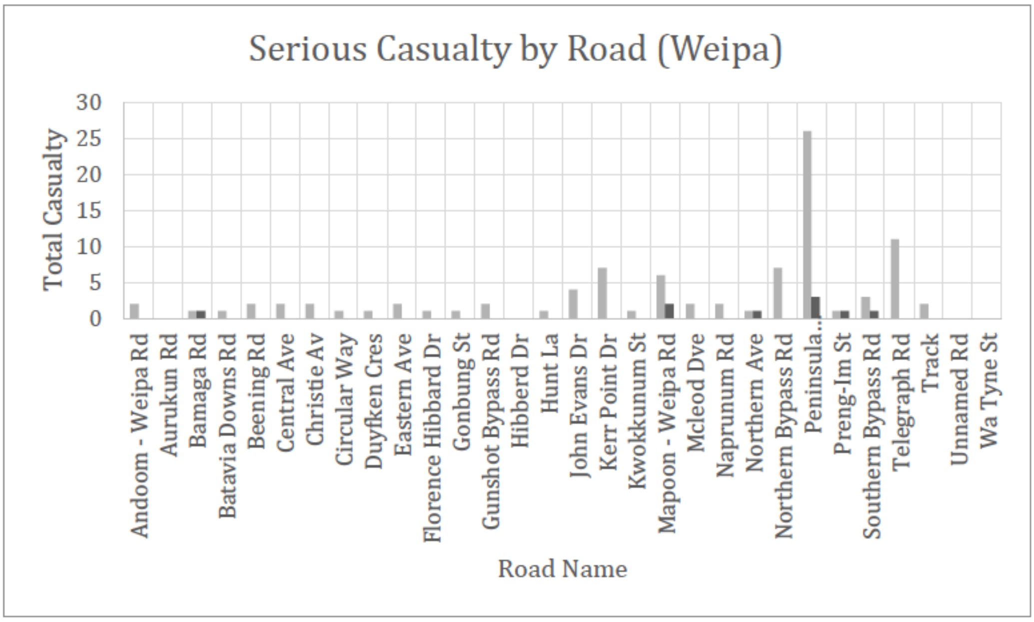


Figure 17: Road Crash Fatality Histogram (Weipa)

The Peninsula Developmental Road has a total of three fatalities, one fatality higher than that of the second highest road network – Mapoon – Weipa Road. The Peninsula Developmental Road also significantly outweighs other road networks when comparing hospitalisations, with a total of twenty-six to account for in the Weipa region. When considering the Peninsula

Development Road, there are now eight fatalities recorded on the network since 2012, deeming this a problematic road for road fatalities.

4.1.2 Data Reduction

Based on the assessment of the data, three roads highlight an unfavourable trend over the last ten years with fatal crash rates particularly high. The Mulligan Highway has experienced a total over ten separate fatalities and sixty-five hospitalisations; the Peninsula Development Road saw a total of eight fatalities and ninety-one hospitalisations; and the Bruce Highway recording a total of five fatalities and thirty-five hospitalisations.

When plotting the figures from the histograms onto a map to inspect the coverage of the data, the problematic areas can easily be drawn and understood for context. The below map has been constructed by plotting the crash coordinates, sourced from the Queensland Data Portal, to visualise each crash location with respect to the extents of Rural Far North Queensland:

For the assessment of the Geometry and Safe Systems Assessment Framework, focus will be drawn to road networks that have experienced greater than five fatal car accidents since 2012. The four networks extracted for analysis are the following:

- The Mulligan Highway – ten fatalities
- Peninsula Developmental Road – eight fatalities
- Bruce Highway – six fatalities

4.2 Crash Causation Analysis

The Austroads study Road Geometry Study for Improved Rural Safety conducted a study on Australia and New Zealand rural road crashes to identify factors which contributed to fatal and serious injury outcomes. The study was published in 2015 and refers technical report AP-T295-15.

The study concluded that the most common type of rural road crash in Australia and New Zealand was off-path crashes, contributing approximately 55% of all crashes in rural Australia (Austroads, 2015). The report states the five most common crash types in 2015 that related to road geometry (based on crash trends) were curvature, straight sections, head-on collision, rear-end, and T-intersections. The road sections explored in the report have clearly identified gaps in rural road safety treatments and render the sections a greater risk for a serious road crash. Safety treatments implemented in the identified locations, saw a decrease in the likelihood and severity of a serious crash happening in the same locations.

The following section will identify specific road chainages that experience higher amounts of serious car accidents along the three road networks in Section 4.1.2. Assessment of the sites will also extract the current road safety treatments in place and any gaps evident in road safety using the Austroads Guide to Road Safety Part 2.

4.2.2 Bruce Highway

This section will focus on the Geometrical and Environmental impacts on the serious road crashes that have been identified on the **rural** Bruce Highway network. All the information described in the nature and outcome of the vehicles crash have been sourced from the Queensland Data Portal and Queensland Globe.

Plotting the crash locations on the Bruce Highway using KML converted data, partiularly dangerous road sections have been identified with groups of serious car crashes within close proximity. Other road crashes have been filtered out that may be stand alone accidents that do not represent a problematic trend for a section of road.

Chainage 60 500 - 66 000

Figure 18: Aerial view of crash locations: Bruce Highway CH60 500-66 000

This section of the Bruce Highway has been selected for analysis as there is a recorded nine serious road crashes in less than seven kilometres of road network.

Crash Chainage	Crash Description	Vertical Alignment	Horizontal Alignment	Driving Conditions	Surface
66 120	Out of control on curve – hit object	Level	Curved – open view	Clear, daylight	Sealed
65 610	Out of control on curve – hit object	Grade	Curved – open view	Rain, darkness not lighted	Sealed
64 350	Out of control on curve	Level	Curved – open view	Clear, darkness not lighted	Sealed
63 400	Head on	Level	Straight	Clear, daylight (wet seal)	Sealed
63 860	Out of control on straight (vehicle overtaking)	Level	Straight	Clear, daylight	Sealed
62 800	Out of control on straight – hit object	Level	Straight	Clear, dawn/dusk	Sealed
60 940	Head on	Level	Curved – open view	Clear, daylight	Sealed
60 400	Out of control on curve – hit object	Level	Curved – open view	Clear, darkness not lighted	Sealed
59 530	Rear end	Level	Straight	Clear, daylight	Sealed

Findings

- 56% of the crashes were on a horizontal curve
- 44% of the crashes were during times of poor visibility
- Three crashes were a result of colliding with another vehicle

Chainage 47 900 – 41 570

Figure 19: Aerial view of crash locations: Bruce Highway CH47 900-41 570

This section on the Bruce Highway has been identified with seven serious road crashes in less than seven kilometres of road network.

Crash Chainage	Crash Description	Vertical Alignment	Horizontal Alignment	Driving Conditions	Surface
47 900	Sideswipe (vehicle overtaking)	Level	Straight	Clear, daylight	Sealed
47 100	Out of control on curve – hit object	Level	Curved – open view	Clear, daylight	Sealed
46 430	Angle, vehicle leaving driveway	Level	Straight	Clear, daylight	Sealed
45 210	Hit animal	Level	Curved – open view	Clear, darkness not lighted	Sealed
45 030	Angle, opposite vehicle turning	Level	Straight, T intersection	Clear, daylight	Sealed
42 810	Out of control on curve	Grade	Curved – open view	Clear, darkness not lighted	Sealed
41 570	Rear end	Level	Straight	Rain, daylight	Sealed

Findings

- 43% of the crashes were on a horizontal curve
- No crashes were as a result of out of control on a straight
- 86% of crashes were as a result of colliding with another object

- Two crashes were located at junctions

4.2.2 Peninsula Developmental Road

This section will focus on the Geometrical and Environmental impacts on the fatal road crashes that have been identified on the Peninsula Developmental Road network. All of the information described in the nature and outcome of the vehicles crash have been sourced from the Queensland Data Portal and Queensland Globe.

Plotting the crash locations on the Peninsula Developmental Road using KML converted data, partiularly dangerous road sections have been identified with groups of serious car crashes within close proximity. Other road crashes have been filtered out that may be stand alone accidents that do not represent a problematic trend for a section of road.

Chainage 3 000 – 6 351

Figure 20: Aerial view of crash locations: Peninsula Developmental Road CH3 000-6 351

This section on the Peninsula Highway has been identified with four serious road crashes in less than four kilometres of road network. Although data prior to 2012 will not be considered in the analysis, it is worth noting historical figures show a further six serious road crashes since 2003 for this section of the Peninsula Highway.

Crash Chainage	Crash Description	Vertical Alignment	Horizontal Alignment	Driving Conditions	Surface
3000	Hit animal	Crest	Straight	Rain, darkness not lighted	Sealed
4380	Out of control on curve – hit object	Level	Curve – view open	Clear, daylight	Sealed
6350	Out of control on straight	Dip	Straight	Clear, darkness not lighted	Sealed
6351	Out of control on curve	Dip	Curved – view open	Clear, dawn/dusk	Sealed

Findings

- 50% of the crashes were on a horizontal curve
- 75% of crashes were at a time of poor visibility standards

- 75% of crashes were at a point of abnormal vertical alignment properties (dip or crest)

Chainage 54 850 – 66 000

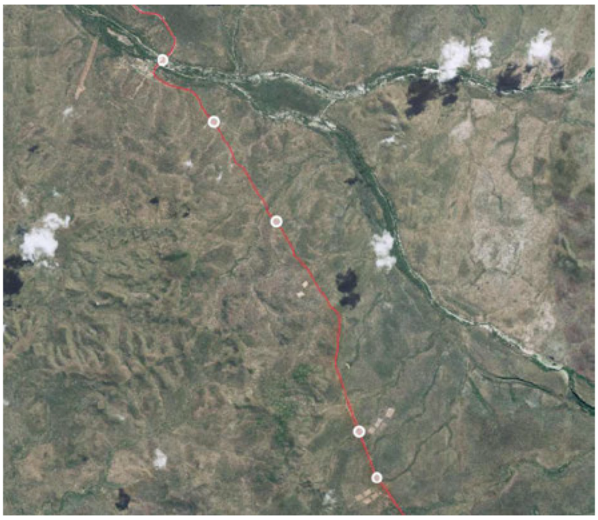


Figure 21: Aerial view of crash locations: Peninsula Developmental Road CH54 850-66 000

This section on the Peninsula Highway has been identified with five serious road crashes in approximately ten kilometres of road network.

Crash Chainage	Crash Description	Vertical Alignment	Horizontal Alignment	Driving Conditions	Surface
54 850	Out of control on curve – hit object	Grade	Curved – view obscured	Clear, darkness not lighted	Unsealed
55 960	Hit object on path	Crest	Straight	Clear, daylight	Unsealed
61 170	Out of control on straight – hit object	Crest	Straight	Clear, darkness not lighted	Unsealed
63 780	Hit object on path	Level	Straight	Clear, daylight	Unsealed
66 000	Out of control on straight	Level	Straight	Clear, Daylight	Causeway

Findings

- 80% of crashes were a result of hitting an object
- Two of the three out of control on a straight were during times of poor visibility
- Two crashes resulted from a temporary object on the road
- One crash was located on a sealed causeway

Chainage 142 800 – 146 000

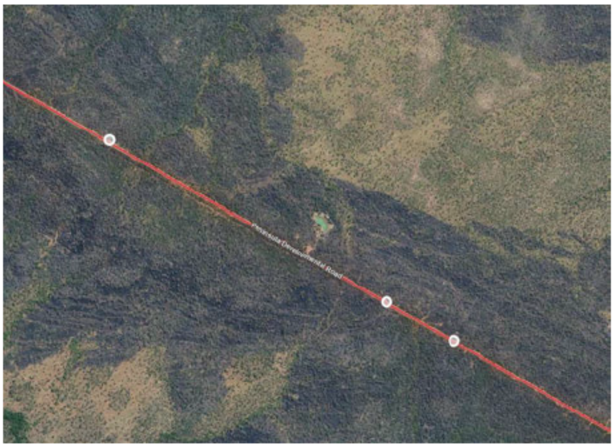


Figure 22: Aerial view of crash locations: Peninsula Developmental Road CH142 800-146 000

This section on the Peninsula Highway has been identified with three serious road crashes in approximately three kilometres of road network.

Crash Chainage	Crash Description	Vertical Alignment	Horizontal Alignment	Driving Conditions	Surface
142 800	Out of control on straight	Level	Straight	Clear, daylight	Unsealed
143 500	Out of control on straight	Level	Straight	Clear, darkness not lighted	Unsealed
146 000	Out of control on straight	Level	Straight	Clear, daylight	Unsealed

Findings

- All crashes were as a result of losing control on a straight
- All crashes were on an unsealed surface

4.2.4 Mulligan Highway

This section will focus on the Geometrical and Environmental impacts on the fatal road crashes that have been identified on the Mulligan Highway network. All of the information described in the nature and outcome of the vehicles crash have been sourced from the Queensland Data Portal and Queensland Globe.

Plotting the crash locations on the Mulligan Highway using KML converted data, partiularly dangerous road sections have been identified with groups of serious car crashes within close proximity. Other road crashes have been filtered out that may be stand alone accidents that do not represent a problematic trend for a section of road.

Chainage 12 180 – 14 090

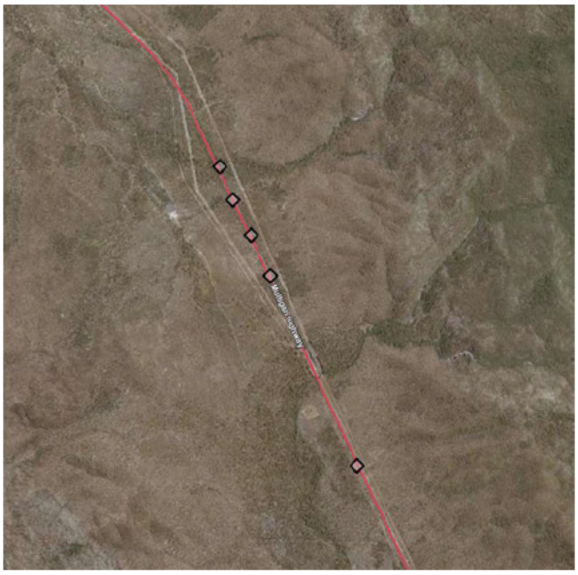


Figure 23: Aerial view of crash locations: Mulligan Highway CH12 180-14 090

This section of the Mulligan Highway has been selected for analysis as there is a recorded five serious road crashes in less than three kilometres of road network.

Crash Chainage	Crash Description	Vertical Alignment	Horizontal Alignment	Driving Conditions
12 180	Out of control on straight – hit object	Level	Straight	Clear, daylight
13 500	Out of control on straight – hit object	Level	Straight	Clear, darkness not lighted
13 800	Out of control on straight	Level	Straight	Clear, darkness not lighted
14 090	Out of control on straight – hit object	Level	Straight	Clear, daylight
14 300	Out of control on straight – hit object	Level	Straight	Clear, daylight

Findings

- 80% of crashes were a result of hitting an object
- Two of the five crashes were during a time of poor visibility
- No abnormalities in horizontal or vertical geometric properties evident

Chainage 98 100 – 116 770

Figure 24: Aerial view of crash locations: Mulligan Highway CH98 100-116 770

This section of the Mulligan Highway has been selected for analysis as there is a recorded eleven serious road crashes in less than nineteen kilometres of road network.

Crash Chainage	Crash Description	Vertical Alignment	Horizontal Alignment	Driving Conditions
98 100	Out of control on straight – hit object	Level	Straight	Clear, daylight
98 250	Out of control on straight	Grade	Straight	Clear, daylight
101 650	Out of control on straight – hit object	Crest	Straight	Clear, daylight
104 300	Out of control on straight – hit object	Crest	Straight	Clear, daylight
104 410	Out of control on curve	Crest	Curve – open view	Clear, darkness not lighted
106 480	Out of control on straight	Level	Straight	Clear, daylight
107 510	Out of control on straight	Grade	Straight	Clear, darkness not lighted
110 300	Out of control on straight	Level	Straight	Clear, daylight
111 350	Out of control on straight	Level	Straight	Clear, daylight
116 670	Out of control on straight – hit object	Level	Straight	Clear, daylight
116 770	Out of control on curve – hit object	Level	Curved – view obscured	Clear, daylight

Findings

- 45% of crashes were located on a vertical alignment abnormality (crest or grade)
- 82% of the crashes were as a result of out of control on a straight
- Most of the crashes were at a time of clear visibility standards

Chainage 124 430 – 127 350

Figure 25: Aerial view of crash locations: Mulligan Highway CH124 430-127 350

This section of the Mulligan Highway has been selected for analysis as there is a recorded four serious road crashes in less than three kilometres of road network.

Crash Chainage	Crash Description	Vertical Alignment	Horizontal Alignment	Driving Conditions
124 430	Out of control on curve	Level	Curved – view open	Clear, daylight
125 900	Out of control on straight	Crest	Straight	Clear, daylight
127 160	Hit animal	Crest	Curved – view open	Clear, daylight
127 350	Out of control on straight – hit object	Level	Straight	Clear, daylight

Findings

- 50% of crashes were located on a vertical alignment abnormality (crest or grade)
- 75% of the crashes were as a result of out of control vehicle
- 50% of crashes were located on horizontal curvature
- All of the crashes were at a time of clear visibility standards

Chainage 59 390 – 63 220

Figure 26: Aerial view of crash locations: Mulligan Highway CH59 390-63 220

This section of the Mulligan Highway has been selected for analysis as there is a recorded five serious road crashes in less than four kilometres of road network.

Crash Chainage	Crash Description	Vertical Alignment	Horizontal Alignment	Driving Conditions
59 390	Hit animal	Level	Curved – view open	Clear, darkness not lighted
59 550	Hit animal	Level	Curved – view open	Clear, darkness not lighted
60 500	Hit animal	Grade	Straight	Clear, darkness not lighted
63 120	Hit animal	Level	Curved – view open	Rain, darkness not lighted
63 220	Hit animal	Level	Straight	Clear, darkness not lighted

Findings

- All crashes were as a result of hitting an animal
- 60% of crashes were located on horizontal curvature
- All of the crashes were at a time of poor visibility standards

4.2.5 Results Summary

From the analysis of each section, a summary can be drawn from the description of the crash to group crash types to form an overall crash identification summary histogram. This histogram will be used to draw a conclusion on the likely influence of rural road crashes in the discussed sections, where crash rates are relatively high.

Bruce Highway Crash Causation Summary

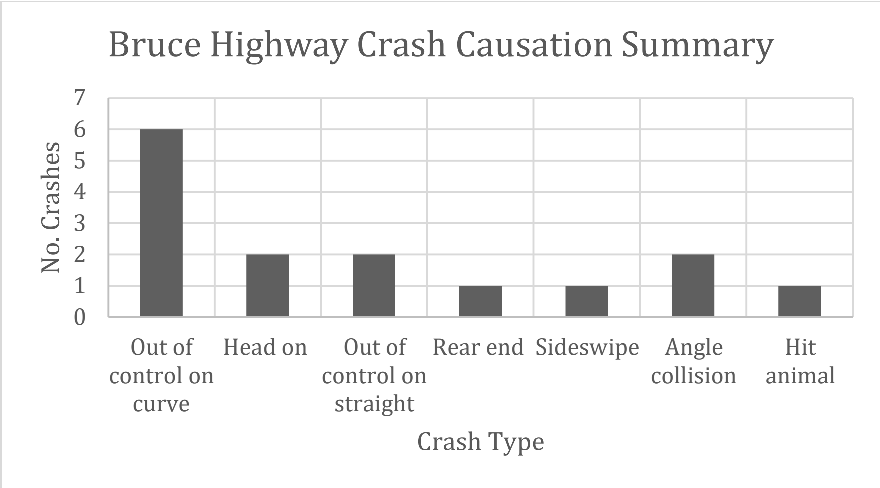


Figure 27: Bruce Highway Crash Causation Summary

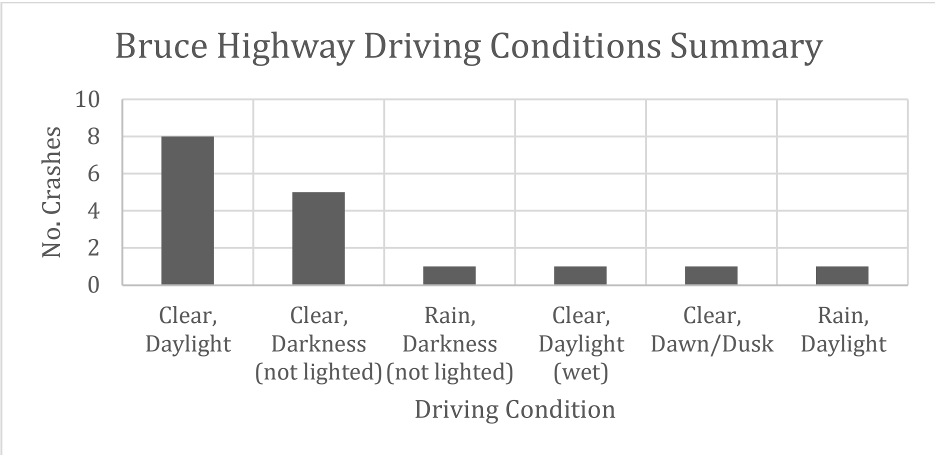


Figure 28: Bruce Highway Driving Conditions Summary

To summarise, 53% of the crashes assessed on the Bruce Highway were during unfavourable driving conditions with nine being at a time of poor visibility or slippery environments. 67% of crashes were also correlated with the geometrical properties of the road, with predominant numbers falling within the ‘out of control’ or vehicle collision category. From this summary, it can be highlighted that visibility and road geometry play a crucial role in the outcome of the road crash.

Peninsula Developmental Road Crash Causation Summary

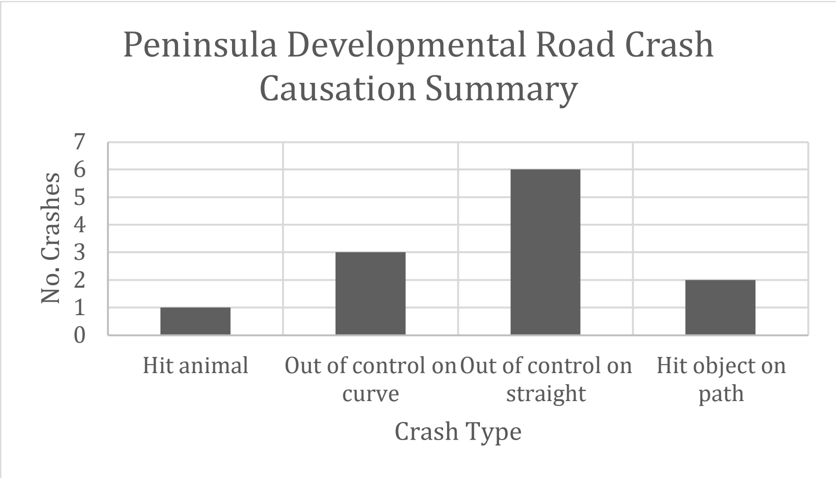


Figure 29: Peninsula Developmental Road Crash Causation Summary

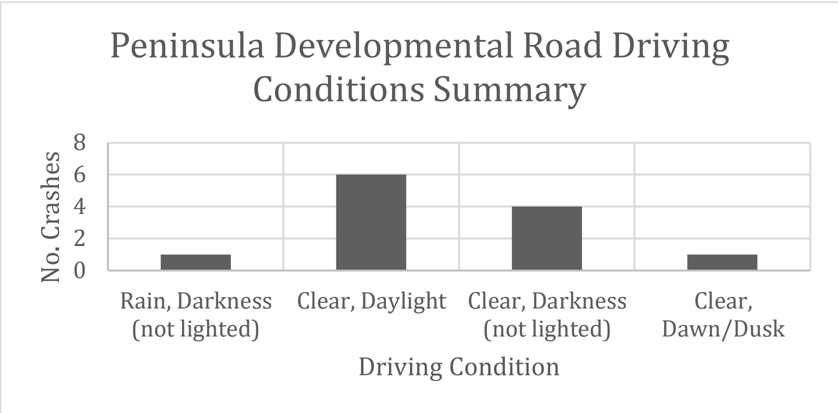


Figure 30: Peninsular Developmental Road Driving Conditions Summary

The Peninsula Developmental Road Crash data suggests that out of control on path crash types are very dominant. Visibility standards are also a concerning factor as 50% of the road crashes were at a time where visibility was low or raining. Notably, there is also a high presence of collisions with objects or animals present on the road.

Mulligan Highway Crash Causation Summary

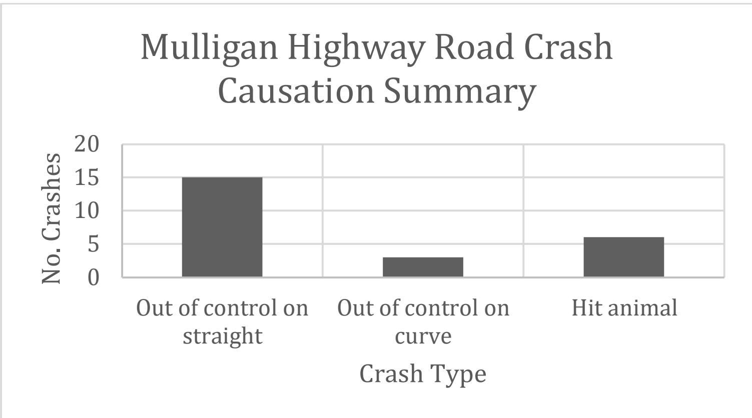


Figure 31: Mulligan Highway Crash Causation Summary

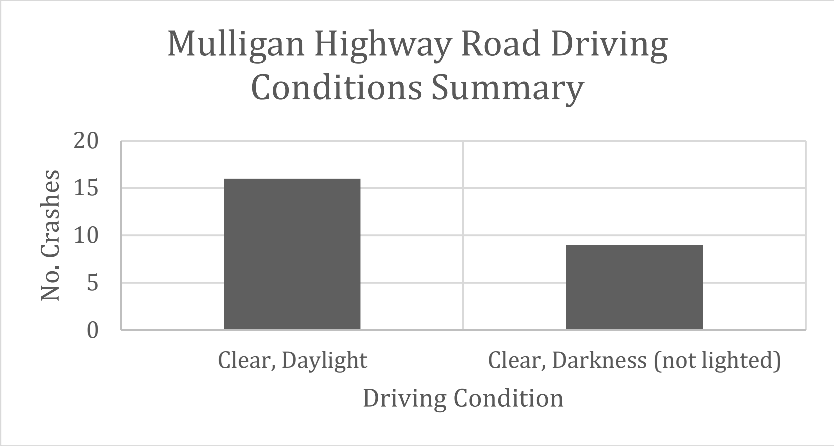


Figure 32: Mulligan Highway Driving Conditions Summary

The Mulligan Highway experiences mostly run-off-road type crashes with a notable number of animal collisions too. More than 36% of crashes were during a time of low visibility standards and 75% were caused by out-of-control vehicles. To summarise, visibility standards and road geometry are the dominant causations in road crash outcomes on the Mulligan Highway.

4.3 Geometric and Environmental Characteristics

The Austroads publication, Road Geometry Study for Improved Rural Road Safety, states that crash trends in 2015 showed a link between horizontal, vertical, cross sectional, and intersection design properties and the severity of a crash outcome in Australia (Austroads, 2015).

Horizontal curvature is suggested to have a large impact on the severity of a road crash. High speed approaches, combined with speed reductions, on horizontal curvature increases the severity of a road crash particularly for run-off road. The Austroad Study found that a speed reduction of 30km/h from an approach of 100km/h increases the likelihood of casualty by 5.1 times. Lesser speed approaches such as 60km/h to a speed reduction of 30km/h, lowered the chance of a run-off casualty to 3.1 times. The study links this factor with the probable reason as to why there are frequent run-off casualties seen in rural and isolated areas, where a speed reduction from 100km/h is often needed to navigate the approaching horizontal curvature.

The vertical alignment of a road can be described as the longitudinal profile of a road. The direct linkage between vertical alignment and the severity of a road crash is evident when the grade of a road increases. The Austroads study states that sight distance along a road is affected when the crest or dip is deficient by greater than 40% of the design value (Austroads, 2015). Jurewicz et al. found that uphill grades of 6% directly increased the severity of a road crash by 2.6 times and a downhill grade of 6% increase the severity to 5.6 times. Evidently, a downhill grade will have a greater impact on the outcome of a crash than that of an uphill grade.

To coincide with the horizontal and vertical alignment, a road's cross section also directly influences the outcome of a road crash. The study shows that rural roads with 2.5m wide lanes see approximately 50% more road crashes than that of 3.5m wide lanes. Correspondingly, roads with little to no shoulder widths were 1.7 times more likely to experience a crash casualty than roads with sealed shoulders (Austroads, 2015).

The Austroads study suggests that the design of road alignment and road delineation are important factors in decreasing the likelihood of a road accident. Therefore, it is crucial for Engineers to design a road in accordance with the required parameters. When an error is encountered by a driver, it is important that the roadside features are also considered to decrease the severity of the outcome of the crash. Austroads link the severity of a crash with the roadside features by stating that roads with little to no clear zones of less than two metres, saw an increased risk of run-off road casualty by 2.2 times when compared to the risk of run-off during clear zones (> 8m) (Austroads, 2015). However, noticeably evident was the increase in vehicle roll over casualty in sections of clear zones and a decrease in roadside object collision.

Undertaking a preliminary site assessment of each of the site is required to understand the nature of the current safety treatments in place. A brief geometric and environmental analysis is provided with the context within the Safe Systems assessment. Site assessment is conducted with the use of google imagery and street view – while this is not the most accurate visualisation technique, due to the extents of the remote networks, it has been considered as the most feasible way of assessment for this research.

4.4 Safe Systems Framework Analysis

The following section will be an assessment of the identified road chainages against the Austroads *Safe System Assessment Framework*. The resources used throughout this section including the Safe System Assessment Matrix have been sourced from the Austroads Guideline: Research Report AP-R509-16 and conducted in accordance with the Austroads Guidelines.

The aim of this section is to development an assessment that is used to assist in the identification of potential Safe System modifications to implement in rural areas in Far North Queensland. The framework will identify key crash types from the assessed road networks that resulted in one or more fatalities, the causations that potentially contributed to the outcome of the crash, and a safety treatment that addresses each key crash problem. Innovative safety treatments identified in Section 2.3 of this report will be applied using the Safe System Assessment Matrix to identify gaps within current safety treatments seen throughout Australia on the road network system.

4.4.1 Bruce Highway

Context

Table 1: Bruce Highway Prompts

Prompts	Comments
What is the function of the road? Consider location, roadside land use, area type, speed limit, intersection type, presence of parking,	• Rural road network connecting outer regional towns

public transport services and vehicle flows. What traffic features exist nearby (e.g. upstream and downstream)?	• Tourism and travellers utilising road due to being the main connection to Northern Queensland • High annual daily traffic
What road users are present? Consider the presence of elderly, school children and cyclists. Also note what facilities are available to vulnerable road users (e.g. signalised crossings, bicycle lanes, school zone speed limits, etc.).	• Tourists • Cyclists • Kennedy State School located nearby
What is the vehicle composition? Consider the presence of heavy vehicles (and what type), motorcyclists and other vehicles using the roadway.	• Camper vans and trailers • Regular light vehicles • Unrestricted road network – presence of heavy vehicles and road trains may be present
What is the reason for the project? Is there a specific crash type risk? Is it addressing specific issues such as poor speed limit compliance, road access, congestion, future traffic growth, freight movement, amenity concerns from the community, etc.	• Frequent crash zone. Higher fatalities seen on the road • Specific crash type risk seen on horizontal curvature and unlit road paths • To address poor driving conditions that may result in higher frequency of road crashes

CH60 500 – CH66 000 Existing Conditions

The section between chainage 60 500 and 66 000 was selected for framework analysis as the high risk of run-off-road crash types is presently high in this section. The section forms part of a connecting rural Highway between Cardwell and Tully and sees between 5,999 – 10,000 Average Annual Daily Traffic (qglobe, 2023). The section features a single carriageway with 3.5m width lanes and > 1.0m shoulder width. In certain areas, the horizontal curvature of the road is steep, and eyesight is obstructed by dense roadside bushland. There is no street lighting between these chainages, adding to the difficulty of visibility. Table 2 is an assessment of the current chainage section Safe System condition.

Table 2: CH60 500 - 66 000 Geometrical and Environmental Commentary

Imagery	**Geometrical/ Environmental Comments**
 Bruce Highway facing South	Roadside barriers Sight distance obstructed by curvature and roadside environment (bushland). No street lighting

 Bruce Highway facing South (2)	Sight distance obstructed by curvature and roadside environment (bushland) Turning lane located on horizontal curvature. No street lighting
 Intersection	Uncontrolled intersection
 Bruce Highway facing South (3)	Vertical grading minimising site distance. No street lighting

Chainage 60 500 – 66 000: Safe System matrix – Current Condition

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	High exposure ✗ $^4/_4$	High exposure ✗ $^4/_4$	High number of intersections ✗ $^3/_4$	High exposure ✗ $^4/_4$	Low pedestrian volumes ✓ $^1/_4$	Low cyclist volumes ✓ $^1/_4$	Moderate motorcycle volumes ✗ $^2/_4$	
Likelihood	Steep curvature, no lighting, obstructed view, high speed ✗ Guideposts, sealed shoulder ✓ $^3/_4$	Obstructed views due to bushland, no lighting, high overtaking zone ✗ Linemarking ✓ $^3/_4$	Merging or turning cars on high speed road ✗ $^3/_4$	Site distance obstructed by roadside hazards, slippery road surface when wet ✗ $^3/_4$	No footpath ✗ No crossing facilities ✗ $^2/_4$	No cyclist lane ✗ No crossing facilities ✗ $^2/_4$	Sealed road ✗ Steep curvature ✗ $^3/_4$	
Severity	High speed, heavy traffic, dense bushland ✗ Some roadside barriers ✓ $^3/_4$	High speed on curves, poor visibility due to roadside obstruction ✗ $^4/_4$	High speed ✗ $^3/_4$	High speed section ✗ $^3/_4$	High speed section ✗ No crossings ✗ $^4/_4$	Moderate speed sections ✗ $^4/_4$	Dense bushland, high speed ✗ Some roadside barriers ✓ $^3/_4$	Total
Product	$^{36}/_{64}$	$^{48}/_{64}$	$^{27}/_{64}$	$^{36}/_{64}$	$^{8}/_{64}$	$^{8}/_{64}$	$^{18}/_{64}$	$^{157}/_{448}$

Table 3: CH60 500 - 66 000 Additional Safety Components

Additional Safe System Components	Prompts	Comments
Road User	Are road users likely to be alert and compliant, or are there factors that might influence this? What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours) and what is the likelihood of driver fatigue? Are there special road uses (e.g. entertainment precincts, elderly, children, on-road activities), distraction by environmental factors (e.g. commerce, tourism), or risk-taking behaviours?	• Rural highway typically involves high speeding drivers • Long distance between towns – fatigued drivers
Vehicle	What level of alignment is there with the ideal of safer vehicles? Are there factors which might attract large numbers of unsafe vehicles? Is the percentage of heavy vehicles too high for the proposed/existing road design? Are there enforcement resources in the area to detect nonroadworthy, overloaded or unregistered vehicles and thus remove them from the network?	• Heavy presence of farming surrounds • Railway crossings • Popular road network for tourism to the Far North
Post Crash Care	Are there issues that might influence safe and efficient post-crash care in the event of a severe injury? Do emergency and medical services operate as efficiently and rapidly as possible? Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there provision for e-safety (i.e. safety systems based on modern information and communication technologies, C-ITS)?	• Moderate distance to emergency facilities • Accessible for emergency vehicles

CH60 500 – CH66 000: After OmniGrip and Bioluminescent Material

The objective is to assess if the section between chainage 60 500 and 66 000 aligns with the Safe System objective once implmented with OmniGrip technology and Bioluminescent linemarking.

Chainage 60 500 - 66 000: Safe System matrix – After OmniGrip and Bioluminescent Linemarking

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	High exposure ✗ $^{4}/_{4}$	High exposure ✗ $^{4}/_{4}$	High number of intersections ✗ $^{3}/_{4}$	High exposure ✗ $^{4}/_{4}$	Low pedestrian volumes ✓ $^{1}/_{4}$	Low cyclist volumes ✓ $^{1}/_{4}$	Moderate motorcycle volumes ✗ $^{2}/_{4}$	
Likelihood	Steep curvature, no lighting, obstructed view, high speed ✗ Guideposts, sealed shoulder ✓ Road geometry easily seen in darkness ✓ $^{2}/_{4}$	Obstructed views due to bushland, no lighting, high overtaking zone ✗ Linemarking ✓ Road centreline easily seen in darkness ✓ $^{2}/_{4}$	Merging or turning cars on high speed road ✗ $^{3}/_{4}$	Site distance obstructed by roadside hazards ✗ High friction surface reducing likelihood of skidding ✓ $^{2}/_{4}$	No footpath ✗ No crossing facilities ✗ $^{2}/_{4}$	No cyclist lane ✗ No crossing facilities ✗ $^{2}/_{4}$	Sealed road ✗ Steep curvature ✗ Road geometry easily seen in darkness ✓ $^{2}/_{4}$	
Severity	High speed, heavy traffic, dense bushland ✗ Some roadside barriers ✓ $^{3}/_{4}$	High speed, heavy traffic ✗ $^{4}/_{4}$	High speed ✗ $^{3}/_{4}$	High speed section ✗ High skid resistance ✓ $^{2}/_{4}$	High speed section ✗ No crossings ✗ $^{4}/_{4}$	Moderate speed sections ✗ $^{4}/_{4}$	Dense bushland, high speed ✗ Some roadside barriers ✓ $^{3}/_{4}$	Total
Product	$^{24}/_{64}$	$^{32}/_{64}$	$^{27}/_{64}$	$^{16}/_{64}$	$^{8}/_{64}$	$^{8}/_{64}$	$^{12}/_{64}$	$^{127}/_{448}$

Comparison of results

Table 4: CH60 500 - 66 000 Comparison Results

	ROR	HO	INT	Other	PED	CYC	M/C	
Baseline	$^{36}/_{64}$	$^{48}/_{64}$	$^{27}/_{64}$	$^{36}/_{64}$	$^{8}/_{64}$	$^{8}/_{64}$	$^{18}/_{64}$	$^{157}/_{448}$
After treatment	$^{24}/_{64}$	$^{32}/_{64}$	$^{27}/_{64}$	$^{16}/_{64}$	$^{8}/_{64}$	$^{8}/_{64}$	$^{12}/_{64}$	$^{127}/_{448}$

It is clear from the analysis that neither scenario produces a fully compliant Safe System outcome. The treated section, with bioluminescent line marking and OmniGrip technology, improves the likelihood and severity of run-off-road case accidents but there is still the risk present. For head-on collisions, the severity is still high given there is no implemented safety treatment to eliminate this outcome. Line marking that is easily seen at low light times does significantly reduce the likelihood of road-run-off and head-on collisions, however, does not eliminate the risk. Further safety treatments could reduce the risk more but the feasibility of implementing more infrastructure in rural locations becomes difficult to justify.

CH47 900 – CH41 570 Existing Conditions

The section between chainage 47 900 and 41 570 was selected for framework analysis as the high risk of run-off-road crash types is presently high in this section. The section forms part of a connecting rural Highway between Cardwell and Tully and sees between 5,999 – 10,000 Average Annual Daily Traffic (qglobe, 2023). The section features a single carriageway with 3.5m width lanes and > 1.0m shoulder width. In certain areas, the horizontal curvature of the road is steep, and eyesight is obstructed by dense roadside bushland. There is no street lighting between these chainages, adding to the difficulty of visibility. Table 3 is an assessment of the current chainage section Safe System condition.

Table 5: CH47 900 - 41 570 Geometrical and Environmental Commentary

Imagery	Geometrical/ Environmental Comments
 Bruce Highway facing South	Sight distance obstructed by curvature and roadside environment (bushland) Vertical grade minimising site distance
 Bruce Highway facing South (2)	Uncontrolled intersection on high-speed section. No street lighting

 Bruce Highway facing North	Site distance obstructed by dense bushland and horizontal curvature. No street lighting
 Bruce Highway facing South (3)	Narrowed carriageway with shoulder and centreline narrowing. No street lighting

Chainage 47 900 – 41 570: Safe System matrix – Current Condition

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	High exposure ✗ $^4/_4$	High exposure ✗ $^4/_4$	High number of intersections ✗ $^3/_4$	High exposure ✗ $^4/_4$	Low pedestrian volumes ✓ $^1/_4$	Low cyclist volumes ✓ $^1/_4$	Moderate motorcycle volumes ✗ $^2/_4$	
Likelihood	Steep curvature, no lighting, obstructed view, high speed ✗ Guideposts, sealed shoulder ✓ $^3/_4$	Obstructed views due to bushland, no lighting, high overtaking zone, vertical crests ✗ Linemarking ✓ $^3/_4$	Merging or turning cars on high speed road ✗ $^3/_4$	Site distance obstructed by roadside hazards, slippery road surface when wet ✗ $^3/_4$	No footpath ✗ No crossing facilities ✗ $^2/_4$	No cyclist lane ✗ No crossing facilities ✗ $^2/_4$	Sealed road ✓ Steep curvature ✗ $^3/_4$	
Severity	High speed, heavy traffic, dense bushland, no roadside barrier ✗ $^4/_4$	High speed on curves, poor visibility due to roadside obstruction ✗ $^4/_4$	High speed ✗ $^3/_4$	High speed section ✗ $^3/_4$	High speed section ✗ No crossings ✗ $^4/_4$	Moderate speed sections ✗ $^4/_4$	Dense bushland, high speed ✗ Some roadside barriers ✓ $^3/_4$	Total
Product	$^{48}/_{64}$	$^{48}/_{64}$	$^{27}/_{64}$	$^{36}/_{64}$	$^{8}/_{64}$	$^{8}/_{64}$	$^{18}/_{64}$	$^{193}/_{448}$

Table 6: CH47 900 - 41 570 Additional Safety Components

Additional Safe System Components	Prompts	Comments
Road User	Are road users likely to be alert and compliant, or are there factors that might influence this? What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours) and what is the likelihood of driver fatigue? Are there special road uses (e.g. entertainment precincts, elderly, children, on-road activities), distraction by environmental factors (e.g. commerce, tourism), or risk-taking behaviours?	• Rural highway typically involves high speeding drivers • Long distance between towns – fatigued drivers
Vehicle	What level of alignment is there with the ideal of safer vehicles? Are there factors which might attract large numbers of unsafe vehicles? Is the percentage of heavy vehicles too high for the proposed/existing road design? Are there enforcement resources in the area to detect nonroadworthy, overloaded or unregistered vehicles and thus remove them from the network?	• Heavy presence of farming surrounds • Railway crossings • Popular road network for tourism to the Far North
Post Crash Care	Are there issues that might influence safe and efficient post-crash care in the event of a severe injury? Do emergency and medical services operate as efficiently and rapidly as possible? Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there provision for e-safety (i.e. safety systems based on modern information and communication technologies, C-ITS)?	• Moderate distance to emergency facilities • Accessible for emergency vehicles

CH47 900 – CH41 570: After OmniGrip, fleixble barriers and Bioluminescent Material

The objective is to assess if the section between chainage 47 900 and 41 570 aligns with the Safe System objective once implmented with OmniGrip high friction surface technology and Bioluminescent linemarking.

Chainage 47 900 – 41 570: Safe System matrix – After OmniGrip, flexible barriers and Bioluminescent Linemarking

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	High exposure ✗ $^4/_4$	High exposure ✗ $^4/_4$	High number of intersections ✗ $^3/_4$	High exposure ✗ $^4/_4$	Low pedestrian volumes ✓ $^1/_4$	Low cyclist volumes ✓ $^1/_4$	Moderate motorcycle volumes ✗ $^2/_4$	
Likelihood	Steep curvature, no lighting, obstructed view, high speed ✗ Guideposts, sealed shoulder ✓ Road geometry easily seen in darkness, flexible roadside barrier ✓ $^2/_4$	Obstructed views due to bushland, no lighting, high overtaking zone ✗ Linemarking ✓ Road centreline easily seen in darkness, flexible centreline barrier ✓ $^2/_4$	Merging or turning cars on high speed road ✗ $^3/_4$	Site distance obstructed by roadside hazards ✗ High friction surface reducing likelihood of skidding ✓ $^2/_4$	No footpath ✗ No crossing facilities ✗ $^2/_4$	No cyclist lane ✗ No crossing facilities ✗ $^2/_4$	Sealed road ✗ Steep curvature ✗ Road geometry easily seen in darkness ✓ $^2/_4$	
Severity	High speed, heavy traffic, dense bushland ✗ Roadside barriers ✓ $^3/_4$	High speed, heavy traffic ✗ Flexible centreline barrier ✓ $^3/_4$	High speed ✗ $^3/_4$	High speed section ✗ High skid resistance ✓ $^2/_4$	High speed section ✗ No crossings ✗ $^4/_4$	Moderate speed sections ✗ $^4/_4$	Dense bushland, high speed ✗ Some roadside barriers ✓ $^3/_4$	Total
Product	$^{24}/_{64}$	$^{24}/_{64}$	$^{27}/_{64}$	$^{16}/_{64}$	$^8/_{64}$	$^8/_{64}$	$^{12}/_{64}$	$^{119}/_{448}$

Comparison of results

Table 7: CH47 900 - 41 570 Results Comparison

	ROR	HO	INT	Other	PED	CYC	M/C	
Baseline	$^{48}/_{64}$	$^{48}/_{64}$	$^{27}/_{64}$	$^{36}/_{64}$	$^{8}/_{64}$	$^{8}/_{64}$	$^{18}/_{64}$	$^{193}/_{448}$
After treatment	$^{24}/_{64}$	$^{24}/_{64}$	$^{27}/_{64}$	$^{16}/_{64}$	$^{8}/_{64}$	$^{8}/_{64}$	$^{12}/_{64}$	$^{119}/_{448}$

From the matrix assessment, the baseline condition of the Bruce Highway in this section is largely from being in accordance with the safe system principles. With treatments applied, the likelihood and severity of run-off-road, head-on, and intersection type crashes are still relatively high. However, the safety treatments do lower the scoring by half for run-off-road and head-on collisions.

The innovative treatments provide opportunity for improvement of the current road section even though there are currently multiple safety treatments in place to lower the risk of crash outcomes. This highlights the importance of considering advanced treatments in road design where geometric and environmental factors are crucial constraints.

4.4.2 Peninsula Developmental Road

Context

Table 8: Peninsula Developmental Road Prompts

Prompts	Comments
What is the function of the road? Consider location, roadside land use, area type, speed limit, intersection type, presence of parking, public transport services and vehicle flows. What traffic features exist nearby (e.g. upstream and downstream)?	• Rural road network connecting outer rural towns • Main road connecting Far North Queensland farming • Moderate annual daily traffic • Heavy vehicle access for farming and transportation
What road users are present? Consider the presence of elderly, school children and cyclists. Also note what facilities are available to vulnerable road users (e.g. signalised crossings, bicycle lanes, school zone speed limits, etc.).	• Tourists • No cyclist or pedestrians • Rural locality • Frequent farming use
What is the vehicle composition? Consider the presence of heavy vehicles (and what type), motorcyclists and other vehicles using the roadway.	• Camper vans and trailers • Regular light vehicles • Unrestricted road network – presence of heavy vehicles and road trains
What is the reason for the project? Is there a specific crash type risk? Is it addressing specific issues such as poor speed limit compliance, road access, congestion, future traffic growth, freight movement, amenity concerns from the community, etc.	• Frequent crash zone. Higher fatalities seen on the road • Specific crash type risk seen – losing control on straight • High speed, long straights

	• To address poor driving conditions that may result in higher frequency of road crashes

CH3 000 – CH6 351 Existing Conditions

The section between chainage 3 000 and 6 351 was selected for framework analysis as the high risk of run-off-road crash types and animal collision is presently in this section. The section is within close proximity to the rural town, Lakeland. The average annual daily traffic seen on this section is 100 – 499 vehicles (qldglobe, 2023). The section features a single carriageway with 3.5m width sealed lanes and > 0.5m shoulder width. In the Western section, the horizontal curvature of the road is steep. The Eastern section features multiple vertical grades with minimum sight distance. There is no street lighting between these chainages, adding to the difficulty of visibility. Table 3 is an assessment of the current chainage section Safe System condition.

Table 9: CH3 000 - 6 351 Geometrical and Environmental Commentary

Imagery	Geometrical/ Environmental Comments
 Peninsula Dev. Road facing West	Vertical grade minimising site distance. No street lighting
 Peninsula Dev. Road facing West (2)	Slight horizontal curvature at the beginning of the section. No street lighting

Chainage 3 000 – 6 351: Safe System matrix – Current Condition

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	Low exposure ✓ $^2/_4$	Low exposure ✓ $^2/_4$	Low intersection number ✓ $^1/_4$	Low exposure ✓ $^2/_4$	Low pedestrian volumes ✓ $^1/_4$	Low cyclist volumes ✓ $^1/_4$	Low motorcycle volumes ✗ $^1/_4$	
Likelihood	Steep curvature and vertical crest, high speed, very remote, no lighting ✗ Guideposts ✓ $^4/_4$	No lighting, high overtaking zone ✗ Linemarking, low vehicle interaction ✓ $^3/_4$	Merging or turning cars on high speed road, intersection sight distance obstructed ✗ $^3/_4$	Site distance obstructed by vertical grades and horizontal curves, high farming population ✗ $^3/_4$	No footpath ✗ No crossing facilities ✗ $^1/_4$	No cyclist lane ✗ No crossing facilities ✗ $^1/_4$	Sealed road ✓ Steep curvature ✗ $^3/_4$	
Severity	High speed, no roadside barriers ✗ $^4/_4$	High speed on curves ✗ $^4/_4$	High speed ✗ $^4/_4$	High speed section ✗ $^4/_4$	High speed section ✗ No crossings ✗ $^4/_4$	Moderate speed sections ✗ $^4/_4$	Dense bushland, high speed, no roadside barrier, high speed ✗ $^4/_4$	Total
Product	$^{32}/_{64}$	$^{24}/_{64}$	$^{12}/_{64}$	$^{24}/_{64}$	$^4/_{64}$	$^4/_{64}$	$^{12}/_{64}$	$^{112}/_{448}$

Table 10: CH3 000 - 6 351 Additional Safety Components

Additional Safe System Components	Prompts	Comments
Road User	Are road users likely to be alert and compliant, or are there factors that might influence this? What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours) and what is the likelihood of driver fatigue? Are there special road uses (e.g. entertainment precincts, elderly, children, on-road activities), distraction by environmental factors (e.g. commerce, tourism), or risk-taking behaviours?	• Rural highway typically involves high speeding drivers • Long distance between towns – fatigued drivers
Vehicle	What level of alignment is there with the ideal of safer vehicles? Are there factors which might attract large numbers of unsafe vehicles? Is the percentage of heavy vehicles too high for the proposed/existing road design? Are there enforcement resources in the area to detect nonroadworthy, overloaded or unregistered vehicles and thus remove them from the network?	• Heavy presence of farming surrounds • High percentage of heavy vehicles i.e. road trains and cattle farming equipment • Nearby rural town
Post Crash Care	Are there issues that might influence safe and efficient post-crash care in the event of a severe injury? Do emergency and medical services operate as efficiently and rapidly as possible? Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there provision for e-safety (i.e. safety systems based on modern information and communication technologies, C-ITS)?	• Moderate distance to emergency facilities • Accessible for emergency vehicles • Remote area – may no receive immediate required emergency care (hospitals)

CH3 000 – CH6 351: Flexible barriers and Bioluminescent Linemarking

The objective is to assess if the section between chainage 3 000 and 6 351 aligns with the Safe System objective once implmented with Flexbile barriers and Bioluminescent linemarking.

Chainage 3 000 – 6 351: Safe System Matrix – After Flexible Barriers and Bioluminescent Linemarking

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	Low exposure ✓ $^2/_4$	Low exposure ✓ $^2/_4$	Low intersection number ✓ $^1/_4$	Low exposure ✓ $^2/_4$	Low pedestrian volumes ✓ $^1/_4$	Low cyclist volumes ✓ $^1/_4$	Low motorcycle volumes ✗ $^1/_4$	
Likelihood	Steep curvature and vertical crest, high speed, very remote ✗ Guideposts ✓ Carriageway boundary lightened, roadside barrier ✓ $^2/_4$	High overtaking zone ✗ Linemarking, low vehicle interaction ✓ Vehicle path is lit ✓ $^2/_4$	Merging or turning cars on high speed road, intersection sight distance obstructed ✗ $^3/_4$	Site distance obstructed by vertical grades and horizontal curves, high farming population ✗ Vehicle path clear ✓ $^2/_4$	No footpath ✗ No crossing facilities ✗ $^1/_4$	No cyclist lane ✗ No crossing facilities ✗ $^1/_4$	Sealed road ✓ Steep curvature ✗ $^3/_4$	
Severity	High speed ✗ Flexible roadside barrier ✓ $^3/_4$	High speed on curves ✗ $^4/_4$	High speed ✗ $^4/_4$	High speed section ✗ $^4/_4$	High speed section ✗ No crossings ✗ $^4/_4$	Moderate speed sections ✗ $^4/_4$	Dense bushland, high speed ✗ Flexible roadside barrier ✓ $^3/_4$	Total
Product	$^{12}/_{64}$	$^{16}/_{64}$	$^{12}/_{64}$	$^{16}/_{64}$	$^4/_{64}$	$^4/_{64}$	$^9/_{64}$	$^{73}/_{448}$

Comparison of results

Table 11: CH3 000 – 6 351 Results Comparison

	ROR	HO	INT	Other	PED	CYC	M/C	
Baseline	$^{32}/_{64}$	$^{24}/_{64}$	$^{12}/_{64}$	$^{24}/_{64}$	$^{4}/_{64}$	$^{4}/_{64}$	$^{12}/_{64}$	$^{112}/_{448}$
After treatment	$^{12}/_{64}$	$^{16}/_{64}$	$^{12}/_{64}$	$^{16}/_{64}$	$^{4}/_{64}$	$^{4}/_{64}$	$^{9}/_{64}$	$^{73}/_{448}$

This section through the Peninsula Developmental Road is not particularly high with regards to the matrix scoring. Although the section experiences predominantly run-off-road crash types, the exposure is low therefore minimising the risk. There is slight differentiation between the baseline condition and the after-treatment condition, however the high risk of speeding is still present in the area.

Implementing flexible road safety barriers will significantly reduce the likelihood and severity of run-off-road type crashes as a physical restriction. Bioluminscent line marking, while it does assist with visibility control, does not provide a barrier for driver behaviour.

CH54 850– CH66 000 Existing Conditions

The section between chainage 54 850 and 66 000 was selected for analysis due to the high presence of run-off-road crashes in lowlight conditions. This section of road is an unsealed gravel road with dense bushland covering the roadside. The average annual daily traffic along this section is 0 – 99 vehicles, which is considerably low (qldglobe, 2023). Concerning geometrical factors include reverse horizontal curvature in multiple sections and sharp curvature leading into a causeway. Steep vertical dips and crests are present throughout the section with signage erected prior to the hazard. Due to the unsealed nature of this section, constraints are involved in the selection of safety treatments.

Table 12: CH54 850 - 66 000 Geometrical and Environmental Commentary

Imagery	Geometrical/ Environmental Comments
 Peninsula Dev. Road Aerial view	Steep reverse curvature on unsealed road

 Peninsula Dev. Road facing North	Obstructed site distance due to curvature and dense roadside bushland. No street lighting
 Peninsula Dev. Road Aerial view (2)	Minimal transitional curves to lead out of straights
 Peninsula Dev. Road facing North (2)	Obstructed site distance due to curvature and dense roadside bushland. No street lighting
 Peninsula Dev. Road facing South (1)	Causeway followed from vertical grading and unlit path

Chainage 54 850 – 66 000: Safe System matrix – Current Condition

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	Very Low exposure ✓ $^1/_4$	Very Low exposure ✓ $^1/_4$	No intersections ✓ $^0/_4$	Very Low exposure ✓ $^1/_4$	No pedestrians ✓ $^0/_4$	No cyclists ✓ $^0/_4$	Very Low motorcycle volumes ✗ $^1/_4$	
Likelihood	Steep curvature and vertical crest, high speed, very remote, no lighting, unsealed road ✗ $^4/_4$	High overtaking zone, no linemarking, unsealed road ✗ Low vehicle interaction ✓ $^4/_4$	No intersections ✓ $^0/_4$	Site distance obstructed by vertical grades and horizontal curves, high farming population ✗ $^4/_4$	No pedestrians ✓ $^0/_4$	No cyclists ✓ $^0/_4$	Unsealed road, Steep curvature ✗ $^3/_4$	
Severity	High speed, no roadside barriers ✗ $^4/_4$	High speed on curves ✗ $^4/_4$	No intersections ✓ $^0/_4$	High speed section ✗ $^4/_4$	No pedestrians ✓ $^0/_4$	No cyclists ✓ $^0/_4$	Dense bushland, high speed ✗ $^4/_4$	Total
Product	$^{16}/_{64}$	$^{16}/_{64}$	$^0/_{64}$	$^{16}/_{64}$	$^0/_{64}$	$^0/_{64}$	$^{16}/_{64}$	$^{64}/_{448}$

Table 13: CH54 850 - 66 000 Additional Safety Components

Additional Safe System Components	Prompts	Comments
Road User	Are road users likely to be alert and compliant, or are there factors that might influence this? What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours) and what is the likelihood of driver fatigue? Are there special road uses (e.g. entertainment precincts, elderly, children, on-road activities), distraction by environmental factors (e.g. commerce, tourism), or risk-taking behaviours?	• Rural highway typically involves high speeding drivers • Long distance between towns – fatigued drivers
Vehicle	What level of alignment is there with the ideal of safer vehicles? Are there factors which might attract large numbers of unsafe vehicles? Is the percentage of heavy vehicles too high for the proposed/existing road design? Are there enforcement resources in the area to detect nonroadworthy, overloaded or unregistered vehicles and thus remove them from the network?	• Heavy presence of farming surrounds • High percentage of heavy vehicles i.e. road trains and cattle farming equipment • Nearby rural town
Post Crash Care	Are there issues that might influence safe and efficient post-crash care in the event of a severe injury? Do emergency and medical services operate as efficiently and rapidly as possible? Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there provision for e-safety (i.e. safety systems based on modern information and communication technologies, C-ITS)?	• Moderate distance to emergency facilities • Accessible for emergency vehicles • Remote area – may no receive immediate required emergency care (hospitals)

CH54 850 – CH66 000: Flexible barriers

The objective is to assess if the section between chainage 54 850 and 66 000 aligns with the Safe System objective once implmented with Flexbile barriers. As run-off-road crashes are high in this section of road, treatments should be assessed according to reducing this criteria. Limitations are present in this section given the unsealed pavement, making selection of safety treatments scarce.

Chainage 54 850 – 66 000: Safe System Matrix – After Flexible Barriers

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	Very Low exposure ✓ $^{1}/_{4}$	Very Low exposure ✓ $^{1}/_{4}$	No intersections ✓ $^{0}/_{4}$	Very Low exposure ✓ $^{1}/_{4}$	No pedestrians ✓ $^{0}/_{4}$	No cyclists ✓ $^{0}/_{4}$	Very Low motorcycle volumes ✗ $^{1}/_{4}$	
Likelihood	Steep curvature and vertical crest, high speed, very remote, no lighting, unsealed road ✗ $^{4}/_{4}$	High overtaking zone, no linemarking, unsealed road ✗ Low vehicle interaction ✓ $^{4}/_{4}$	No intersections ✓ $^{0}/_{4}$	Site distance obstructed by vertical grades and horizontal curves, high farming population ✗ $^{4}/_{4}$	No pedestrians ✓ $^{0}/_{4}$	No cyclists ✓ $^{0}/_{4}$	Unsealed road, Steep curvature ✗ $^{3}/_{4}$	
Severity	High speed ✗ Flexible barrier ✓ $^{2}/_{4}$	High speed on curves ✗ $^{4}/_{4}$	No intersections ✓ $^{0}/_{4}$	High speed section ✗ $^{4}/_{4}$	No pedestrians ✓ $^{0}/_{4}$	No cyclists ✓ $^{0}/_{4}$	Dense bushland, high speed ✗ Flexible barrier ✓ $^{2}/_{4}$	Total
Product	$^{8}/_{64}$	$^{16}/_{64}$	$^{0}/_{64}$	$^{16}/_{64}$	$^{0}/_{64}$	$^{0}/_{64}$	$^{12}/_{64}$	$^{52}/_{448}$

Comparison of results

Table 14: CH54 850 – 66 000 Results Comparison

	ROR	HO	INT	Other	PED	CYC	M/C	
Baseline	$^{16}/_{64}$	$^{16}/_{64}$	$^{0}/_{64}$	$^{16}/_{64}$	$^{0}/_{64}$	$^{0}/_{64}$	$^{16}/_{64}$	$^{64}/_{448}$
After treatment	$^{8}/_{64}$	$^{16}/_{64}$	$^{0}/_{64}$	$^{16}/_{64}$	$^{0}/_{64}$	$^{0}/_{64}$	$^{12}/_{64}$	$^{52}/_{448}$

The matrix comparison for Chainage 54 850 to 66 000 shows that the section is not extremely out of the safe systems objectives. As the average annual daily traffic is very low throughout this section, the exposure is very minimal. With a score difference of twelve between the baseline condition and the treated condition, feasibility will become a factor in the implementation of advanced road treatments.

Installing flexible barriers along this section of road may be of lower priority than sealing the section. With advancements in rural road safety projects including the sealing of highway sections, the installation of flexible barriers may be avoided while the section is unsealed. Installing flexible barrier along unsealed sections may also pose as a costly countermeasure due to flooding and an increase in road damage during the wet season in Far North Queensland. Maintaining the flexible barrier may be out of alignment with the cost-benefit ratio for this section of road.

CH142 800 – CH146 000 Existing Conditions

The section between chainage 142 800 and 146 000 was selected for analysis due to the high presence of run-off-road crashes. This section is a long and narrow, unsealed straight that is very remote. The average annual daily traffic along this section is very low with an average of 0 – 99 vehicles (qldglobe, 2023). There are no concerning geometrical characteristics of the site except for the narrow carriageway. Straight and level sections of road are prone to increases in speeding as there are no potential hazards visible to the driver. Speeding on a gravel road leads to traction loss and therefore may result in loss of control of a vehicle (qld.gov.au, 2023).

Table 15: CH142 800 - 146 000 Geometrical and Environmental Commentary

<table>
<tr><th>Imagery</th><th>Geometrical/ Environmental Comments</th></tr>
<tr><td>

Peninsula Dev. Road facing North</td><td>Long narrow straight sections. No street lighting</td></tr>
</table>

 Peninsula Dev. Road facing North (2)	No road delineation, flood damage/ rutting evident along road section. No street lighting

Chainage 142 800 – 146 000: Safe System matrix – Current Condition

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	Very Low exposure ✓ 1/4	Very Low exposure ✓ 1/4	No intersections ✓ 0/4	Very Low exposure ✓ 1/4	No pedestrians ✓ 0/4	No cyclists ✓ 0/4	Very Low motorcycle volumes ✓ 1/4	
Likelihood	High speed, very remote, no lighting, unsealed road ✗ 3/4	High overtaking zone, no linemarking, unsealed road ✗ Low vehicle interaction ✓ 2/4	No intersections ✓ 0/4	High farming population ✗ 3/4	No pedestrians ✓ 0/4	No cyclists ✓ 0/4	Unsealed road ✗ 2/4	
Severity	High speed, no roadside barriers, dense bushland ✗ 4/4	High speed ✗ 4/4	No intersections ✓ 0/4	High speed section ✗ 4/4	No pedestrians ✓ 0/4	No cyclists ✓ 0/4	Dense bushland, high speed, no roadside barrier ✗ 4/4	Total
Product	12/64	8/64	0/64	12/64	0/64	0/64	8/64	80/448

Table 16: CH142 800 - 146 000 Additional Safety Components

Additional Safe System Components	Prompts	Comments
Road User	Are road users likely to be alert and compliant, or are there factors that might influence this? What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours) and what is the likelihood of driver fatigue? Are there special road uses (e.g. entertainment precincts, elderly, children, on-road activities), distraction by environmental factors (e.g. commerce, tourism), or risk-taking behaviours?	• Rural highway typically involves high speeding drivers • Long distance between towns – fatigued drivers •
Vehicle	What level of alignment is there with the ideal of safer vehicles? Are there factors which might attract large numbers of unsafe vehicles? Is the percentage of heavy vehicles too high for the proposed/existing road design? Are there enforcement resources in the area to detect nonroadworthy, overloaded or unregistered vehicles and thus remove them from the network?	• Heavy presence of farming surrounds • High percentage of heavy vehicles i.e. road trains and cattle farming equipment • No enforcement nearby
Post Crash Care	Are there issues that might influence safe and efficient post-crash care in the event of a severe injury? Do emergency and medical services operate as efficiently and rapidly as possible? Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there provision for e-safety (i.e. safety systems based on modern information and communication technologies, C-ITS)?	• Very far from emergency care • Long wait time for emergency services • Remoteness limits immediate care if driver unconscious • Remote area – may no receive immediate required emergency care (hospitals)

CH142 800– CH146 000: Flexible barriers

The objective is to assess if the section between chainage 142 800 and 146 000 aligns with the Safe System objective once implmented with Flexbile barriers and Bioluminescent linemarking.

Chainage 142 800 – 146 000: Safe System Matrix – After Flexible Barriers

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	Very Low exposure ✓ $^{1}/_{4}$	Very Low exposure ✓ $^{1}/_{4}$	No intersections ✓ $^{0}/_{4}$	Very Low exposure ✓ $^{1}/_{4}$	No pedestrians ✓ $^{0}/_{4}$	No cyclists ✓ $^{0}/_{4}$	Very Low motorcycle volumes ✓ $^{1}/_{4}$	
Likelihood	High speed, very remote, no lighting, unsealed road ✗ Flexible roadside barrier ✓ $^{2}/_{4}$	High overtaking zone, no linemarking, unsealed road ✗ Low vehicle interaction ✓ $^{2}/_{4}$	No intersections ✓ $^{0}/_{4}$	High farming population ✗ $^{3}/_{4}$	No pedestrians ✓ $^{0}/_{4}$	No cyclists ✓ $^{0}/_{4}$	Unsealed road ✗ Flexible roadside barrier ✓ $^{2}/_{4}$	
Severity	High speed ✗ Flexible roadside barrier ✓ $^{2}/_{4}$	High speed on curves ✗ $^{4}/_{4}$	High speed ✗ $^{4}/_{4}$	High speed section ✗ $^{4}/_{4}$	High speed section ✗ No crossings ✗ $^{4}/_{4}$	Moderate speed sections ✗ $^{4}/_{4}$	Dense bushland, high speed ✗ Flexible roadside barrier ✓ $^{2}/_{4}$	Total
Product	$^{12}/_{64}$	$^{16}/_{64}$	$^{12}/_{64}$	$^{16}/_{64}$	$^{4}/_{64}$	$^{4}/_{64}$	$^{9}/_{64}$	$^{73}/_{448}$

Comparison of results

Table 17: CH142 800 – 146 000 Results Comparison

	ROR	HO	INT	Other	PED	CYC	M/C	
Baseline	$^{12}/_{64}$	$^{8}/_{64}$	$^{0}/_{64}$	$^{12}/_{64}$	$^{0}/_{64}$	$^{0}/_{64}$	$^{8}/_{64}$	$^{80}/_{448}$
After treatment	$^{12}/_{64}$	$^{16}/_{64}$	$^{12}/_{64}$	$^{16}/_{64}$	$^{4}/_{64}$	$^{4}/_{64}$	$^{9}/_{64}$	$^{73}/_{448}$

The matrix comparison for Chainage 54 850 to 66 000 shows that the section is not extremely out of the safe systems objectives. As the average annual daily traffic is very low throughout this section, the exposure is very minimal. With a score difference of twelve between the baseline condition and the treated condition, feasibility will become a factor in the implementation of advanced road treatments.

Installing flexible barriers along this section of road may be of lower priority than sealing the section. With advancements in rural road safety projects including the sealing of highway sections, the installation of flexible barriers may be avoided while the section is unsealed. Installing flexible barrier along unsealed sections may also pose as a costly countermeasure due to flooding and an increase in road damage during the wet season in Far North Queensland. Maintaining the flexible barrier may be out of alignment with the cost-benefit ratio for this section of road.

4.4.3 Mulligan Highway

Context

Table 18: Mulligan Highway Prompts

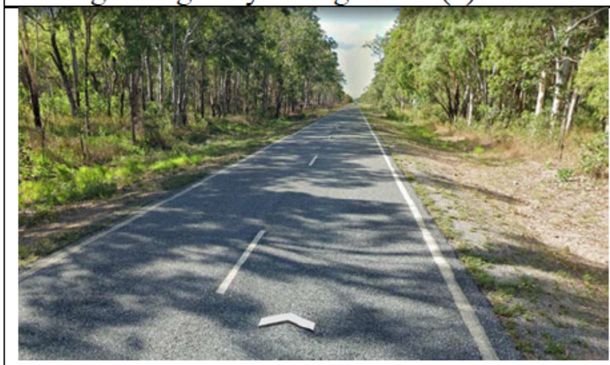
Prompts	Comments
What is the function of the road? Consider location, roadside land use, area type, speed limit, intersection type, presence of parking, public transport services and vehicle flows. What traffic features exist nearby (e.g. upstream and downstream)?	• Rural road network connecting outer rural towns • Central Queensland road network • Moderate annual daily traffic • Heavy vehicle access for farming and transportation
What road users are present? Consider the presence of elderly, school children and cyclists. Also note what facilities are available to vulnerable road users (e.g. signalised crossings, bicycle lanes, school zone speed limits, etc.).	• Tourists • No cyclist or pedestrians • Rural locality • Frequent farming use
What is the vehicle composition? Consider the presence of heavy vehicles (and what type), motorcyclists and other vehicles using the roadway.	• Camper vans and trailers • Regular light vehicles • Unrestricted road network – presence of heavy vehicles and road trains may be present
What is the reason for the project? Is there a specific crash type risk? Is it addressing specific issues such as poor speed limit compliance, road access, congestion, future traffic growth, freight	• Frequent crash zone. Higher fatalities seen on the road • Specific crash type risk seen – losing control on straight • High speed, long straights

movement, amenity concerns from the community, etc.	• To address poor driving conditions that may result in higher frequency of road crashes

CH12 180– CH14 090 Existing Conditions

The section between chainage 12 180 and 14 090 was selected for analysis due to the high number of run-off-road crash types. This section is a high vehicular traffic (up to 10,000 vehicles) section that features dual lane, sealed carriageway. The sealed shoulder is > 0.5m and there is no street lighting present throughout. The use of guideposts is present along the edge line and a relatively steep batter is present on both sides of the carriageway.

Table 19: CH12 180 – 14 090 Geometrical and Environmental Commentary

Imagery	Geometrical/ Environmental Comments
 Mulligan Highway facing North	Vertical grade minimising site distance. No street lighting
 Mulligan Highway facing North (2)	Long, narrow straight. No street lighting
 Mulligan Highway facing South	Minimal shoulder width. Becomes thinner heading North. No street lighting

Chainage 12 180 – 14 090: Safe System matrix – Current Condition

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	High exposure $^3/_4$	High exposure ✗ $^3/_4$	No intersections ✓ $^0/_4$	High exposure ✗ $^3/_4$	No pedestrians ✓ $^0/_4$	Low cyclist volumes ✓ $^1/_4$	Moderate motorcycle volumes ✗ $^2/_4$	
Likelihood	No lighting, long straight sealed section – speed prone ✗ Guideposts ✓ $^3/_4$	High overtaking zone, no lighting Linemarking ✓ $^3/_4$	No intersections ✓ $^0/_4$	Site distance minimised at night ✗ $^3/_4$	No pedestrians ✓ $^0/_4$	No cyclist lane ✗ No crossing facilities ✗ $^2/_4$	Sealed road ✓ Steep curvature ✗ $^3/_4$	
Severity	High speed, frequent traffic, dense bushland, no roadside barrier ✗ $^4/_4$	High speed ✗ $^4/_4$	No intersections ✓ $^0/_4$	High speed section ✗ $^3/_4$	No pedestrians ✓ $^0/_4$	High speed sections ✗ $^4/_4$	Dense bushland, high speed ✗ $^4/_4$	Total
Product	$^{36}/_{64}$	$^{36}/_{64}$	$^0/_{64}$	$^{27}/_{64}$	$^0/_{64}$	$^8/_{64}$	$^{24}/_{64}$	$^{123}/_{448}$

Table 20: CH12 180 - 14 090 Additional Safety Components

Additional Safe System Components	Prompts	Comments
Road User	Are road users likely to be alert and compliant, or are there factors that might influence this? What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours) and what is the likelihood of driver fatigue? Are there special road uses (e.g. entertainment precincts, elderly, children, on-road activities), distraction by environmental factors (e.g. commerce, tourism), or risk-taking behaviours?	• Rural highway typically involves high speeding drivers • Long distance between towns – fatigued drivers • Sealed straights provide drivers with false sense of security for speeding
Vehicle	What level of alignment is there with the ideal of safer vehicles? Are there factors which might attract large numbers of unsafe vehicles? Is the percentage of heavy vehicles too high for the proposed/existing road design? Are there enforcement resources in the area to detect nonroadworthy, overloaded or unregistered vehicles and thus remove them from the network?	• Heavy presence of farming surrounds • High percentage of heavy vehicles i.e. road trains and cattle farming equipment • Nearby rural town
Post Crash Care	Are there issues that might influence safe and efficient post-crash care in the event of a severe injury? Do emergency and medical services operate as efficiently and rapidly as possible? Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there provision for e-safety (i.e. safety systems based on modern information and communication technologies, C-ITS)?	• Moderate distance to emergency facilities • Accessible for emergency vehicles • Remote area – may not receive immediate required emergency care (hospitals)

CH12 180 – CH14 090: Flexible barriers, OmniGrip and Bioluminscent Linemarking

The objective is to assess if the section between chainage 12 180 to 14 090 aligns with the Safe System objective once implmented with Flexbile barriers, OmniGrip high friction surfaces, and bioluminscent linemarking. As run-off-road crashes are high in this section of road, treatments should be assessed according to reducing this criteria. Current safety treatments for run-off-road type crashes pesent in this section include guide posts and sealed shoulders.

Chainage 12 180 – 14 090: Safe System Matrix – After Flexible Barriers, OmniGrip and Bioluminscent Linemarking

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	High exposure $^3/_4$	High exposure ✗ $^3/_4$	No intersections ✓ $^0/_4$	High exposure ✗ $^3/_4$	No pedestrians ✓ $^0/_4$	Low cyclist volumes ✓ $^1/_4$	Moderate motorcycle volumes ✗ $^2/_4$	
Likelihood	No lighting, long straight sealed section – speed prone ✗ Guideposts, sealed shoulder ✓ Roadside barrier, high friction surface to prevent skidding, linemarking visible at night ✓ $^2/_4$	High overtaking zone, no lighting Linemarking ✓ linemarking visible at night ✓ $^2/_4$	No intersections ✓ $^0/_4$	Site distance minimised at night ✗ high friction surface to aid stopping distance ✓ $^2/_4$	No pedestrians ✓ $^0/_4$	No cyclist lane ✗ No crossing facilities ✗ $^2/_4$	Sealed road ✓ Steep curvature ✗ $^3/_4$	
Severity	High speed, frequent traffic, dense bushland ✗ Roadside barrier ✓ $^2/_4$	High speed ✗ $^4/_4$	No intersections ✓ $^0/_4$	High speed section ✗ $^3/_4$	No pedestrians ✓ $^0/_4$	High speed sections ✗ $^4/_4$	Dense bushland, high speed ✗ Roadside barrier ✓ $^3/_4$	Total
Product	$^{12}/_{64}$	$^{24}/_{64}$	$^0/_{64}$	$^{18}/_{64}$	$^0/_{64}$	$^8/_{64}$	$^{18}/_{64}$	$^{89}/_{448}$

Comparison of results

Table 21:CH12 180 – 14 090 Results Comparison

	ROR	HO	INT	Other	PED	CYC	M/C	
Baseline	$^{36}/_{64}$	$^{36}/_{64}$	$^{0}/_{64}$	$^{27}/_{64}$	$^{0}/_{64}$	$^{8}/_{64}$	$^{24}/_{64}$	$^{123}/_{448}$
After treatment	$^{12}/_{64}$	$^{24}/_{64}$	$^{0}/_{64}$	$^{27}/_{64}$	$^{0}/_{64}$	$^{8}/_{64}$	$^{18}/_{64}$	$^{89}/_{448}$

The above table suggests that both conditions are still relatively high with respect to the safe system objectives. The treated options do significantly reduce the score, however there is little impact on the head-on crash type. The reduction in run-off-road type crashes is a good indication of the innovative treatments being implemented correctly.

Further treatment options that are currently used for safety improvements could be selected to reduce the head-on risk, such as wide centreline treatments. Further investigation of the impact of the bioluminescent line marking on head-on collisions is needed before proper justification of the material can be made.

CH98 100– CH116 770 Existing Conditions

The section between chainage 98 100 and 116 770 was selected for analysis due to the high presence of run-off-road crashes in lowlight conditions. Contributing factors in this section include horizontal curvature and steep vertical crests. This section is a relatively used chainage with an average annual daily traffic of 500 – 10,000 (qldglobe, 2023). The road throughout this section is sealed and features guideposts along the edge line. There is no street lighting present in the section and dense bushland is evident throughout.

Table 22: CH98 100 – 116 770 Geometrical and Environmental Commentary

Imagery	Geometrical/ Environmental Comments
 Mulligan Highway facing North	Horizontal curvature minimising sight distance. Steep roadside drainage/ batters. No street lighting

 Mulligan Highway facing North (2)	Change in vertical grade on reverse curve. No street lighting
 Mulligan Highway facing North (3)	Change in vertical grade on steep horizontal curvature. Sight distance obstructed by roadside bushland. No street lighting
 Mulligan Highway facing North (4)	Steep vertical crest. No street lighting

Chainage 98 100 – 116 770: Safe System matrix – Current Condition

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	High exposure $^{3}/_{4}$	High exposure ✗ $^{3}/_{4}$	No intersections ✓ $^{0}/_{4}$	High exposure ✗ $^{3}/_{4}$	No pedestrians ✓ $^{0}/_{4}$	Low cyclist volumes ✓ $^{1}/_{4}$	Moderate motorcycle volumes ✗ $^{2}/_{4}$	
Likelihood	No lighting, multiple vertical grades, steep horizontal curvature with obstructed view ✗ Guideposts, sealed shoulder ✓ $^{3}/_{4}$	High overtaking zone, no lighting Linemarking ✓ $^{3}/_{4}$	No intersections ✓ $^{0}/_{4}$	Site distance minimised at night, obstructed views ✗ $^{3}/_{4}$	No pedestrians ✓ $^{0}/_{4}$	No cyclist lane ✗ No crossing facilities ✗ $^{2}/_{4}$	Sealed road ✓ Steep curvature ✗ $^{3}/_{4}$	
Severity	High speed, frequent traffic, dense bushland, no roadside barrier ✗ $^{4}/_{4}$	High speed ✗ $^{4}/_{4}$	No intersections ✓ $^{0}/_{4}$	High speed section ✗ $^{3}/_{4}$	No pedestrians ✓ $^{0}/_{4}$	High speed sections ✗ $^{4}/_{4}$	Dense bushland, high speed ✗ $^{4}/_{4}$	Total
Product	$^{36}/_{64}$	$^{36}/_{64}$	$^{0}/_{64}$	$^{27}/_{64}$	$^{0}/_{64}$	$^{8}/_{64}$	$^{24}/_{64}$	$^{123}/_{448}$

Table 23: CH98 100 - 116 770 Additional Safety Components

Additional Safe System Components	Prompts	Comments
Road User	Are road users likely to be alert and compliant, or are there factors that might influence this? What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours) and what is the likelihood of driver fatigue? Are there special road uses (e.g. entertainment precincts, elderly, children, on-road activities), distraction by environmental factors (e.g. commerce, tourism), or risk-taking behaviours?	• Rural highway typically involves high speeding drivers • Long distance between towns – fatigued drivers
Vehicle	What level of alignment is there with the ideal of safer vehicles? Are there factors which might attract large numbers of unsafe vehicles? Is the percentage of heavy vehicles too high for the proposed/existing road design? Are there enforcement resources in the area to detect nonroadworthy, overloaded or unregistered vehicles and thus remove them from the network?	• Heavy presence of farming surrounds • High percentage of heavy vehicles i.e. road trains and cattle farming equipment • Nearby rural town
Post Crash Care	Are there issues that might influence safe and efficient post-crash care in the event of a severe injury? Do emergency and medical services operate as efficiently and rapidly as possible? Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there provision for e-safety (i.e. safety systems based on modern information and communication technologies, C-ITS)?	• Moderate distance to emergency facilities • Accessible for emergency vehicles • Remote area – may no receive immediate required emergency care (hospitals)

CH98 100– CH116 770: Flexible barriers, OmniGrip and Bioluminscent Linemarking

The objective is to assess if the section between chainage 98 100 to 116 770 aligns with the Safe System objective once implmented with Flexbile barriers, OmniGrip high friction surfaces, and bioluminscent linemarking. As run-off-road crashes are high in this section of road, treatments should be assessed according to reducing this criteria. Current safety treatments for run-off-road type crashes pesent in this section include guide posts and sealed shoulders.

Chainage 98 100 – 116 770: Safe System Matrix – After Flexible Barriers, OmniGrip and Bioluminscent Linemarking

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	High exposure 3/4	High exposure ✗ 3/4	No intersections ✓ 0/4	High exposure ✗ 3/4	No pedestrians ✓ 0/4	Low cyclist volumes ✓ 1/4	Moderate motorcycle volumes ✗ 2/4	
Likelihood	No lighting, multiple vertical grades, steep horizontal curvature with obstructed view ✗ Guideposts, sealed shoulder ✓ Roadside barrier, high friction surface to prevent skidding, linemarking visible at night ✓ 2/4	High overtaking zone, no lighting Linemarking ✓ linemarking visible at night ✓ 2/4	No intersections ✓ 0/4	Site distance minimised at night ✗ high friction surface to aid stopping distance ✓ 2/4	No pedestrians ✓ 0/4	No cyclist lane ✗ No crossing facilities ✗ 2/4	Sealed road ✓ Steep curvature ✗ 3/4	
Severity	High speed, frequent traffic, dense bushland ✗ Roadside barrier ✓ 2/4	High speed ✗ 4/4	No intersections ✓ 0/4	High speed section ✗ 3/4	No pedestrians ✓ 0/4	High speed sections ✗ 4/4	Dense bushland, high speed ✗ Roadside barrier ✓ 3/4	Total
Product	12/64	24/64	0/64	18/64	0/64	8/64	18/64	89/448

Comparison of results

Table 24: CH98 100 – 116 770 Results Comparison

	ROR	HO	INT	Other	PED	CYC	M/C	
Baseline	$^{36}/_{64}$	$^{36}/_{64}$	$^{0}/_{64}$	$^{27}/_{64}$	$^{0}/_{64}$	$^{8}/_{64}$	$^{24}/_{64}$	$^{123}/_{448}$
After treatment	$^{12}/_{64}$	$^{24}/_{64}$	$^{0}/_{64}$	$^{27}/_{64}$	$^{0}/_{64}$	$^{8}/_{64}$	$^{18}/_{64}$	$^{89}/_{448}$

Likewise with the previous chainage section along the Mulligan Highway, this section is still relatively high scoring with baseline and treated conditions. Evidently OmniGrip and Flexible Barrier treatments work to minimise the severity as well as the likelihood of run-off-road crash types, resulting in a lower overall score. The bioluminescent treatment does not provide any improvement for the severity score and therefore can only have an impact on the likelihood of a road crash happening.

CH124 430 – CH127 350 Existing Conditions

The section between chainage 124 430 and 127 350 was selected for analysis due to the high presence of run-off-road crashes where vertical grading was present. Also seen throughout the section is animal-vehicle collision. The section is a sealed, single carriageway road with line marking. There is a high presence of reverse curves throughout the section with views obstructed by the horizontal curvature and roadside bushland. The carriageway transitions into the roadside margin seamlessly, which raises concern for road delineation. Guideposts are placed scarcely along the section and no street lighting is present. The average annual daily traffic seen throughout this section is between 500 to 10,000 vehicles (qldglobe, 2023).

Table 25: CH124 430 – 127 350 Geometrical and Environmental Commentary

Imagery	Geometrical/ Environmental Comments
 Mulligan Highway Aerial view	Reverse broken back curvature

 Mulligan Highway facing North	Steep vertical crest, no road delineation. No street lighting
 Mulligan Highway facing South	Steep vertical crest. No street lighting
 Mulligan Highway facing North (2)	Obstructed views due to horizontal curvature and dense roadside bushland. No street lighting

Chainage 124 430 – 127 350: Safe System matrix – Current Condition

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	Low exposure ✓ $^2/_4$	Low exposure ✓ $^2/_4$	Two intersections ✗ $^2/_4$	Low exposure ✓ $^2/_4$	No pedestrians ✓ $^0/_4$	No cyclists ✓ $^0/_4$	Low motor cyclist exposure ✓ $^2/_4$	
Likelihood	Reverse curves on high speed and vertical crest, remote, no lighting ✗ Sealed road shoulder ✓ $^3/_4$	High overtaking zone, views obstructed on curves ✗ Low vehicle interaction, linemarking ✓ $^2/_4$	Site distance minimised by horizontal curves ✗ $^2/_4$	Site distance obstructed by vertical grades and horizontal curves, high farming population ✗ $^3/_4$	No pedestrians ✓ $^0/_4$	No cyclists ✓ $^0/_4$	Reverse curvature on high speed sections, vertical crests ✗ $^3/_4$	
Severity	High speed, no roadside barriers ✗ $^4/_4$	High risk behaviour ✗ $^4/_4$	High speed section ✗ $^4/_4$	High speed section ✗ $^4/_4$	No pedestrians ✓ $^0/_4$	No cyclists ✓ $^0/_4$	High speed section ✗ $^4/_4$	Total
Product	$^{24}/_{64}$	$^{16}/_{64}$	$^{16}/_{64}$	$^{24}/_{64}$	$^0/_{64}$	$^0/_{64}$	$^{24}/_{64}$	$^{104}/_{448}$

Table 26: CH124 430 - 127 350 Additional Safety Components

Additional Safe System Components	Prompts	Comments
Road User	Are road users likely to be alert and compliant, or are there factors that might influence this? What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours) and what is the likelihood of driver fatigue? Are there special road uses (e.g. entertainment precincts, elderly, children, on-road activities), distraction by environmental factors (e.g. commerce, tourism), or risk-taking behaviours?	• Rural highway typically involves high speeding drivers • Risky driver behaviour on reverse curves (swerving, not keeping to one lane) • Long distance between towns – fatigued drivers
Vehicle	What level of alignment is there with the ideal of safer vehicles? Are there factors which might attract large numbers of unsafe vehicles? Is the percentage of heavy vehicles too high for the proposed/existing road design? Are there enforcement resources in the area to detect nonroadworthy, overloaded or unregistered vehicles and thus remove them from the network?	• Heavy presence of farming surrounds • High percentage of heavy vehicles i.e. road trains and cattle farming equipment • Nearby rural town
Post Crash Care	Are there issues that might influence safe and efficient post-crash care in the event of a severe injury? Do emergency and medical services operate as efficiently and rapidly as possible? Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there provision for e-safety (i.e. safety systems based on modern information and communication technologies, C-ITS)?	• Moderate distance to emergency facilities • Accessible for emergency vehicles • Remote area – may not receive immediate required emergency care (hospitals)

CH124 430 – CH127 350: Flexible barriers, OmniGrip and RADS

The objective is to assess if the section between chainage 124 430 and 127 350 aligns with the Safe System objective once implmented with Flexbile barriers, OmniGrip high frixtion surface and Roadside Animal Detection System. Run-off-road type crashes are high in this section as well as animal collision accidents. As all of the accidents were at times of clear visibility conditions, lighting factors are not considerd to be a causation in the outcome of the crash. Therefore, linemarking technology may not be necessary is this particular section.

Chainage 124 430 – 127 350: Safe System Matrix – After Flexible Barriers, OmniGrip and RADS

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	Low exposure ✓ $^{2}/_{4}$	Low exposure ✓ $^{2}/_{4}$	Two intersections ✗ $^{2}/_{4}$	Low exposure ✓ $^{2}/_{4}$	No pedestrians ✓ $^{0}/_{4}$	No cyclists ✓ $^{0}/_{4}$	Low motor cyclist exposure ✓ $^{2}/_{4}$	
Likelihood	Reverse curves on high speed and vertical crest, remote, no lighting ✗ Sealed road shoulder ✓ Roadside barrier, high friction surface ✓ $^{2}/_{4}$	High overtaking zone, views obstructed on curves ✗ Low vehicle interaction, linemarking ✓ $^{2}/_{4}$	Site distance minimised by horizontal curves ✗ $^{2}/_{4}$	Site distance obstructed by vertical grades and horizontal curves, high farming population ✗ High friction surface to aid stopping capability, animal on road detection ✓ $^{2}/_{4}$	No pedestrians ✓ $^{0}/_{4}$	No cyclists ✓ $^{0}/_{4}$	Reverse curvature on high speed sections, vertical crests ✗ Roadside barrier, high friction surface ✓ $^{2}/_{4}$	
Severity	High speed ✗ Roadside barrier ✓ $^{2}/_{4}$	High risk behaviour ✗ $^{4}/_{4}$	High speed section ✗ $^{4}/_{4}$	High speed section ✗ $^{4}/_{4}$	No pedestrians ✓ $^{0}/_{4}$	No cyclists ✓ $^{0}/_{4}$	High speed section ✗ Roadside barrier ✓ $^{2}/_{4}$	Total
Product	$^{8}/_{64}$	$^{16}/_{64}$	$^{16}/_{64}$	$^{16}/_{64}$	$^{0}/_{64}$	$^{0}/_{64}$	$^{16}/_{64}$	$^{72}/_{448}$

Comparison of results

Table 27: CH124 430 – 127 350 Results Comparison

	ROR	HO	INT	Other	PED	CYC	M/C	
Baseline	24/64	16/64	16/64	24/64	0/64	0/64	24/64	104/448
After treatment	8/64	16/64	16/64	16/64	0/64	0/64	16/64	72/448

The comparison table for the section suggests the head-on and intersection risk has not been reduced after implementing the safety treatments. As the crash data does not indicate that these crash types are not problematic throughout this section on the Mulligan Highway, more attention is drawn to the significant reduction of run-off-road risk.

Evidently, The flexible barrier and OmniGrip combined in this section will significantly reduce the risk to road users in the likelihood and severity of a run-off-road type crash. The use of the RADS technology will also decrease the risk of animal interaction on the road. However, as human behaviour still plays a crucial role in how a driver reacts to the RADS technology, means that the RDAS will not decrease the severity of an animal collision outcome. All of the treatments applied in this section will have a significant impact on the reduction of road crashes.

CH59 390– CH63 220 Existing Conditions

The section between chainage 59 390 and 63 220 was selected for analysis due to the high number of accidents caused by collision with an animal. All crashes present in this section were as a result of hitting an animal during times of no light. The section experiences an average annual daily traffic between 500 – 10,000 vehicles per day (qldglobe, 2023). The existing features of the section are horizontal curvatures with dense bushland covering the roadside. In most sections, the combination of the curvature and bushland make it difficult to see even in light conditions. The safe systems matrix is assessed based on animal collision being the predominant issue seen in this section.

Table 28: CH59 390 – 63 220 Geometrical and Environmental Commentary

Imagery	Geometrical/ Environmental Comments
	Short sight distance due to obstructed views from curvature and roadside bushland. No street lighting

Mulligan Highway facing North	
 Mulligan Highway facing North (2)	Views obstructed by vertical crest. No street lighting

Chainage 59 390 – 63 220: Safe System matrix – Current Condition

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	High exposure $^3/_4$	High exposure ✗ $^3/_4$	No intersections ✓ $^0/_4$	High exposure ✗ $^3/_4$	No pedestrians ✓ $^0/_4$	Low cyclist volumes ✓ $^1/_4$	Moderate motorcycle volumes ✗ $^2/_4$	
Likelihood	No lighting, steep horizontal curvature with obstructed view ✗ Guideposts, sealed shoulder ✓ $^3/_4$	High overtaking zone, no lighting Linemarking ✓ $^3/_4$	No intersections ✓ $^0/_4$	Site distance minimised at night, obstructed views, high farming population surrounding ✗ $^4/_4$	No pedestrians ✓ $^0/_4$	No cyclist lane ✗ No crossing facilities ✗ $^2/_4$	Sealed road ✓ Steep curvature ✗ $^3/_4$	
Severity	High speed, frequent traffic, dense bushland, no roadside barrier ✗ $^4/_4$	High speed ✗ $^4/_4$	No intersections ✓ $^0/_4$	High speed section ✗ $^4/_4$	No pedestrians ✓ $^0/_4$	High speed sections ✗ $^4/_4$	Dense bushland, high speed ✗ $^4/_4$	Total
Product	$^{36}/_{64}$	$^{36}/_{64}$	$^0/_{64}$	$^{48}/_{64}$	$^0/_{64}$	$^8/_{64}$	$^{24}/_{64}$	$^{152}/_{448}$

Table 29: CH59 390 - 63 220 Additional Safety Components

Additional Safe System Components	Prompts	Comments
Road User	Are road users likely to be alert and compliant, or are there factors that might influence this? What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours) and what is the likelihood of driver fatigue? Are there special road uses (e.g. entertainment precincts, elderly, children, on-road activities), distraction by environmental factors (e.g. commerce, tourism), or risk-taking behaviours?	• Rural highway typically involves high speeding drivers • Long distance between towns – fatigued drivers
Vehicle	What level of alignment is there with the ideal of safer vehicles? Are there factors which might attract large numbers of unsafe vehicles? Is the percentage of heavy vehicles too high for the proposed/existing road design? Are there enforcement resources in the area to detect nonroadworthy, overloaded or unregistered vehicles and thus remove them from the network?	• Heavy presence of farming surrounds • High percentage of heavy vehicles i.e. road trains and cattle farming equipment • Nearby rural town
Post Crash Care	Are there issues that might influence safe and efficient post-crash care in the event of a severe injury? Do emergency and medical services operate as efficiently and rapidly as possible? Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there provision for e-safety (i.e. safety systems based on modern information and communication technologies, C-ITS)?	• Moderate distance to emergency facilities • Accessible for emergency vehicles • Remote area – may not receive immediate required emergency care (hospitals)

CH54 850 – CH66 000: RADS, OmniGrip and Bioluminescent Linemarking

The objective is to assess if the section between chainage 54 850 and 66 000 aligns with the Safe System objective once implmented with Roadside Animal Detection, OmniGrip high friction surface, and bioluminscent linemarking. Due to the only accident causation being animal collision on this section, the RADS system has been employed as a safety treatment to target this specific problem.

Chainage 59 390 – 63 220: Safe System Matrix – After RADS, OmniGrip and Bioluminescent Linemarking

	ROR	HO	INT	OTHER	PED	CYC	M/C	
Exposure	High exposure $^3/_4$	High exposure ✗ $^3/_4$	No intersections ✓ $^0/_4$	High exposure ✗ $^3/_4$	No pedestrians ✓ $^0/_4$	Low cyclist volumes ✓ $^1/_4$	Moderate motorcycle volumes ✗ $^2/_4$	
Likelihood	No lighting, steep horizontal curvature with obstructed view ✗ Guideposts, sealed shoulder ✓ Carriageway visible at night ✓ $^2/_4$	High overtaking zone, no lighting Linemarking ✓ Centreline visible at night ✓ $^2/_4$	No intersections ✓ $^0/_4$	Site distance minimised at night, obstructed views, high farming population surrounding ✗ RADS to alert animal activity on road ✓ $^2/_4$	No pedestrians ✓ $^0/_4$	No cyclist lane ✗ No crossing facilities ✗ $^2/_4$	Sealed road ✓ Steep curvature ✗ Carriageway visible at night ✓ $^2/_4$	
Severity	High speed, frequent traffic, dense bushland, no roadside barrier ✗ $^4/_4$	High speed ✗ $^4/_4$	No intersections ✓ $^0/_4$	High speed section ✗. High friction surface to help stopping vehicle ✓ $^3/_4$	No pedestrians ✓ $^0/_4$	High speed sections ✗ $^4/_4$	Dense bushland, high speed ✗ $^4/_4$	Total
Product	$^{24}/_{64}$	$^{24}/_{64}$	$^0/_{64}$	$^{18}/_{64}$	$^0/_{64}$	$^8/_{64}$	$^{16}/_{64}$	$^{90}/_{448}$

Comparison of results

Table 30: CH59 390 – 63 220 Results Comparison

	ROR	HO	INT	Other	PED	CYC	M/C	
Baseline	$^{36}/_{64}$	$^{36}/_{64}$	$^{0}/_{64}$	$^{48}/_{64}$	$^{0}/_{64}$	$^{8}/_{64}$	$^{24}/_{64}$	$^{152}/_{448}$
After treatment	$^{24}/_{64}$	$^{24}/_{64}$	$^{0}/_{64}$	$^{18}/_{64}$	$^{0}/_{64}$	$^{8}/_{64}$	$^{16}/_{64}$	$^{90}/_{448}$

The baseline condition for this road section along the Mulligan Highway portrays a significantly out of safe systems objectives scope. The high risk of animal collision is demonstrated along this section, with a clear risk of other crash types as well. The treated option specifically targets the risk of animal collision by implementing the RADS technology with the OmniGrip high friction surface implemented as a vehicle stopping control. With the added benefit of the bioluminescent line marking, drivers will be able to exercise further caution when approaching curvature.

Further treatments options may be explored to reduce the scoring for run-off-road and head-on type crashes, however, as the data suggests, those particular road crashes were not historically risks for this section of road. As demonstrated in previous assessments, the flexible roadside barrier proves to be an excellent option to reduce run-off-road and head-on crash types.

4.5 Crash Modification Factors

The crash modification factors have been developed in accordance with the Austroads Guide to Road Safety Part 2: Safe Roads. With reference to Appendix D, the following analysis of the crash-modification factors has been completed.

In this analysis, the aim is to compare the crash modification factors (CMFs) associated with the discussed safety treatments: Bioluminscent Linemarking, OmniGrip surfacing, Flexible barriers, and RADS technology. CMFs provide valuable insights into the effectiveness of these treatments in reducing crash risk, and this comparison is essential for making informed decisions regarding their implementation.

Treatment A: Bioluminscent Linemarking

The CMF for Treatment A, which involves applying bioluminescent linemarking on sealed roads, was found to be 0.85. From the Austroads crash modification factors table for various countermeasure, road Delineation is expected to reduce off-road crashes by 15% on curves and straights. This reduction is low, however when combined with other treatments, it may contribute to a significant reduction in crashes.

Treatment B: OmniGrip High Friction Surface

Treatment B involves the sealing of roads with OmniGrip high friction surface pavements. The CMF for this treatment is 0.43 for all crash types and 0.279 for run-off-road type crashes (both evaluated on curves). These crash modification factors have been developed by Merritt, Lyon, and Persaud in the research publication for the development of crash-modification factors for high friction surface treatments. This figure suggests that OmniGrip can reduce a crash outcome by 72% on curvature and 57% for all road crash types. This reduction is statistically significant and indicates this treatment will be very effective if implemented in rural Far North Queensland.

Treatment C: Flexible Barriers

From the Austroads crash modification factors table, wired rope safety barriers have a CMF of 0.15 for roadside treatments for run-off-road crashes and 0.1 for run-off-road (hit object) type crashes for both curved and straight sections. This indicates a significant impact for road crashes, making the overall reduction for run-off-road crash types greater than 85%. This treatment evidently will create safer roads when implemented in problematic sections.

Treatment D: Roadside Animal Detection System

A study by Marcel P. Huijser and Christa Mosler-berger found that the use of animal warning signs that are time specific can have a CMF of 0.66. This indicates a crash reduction of up to 36%. The limitation of the RADS technology is also the high impact driver behaviour has for the system to improve safety.

Application of multiple safety treatments

Throughout the analysis of the safe systems assessment, multiple combinations of the safety treatments were used to increase the safe systems objectives in each section. Using the crash-modification factors for each treatment, a further conclusion can be drawn for the operational effectiveness of each treatment application for each section of road assessed. The combinations of CMF's seen throughout the assessment can be described below:

Flexible Barriers: CMF of 0.1 – 0.15. An overall crash reduction of 90 – 85%.

OmniGrip HFST and Bioluminscent Line marking: 0.43 x 0.85 = 0.365. An overall crash reduction of 64%.

Flexible Barriers and Bioluminscent Line marking: 0.15 x 0.85 = 0.13. An overall crash reduction of 87%.

OmniGrup HFST + Flexible barriers + Bioluminescent Line marking: 0.43 x 0.15 x 0.85 = 0.055. An overall crash reduction of greater than 95%.

Roadside Animal Detection System + OmniGrip HFST + Bioluminscent Line marking: 0.66 x 0.43 x 0.15 = 0.05. An overall crash reduction of 95%.

4.6 Discussion

4.6.1 Research Limitations

Due to the minimal research conducted on rural Far North Queensland, limited evidence is supported for the direct crash causation. Assumptions can be drawn from the crash type i.e. run-off-road casualty types and used to form the argument that the road geometry plays a crucial role in road crash accidents. Assessment of a road crash can include numerous amounts of crash factors including weather; visibility at the time of the crash; driver influence (phone use, distractions etc.); road seal condition; and driver conducts such as swerving or speeding. The information provided by the Queensland Data portal, provides vague analysis of the crash and influencing factors. It is impossible to assume the exact actions of a driver prior to the incident Data provided for crash locations is separated from human factor statistics, therefore rendering the data difficult to draw a direct correlation between human behaviour and the crash type. The conclusions drawn from the crash causation have been assessed with the assumption that driver factors contributed minimally to the crash outcome. The Safe System Framework accounts for driver behaviour and works to reduce the impact of the crash, by crash type and the external factors that influence the severity of the outcome.

4.6.2 Methodology Limitations

As the research has been conducted on rural and isolated roads, the physical inspection of the sites was conducted via Google Earth and Google Maps. While these programs provide a general assessment of the environmental conditions of the road sections, true analysis of the crash type should be conducted in similar conditions to the time of the road crash. Limitations were presented where Google imagery could not provide an accurate understanding of the visibility standards during low light hours. This created difficulty to conclude when a crash was directly influenced by site visibility standards and instead assumptions were drawn from presented research relating road crashes and site distance issues, and evidence of little to no manmade lighting sources. Limitations also exist in the assessment of the geometrical compliance of each road section. Given no assessment could be conducted to formally analyse curvature or grading against the Austroads standards, no conclusion could be drawn from non-compliance as a direct crash causation. Instead, the methodology focuses on the current infrastructure, compliant or not, and the link to the crash outcome influenced by external factors.

4.6.3 Results Discussion

Each of the identified sections have been assessed against the Austroads Safe System framework and have individual conclusions drawn. Overall, the implementation of the recognised innovative treatments significantly reduced the likelihood and severity of run-off-road, head-on, and animal collision crash types.

For run-off-road type crashes, the flexible safety barrier proved to consistently reduce the likelihood and severity of the type of crash in each section. The flexible barrier can serve as a roadside barrier or as a centreline median to separate carriageway lanes, as seen in the application on the Bruce Highway assessment. Evidently, the occurrence of run-off-road crashes are high in rural Far North Queensland and the presence of roadside barriers is little to none. With evidence of the flexible barrier reducing road crash severity by up to 95 percent (roadsonline.com, 2018), there is little acknowledgement for the application of the treatment in rural locations. A small feasibility analysis indicates a flexible barrier may cost up to $20,000 per kilometre (roadsonline, 2018). By assessing problematic sections of road, specific chainages have been identified to provide accurate locations for the installation of the flexible barrier without suggesting unnecessarily high-cost projects. Concerns may be present in the maintenance of the barriers, as the roadsonline article suggests, a damaged barrier will need to be repaired after each impact. Flexible barriers located in regional areas may take two hours to repair with readily available personnel, but remote areas will have a far greater delay due to travel time and equipment availability.

Assessment of the crash-modification factors indicated that the use of multiple treatments significantly reduced the crash impact. Analysing the feasibility of multiple treatments in one section of rural highway networks may be out of scope for many rural funding projects. However, treatment specific to crash type should be considered as the CMFs for all treatments are relatively high. Excluding the bioluminescent line marking, which was relatively low in comparison to other treatment options. This can be due to line marking having no impact on the severity of a crash out come and is still heavily influenced by the driver behaviours. From the crash-modification assessment, it can be concluded that the implementation of flexible barriers alone would significantly reduce the crash likelihood and outcome by 85 – 90% as an individual treatment (dependant on use).

Overall, the analysis of the safety treatments proves that the implementation of innovative treatments in rural areas will significantly increase the safety of the roads. The safe system matrix, while not completely aligned to the safe system objectives, shows a reduction in the likelihood and severity of road crashes – run-off-road type crashes specifically.

Chapter 5 – Conclusion

In conclusion, this research has explored the intricate dynamics of rural road safety in depth. Through an extensive review of existing literature and the analysis of available data, valuable insights have been identified.

One of the primary contributions of this study is the identification of rural road crash causations, which significantly advances our understanding of safety treatment implementation. Finding that a primary causation for rural Far North Queensland road casualties is run-off-road type crashes, underscores the need for further safety methods that enhance the safety for road users specifically towards this risk. This study has provided a linkage between geometric and environmental factors and the outcome of rural road crashes. By investigating previous research, it has identified that regardless of human behaviours, the risk of run-off-road, head-on, and animal collisions is still very persistent in the number of lives claimed on rural Far North Queensland roads.

Furthermore, this research has shed light on key advancements in rural road safety that could serve as lifesaving treatments in some areas. Comparison of these treatments with current safety treatments reveals that most assessed road section hazards were reduced significantly. While the complete elimination of the crash risk was not identified, the likelihood of any advanced treatment able to fulfil this requirement is seemingly impossible. Given road crash outcomes are influenced by more than geometric and environmental factors, it is highly unlikely road crashes will be eliminated from safety treatments alone. This research does, however, highlight that crash likelihood and severity can be reduced significantly with the relevant treatments for the identified crash causation. This insight has practical implications for future of Road Design Engineers and underscores the importance of considering innovative technologies in future decision-making processes.

In conclusion, this thesis has made significant strides in advancing the knowledge of rural road safety. It has uncovered the importance of considering external factors in road design. important insights but also paved the way for future research and practical applications. Moving forward, this research intends to inspire further exploration and innovation in the field of rural road safety in Far North Queensland.

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Appendix A – Project Specification

ENG4111/4112 Research Project

Project Specification

For:	Rikki Jaye Hartley
Title:	Comparative analysis of the effectiveness of current and innovative road safety countermeasures implemented in Far North Queensland
Major:	Civil Engineering
Supervisors:	Hannah Seligmann
Enrolment:	ENG4111 – ONL, 2023 ENG4112 – ONL, 2023
Project Aim:	To compare current road safety treatments with innovative safety methods implemented on rural highways and identify the overall risk ratings of innovative technologies.
Programme:	Version 1, 15th March 2023

1. Source the Road Crash Data for select regional road networks in Far North Queensland: Palmerston Highway and Kennedy Highway
2. Compare crash data to identify problematic Roads and crash causations
3. Diagnose the crash problem using road crash data (cause) and site investigations. Present data in graphical formats to demonstrate rural road factors (dominant traffic type, leading crash type, age groups, environmental factors). Assess the road geometry against the Austroad Guide for sections where geometrical or visual factors were present
4. Identify what treatments are currently in place; their effectiveness to be assessed during the below stage
5. Conduct Safety Treatment selection and design process in accordance with the Austroads Guidelines and rank the safety treatments as a result of the Safety Systems Assessment Framework
6. Conduct literature review on current innovations used in trials or previous trials for improved road safety. Literature review to consider road types, traffic type, and environmental factors differentiating between the trial sites and Far North Queensland
7. Conduct Safety Treatment selection and design process in accordance with the Austroads Guidelines and rank the safety treatments as a result of the Safety Systems Assessment Framework
8. Comparison between the results from the Safe Systems Framework
9. Final conclusions drawn from the comparison

If time permits:

- *Conduct site inspections of problematic road sections*
- *Include cost and feasibility of current safety treatments to include in comparison analysis*

Project Resources

Planning:

- Purchase subscription for AutoCAD for centreline analysis
    - AutoCAD has student subscriptions – check access timeframe
- Access and save locally, required Austroad Guidelines
    - Reference to any AS needs to be checked for availability via Student Library
- Access to exemplar reports on using the Safe Systems Assessment Framework
- Access to other subscriptions i.e. Microsoft packages
- Organised and agreed meeting times with Supervisor
    - Currently scheduled for Monday afternoons
    - Consider future availability – work commitments, leave, other factors. Ensure ample notice where possible to supervisor
- Research Project Risk Assessment

Literature Review:

- Austroad Guidelines:
    - AP-R509-16 Safe Systems Assessment Framework
    - Guide to Road Design (Part 3 & 6)
    - Guide to Road Safety
- Access publications on current testing and trials for innovations
- Austroads Online Publications:
    - Road Safety Engineering Risk Assessment Part 1 – 10
    - Effectiveness of Road Safety Engineering Treatments

Site Inspection:

- Site inspections will need to be conducted on weekends
    - Budget time allowance across multiple weekends if needing to inspect multiple sites
- Schedule for delays i.e. weather events, road closures, other issues etc.
- Access the required equipment for site inspections
    - Tape measure; camera; clipboard; PPE

Supplementary Material

1. Data Collection:
    a. Excel file consisting of Pivot Table filtered road crash data from 2011 – 2021
    b. One Safe System Assessment exemplar report
2. Reference material / literature review
    a. Safe System Assessment matrix

Appendix B – Department of Transport and Main Roads: Queensland Road Crash Weekly Report

Queensland Road Crash Weekly Report

Report No: 1341

Data Extracted: 9 Oct 2023

Fatalities: Year to Date to Sunday, 8 October 2023

Table 1: Comparative Queensland Road Fatalities

	2018	2019	2020	2021	2022	2023	Variation in 2023 from 2022		Variation in 2023 from the 2018 to 2022 Avg	
	Year to Date to 8 October						no.	%	no. [1]	%
Total fatal crashes	**178**	**152**	**179**	**190**	**212**	**211**	**-1**	**-0.5%**	**29**	**15.8%**
Total fatalities	**196**	**170**	**202**	**211**	**226**	**222**	**-4**	**-1.8%**	**21**	**10.4%**
Driver fatalities	97	85	90	92	116	105	-11	-9.5%	9	9.4%
Passenger fatalities	37	29	41	46	35	28	-7	-20.0%	-10	-25.5%
Motorcycle/Moped rider and pillion fatalities	34	35	39	54	54	64	10	18.5%	21	48.1%
Bicycle rider and pillion fatalities	3	5	7	5	2	4	2	100.0%	0	-9.1%
Personal mobility device user fatalities[2]	-	-	-	-	0[2]	1	-	-	-	-
Pedestrian fatalities	25	15	25	14	19	20	1	5.3%	0	2.0%
Other fatalities[3]	0	1	0	0	0	0	0	-	0	-100.0%
Fatalities involving heavy freight vehicles[4]	43	29	29	42	44	49	5	11.4%	12	31.0%

Note:

Figures are preliminary.

[1] Figures are rounded to the nearest whole number.

[2] Personal mobility device users were recorded as pedestrians prior to 1 November 2022

[3] Includes other fatalities such as horse riders and train drivers and passengers.

[4] Includes all fatalities as a result of crashes involving heavy freight vehicles. These figures are also included in the road user type breakdown above (e.g. drivers, passengers, etc).

During 1 January to 8 October 2023, there were 222 fatalities as a result of crashes within Queensland, which is four fatalities (or 1.8%) fewer than the same period for the previous year and 21 fatalities (or 10.4%) greater than the previous five year average for the same period (Table 1).

Figure 1: Cumulative Daily Road Fatalities, Queensland

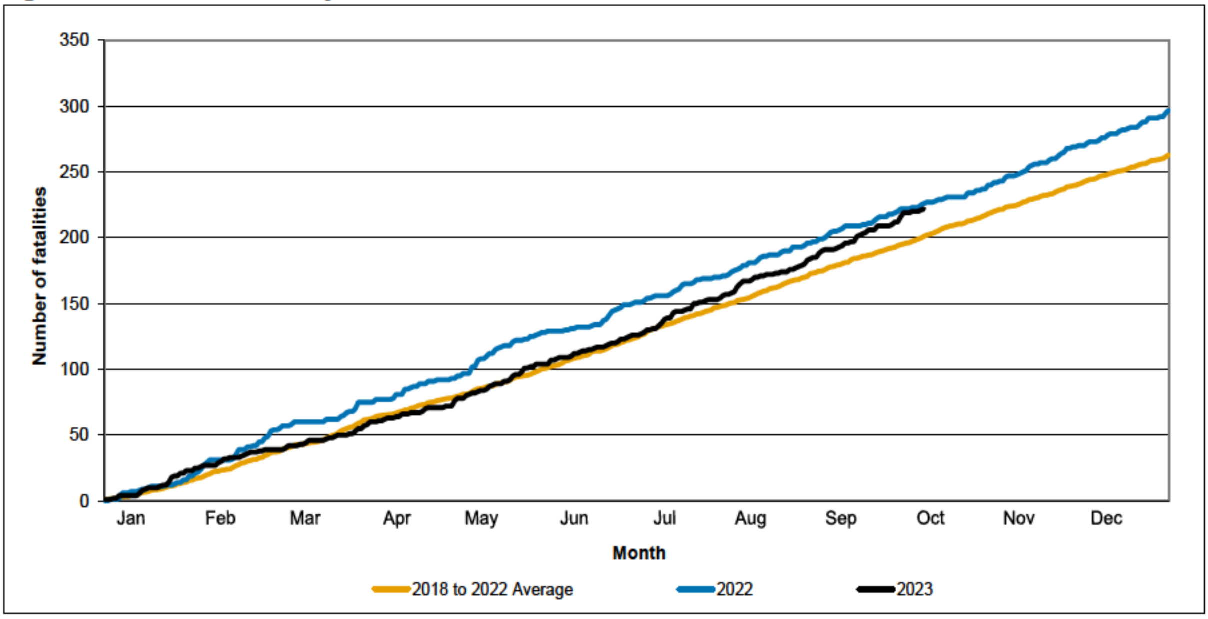


Table 2: Fatalities by Police Region

Police Region	2018	2019	2020	2021	2022	2023	Variation in 2023 from 2022		Variation in 2023 from the 2018 to 2022 Avg	
	Year to Date to 8 October						no.	%	no.*	%
Brisbane	24	20	18	28	22	18	-4	-18.2%	-4	-19.6%
Central	23	20	28	23	44	27	-17	-38.6%	-1	-2.2%
Far Northern	18	21	19	15	25	13	-12	-48.0%	-7	-33.7%
North Coast	52	35	52	54	47	65	18	38.3%	17	35.4%
Northern	12	18	21	22	12	14	2	16.7%	-3	-17.6%
South Eastern	26	12	30	29	25	34	9	36.0%	10	39.3%
Southern	41	44	34	40	51	51	0	0.0%	9	21.4%

Note:
Figures are preliminary.
Where Police Region was known.
** Figures are rounded to the nearest whole number.*

Table 3: Fatalities by TMR Customer Services Branch Region

Transport and Main Roads Customer Services Branch Region	2018	2019	2020	2021	2022	2023	Variation in 2023 from 2022		Variation in 2023 from the 2018 to 2022 Avg	
	Year to Date to 8 October						no.	%	no.*	%
Central	23	20	29	24	44	27	-17	-38.6%	-1	-3.6%
Northern	30	39	40	37	37	27	-10	-27.0%	-10	-26.2%
SEQ North	32	35	33	35	40	42	2	5.0%	7	20.0%
SEQ South	55	33	50	56	58	61	3	5.2%	11	21.0%
Southern	56	43	50	59	47	65	18	38.3%	14	27.5%

Note:
Figures are preliminary.
Where CSB Region was known.
** Figures are rounded to the nearest whole number.*

Table 4: Fatalities by TMR Program Delivery and Operations Region

Transport and Main Roads Program Delivery and Operations Region	2018	2019	2020	2021	2022	2023	Variation in 2023 from 2022		Variation in 2023 from the 2018 to 2022 Avg	
	Year to Date to 8 October						no.	%	no.*	%
Central Queensland	23	20	29	24	44	27	-17	-38.6%	-1	-3.6%
Metropolitan	27	22	22	30	32	26	-6	-18.8%	-1	-2.3%
North Coast	27	29	27	30	36	34	-2	-5.6%	4	14.1%
North Queensland	30	39	40	37	37	27	-10	-27.0%	-10	-26.2%
South Coast	30	14	32	29	28	39	11	39.3%	12	46.6%
Southern Queensland	59	46	52	61	49	69	20	40.8%	16	29.2%

Note
Figures are preliminary.
Where PDO Region was known.
** Figures are rounded to the nearest whole number.*

Fatalities: 1 January 2017 to 31 December 2022 and Year to Date to 31 May 2023

Table 5: Fatalities by characteristic

Behaviour / Characteristic: Fatalities as a result of crashes 1 January 2017 to 31 December 2022 and Year to Date to 31 May 2023	2017	2018	2019	2020	2021	2022		Variation in 2022 from 2021		Variation in 2022 from the 2017 to 2021 Avg		Year to Date to 31 May 2023	
	no.	no.	no.	no.	no.	no.	%	no.	%	no.*	%	no.	%
All fatalities	**247**	**245**	**220**	**278**	**275**	**297**	**-**	**22**	**8.0%**	**44**	**17.4%**	**104**	**-**
Involving speeding drivers/riders	52	51	51	69	78	88	29.6%	10	12.8%	28	46.2%	29	27.9%
Involving drink drivers/riders	63	43	46	62	64	65	21.9%	1	1.6%	9	16.9%	13	12.5%
Involving drug drivers/riders~	28	42	43	68	53	61	20.5%	8	15.1%	14	30.3%	25	24.0%
Involving distracted/inattentive drivers/riders	38	33	22	26	24	33	11.1%	9	37.5%	4	15.4%	14	13.5%
Fatigue related crashes (involving drivers/riders)	23	30	30	33	42	33	11.1%	-9	-21.4%	1	4.4%	12	11.5%
Involving young adult drivers/riders, aged 16 to 24 years	73	61	69	81	79	74	24.9%	-5	-6.3%	1	1.9%	34	32.7%
Involving young adult drivers/riders, aged 16 years	1	0	4	1	0	2	0.7%	2	-	1	66.7%	0	0.0%
Involving young adult drivers/riders, aged 17 to 20 years	28	30	42	32	49	33	11.1%	-16	-32.7%	-3	-8.8%	20	19.2%
Involving young adult drivers/riders, aged 21 to 24 years	46	31	24	49	34	40	13.5%	6	17.6%	3	8.7%	15	14.4%
Involving senior adult drivers/riders, aged 60 to 74 years	58	62	46	49	50	76	25.6%	26	52.0%	23	43.4%	19	18.3%
Involving senior adult drivers/riders, aged 75 years or over	24	18	24	24	17	26	8.8%	9	52.9%	5	21.5%	9	8.7%
Involving learner drivers/riders	9	7	9	10	14	8	2.7%	-6	-42.9%	-2	-18.4%	6	5.8%
Involving provisional/P1/P2 drivers/riders	30	37	43	34	46	47	15.8%	1	2.2%	9	23.7%	9	8.7%
Involving unlicensed drivers/riders	20	26	24	37	39	40	13.5%	1	2.6%	11	37.0%	18	17.3%
Involving heavy freight vehicles	33	53	36	47	53	52	17.5%	-1	-1.9%	8	17.1%	24	23.1%
Involving motorcycles (excluding mopeds)	50	41	44	55	67	72	24.2%	5	7.5%	21	40.1%	34	32.7%
Involving mopeds	1	2	2	0	0	2	0.7%	2	-	1	100.0%	0	0.0%
Involving buses	10	5	0	3	3	4	1.3%	1	33.3%	0	-4.8%	0	0.0%
Child road user fatalities, aged 16 years or younger^	6	12	14	15	14	17	5.7%	3	21.4%	5	39.3%	3	2.9%
Young adult road user fatalities, aged 17 to 24 years^	47	45	53	49	48	51	17.2%	3	6.3%	3	5.4%	22	21.2%
Mature adult road user fatalities, aged 25 to 59 years^	126	124	98	148	153	151	50.8%	-2	-1.3%	21	16.3%	57	54.8%
Senior adult road user fatalities, aged 60 to 74 years^	33	43	31	38	31	45	15.2%	14	45.2%	10	27.8%	16	15.4%
Senior adult road user fatalities, aged 75 years or over^	35	20	24	28	28	33	11.1%	5	17.9%	6	22.2%	6	5.8%
Vehicle occupant fatalities	153	162	150	183	178	188	-	10	5.6%	23	13.8%	55	-
Vehicle occupant fatalities, where restraint use was known	125	112	110	139	147	144	-	-3	-2.0%	17	13.7%	44	-
Unrestrained vehicle occupant fatalities#	32	31	28	43	40	40	27.8%	-	2.1%	-	1.1%	15	34.1%

Note:

Figures are preliminary.
** Figures are rounded to the nearest whole number.*
^ Where age was known.
~ Drug driving figures for fatal crashes are available from 1 January 2017, therefore figures have been compared against the previous four year average.
 # Restraint use is not applicable for all road user types (i.e. pedestrians, motorcycle riders/pillions, etc) and is not always known. Therefore the variation in unrestrained vehicle occupant casualties is measured as a change in the percentage of all vehicle occupant casualties, instead of the change in number, where restraint use was known.

Fatalities per 100,000 population: 12 months to 31 August 2023

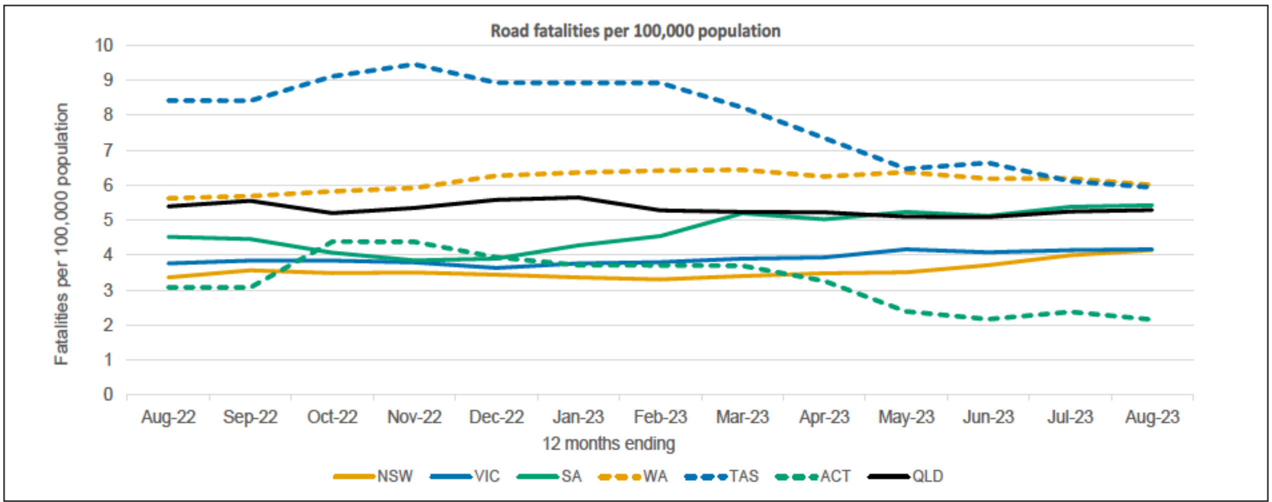
Table 6: Fatalities per 100,000 population, by state

State	September 2021 to August 2022			September 2022 to August 2023			Percentage difference in rate with previous 12 month period
	Fatalities	Population ('000) as at Feb 2022	Fatalities per 100,000 population	Fatalities	Population ('000) as at Feb 2023	Fatalities per 100,000 population	
Queensland	285	5,283.2	5.39	286	5,406.3	5.29	-1.9%
New South Wales	273	8,125.5	3.36	343	8,277.1	4.14	23.3%
Victoria	248	6,591.9	3.76	281	6,748.7	4.16	10.7%
South Australia	82	1,812.2	4.52	100	1,841.4	5.43	20.0%
Western Australia	156	2,772.5	5.63	171	2,846.9	6.01	6.8%
Tasmania	48	569.7	8.43	34	572.5	5.94	-29.5%
Northern Territory	49	249.1	19.67	22	251.3	8.76	-55.5%
Australian Capital Territory	14	454.7	3.08	10	463.4	2.16	-29.9%
Rest of Australia	870	20,580.5	4.23	961	21,006.2	4.57	8.2%
Australian Total	1,155	25,863.7	4.47	1,247	26,412.5	4.72	5.7%

Data source:
Population: Australian Bureau of Statistics - Catalog 3101.0
Interstate fatalities: Relevant State Authority

Note:
Figures are preliminary

Figure 2: Road fatalities per 100,000 population, Australia



For the 12 month period, 1 September 2022 to 31 August 2023:

- There were 286 fatalities within Queensland, which is one fatality (or 0.4%) greater than the previous 12 month period (285).
- The road fatality rate for Queensland was 5.29 fatalities per 100,000 population which is 1.9% lower than the previous 12 month period (5.39) and is fourth behind the Australian Capital Territory (2.16), New South Wales (4.14) and Victoria (4.16).
- There were 1,247 fatalities within Australia, which is 92 fatalities (or 8.0%) greater than the previous 12 month period (1,155).
- The road fatality rate for Australia was 4.72 fatalities per 100,000 population which is 5.7% higher than the previous 12 month period (4.47).

Hospitalised Casualties: 1 January to 31 December 2022

Table 7: Comparative Queensland Hospitalised Casualties

	2017	2018	2019	2020	2021	2022	Variation in 2022 from 2021		Variation in 2022 from the 2017 to 2021 Avg	
							no.	%	no. [1]	%
Total hospitalisation crashes	**5,307**	**5,556**	**5,654**	**5,695**	**6,336**	**6,048**	**-288**	**-4.5%**	**338**	**5.9%**
Total hospitalised casualties	**6,515**	**6,821**	**7,016**	**7,007**	**7,905**	**7,590**	**-315**	**-4.0%**	**537**	**7.6%**
Driver hospitalised casualties	3,558	3,839	3,945	3,977	4,647	4,273	-374	-8.0%	280	7.0%
Passenger hospitalised casualties	1,225	1,279	1,357	1,317	1,408	1,484	76	5.4%	167	12.7%
Motorcycle/Moped rider and pillion hospitalised casualties	967	1,003	1,005	1,016	1,076	1,009	-67	-6.2%	-4	-0.4%
Bicycle rider and pillion hospitalised casualties	391	344	356	368	353	354	1	0.3%	-8	-2.3%
Personal mobility device user hospitalised casualties	-	-	-	-	-	24[2]	-	-	-	-
Pedestrian hospitalised casualties	362	346	336	318	399	434	35	8.8%	82	23.2%
Other hospitalised casualties[3]	12	10	17	11	22	12	-10	-45.5%	-2	-16.7%
Hospitalised casualties involving heavy freight vehicles[4]	445	494	501	454	505	536	31	6.1%	56	11.7%

Note:

Figures are preliminary.

[1] Figures are rounded to the nearest whole number.

[2] Personal mobility device users were recorded as pedestrians prior to 1 November 2022

[3] Includes other hospitalised casualties such as horse riders and train drivers and passengers.

[4] Includes all hospitalised casualties as a result of crashes involving heavy freight vehicles. These figures are also included in the road user type breakdown above (e.g. drivers, passengers, etc).

During 1 January to 31 December 2022, there were 7,590 hospitalised casualties as a result of crashes within Queensland, which is 315 hospitalised casualties (or 4.0%) fewer than the previous year and 537 hospitalised casualties (or 7.6%) greater than the previous five year average (Table 7).

Figure 3: Cumulative Daily Hospitalised Casualties, Queensland

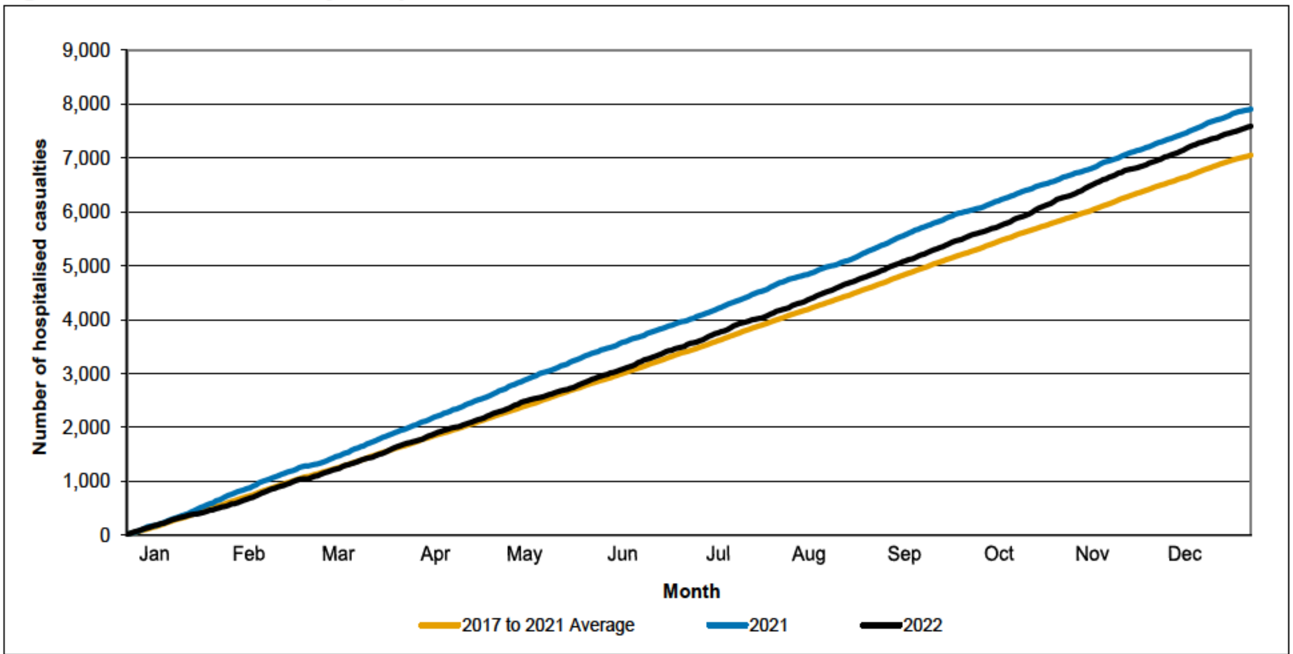


Table 8: Hospitalised Casualties by Police Region

Police Region	2017	2018	2019	2020	2021	2022	Variation in 2022 from 2021		Variation in 2022 from the 2017 to 2021 Avg	
							no.	%	no.*	%
Brisbane	1,535	1,614	1,620	1,496	1,650	1,535	-115	-7.0%	-48	-3.0%
Central	723	739	773	818	942	854	-88	-9.3%	55	6.9%
Far Northern	469	513	513	462	517	488	-29	-5.6%	-7	-1.4%
North Coast	1,284	1,356	1,454	1,532	1,598	1,577	-21	-1.3%	132	9.2%
Northern	418	421	417	452	521	496	-25	-4.8%	50	11.3%
South Eastern	1,241	1,274	1,238	1,250	1,576	1,523	-53	-3.4%	207	15.7%
Southern	845	904	1,001	997	1,101	1,115	14	1.3%	145	15.0%

Note:
Figures are preliminary.
Where Police Region was known.
** Figures are rounded to the nearest whole number.*

Table 9: Hospitalised Casualties by TMR Customer Services Branch Region

Transport and Main Roads Customer Services Branch Region	2017	2018	2019	2020	2021	2022	Variation in 2022 from 2021		Variation in 2022 from the 2017 to 2021 Avg	
							no.	%	no.*	%
Central	730	746	785	821	949	860	-89	-9.4%	54	6.7%
Northern	881	928	925	912	1,034	981	-53	-5.1%	45	4.8%
SEQ North	1,570	1,666	1,715	1,710	1,802	1,821	19	1.1%	128	7.6%
SEQ South	2,450	2,563	2,595	2,529	2,974	2,909	-65	-2.2%	287	10.9%
Southern	884	918	996	1,035	1,146	1,017	-129	-11.3%	21	2.1%

Note:
Figures are preliminary.
Where CSB Region was known.
** Figures are rounded to the nearest whole number.*

Table 10: Hospitalised Casualties by TMR Program Delivery and Operations Region

Transport and Main Roads Program Delivery and Operations Region	2017	2018	2019	2020	2021	2022	Variation in 2022 from 2021		Variation in 2022 from the 2017 to 2021 Avg	
							no.	%	no.*	%
Central Queensland	730	746	785	821	949	860	-89	-9.4%	54	6.7%
Metropolitan	1,729	1,806	1,879	1,720	1,912	1,845	-67	-3.5%	36	2.0%
North Coast	951	1,028	1,078	1,131	1,154	1,242	88	7.6%	174	16.2%
North Queensland	881	928	925	912	1,034	981	-53	-5.1%	45	4.8%
South Coast	1,278	1,301	1,272	1,291	1,607	1,548	-59	-3.7%	198	14.7%
Southern Queensland	946	1,012	1,077	1,132	1,249	1,112	-137	-11.0%	29	2.7%

Note
Figures are preliminary.
Where PDO Region was known.
** Figures are rounded to the nearest whole number.*

Hospitalised Casualties: 1 January 2017 to 31 December 2022

Table 11: Hospitalised Casualties by Characteristic

Behaviour / Characteristic: Hospitalised casualties as a result of crashes	2017	2018	2019	2020	2021	2022		Variation in 2022 from 2021		Variation in 2022 from the 2017 to 2021 Avg	
1 January 2017 to 31 December 2022	no.	no.	no.	no.	no.	no.	%	no.	%	no.*	%
All hospitalised casualties	**6,515**	**6,821**	**7,016**	**7,007**	**7,905**	**7,590**	**-**	**-315**	**-4.0%**	**537**	**7.6%**
Involving speeding drivers/riders	297	380	338	389	451	480	6.3%	29	6.4%	109	29.4%
Involving drink drivers/riders	643	621	634	803	891	817	10.8%	-74	-8.3%	99	13.7%
Involving drug drivers/riders	214	180	263	345	273	259	3.4%	-14	-5.1%	4	1.6%
Involving distracted/inattentive drivers/riders	1,127	1,361	1,482	1,488	1,644	1,730	22.8%	86	5.2%	310	21.8%
Fatigue related crashes (involving drivers/riders)	405	470	479	474	544	541	7.1%	-3	-0.6%	67	14.0%
Involving young adult drivers/riders, aged 16 to 24 years	2,098	2,187	2,221	2,437	2,613	2,408	31.7%	-205	-7.8%	97	4.2%
Involving young adult drivers/riders, aged 16 years	55	40	52	54	66	60	0.8%	-6	-9.1%	7	12.4%
Involving young adult drivers/riders, aged 17 to 20 years	1,051	1,110	1,165	1,304	1,387	1,293	17.0%	-94	-6.8%	90	7.4%
Involving young adult drivers/riders, aged 21 to 24 years	1,076	1,104	1,105	1,182	1,258	1,168	15.4%	-90	-7.2%	23	2.0%
Involving senior adult drivers/riders, aged 60 to 74 years	1,201	1,271	1,386	1,206	1,495	1,466	19.3%	-29	-1.9%	154	11.8%
Involving senior adult drivers/riders, aged 75 years or over	439	500	480	433	558	558	7.4%	0	0.0%	76	15.8%
Involving learner drivers/riders	213	195	189	249	221	265	3.5%	44	19.9%	52	24.2%
Involving provisional/P1/P2 drivers/riders	1,205	1,271	1,261	1,305	1,511	1,298	17.1%	-213	-14.1%	-13	-1.0%
Involving unlicensed drivers/riders	447	500	514	560	571	618	8.1%	47	8.2%	100	19.2%
Involving heavy freight vehicles	445	494	501	454	505	536	7.1%	31	6.1%	56	11.7%
Involving motorcycles (excluding mopeds)	935	964	965	1,004	1,075	1,016	13.4%	-59	-5.5%	27	2.8%
Involving mopeds	65	61	76	54	37	36	0.5%	-1	-2.7%	-23	-38.6%
Involving buses	121	121	112	85	131	108	1.4%	-23	-17.6%	-6	-5.3%
Child road user hospitalised casualties, aged 16 years or younger^	483	481	487	524	610	617	8.1%	7	1.1%	100	19.3%
Young adult road user hospitalised casualties, aged 17 to 24 years^	1,408	1,426	1,448	1,633	1,705	1,573	20.8%	-132	-7.7%	49	3.2%
Mature adult road user hospitalised casualties, aged 25 to 59 years^	3,527	3,694	3,826	3,784	4,221	4,007	52.9%	-214	-5.1%	197	5.2%
Senior adult road user hospitalised casualties, aged 60 to 74 years^	744	850	871	761	920	942	12.4%	22	2.4%	113	13.6%
Senior adult road user hospitalised casualties, aged 75 years or over^	335	357	363	296	434	433	5.7%	-1	-0.2%	76	21.3%
Vehicle occupant hospitalised casualties	4,783	5,118	5,302	5,294	6,055	5,757	-	-298	-4.9%	447	8.4%
Vehicle occupant hospitalised casualties, where restraint use was known	3,928	4,274	4,479	4,367	5,109	4,875	-	-234	-4.6%	444	10.0%
Unrestrained vehicle occupant hospitalised casualties#	185	189	180	188	206	235	4.8%	-	19.6%	-	12.7%

Note:

Figures are preliminary.
** Figures are rounded to the nearest whole number.*
^ Where age was known.
 # Restraint use is not applicable for all road user types (i.e. pedestrians, motorcycle riders/pillions, etc) and is not always known. Therefore the variation in unrestrained vehicle occupant casualties is measured as a change in the percentage of all vehicle occupant casualties, instead of the change in number, where restraint use was known.

Appendix C – Austroad Crash Modification Factors

Appendix E Crash Modification Factors

Table E 1: Crash modification factors of various countermeasures for intersection crashes

Treatment type	Description and DCA code								
	Adjacent approach 101–109	Head-on 201	Opposing turns 202–206	Rear end 301-304	Lane change 305–307	Parallel lanes-turning 308, 309	Vehicle hits ped 001–003	Loss of control, L or R turns 706, 707	Hit parked/ parking vehicle 601, 401, 402
Roundabout	0.3			1.2			0.4		
New traffic signals (no turn arrows)	0.3		1.9				0.7		
New traffic signals (with turn arrows)	0.3		0.55				0.7		
Remodel signals	0.7		0.6				0.7		
Grade separation	0.0		0.5			0.8	0.3	0.5	
Improve sight lines	0.7		0.7				0.7	0.8	
Street closure (one leg of cross-intersection)	0.5		0.5				0.5	0.9	
Street closure (close stem of T)	0.0		0.0				0.5	0.0	
High skid resistance surfacing				0.6				0.9	
Stagger cross-intersection (right-left)	0.5		0.5	1.3	1.1				
Improve/reinforce priority (e.g. add a control sign)	0.7								
Prohibit right turns			0.5			0.5		0.5	
Ban left or U-turns			Note 1	0.5		0.5		0.5	
Improve lighting							0.7		
Traffic islands on approaches		0.8	0.8	0.8				0.9	0.9

Treatment type		Description and DCA code								
		Adjacent approach 101–109	Head-on 201	Opposing turns 202–206	Rear end 301-304	Lane change 305–307	Parallel lanes-turning 308, 309	Vehicle hits ped 001–003	Loss of control, L or R turns 706, 707	Hit parked/ parking vehicle 601, 401, 402
Indented right turn island				0.7	0.6				0.8	0.8
Painted turn lane				0.8	0.8					0.8
Ban parking adjacent to intersection		0.9			0.8	0.8		0.7		0.5
Extend median through intersection		0.0	0.0	0.0				0.5		
Reduce radius on left turn slip lane					0.5					
Protected left turn lane in crossing street					0.9					
Cost per casualty crash ($'000)	Metro	173	373	180	89	135	119	234	140	174
	Rural	367	660	303	208	339	267	410	293	297

Note 1: Costs are in 2014 dollars, and are based on research conducted by Dr David Andreassen for the Australian Transport Safety Bureau in 1996. Costs have been adjusted based on CPI.

Note 1: The treatment 'banning U turns' is a relevant treatment for crash type 207, with an estimated 50% reduction [costs for 207: $142K (metro) and $257K (Rural)]. Banning left turns is a relevant treatment for crash types 203, 205 and 206 with a 50% reduction.

Table E 2: Crash modification factors of various countermeasures for non-Intersection crashes

Treatment type	Description and DCA code					
	Head-on 201	Opposing turns 202–206	Rear end 301–304	Lane change 305–307	Vehicle hits pedestrian 001–003	Hit parked/ parking vehicle 601, 401, 402
Median on existing carriageway	0.1				0.5	
Pedestrian refuge					0.55	
Pedestrian (zebra) crossing					0.6	
Kerb blisters	0.9				0.9	0.5
Pedestrian overpass					0.15	
Pedestrian signals					0.3	
Pedestrian crossing lighting					0.4	
Improved route lighting					0.7	
Clearway, parking bans			0.8		0.7	0.5
Indented right turn island		0.7	0.6			
Painted turn lanes		0.8	0.8			
Roadside hazards – remove	Note 1					
Roadside hazards – guard fence						
Wire rope safety barrier – roadside						
Wire rope safety barrier – median	0.05					
High skid resistance surfacing			0.6			
Seal shoulders	0.6					
Advisory speed signs on curves	0.7					
Delineation						
Edgelines						
Audio-tactile edgelines						

Treatment type		Description and DCA code					
		Head-on 201	Opposing turns 202–206	Rear end 301–304	Lane change 305–307	Vehicle hits pedestrian 001–003	Hit parked/ parking vehicle 601, 401, 402
Reconstruct superelevation on curve		0.5					
Climbing/overtaking lanes		0.7 Note 2			1.1		
Signs (railway level crossing)							
Flashing lights (railway level crossing)							
Barriers or gates (railway level crossing)							
Bridge or overpass (railway level crossing)							
Frangible posts, poles							
Cost per casualty crash ($'000)	Metro	373	180	89	135	234	174
	Rural	660	303	208	339	410	297

Table E 3: Crash modification factors for various countermeasures for midblock crashes

Treatment type	Description and DCA code						
	On straight			On curve			Hit train 903
	Off road 701–702	Off road, hit object 703, 704	Loss of control, on road 705	Off road 801, 802	Off road, hit object 803, 804	Loss of control on road 805	
Median on existing carriageway							
Pedestrian refuge							
Pedestrian (zebra) crossing							
Kerb blisters							
Pedestrian overpass							
Pedestrian signals							
Pedestrian crossing lighting							
Improved route lighting							
Clearway, parking bans							
Indented right turn island							
Painted turn lanes							
Roadside hazards- remove	1.8	0.2		1.8	0.2		
Roadside hazards – guard fence	0.7	0.7	1.3	0.7	0.7	1.3	
Wire rope safety barrier – roadside	0.15	0.1		0.15	0.1		
Wire rope safety barrier – median							
High skid resistance surfacing	0.9	0.9	0.9	0.9	0.0	0.9	
Seal shoulders	0.6	0.6	0.6	0.6	0.6	0.6	
Advisory speed signs on curves				0.7	0.7	0.7	
Delineation	0.85	0.85	0.85	0.85	0.85	0.85	
Edgelines	0.7	0.7		0.7	0.7		

Treatment type		Description and DCA code						
		On straight			On curve			Hit train 903
		Off road 701–702	Off road, hit object 703, 704	Loss of control, on road 705	Off road 801, 802	Off road, hit object 803, 804	Loss of control on road 805	
Audio-tactile edgelines								
Reconstruct superelevation on curve					0.5	0.5	0.5	
Climbing/overtaking lanes								
Signs (railway level crossing)								0.85
Flashing lights (railway level crossing)								0.5
Barriers or gates (railway level crossing)								0.2
Bridge or overpass (railway level crossing)								0.0
Frangible posts, poles			Note 3			Note 3		
Cost per casualty crash ($'000)	Metro	133	272	140	210	323	149	628
	Rural	261	452	293	404	503	268	928

Note 1: For this treatment removing the objects which were hit after the vehicle left the carriageway is to reduce crashes that relate to hitting objects (i.e. crash types 703–704, 803–804) but the reduction in these crashes will be matched by an increase in crash types 701–702 and 801–802, as vehicles will continue to leave the carriageway but now will not be hitting objects (all else being equal). The net benefit will be a reduction in crash severity.

Note 2: For this treatment crash type 501 (head-on, overtaking) is also relevant (use DCA 201 cost).

Note 3: For this treatment, the number of off-road-hit-object crashes is not expected to change. However, the severity outcome of these crashes will be reduced.

Appendix D – Austroad Safe System Matrix

Appendix B Template for Assessment

Background

[insert text on background to project, including photo and/or map of location]

Objectives identification

[insert text on the objectives of the assessment]

Setting the context

Prompt	Comment
What is the reason for the **project**? Is there a specific crash type risk? Is it addressing specific issues such as poor speed limit compliance, road access, congestion, future traffic growth, freight movement, amenity concerns from the community, etc.	
What is the **function** of the road? Consider location, roadside land use, area type, speed limit, intersection type, presence of parking, public transport services and vehicle flows. What traffic features exist nearby (e.g. upstream and downstream)?	
What is the **speed** environment? What is the current speed limit? Has it changed recently? Is it similar to other roads of this type? How does it compare to Safe System speeds? What is the acceptability of lowering the speed limit at this location?	
What **road users** are present? Consider the presence of elderly, school children and cyclists. Also note what facilities are available to vulnerable road users (e.g. signalised crossings, bicycle lanes, school zone speed limits, etc.).	
What is the **vehicle** composition? Consider the presence of heavy vehicles (and what type), motorcyclists and other vehicles using the roadway.	

Safe System matrix

	Run-off-road	Head-on	Intersection	Other	Pedestrian	Cyclist	Motorcyclist
Exposure							
Likelihood							
Severity							

Additional Safe System components

Pillar	Prompts
Road user	Are road users likely to be alert and compliant, or are there factors that might influence this? What are the expected compliance and enforcement levels (alcohol/drugs, speed, road rules, and driving hours) and what is the likelihood of driver fatigue? Can enforcement of these issues be conducted safety? Are there special road uses (e.g. entertainment precincts, elderly, children, on-road activities), distraction by environmental factors (e.g. commerce, tourism), or risk-taking behaviours?
Vehicle	What level of alignment is there with the ideal of safer vehicles? Are there factors which might attract large numbers of unsafe vehicles? Is the percentage of heavy vehicles too high for the proposed/existing road design? Are there enforcement resources in the area to detect non-roadworthy, overloaded or unregistered vehicles and thus remove them from the network? Can enforcement of these issues be conducted safety? Has vehicle breakdown been catered for?
Post-crash care	Are there issues that might influence safe and efficient post-crash care in the event of a severe injury? Do emergency and medical services operate as efficiently and rapidly as possible? Are other road users and emergency response teams protected during a crash event? Are drivers provided the correct information to address travelling speeds on the approach and adjacent to the incident? Is there reliable information available via radio, VMS etc.? Is there provision for e-safety (i.e. safety systems based on modern information and communication technologies, C-ITS)?

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