

## Main Roads Investigation into the Fatal Crash on South-bound Ramp from Bruce Highway to Sunshine Motorway at Tanawha



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## Document sign off

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## Contents

<b>Executive Summary .....</b>	<b>5</b>
<b>1 Introduction.....</b>	<b>8</b>
1.1 Report Purpose/Objectives.....	9
1.2 Report Structure .....	9
1.3 Investigation Panel.....	10
1.4 Stakeholders .....	10
<b>2 Background.....</b>	<b>11</b>
<b>3 Road Geometry Factors.....</b>	<b>12</b>
3.1 General Considerations .....	12
3.2 Conformance with original and current design guidelines .....	14
<b>4 Surface Characteristics.....</b>	<b>14</b>
<b>5 Relevant Road Factors.....</b>	<b>16</b>
5.1 The contribution of various road factors.....	16
5.2 Results of QPS Investigations.....	18
5.3 Summary Assessment .....	20
<b>6 General Assessment of the "Road Safety Adequacy" of this Ramp .....</b>	<b>21</b>
<b>7 Enhancements Already Implemented .....</b>	<b>24</b>
<b>8 Potential Enhancement Actions on the Ramp.....</b>	<b>24</b>
8.1 Improve visual cues to reduce speeds .....	24
8.2 Re-surface the ramp to improve micro-texture .....	25
8.3 Improve visibility on the inside of the curve .....	26
8.4 Increase the cross-fall on the ramp.....	26
8.5 Improve both the horizontal geometry of the ramp and its approach .....	26
<b>9 Recommendations .....</b>	<b>27</b>
9.1 Recommendations for enhancement measures at this location.....	27
9.2 General recommendations.....	27
<b>Appendix A – North Coast-Hinterland District Crash Investigation Report</b>	
<b>Appendix B – Geometric Assessment of Bruce Highway Southbound to Sunshine Motorway Eastbound Connection</b>	
<b>Appendix C – Summary of Pavement Surface Properties</b>	
<b>Appendix D – QPS Vericom VC3000 (Accelerometer) Test Results</b>	
<b>Appendix E – Calcined Bauxite High Friction Surfacing</b>	
<b>Appendix F – The Influence of Speed, Tyre Wear and Surface Water Depth on Vehicle Control</b>	

## List of Figures

Figure 1 – Crash site locality plan.....	8
Figure 2 – Crash site location sketch.....	8
Figure 3 – Aerial view of ramp .....	11
Figure 4 – Permanent signs installed at the time of the crash .....	12
Figure 5 – Diagrammatic explanation of macro-texture and micro-texture .....	15
Figure 6 – from Bennis and De Wit, <i>State of the art on friction and texture measurements</i> , 2003 as referenced in Austroads Guidelines for the Management of Road Surface Skid Resistance (2005) .....	17
Figure 7 – Interpretation of friction supply data from QPS tests .....	19
Figure 8 – Collision diagram (1 June 2001 to 24 May 2007).....	23
Figure 9 – Proposed modifications to static signs .....	25

## Executive Summary

The occurrence of the fatal crash on 21 May 2007 on the south-bound ramp from the Bruce Highway to the Sunshine Motorway at Tanawha suggests a most unusual set of circumstances. Two vehicles at almost the same time lost control and ran off the road at approximately the same location. Based on the reported crash history on this ramp (seven reported and validated crashes for an estimated 11.2 million vehicle movements since October 1995), and the lack of reported crashes since the 21 May crash, the fact that two vehicles lost control in close succession indicates an abnormal situation.

This report provides Main Roads' assessment of the roads factors that contributed to the fatal crash. The report only investigates and reports on road matters – it does not investigate or consider any other factors that may have contributed to the crash such as vehicle or driver related factors. These factors are being considered as part of the police investigation into the crash and will be included in their report which is currently being finalised.

The report has taken into account:

- the standard crash investigation report carried out by North Coast Hinterland District. These investigations are undertaken after every fatal crash.
- a specialist investigation into the roadway geometry where the crash occurred, carried out by experts in Main Roads' Planning and Design Branch.
- a specialist investigation into the ramp's surface skid-resistance characteristics, carried out by experts in Main Roads' Pavements and Materials Branch.
- road-related information made available by the Queensland Police Service arising from investigations they are carrying out into the same crash.

It finds:

- A surface contaminant, perhaps oil or diesel, was the most likely road-related factor that contributed to the crash.
- The geometric design of the ramp is satisfactory for the requirements placed upon it – the ramp joins two motorways, and includes a further diverge to give traffic access to Wilsons Road.
- The ramp configuration does require drivers to pay attention and, in some circumstances, to brake and corner heavily. The crash history at this site shows the vast majority of motorists have been able to do this in all weather conditions without incident.
- Speed monitoring carried out as part of the investigation, showed more than 7000 vehicles – some 15% of the 50,644 motorists using the ramp over a two-week period – were travelling at more than 80 kilometres per hour in all weather conditions, with no further reported crashes. This translates to 225,000 vehicles per annum that safely traverse the ramp at speeds in excess of 80 km/h – strongly suggesting that there may have been some unusual factor present at the time of the crash for two vehicles to lose control in close succession.
- An increase in vehicle numbers (doubling between 2000 and 2007), when combined with the extra braking and cornering at the ramp curve, has led to the stone in the surface of the road "polishing" more quickly than would otherwise reasonably have been expected.

- Polishing is normal in all stone surfaces, and relates to the wearing away by traffic. This takes place regardless of the asphalt used. Testing shows that on this ramp the polishing has taken place at different rates. Over time, this has meant the surface has gone from one with adequate surface friction to one where the surface friction, while adequate in dry conditions, is now marginal in wet conditions at the previously posted speed of 80km/h.
- The two surfaces used to date on the ramp (spray seal and Stone Mastic Asphalt) have been appropriate for the circumstances.

The report also details the actions Main Roads will take to enhance the future safety performance of this ramp and to investigate progressively other off-ramps from 110 and 100 kph motorways and highways in similar circumstances and determine appropriate safety enhancements if required.

Main Roads will place a high-friction surfacing treatment on this ramp as a matter of urgency to address the faster than expected "polishing" of the surfacing aggregate as a result of the significant increase in traffic volumes.

The report makes the following recommendations for this particular ramp and more generally.

### **Recommendations for improved safety measures at this location**

1. Since the fatal crash on 21 May, Main Roads has temporarily reduced the advisory and regulatory speed limits on the ramp from 80 km/h to 70 km/h. It is recommended that this change be made permanent.
2. It is recommended that enhanced warning signs be installed (including chevron alignment markers on the outside of the curve, higher impact exit advisory speed sign and "slippery when wet" sign).
3. It is recommended that visibility on the inside of the curve be improved by removing vegetation.
4. It is recommended that a new calcined bauxite surfacing be applied to improve skid resistance. (Once the surface is installed, the high-impact "slippery when wet" warning sign can be removed.)

The above recommendations will result in a significant improvement to ramp safety.

5. It is also recommended that the following general road safety improvements at this ramp, not related to the crash, but noted by the District during the crash investigation be considered:
  - 5.1 Replacement of the "Wrong Way Go Back" sign to improve night-time reflective performance.
  - 5.2 Replacement of existing guardrail (behind the chevroned area) with a terminal treatment to enhance safety (a slotted "thrie beam" bull-nose terminal).
  - 5.3 Undertake regular inspections to address general maintenance issues such as ensuring guide posts and delineators are in place.
  - 5.4 Increase in guardrail height by approximately 100 mm.
  - 5.5 Improvements to road lighting to enhance illumination of the approach ramp and curve.
  - 5.6 Clearing of large trees on the outside of the ramp curve to improve safety in the event of run-off-the-road events.

### **General recommendations**

6. It is recommended that:
  - 6.1 Delays in receipt of crash reports be addressed.
  - 6.2 On other off-ramps from 100 or 110 km/h motorways and highways, Main Roads undertake detailed measurements of friction demand and supply in wet conditions, progressively as part of the ongoing program to enhance the safety of the road network.

- 6.3 Main Roads purchases dual-axis acceleration measuring equipment to undertake lateral acceleration tests; and ensure that relevant Districts are supplied with this equipment and have officers on staff experienced in its use for this purpose. (Skid test measurements using such equipment may need to be procured from QPS<sup>1</sup>).
- 6.4 Main Roads reviews its design methods and its guidelines and specifications to ensure, in areas of roadway with increased surface friction demands and potential for increased polishing (such as at tight curves and approaches to intersections on heavily trafficked roads), that better performing aggregates (with higher polished aggregate friction values) are specified.
- 6.5 Main Roads progressively undertakes a state-wide review of advisory speed signs on curves, to confirm advisory speeds remain appropriate using the procedures in the Manual of Uniform Traffic Control Devices.
- 6.6 Main Roads develops a program of activities by October 2007 that addresses recommendations 6.1 to 6.5.

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<sup>1</sup> As the friction supply tests require the test vehicle's ABS braking system to be disabled, and for the vehicle to skid in a controlled manner (at low speed), it is probable that workplace health and safety issues preclude Main Roads officers from undertaking this assessment.

# 1 Introduction

This report summarises Main Roads' investigations into the fatal crash that occurred on 21 May 2007 on the south-bound ramp from the Bruce Highway to the Sunshine Motorway at Tanawha. The driver of a sedan lost control on the ramp in light rain at approximately 3.00pm and was standing behind her car, making a call for assistance. A four-wheel drive vehicle also lost control and collided with the first car, causing the first car to back over its driver.

A locality plan and schematic drawing outlining the location of the crash and postulated vehicle paths is provided in the figures below.

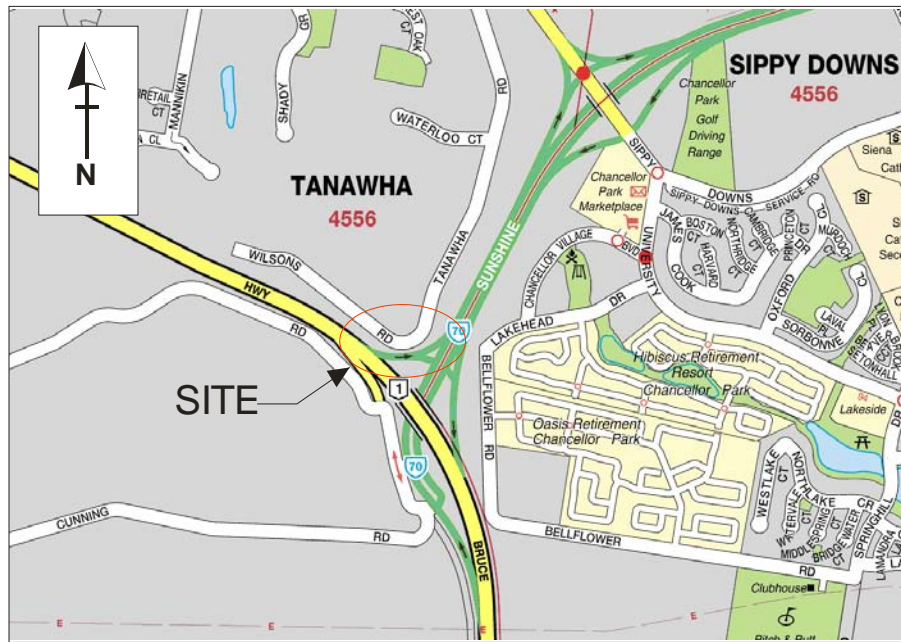


Figure 1 – Crash site locality plan

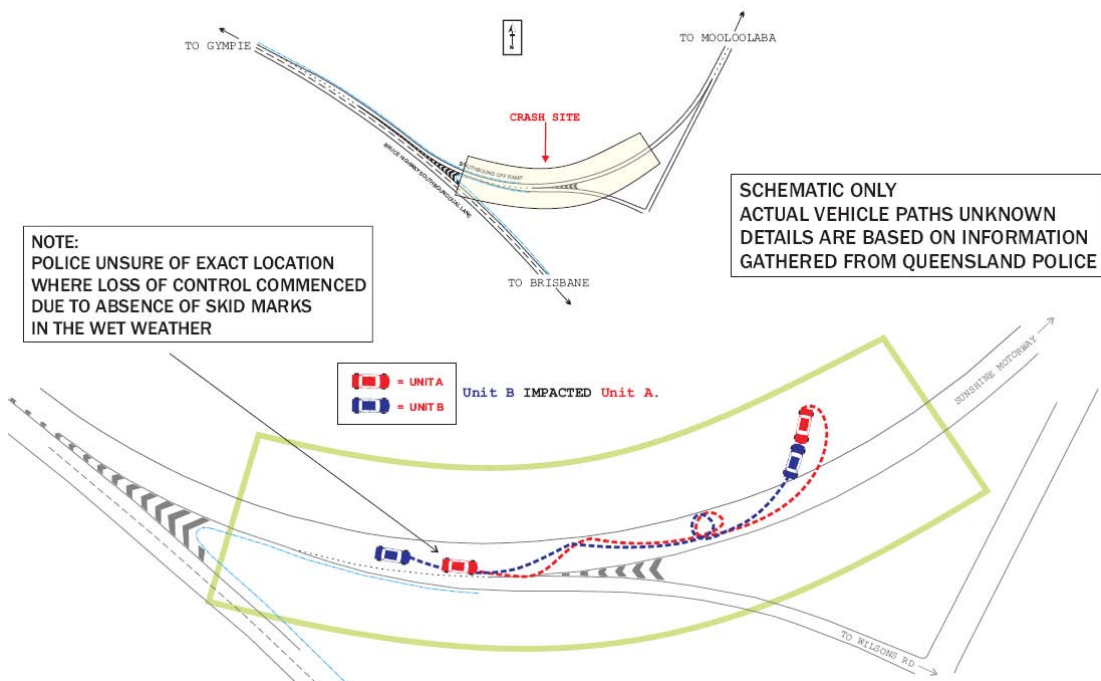


Figure 2 – Crash site location sketch

The report integrates, draws summary conclusions from a number of Main Roads investigations and makes recommendations. The Main Roads investigations include:

- the standard crash investigation report carried out by the North Coast-Hinterland District. These investigations are undertaken following every fatal crash. (Appendix A)
- a specialist investigation into the roadway geometry where the crash occurred undertaken by experts in Road Planning and Design Branch. (Appendix B)
- a specialist investigation into the ramp surface skid resistance characteristics undertaken by experts in Pavements and Materials Branch. (Appendix C)

This report also draws upon:

- information made available by the Queensland Police Service (QPS), arising from investigations they undertook into this same crash (Appendix D)

It is noted that Professor Rod Troutbeck<sup>2</sup> has been commissioned to undertake an independent investigation into the road safety performance of this ramp (and other sections of roadway). That report is due to be provided to Main Roads by the end July 2007.

## 1.1 Report Purpose/Objectives

The purpose of this report is to:

- Outline the results of a detailed investigation into road features at the location of the fatal crash that occurred on the south-bound ramp from the Bruce Highway to the Sunshine Motorway, on Monday 21 May 2007.
- Establish whether the road conforms to current design guidelines (that is, in its design and condition) and, whether it conformed to the design guidelines of the day when it was designed and built.
- Identify any corrective measures that could be undertaken to enhance the safety of this ramp.
- Only investigate road factors – it does not consider any other factors that may have contributed to the crash such as vehicle or driver related factors. These factors are being considered as part of the police investigation into the crash and will be included in their report which is currently being finalised.

## 1.2 Report Structure

The report is structured in the following sequence.

It examines various road factors that may have contributed to the fatal crash on 21 May 2007. It looks at these factors first individually then in combination. It seeks to explain the role of road factors, if any, in this particular crash. In doing so it makes reference to certain road related findings made available by QPS from their separate investigation into the crash. The report then looks more broadly at the road safety performance and adequacy of this ramp.

The report considers the appropriateness of the ramp geometry by reference to the relevant guidelines at the time of the original design and also by reference to current guidelines.

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<sup>2</sup> Following a series of crashes in 2005 on the Bruce Highway at Federal, Professor Troutbeck co-authored the Troutbeck-Kennedy report, which examined the road safety performance of SMA-surfaced road sections.

The report then examines a number of options for improving the road safety performance of this ramp. It concludes by making a series of recommendations in relation to measures that could be undertaken at this particular ramp; as well as more general recommendations for Main Roads' consideration.

### 1.3 Investigation Panel

The Investigation Panel (tasked to prepare this report) comprised:

- Deputy Director-General (Panel Chair)
- General Manager (Engineering and Technology)
- Executive Director (Special Projects – Planning, Design and Operations)
- District Director (North Coast-Hinterland District)
- Manager Traffic Operations (North Coast-Hinterland District)
- Principal Traffic Engineer Traffic Operations (North Coast-Hinterland District)
- Director (Traffic Engineering and Road Safety)
- A/Director (Pavements & Materials)
- Principal Advisor (Design Innovation and Standards)

The Panel was supported by other North Coast-Hinterland District, Engineering and Technology and RoadTek officers as required.

### 1.4 Stakeholders

Stakeholder area	Stakeholder representative	Responsibility	Interest/context
Main Roads Senior Management	Director-General, Deputy Director-General, General Manager (Engineering & Technology)	DDG – Investigation Panel Chair, GM (E&T) – Project Manager	Technical governance
North Coast-Hinterland District	District Director, Manager (Traffic Operations)	Crash investigation. Design review. Co-ordination of site investigation activities. Provision of expert advice.	Network operation management
Planning Design and Operations Division	Executive Director (PD&O), Director (TE&RS), PA (Design Innovation and Standards)	Project management. Provision of expert advice.	Geometric design, traffic engineering and road safety considerations
Roads Delivery and Performance Division	A/Director (Pavements and Materials)	Materials testing. Provision of expert advice.	Surfacing performance
RoadTek	Principal Engineer (Pavement Testing)	Pavement testing on site (ROAR skid resistance testing)	State-wide testing
Queensland Police Service	Forensic Crash Investigation Unit officers	Crash investigation and coronial report in accordance with QPS procedures	Report to Coroner

## 2 Background

The Sunshine Motorway was constructed in 1990. The Bruce Highway/Sunshine Motorway interchange was designed in 1987 and constructed in 1989.

An aerial view of the south-bound ramp from the Bruce Highway to the Sunshine Motorway is shown in Figure 3.

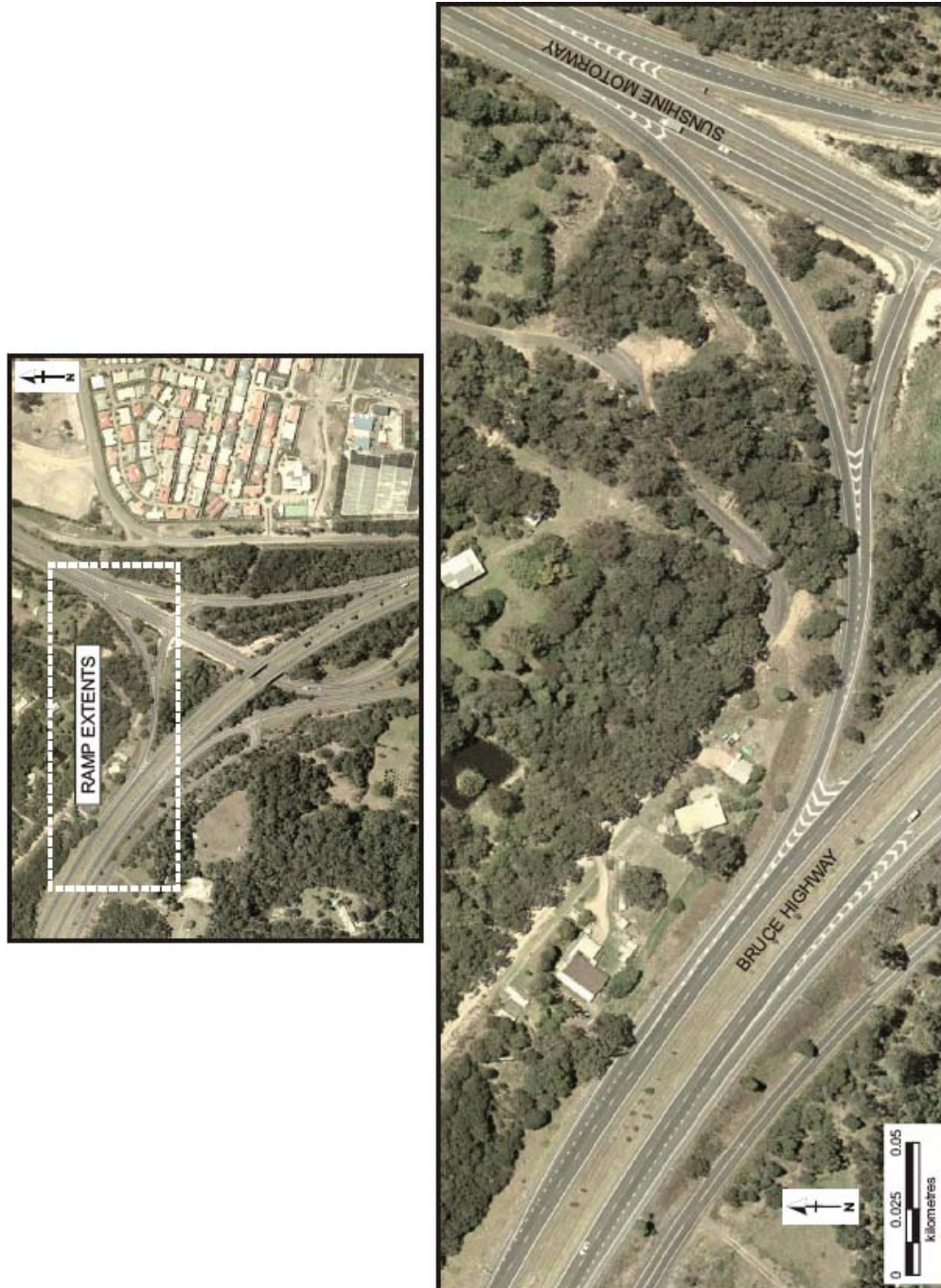


Figure 3 – Aerial view of ramp

When the interchange was constructed in 1989, the posted speed limit on the duplicated Bruce Highway was 100 km/h. The Bruce Highway speed limit was increased to 110 km/h in 1993. The original design provided for a short off-ramp. This was lengthened in May 2000 to provide motorists with a longer distance to decelerate before the start of the ramp linking the Bruce Highway to the Sunshine Motorway.

At the time of the crash, a number of speed signs were located on the ramp, as depicted in Figure 4:

- an 80 km/h exit advisory speed sign, located near the start of the left hand curve.
- 80 km/h regulatory speed signs, located near the Wilsons Road diverge.

Both the advisory and regulatory signs were changed to 70 km/h on 14 June 2007, as a result of a recommendation from QPS arising from their investigations at that point in time into the crash (see section 5.2 – Results of QPS Investigations).

When the ramp was constructed, the surfacing consisted of a sprayed bitumen seal. This was overlaid with stone mastic asphalt (SMA) in October 2000, in response to increased traffic volumes (and associated need for improved resistance to rutting).

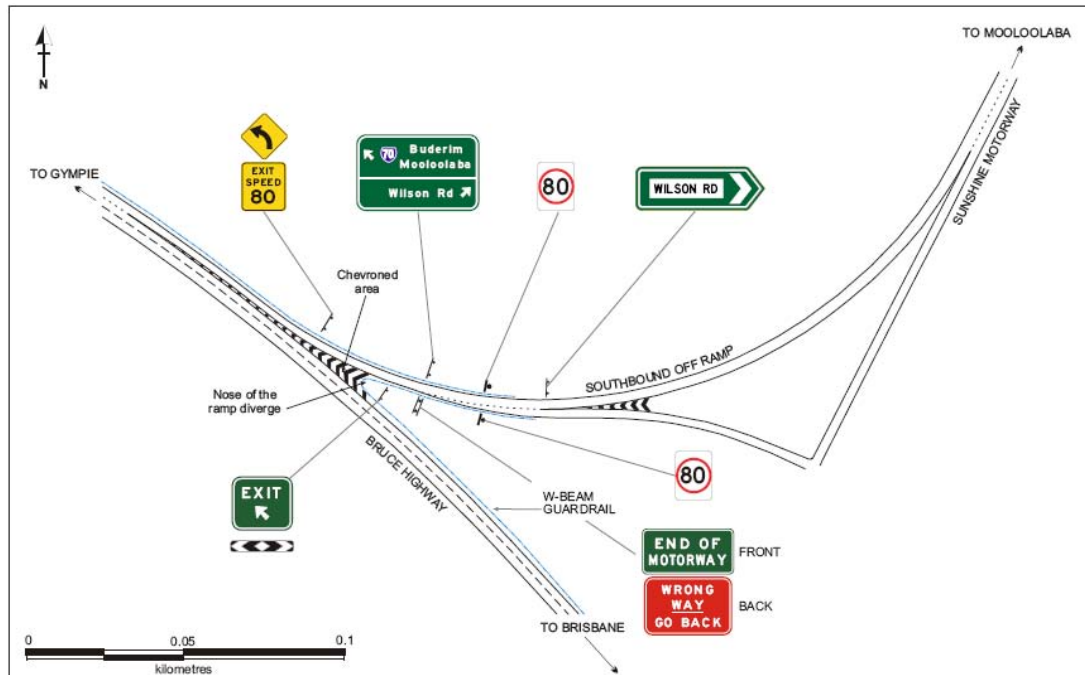


Figure 4 – Permanent signs installed at the time of the crash

## 3 Road Geometry Factors

### 3.1 General Considerations

When a vehicle traverses a curve, its stability is dependent on a number of primary factors:

- the vehicle speed
- the radius of the curve
- the cross-fall of the pavement (also termed *super-elevation*)
- the friction coefficient between the vehicle tyres and the roadway surface.

The gradient of the road is also a factor; and in this case there was a maximum down-gradient of 7% (average 5%).

Water or contaminants on the surface can also be significant factors (these factors are discussed in Section 5 of this report).

One of the fundamental principles in undertaking road design, as outlined in the Main Roads Road Planning and Design Manual, is the need to make an assessment of the appropriate

design speed. The adopted design speed needs to take account of the relevant circumstances and of speeds which responsible drivers would adopt in response to road and traffic conditions.

Based on the ramp design speed of 80 km/h, a curve radius of 204m was adopted with 3% cross-fall (refer Appendix B).

The performance of vehicles on curves also depends on driver technique. Successful curve negotiation by a driver relies upon the choice of an appropriate approach speed, lateral positioning through the curve and the speed pattern adopted from the time of sighting the curve until passing through it<sup>3</sup>. When drivers steer a horizontal curve they do not normally drive the curve as a single arc. This is especially the case with long curves and larger radii curves (this includes the 204m radius horizontal curve). Drivers tend to steer the curve as a series of disjointed arcs. When a steering correction is made, a higher side friction demand is made. National curve design criteria used by Main Roads are derived from actual driving practice and so take this into account.

Another relevant design feature for this particular ramp is the secondary diverge roadway that commences on the right-hand side of the ramp (to access Wilsons Road). Because of the existence of this diverge; the cross-fall on the curve has been kept lower (at 3%). Had this diverge to Wilsons Road not been required then 6% cross-fall would have been provided on this curve. The 3% off-ramp cross-fall took account of the 3% cross-fall to the right on the highway leading to the off-ramp. Given the ramp cross-fall was to the left, accommodating more than 6% rotation in the distance available would have introduced other safety issues. 3% is an acceptable value.

It is also worth noting that the distance ahead to which an approaching driver, in a sedan, can view the roadway of the ramp, is 84m. (This figure is based on the driver height assumed in design guidelines). This is due to the downgrade (7% maximum) and the 204 m radius curve. As a result, there is a limitation on how well drivers can "read" the curvature of the roadway ahead. Where drivers have not appropriately decelerated in advance to slow down to 80 km/h at the exit speed sign location to negotiate the curve, they may need to apply their brakes or 'corner' harshly; both of which impose higher stresses on the road surface. Consequently there is reliance on adequate surface skid resistance. The surface characteristics are addressed in Section 4 of this report.

As noted earlier, the design speed on the curve was 80 km/h. (This means the curve was designed to be safe at 80km/h). An 80 km/h exit advisory speed sign was in place. Had the advisory signing been done post-construction, the speed value would have been determined by use of a "ball-bank indicator". (This is an instrument which gauges a driver's ability to comfortably negotiate a curve.) During the investigation following this crash, a ball-bank indicator test was undertaken in accordance with the MUTCD guidelines. Using that test, a comfortable curve negotiation speed would be 70 km/h.

However, it is not believed this signing contributed to this fatal crash as both drivers were regular users of this ramp and were unlikely to have relied on the curve warning sign in any event.

Speed measurements undertaken by Main Roads in the course of the investigation showed that 15% of drivers exceeded the advisory speed sign in all weather conditions. This means that some 225,000 vehicles per annum have safely traversed the curve at speeds in excess of

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<sup>3</sup> Max Lay: Handbook of Road Technology Volume 2 (1990).

80 km/h – strongly suggesting that there may have been some unusual factor present at the time of the crash for two vehicles to lose control in close succession.

## 3.2 Conformance with original and current design guidelines

The detailed geometric assessment provided in Appendix B concludes that while the final design met safety requirements, there were a number of variances from Main Roads design guidelines. These variances, listed below, are not considered to constitute design errors or safety issues:

- Superelevation of 3% instead of the preferred 6%, primarily due to the need to accommodate access to Wilsons Road. This also meant that no entry and exit transition curves were applied.
- The fact that the ramp exits tangentially from the highway curve, rather than at the usual 1:15 exit angle. As a result, the length of roadway with chevron markings is less than it would otherwise have been.
- A short section (less than 10m) of the ramp reaching a maximum down-grade of 7% instead of the recommend maximum down-grade of 5%.
- Provision of 84m sight distance to a point 60m past the "nose" of the ramp, when ideally, 300m sight distance should have been provided (current design guidelines would ideally seek 350m). Though not a design guideline issue, it is noted that the sight distance over the safety barrier on the inside of the ramp curve was obstructed by vegetation at the time of the crash.
- Installation of guardrail at the diverge nose rather than a desirable obstruction-free run-off length of 120m beyond the diverge nose.
- Under current guidelines, this interchange would be classified as a high speed 'system interchange'. The ramp would be designed for 100km/h operation (requiring a 400m curve radius). It should be noted, however, that it is probable that a curve suitable for 90km/h (requiring a 300m curve radius) will be specified as "adequate" in the next revision of the Road Planning and Design Manual.
- The high speed system interchange classification would require the Wilsons Road connection to be accommodated at some other location.

## 4 Surface Characteristics

The term "skid resistance" describes the friction force developed at the tyre-pavement contact area. In other words, skid resistance is the force that resists sliding on road pavement surfaces. Road pavement surface characteristics form only part of the complex suite of factors which influence skid resistance. For example, tyre characteristics are also very important.

A number of tests have been developed to measure skid resistance. Some are suitable as coarse comparative screening tools that are applied at a network level, and involve a number of tests conducted over a length of road at highway speed (such as the ROAR skid tester used by Main Roads on asphalt surfaced sections of the state-controlled road network; or the SCRIM tester as used by VicRoads and NSW Roads and Traffic Authority). These network-wide tests may indicate locations requiring closer investigation. Closer investigation of these

locations would involve other tests and safety assessments which are used at identified locations. The more specific tests referred to in this report (outlined in Appendix C) include:

- sand patch tests (used for measuring surface macro-texture); and
- British pendulum tests (used to gauge the contribution of the aggregate micro-texture to skid resistance and used for both the initial selection of aggregate, by means of laboratory testing and also for in-service field testing).
- The Main Roads Pavement Condition Test Unit (Multi Laser Profilometer), collects macro-texture data at highway speeds and reports this data as "Sand Patch Equivalent".

Road surface macro-texture and micro-texture are explained diagrammatically in Figure 5.

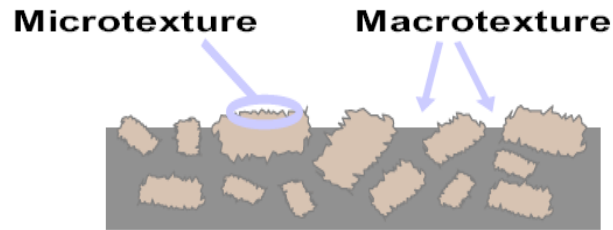


Figure 5 – Diagrammatic explanation of macro-texture and micro-texture

Macro-texture describes the large irregularities and voids between the aggregates. Macro-texture influences water drainage capacity, which is important in removing water from where the road surface and tyres come into contact, and in providing skid resistance through tyre deformation.

Micro-texture describes the smoothness of the surface of aggregates protruding from the asphalt or other surfacing treatment. Micro-texture is significant in wet weather because this is what enables the tyre to cut through the water film and grip the road surface. 'Polishing' reduces micro-texture and results from the action of traffic over time. The contribution of micro-texture to skid resistance in the wet reduces as speed increases.

The rate of polishing increases in areas where high stresses are imparted to the road surface by acceleration, braking and cornering manoeuvres of vehicles. Some aggregates are more susceptible to polishing than others. Micro-texture is a property of the stone aggregates used in asphalt irrespective of the type of asphalt. This means all asphalt surfacings are subject to polishing.

Further discussion about the role of micro-texture and macro-texture is provided in Austroads Guidelines for the Management of Road Surface Skid Resistance – 2005. Susceptibility to polishing is measured in a laboratory test which involves an artificial polishing cycle and gives a Polished Aggregate Friction Value (PAFV). PAFV is a specification requirement for aggregate used in asphalt surfacing.

Macro-texture along this ramp was tested using both laser and sand patch testing. The results showed that the ramp roadway has adequate macro-texture properties. Given the gradient of the ramp; the short pavement drainage paths; and the absence of wheel ruts where

water could have ponded (together with the light rain at the time of the crash), it is clear that dynamic aquaplaning<sup>4</sup> could not have occurred for a vehicle with well-maintained tyres<sup>5</sup>.

Hence it can be concluded that macro-texture was not a road factor that could have contributed to the crash.

The adequacy of micro-texture was assessed using the British pendulum test. Tests were undertaken at the locations shown in the diagram at Appendix C. This testing, in association with ROAR test results, indicated that the aggregate has been more extensively polished in those areas, where over time there has been more intensive braking and side-friction forces applied to the aggregate by vehicle tyres.

As mentioned previously, the asphalt in this locality is stone mastic asphalt which was laid in October 2000. It has been subjected to tyre forces for nearly seven years which represents approximately 8.2 million vehicle movements since the current surfacing was laid.

The stone used in the asphalt on the ramp met Main Roads' specification at the time of construction and this specification is still current. The fact that the stone has been polished within seven years, at this location, raises the question of whether it had adequate polishing resistance for use in a high stress location like this.

The Main Roads' specification currently makes no provision for stone more resistant to polishing to be used on areas of roadway subject to more intense tyre stresses.

## 5 Relevant Road Factors

### 5.1 The contribution of various road factors

If the various road factors are examined individually, the situation is as follows:

- macro-texture was not a road factor that could have contributed to a crash involving a vehicle with well-maintained tyres.
- surface contamination may well have been a significant factor. An eye-witness to the crash reported to QPS the appearance of an oil-like film in the outer wheel path on the road surface where the second vehicle lost control<sup>6</sup>. The outer wheel path is significant because there is weight transfer to the outer wheels when cornering and therefore

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<sup>4</sup> Austroads Guidelines for the Management of Road Surface Skid Resistance (2005) notes that *Dynamic Aquaplaning will occur once the vehicle has exceeded a critical speed (which is a function of the tyre pressure), at which time surface water in front of the tyre, acting as a wedge, can penetrate the tyre footprint and reduce the surface contact area. At high speeds only a small portion of the tyre footprint has dry contact. Under total dynamic aquaplaning, virtually no part of the tyre will have any contact with the surface and, even though the vehicle is travelling at great speed, the tyre can be fully locked.*

<sup>5</sup> A discussion of the influence of speed, tyre wear and surface water depth on vehicle control is provided in an article entitled "Get a Grip – Tyre, Road Surfaces and Traffic Accidents" published by AA Motoring Trust in June 2005. Refer Appendix F.

<sup>6</sup> Austroads Guidelines for the Management of Road Surface Skid Resistance (2005) notes that *The presence of water or surface contaminants (mud, dust, loose gravel, oil, stock effluent etc.) at the tyre-road interface interferes with the intimate interaction between the tyre and road surface. This explains the practical observation that skid resistance measured when the road surface is wet or contaminated is almost invariably lower than in dry conditions. This has potentially adverse consequences for road user safety.*

greater reliance on the friction available there. QPS took swabs from the road surface some time after the crash. The results of the swab tests are not yet available. Even if they show no sign of contaminants, it must be recognised the swabs were not taken until some time after the crash. By that time, any contamination may well have been removed by the action of rain and vehicle tyre scrubbing.

- another possible factor affecting skid resistance at the time of the crash is the influence of "road pollution". Research shows that in light rain after a period of dry, road pollution can significantly reduce available friction (refer Figure 6). Based on rainfall information sourced from the Bureau of Meteorology, it appears that this crash did occur in light rain, although given the "patchy" nature of rainfall in the vicinity, it is difficult to establish whether there was a significant preceding dry period<sup>7</sup>.

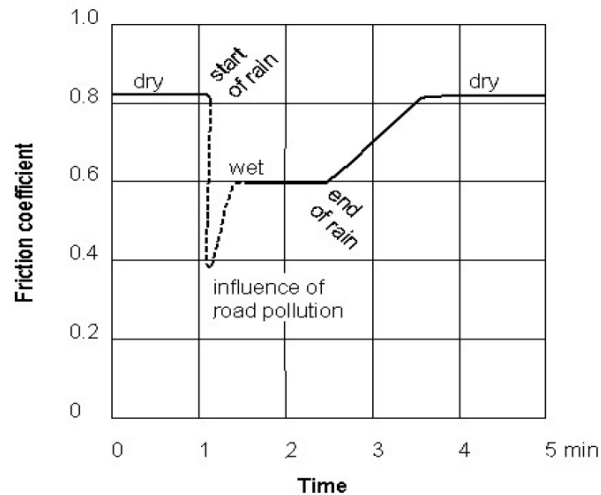


Figure 6 – from Bennis and De Wit, *State of the art on friction and texture measurements*, 2003 as referenced in Austroads Guidelines for the Management of Road Surface Skid Resistance (2005)

- the demand for surface friction by vehicles would have been influenced by vehicle speed; curve radius (as well as driver technique of steering wheel adjustments in negotiating the curve); ramp cross-fall; and gradient.
- the surface friction supplied by the road would have depended on the factors described above, including the micro and macro texture of the surfacing, the presence of a thin film of water due to light rain and the presence of any contaminants.

Given that it had started to rain lightly only shortly before the crash; the eye-witness account of the presence of an oil-like film on the surface (as reported by QPS); and the extremely unlikely sequential loss of control of two vehicles, it is Main Roads' assessment that surface contamination was likely to have been a significant factor in this crash.

Some 225,000 vehicles per annum have been safely traversing this curve (in all weather conditions) at speeds in excess of 80 km/h. While the condition of the surface on 21 May would not necessarily have led to the driver losing control, the presence of a contaminant or fuel spill (according to eye-witness advice) is likely to have greatly exaggerated all other contributing factors. However, the surface micro-texture has been shown to be variable and

<sup>7</sup> The closest weather station operating at the time was at Mountain Creek, 3.4km from the crash site. The Bureau of Meteorology advised that 1mm was recorded between 9am and 11:20am on Monday 21 May, 1mm between 11:20am and 1:15pm on Monday 21 May and 1mm between 1:15pm on Monday 21 May and 2:57pm on Tuesday 22 May.

in places may not have been sufficient to provide an adequate margin of safety for the friction demands that were placed upon it at the time of the crash.

## 5.2 Results of QPS Investigations

The QPS Forensic Crash Investigation Unit conducted on-site measurements using a vehicle equipped with a dual-axis accelerometer. This was a Vericom VC3000, capable of recording both longitudinal and lateral accelerations (or decelerations). Skid tests were conducted in dry conditions on 31 May 2007 and in wet conditions on 5 June 2007, in order to establish the surface friction available. (This may be termed the surface friction "supply"). In addition, measurements of lateral acceleration were undertaken at various speeds in dry conditions, to establish the surface friction "demand"; that is the surface friction required by a vehicle to keep it stable and under control while traversing the curve. Some of these friction demand tests also involved the application of brakes at the location where the lower surface friction results were recorded. The results of these QPS tests are attached at Appendix D.

QPS reported the following preliminary conclusion to Main Roads on 14 June: *"As part of a QPS investigation into the fatal crash on the southbound Sippy Downs exit ramp from the Bruce Highway to the Sunshine Motorway, the Forensic Crash Unit have undertaken wet and dry weather skid and lateral acceleration tests using a vehicle mounted Vericom VC 3000 (accelerometer). On the basis of the preliminary data extracted from these tests, it is recommended as a precautionary measure (pending the completion of more detailed investigations currently being undertaken by Main Roads) to reduce the advisory and regulatory speeds that apply to the ramp."*

The QPS preliminary conclusion was based upon test results in wet weather in which the brakes were applied on the approach to the curve<sup>8</sup>. It was noted that the combined lateral and longitudinal acceleration resulting from a driver touching the brake while negotiating the curve at 70 km/h, represented a surface friction demand that would be approaching the friction supply at which locking of wheels occurs.

The lateral surface friction demand was assessed by QPS as 0.20. This is well within the lowest measured surface friction supply in wet weather. However, when the brakes were applied at the entry to the curve, a longitudinal friction demand of 0.40 was measured. With longitudinal and lateral components combined, the resultant total friction demand was 0.44. This is close to the friction supply just before wheels "lock up", which was assessed to be 0.49 (average of 4 runs).

After wheels "lock up", the value of friction supply was assessed as 0.38. A diagrammatic explanation of the source of these friction values (from the QPS graphs in Appendix D) is depicted in Figure 7, together with a tabular summary.

---

<sup>8</sup> It is reasonable to assume that these results were not influenced by any pavement contamination, as further rain had occurred.

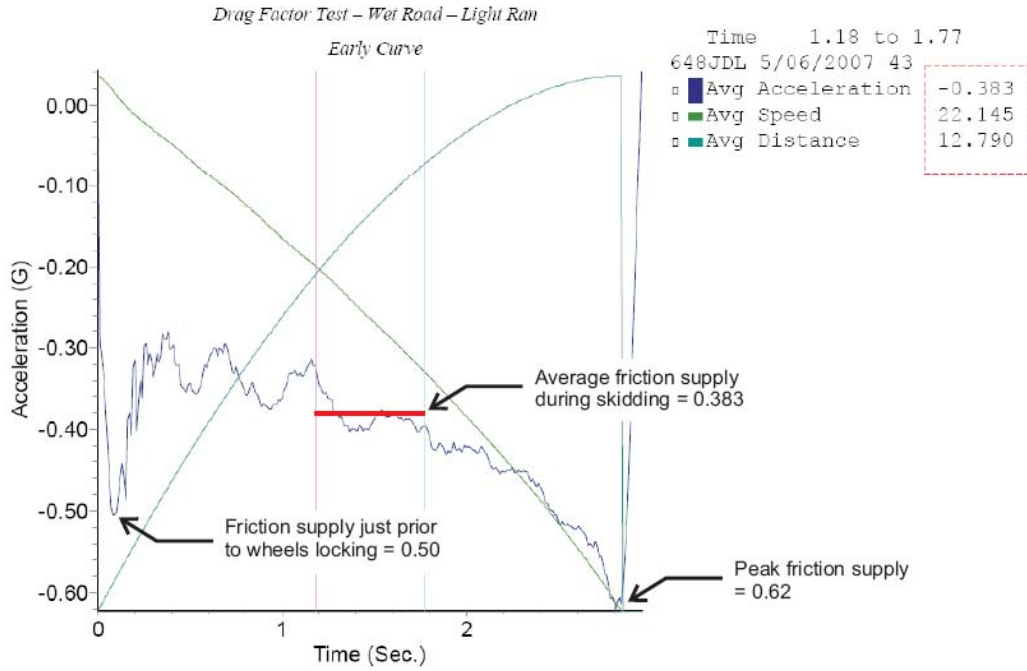


Figure 7 – Interpretation of friction supply data from QPS tests

Surface Friction Demand and Supply Measurements				
Friction Demand <sup>a</sup> (independent of surface condition, but measured on dry surface)			Average Friction Supply <sup>b</sup> (measured on wet surface)	
Lateral	Longitudinal	Combined	Prior to wheels "locking up" <sup>c</sup>	During skidding <sup>d</sup>
0.20	0.40	0.44	0.49	0.38
a. As measured by QPS in a run at 70 km/h with application of brakes b. As measured by QPS in multiple runs (typically 40-50 km/h) c. As interpreted from QPS graphs in Appendix D d. As measured by QPS				

The action by the Police test driver in applying the brakes at entry to the curve simulates what most drivers of the ramp were observed to do by the Police officers on site.

Hence it can be concluded that, on the section of ramp where these vehicles lost control, there would not have been a large margin of safety for a vehicle travelling at 70km/h in the wet and applying its brakes whilst negotiating the curve.

There are no measurements of the speeds of the vehicles that lost control on 21 May 2007.

At 70 km/h, the speed at which the Police conducted one of their tests, there should have been sufficient surface friction to provide vehicle stability even in the wet and with braking applied. However the eye-witness also reported the appearance of an oil-like film on the road surface where the vehicle started to lose control. This lends support to the earlier discussion that surface contamination may have been a significant factor in this crash – either some sort of "spillage" or "surface pollution" activated by light rain following a long dry period.

## 5.3 Summary Assessment

While the geometry is considered satisfactory, there was a faster than anticipated rate of "polishing" of the micro-texture of the surface, for the following reasons:

- a. The available deceleration distance made it necessary for vehicles to have to reduce speed over a shorter distance than desirable (104m available, 170m desirable).
- b. Vehicle speeds on entry to the curve were likely on average to have been higher than desirable, so tyre forces from braking and cornering were correspondingly higher.
- c. The superelevation was 3% (6% desirable).

Over the seven years since the current asphalt surface was laid, the protruding aggregate has been polished more than usual by the action of tyre forces (that is, tyres under braking action and tyres scrubbing the aggregate as vehicles were traversing the curve). Such polishing effectively reduced the micro-texture over-time. The friction characteristics (a surrogate for micro-texture) on this curve were measured by British pendulum test giving lower values in the range 41 – 47. Individual values as high as 53 were recorded indicating that differential rates of polishing had occurred. While there are no Australian criteria for this test, British standards for a gradient of 5% or more and greater than 100m in length would require a minimum value of 61. (The British criteria are not directly translatable to Australian conditions because weather, aggregate and traffic loadings differ appreciably).

The aggregate used for this asphalt was sourced from a quarry whose product was tested on 11 June 1999 and recorded a Polished Aggregate Friction Value (PAFV) of 45-46. Main Roads specifications required 45 minimum. Main Roads specifications do not distinguish between PAFV requirements for aggregate used in different stress applications. Main Roads should review its approach in this regard, at places such as at tight curves and approaches to intersections.

The surface macro-texture was more than adequate.

The average surface friction supply in the wet, under controlled braking (prior to wheels "locking-up") was assessed in police accelerometer tests to be 0.49. This might not provide a high margin of safety if a driver applied the brakes on entering the curve; since the resultant friction demand was then 0.44 (after combining the longitudinal friction demand due to braking and the lateral friction demand due to cornering).

The advantage of the QPS Vericom test is that it incorporates all relevant factors, including the longitudinal gradient (which at 7% maximum for a short distance was a significant factor). Observation of drivers entering the curve showed that most did apply their brakes.

Apart from the polishing of aggregate, over time, as the result of the action of traffic as explained above, the surface friction supply on the day of the crash was influenced by the following factors:

- a water film on the road due to light rain.
- possible contamination due to recent spillage of oil or fuel. An eye-witness reported an oil-like film in the outer wheel path – and the friction supply in that wheel path is particularly important.
- possible surface pollution on the road as a result of this being the start of light rain after a period of dry – thus "activating" things like oil drops and other fine material that may have been present on the road surface.

Two vehicles lost control in about the same location and about the same time. The combination of these factors reduced friction supply at that point in time, resulting in loss of control of these two vehicles in close succession (and close proximity).

## 6 General Assessment of the "Road Safety Adequacy" of this Ramp

Main Roads and Queensland Transport have a Crash Data Interpretive Modelling Tool to identify emerging crash locations. (This was developed following the investigation of crashes that occurred on the Bruce Highway at Federal, in 2005). This ramp does not appear as an emerging crash location using that tool with the most up-to-date crash data set available (namely crashes up to 30 June 2006).

Had Troutbeck and Kennedy included this ramp in their earlier analysis, it would not have shown up as a site warranting further investigation. This conclusion is reached from an analysis undertaken by Main Roads using the methodology adopted by Troutbeck and Kennedy in their earlier assessment (which compared five years pre-SMA crash history with up to five years post-SMA crash history). The analysis did not reveal a statistically significant increase in wet surface crashes.

Furthermore, when the crash history is expressed per unit of travel, it is noted that the crash rate was one crash per 3.1 million vehicle movements in the five year period prior to the current surface being laid. The comparable crash rate in the period since the new surface was placed, up to and just prior to the crash on 21 May 2007 was one per 2.7 million vehicle movements. That is, there was not an appreciable increase in crash risk (that is, crashes per unit of exposure). (This analysis excludes two crashes which did not involve road related issues, one resulting from impact with a rock on the road surface and the other from a blown tyre).

As mentioned previously, there is a strong suggestion that there was a contaminant on the road surface at the time of the crash. Consequently, the panel considers that a surface contaminant, perhaps oil or diesel, was the most likely road-related factor that contributed to the crash.

Figure 8 outlines the crash history on the ramp from 1 June 2001 to 24 May 2007<sup>9</sup>.

As noted earlier, the asphalt on this ramp is Stone Mastic Asphalt (SMA). Following the emergence of a crash concentration on the Bruce Highway, at Federal, an investigation was made by Troutbeck and Kennedy<sup>10</sup> into the crash performance "pre-" and "post-" surfacing with SMA. The scope of that investigation covered all SMA on State-controlled roads in Queensland where the necessary data existed to undertake the analysis.

Some sections of "through carriageway" couldn't be included, since there was an insufficient period "post-SMA" to support reliable findings. Ancillary roadways such as ramps and service roads were also omitted from that analysis due to paucity of traffic flow data.

---

<sup>9</sup> It should also be noted that Main Roads has received advice of two further crashes on this ramp, however these have not been validated by other agencies. Neither of these crashes are recorded in Main Roads' crash database and consequently were not considered in the analysis to identify emerging crash locations.

<sup>10</sup> Rod Troutbeck and Chris Kennedy – Review of the use of Stone Mastic Asphalt (SMA) surfacings by the Queensland Department of Main Roads, 2005.

Professor Troutbeck has been further engaged to:

- extend the earlier analysis to cover all SMA surfacing on state-controlled roads in Queensland.
- pay particular attention to the crash performance on this ramp “pre-” and “post-” surfacing with SMA.

Professor Troutbeck is not due to report on his investigations until end July 2007.

COLLISION DIAGRAM - Fatal Crash Investigation # 20700097149

SHIRE Maroochy Shire JOB/FILE#

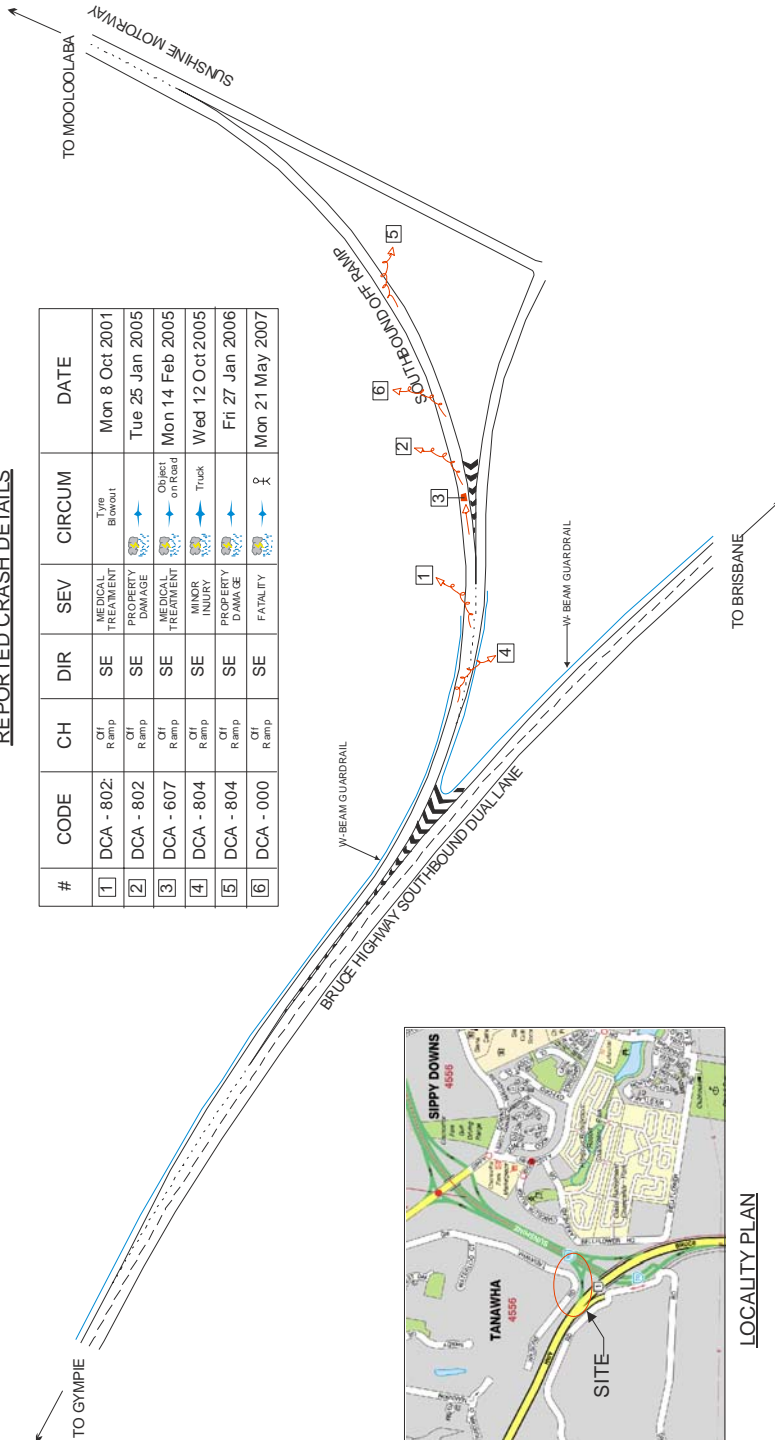
LOCATION South Bound Bruce Hwy Off Ramp to Sunshine Motorway

PERIOD 5.9 YRS FROM 1/6/2001 TO 24/05/2007



REPORTED CRASH DETAILS

#	CODE	CH	DIR	SEV	CIRCUM	DATE
1	DCA - 802	OT Ramp	SE	MEDICAL TREATMENT	Type Blowout	Mon 8 Oct 2001
2	DCA - 802	OT Ramp	SE	PROPERTY DAMAGE	Object on Road	Tue 25 Jan 2005
3	DCA - 607	OT Ramp	SE	MEDICAL TREATMENT	Truck	Mon 14 Feb 2005
4	DCA - 804	OT Ramp	SE	MINOR INJURY	Object on Road	Wed 12 Oct 2005
5	DCA - 804	OT Ramp	SE	PROPERTY DAMAGE	Object on Road	Fri 27 Jan 2006
6	DCA - 000	OT Ramp	SE	FATALITY	Object on Road	Mon 21 May 2007



LOCALITY PLAN

LEGEND	YEAR	FATAL	PERSONAL INJURY	PROPERTY DAMAGE	TOTAL
Side Swipe	2001		1		1
Out of Control	2004		2		2
Fatal Accident	2005		1		1
Personal Injury	2006		1		1
Property Damage	2007	1	3	2	6
Only	TOTAL	1	3	2	6
Rear End Collision					
Vehicle Backing					
Moving Vehicle					
Pedestrian					
Tram car					
Stationary Vehicle					
Parked Vehicle					
Fixed Object					

RESULTS OF ACCIDENTS	CIRCUMSTANCES	DCA CODE	No.
1	Pedestrian	DCA - 000	1
2	Motorbike	DCA - 607	1
3	Bicycle	DCA - 802	2
4	Night	DCA - 804	2
5	Night/Street Light		
6	Fatigue/Fell Asleep		

RESULTS OF ACCIDENTS	CIRCUMSTANCES	DCA CODE	No.
1	Caused Secondary	DCA - 000	1
2	Object (Guardrail/Tree)	DCA - 607	1
3	Driving Under Influence	DCA - 802	2
4	Raining	DCA - 804	2
5	Wet / Slippery		
6	Animal on Road		

COMPILLED BY LJKIDD / TYUC DATE 06/07/2007

DWG # 20700097149 DATE 20/07/2007 SCALE AS SHOWN

Figure 8 – Collision diagram (1 June 2001 to 24 May 2007)

## 7 Enhancements Already Implemented

As outlined in section 5.2, the speed signs on this ramp roadway were changed from 80 km/h to 70 km/h on 14 June 2007. A trailer mounted variable message sign was placed in advance of the ramp to forewarn motorists of the changed speed limit on 27 June 2007.

## 8 Potential Enhancement Actions on the Ramp

The following potential measures to improve safety for vehicles traversing the ramp in wet conditions, have been identified and considered:

- take action to ensure drivers enter this curve at speeds which are safe;
- re-surface that portion of the roadway, which is subjected to higher friction demands, with a material which is more resistant to polishing, and also, more likely to compensate for the presence of any surface contamination;
- improve visibility on the inside of the curve (which is currently limited by the presence of vegetation and guardrail);
- increase the cross-fall on the ramp;
- change the horizontal geometry of the ramp and its approach (for example increase both the radius and the cross-fall of the curve and the deceleration distance to the start of the curve).

These options are further discussed and evaluated in the sections below.

### 8.1 Improve visual cues to reduce speeds

Despite the limited preview time on the approach to the curve, the level of compliance with the speed limit suggests that the majority of motorists are responding to the existing visual cues (and adopting speeds similar to the road design speed). This may also reflect the fact the majority of drivers are familiar with the ramp characteristics; and the volume of traffic is such that the behaviour of unfamiliar drivers is influenced by vehicles ahead. Two options are proposed:

- a. Enhance the existing static signs by:
  - installing chevron alignment markers to enhance the delineation of the curve.
  - installing a high-impact exit advisory speed sign (TC9939) and a high-impact “slippery when wet” sign (TC9822) to emphasise the need for drivers to take care on this curve.

These signs (depicted in Figure 9) could be quickly installed.



Figure 9 – Proposed modifications to static signs

- b. Ultimately consideration could be given to the installation of permanent active warning signs which detect vehicle speeds and provide feedback to drivers that they are exceeding a safe approach speed. (Optimally, it would be desirable to convey an even higher impact message in the event of a wet road surface being detected). Permanent active warning signs, linked to pavement moisture detectors, could take 3-4 months to install. **This treatment would not be necessary if surface friction improvements were made, such as the application of calcined bauxite treatment.**

It is important to note that the effectiveness of these signing options would be reliant upon driver observation and compliance. In addition, in the case of active warning signs, a high level of confidence in the technology would be essential. (The design would require a high “safety integrity level”).

## 8.2 Re-surface the ramp to improve micro-texture

Investigations indicate that the best available treatment for this purpose is calcined bauxite<sup>11</sup>.

Calcined bauxite has a very high skid resistance. Its PAFV will be in the range of 70-75, which is much higher than the PAFV of the aggregate used in the current surfacing on the ramp (45-46) or any other standard surfacing options.

In the VicRoads "Guide to the Measurement and Interpretation of Skid Resistance using SCRIM" in Table 1 "Investigatory Levels", the SCRIM sideways friction coefficient (sfc) minimum investigatory level for the highest stress category (Category 1) is 0.55 for traffic volumes greater than 2500 vehicles / lane / day.

<sup>11</sup> Calcined bauxite is an extremely hard manufactured aggregate which retains the "sharp" edges and facets produced at the time of crushing for the life of the treatment. Its surface is very resistant to polishing (that is, it has a high PAFV). These attributes greatly enhance the skid resistant properties of the surface. Calcined bauxite is "bound" to the existing surface using an epoxy resin.

VicRoads' Technical Note No. 60 states: "*When tested using SCRIM, sideways friction coefficient (sfc) values of 0.75, and more, have been measured in trials of calcined bauxite surfacing systems*".

This demonstrates the superior performance of calcined bauxite. With this level of skid resistance, the ramp will be safe for use, in the wet, and with the current geometric configuration.

Appendix E provides further details of calcined bauxite, and experience with its application. This treatment has an excellent performance record, has been in use in UK since the 1960s and in Australia for more than two decades. To ensure the best result, Main Roads will use a specialist supplier with an excellent track record and engage field supervisors who are experienced with surface preparation, application processes and performance risks.

### **8.3 Improve visibility on the inside of the curve**

Both the District crash investigation report (Appendix A) and the detailed geometric assessment (Appendix B) noted that sight distance was restricted by the presence of the safety barrier and vegetation on the inside of the curve. Vegetation clearing would improve drivers' view to the curve ahead (and better reinforce the need to reduce speed). It is probable that the ramp would need to be closed to undertake this work (and to assist visual confirmation of the extent of work required).

### **8.4 Increase the cross-fall on the ramp**

The contribution that an increase in the ramp cross-fall (from 3% to 6%) would have on the friction demand is relatively small. (At 70 km/h, lateral friction demand would reduce from 0.16 to 0.13). In terms of an immediate fix, this option is not necessary at this time because the calcined bauxite surfacing will more than adequately accommodate this issue. However, it should be considered further in the context of any future development of the interchange to accommodate future traffic volumes.

### **8.5 Improve both the horizontal geometry of the ramp and its approach**

This is not a short term solution; and development of detailed options and a cost estimate was outside of the scope of this report. An increase in curve radius to 300m (the proposed design guideline for 'system interchanges'), together with the provision of 5% cross-fall, would reduce friction demand to 0.16 at 90 km/h (the system interchange ramp design speed). That is, the improved geometry would allow ramp speeds to increase, but would not provide a significant reduction in friction demand. Once again, it should be considered further in the context of any future development of the interchange to accommodate future traffic volumes.

## 9 Recommendations

### 9.1 Recommendations for enhancement measures at this location

1. Since the fatal crash on 21 May, Main Roads has temporarily reduced the advisory and regulatory speed limits on the ramp from 80 km/h to 70 km/h. It is recommended that this change be made permanent.
2. It is recommended that enhanced warning signs be installed (including chevron alignment markers on the outside of the curve, higher impact exit advisory speed sign and “slippery when wet” sign).
3. It is recommended that visibility on the inside of the curve be improved by removing vegetation.
4. It is recommended that a new calcined bauxite surfacing be applied to improve skid resistance. (Once the surface is installed, the high-impact “slippery when wet” warning sign can be removed.)

The above recommendations will result in a significant improvement to ramp safety.

5. It is also recommended that the following general road safety improvements at this ramp, not related to the crash, but noted by the District during the crash investigation be considered:
  - 5.1 Replacement of the "Wrong Way Go Back" sign to improve night-time reflective performance.
  - 5.2 Replacement of existing guardrail (behind the chevroned area) with a terminal treatment to enhance safety (a slotted "thrie beam" bull-nose terminal).
  - 5.3 Undertake regular inspections to address general maintenance issues such as ensuring guide posts and delineators are in place.
  - 5.4 Increase in guardrail height by approximately 100 mm.
  - 5.5 Improvements to road lighting to enhance illumination of the approach ramp and curve.
  - 5.6 Clearing of large trees on the outside of the ramp curve to improve safety in the event of run-off-the-road events.

### 9.2 General recommendations

6. It is recommended that:
  - 6.1 Delays in receipt of crash reports be addressed.
  - 6.2 On other off-ramps from 100 or 110 km/h motorways and highways, Main Roads undertake detailed measurements of friction demand and supply in wet conditions, progressively as part of the ongoing program to enhance the safety of the road network.
  - 6.3 Main Roads purchases dual-axis acceleration measuring equipment to undertake lateral acceleration tests; and ensure that relevant Districts are supplied with this

equipment and have officers on staff experienced in its use for this purpose. (Skid test measurements using such equipment may need to be procured from QPS<sup>12</sup>).

- 6.4 Main Roads reviews its design methods and its guidelines and specifications to ensure, in areas of roadway with increased surface friction demands and potential for increased polishing (such as at tight curves and approaches to intersections on heavily trafficked roads), that better performing aggregates (with higher polished aggregate friction values) are specified.
- 6.5 Main Roads progressively undertakes a state-wide review of advisory speed signs on curves, to confirm advisory speeds remain appropriate using the procedures in the Manual of Uniform Traffic Control Devices.
- 6.6 Main Roads develops a program of activities by October 2007 that addresses recommendations 6.1 to 6.5.

---

<sup>12</sup> As the friction supply tests require the test vehicle's ABS braking system to be disabled, and for the vehicle to skid in a controlled manner (at low speed), it is probable that workplace health and safety issues preclude Main Roads officers from undertaking this assessment.

## **Appendix A – North Coast-Hinterland District Crash Investigation Report**



**Queensland  
Government**

Department of  
Main Roads

**TRAFFIC  
OPERATIONS**

## Investigating and Reporting Road Safety and Road Environment Conditions at Crash Sites

### NORTH COAST-HINTERLAND DISTRICT

**Final**

### CRASH INVESTIGATION REPORT

**Accident No:** 20700097149

**Shire:** Maroochy

**Road:** Bruce Hwy, Tanawha (Sippy  
Downs) – Road 10A

**Chainage:** QE 66.134

**DMR Investigating Officer:**

**Crash Date:** 21 May 2007

**Prepared by  
Title**

**Branch**

North Coast-Hinterland District

**Division**

Traffic Operations

**Location**

Parkyn Parade, Mooloolaba, Queensland, 4557

**Version no.**

5

**Version date**

29-06-2007

**Status**

Final report

## Document Control Sheet

### Contact for enquiries and proposed changes

If you have any questions regarding this document, please contact:

**Contact Officer:**

**Title:**

**Phone:**

### Version History

Version No.	Date	Changed By	Nature of Amendment
1	24/05/2007	MPL	Preliminary draft
2	8/06/2007	MPL	Draft
3	20/06/2007	PMV/RJG	Draft review changes
4	21/06/2007	JCD	Draft review changes
5	29/06/2007	MPL	Final report

# TABLE OF CONTENTS

<b><u>SECTION 1 – SITE INVESTIGATION DETAILS, SKETCH AND PHOTOS</u></b>	<b><u>4</u></b>
<b><u>SECTION 2 – RECORD OF INTERVIEW WITH POLICE</u></b>	<b><u>20</u></b>
<b><u>SECTION 3 – ADDITIONAL PHYSICAL FEATURES OF CRASH SITE</u></b>	<b><u>22</u></b>
<b><u>SECTION 4 – ADDITIONAL TESTING/CHECKING ORDERED</u></b>	<b><u>23</u></b>
<b><u>SECTION 5 – CRASH HISTORY AND ANALYSIS</u></b>	<b><u>24</u></b>
<b><u>SECTION 6 – REMEDIAL TREATMENTS</u></b>	<b><u>44</u></b>
<b><u>SECTION 7 – CRASH INVESTIGATION OFFICER'S STATEMENT</u></b>	<b><u>46</u></b>
<b><u>APPENDIX A - RECOMMENDED REMEDIAL COUNTERMEASURES - DISTRICT ACTION PLAN</u></b>	<b><u>47</u></b>
<b><u>APPENDIX B - MEDIA ARTICLES</u></b>	<b><u>49</u></b>
<b><u>APPENDIX C- PLAN</u></b>	<b><u>50</u></b>
<b><u>APPENDIX D – ADVISORY SPEED STUDY</u></b>	<b><u>60</u></b>
<b><u>APPENDIX E – ASSESSMENT OF EXISTING LIGHTING LEVELS</u></b>	<b><u>61</u></b>

## **Section 1 – Site Investigation Details, Sketch and Photos**

### **1.1 ROAD INVENTORY DETAILS**

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1.11 Time, Day & Date of Incident:

3:00pm, Monday, 21 May 2007

1.12 Road Number and Gazetted Name:

10A – Bruce Highway

1.13 Exact Location of Crash :

SB Off-ramp to Sunshine Motorway ch. QE 66.134 – (approx. 294m along ramp chainage)

1.14 Special features – Intersection, Bridge/Causeway, Railway Crossing, Median Opening, Sidetrack, Detour, Merging lane, Other:

Highway Off-ramp

1.15 Traffic Volume and Composition. AADT: 3800; % Commercial Vehicles: 5.3%

### **1.2 ENVIRONMENTAL CONDITIONS**

1.21 Atmospheric Conditions – Clear, Raining, Smoke/Dust, Fog, Other:

Light rain

1.22 Road Surface – Wet, Dry:

Wet

1.23 Lighting – Daylight, Dawn/Dusk, Darkness-Street Lighting, Darkness-Unlit, Other:

Daylight

### **1.3 REGULATORY DEVICES**

1.31 Traffic Control (Specify below and include details on Site Sketch Plan) –

Person - Police, Road/Railway Worker, Supervised School Crossing:

Lights - Operating traffic lights, Flashing amber traffic lights, Railway-lights only, Railway-lights and boomgate:

Sign/Crossing - Stop sign, Give way sign, Rail Xing sign, Pedestrian (Zebra) Xing, School Xing-flags only:

Other – other regulatory signs or devices (excluding speed signs):

End Motorway sign

Wrong Way Go Back sign

1.32 Speed Limit (Specify below and include details on Site Sketch Plan) -

Posted Limit at time of incident:

110 km/h on Bruce Highway

80 km/h along ramp (interim 70km/h regulatory speed installed 14/06/2007 pending outcome of investigations)

Location of Speed Signs (if located beyond limits of the Site Sketch Plan):

110 km/h @ ch. 70.950 (against gazettal – duplicated LHS / RHS)

80 km/h @ ch. 66.022 (approx. midway along off-ramp – duplicated LHS / RHS) (interim 70km/h regulatory speed installed 14/06/2007 pending outcome of investigations.)

Condition of Speed Signs – Good, Faded, Low Reflectivity, Damaged:

Good

Signs on ramp are B-size, should be larger - C-size, MUTCD, Part 4, Clause 4.2.7, Table 4.2

Visibility (Specify any speed sign visibility restrictions):

80 km/h (interim 70 km/h) on LHS obstructed by direction sign – visibility = 60m

Sign on RHS is visible and advisory ramp speed precedes regulatory speed signs.

1.4 ROAD FURNITURE (Including Pavement Markings)

1.41 Road Signs – show all signs in the vicinity of the crash site on the Site Sketch Plan. Complete the table below for any signs in poor condition.

CLASS	TYPE	LOCATION	SIZE	CONDITION
Regulatory:	Wrong Way Go Back	Off-ramp opposite dir.	2300 x 1470	Faded Low Reflectivity
Warning:				
Advisory:	Exit Speed 80 (interim 70 km/h patch installed)	Off-ramp	1500 x 1400	Faded Low Reflectivity
Direction:				
Temporary:				

- 1.42 Pavement Markings incl. reflective raised pavement markers (RRPM's) in vicinity of crash site (Specify below and include details on Site Sketch Plan) -

Condition: **Good**

- 1.43 Guide Posts and Delineators in vicinity of crash site (Specify below and include details on Site Sketch Plan) -

Condition: **Good**

**No delineators on guardrail near gore area**

**A few guides posts are missing towards end of ramp**

- 1.44 Existing Barriers in vicinity of crash site (Specify below and include details on Site Sketch Plan) -

Barrier Type: **W-beam**

End Terminal 1: **LHS – MELT terminal**

End Terminal 2: **Gore area – Continuous curved W-beam section**

Comments: **Height of guardrail LHS 630 - 660mm, RHS 600 - 650mm**

If a vehicle collided with a Barrier, did it perform safely/adequately (a post-crash assessment of barriers is required under AS3845, clause B2.6)? **N/a**

If "No", provide comments: **N/a**

- 1.45 Road Lighting -

Is Street Lighting present: **Yes**. (If present, record locations on Site Sketch Plan)

If present, does it appear suitable: **No**. If "No", complete section 4.1(l).

If not present, is it required: **N/a**. If "Yes", indicate basis of requirement:

## **1.5 ROADSIDE HAZARDS**

- 1.51 Physical Obstructions (Specify below and include details on Site Sketch Plan) -

Is the recommended clear zone achieved: **No** (If "Yes" Go to section 1.6)

State the nature of rigid objects located within the clear zone, and the lateral offset from the edge line:

**Guardrail – varies between 0.9m to 2.1m**

Trees various RHS located @ 2.6m, 4.6m, 5.1m, 8.6m offset.

Table drain LHS @ 2.0m off-set

Is the roadside environment in the vicinity of the crash site consistent with adjacent road sections:

Yes

## 1.6 VISIBILITY

1.61 What is the required sight distance for the speed conditions present?

Stopping Sight Distance @ 85 km/h and reaction time 2.5 sec = 127m (cars)

What is the actual sight distance 76m to 102m

Is the required Sight Distance achieved: No

If "No", what are the restrictions to sight distance:

Guardrail and vegetation on inside of bend

## 1.7 ROAD SURFACING

1.71 Road Surface Type (Traffic Lanes Only) – Eg. Stone Mastic Asphalt, Dense Graded Asphalt, Hot Mixed Asphalt, Open Graded Asphalt, Stone Seal, Unsealed: Stone Mastic Asphalt

1.72 Road Surface Type (Shoulders Only) – Eg. Stone Mastic Asphalt, Dense Graded Asphalt, Hot Mixed Asphalt, Open Graded Asphalt, Stone Seal, Unsealed: Stone Mastic Asphalt

Road Surface/Pavement Condition (Traffic Lanes and Shoulders) – Eg. Good, or Surface Defects such as Pot Holes, Rutting, Cracking, Unevenness, Slippery, Fatty, Polished, Flushed, Loose Material, Drainage Issues, etc.:

To be assessed and reported separately.

## 1.8 GEOMETRY

- 1.81 Cross Section Details (Specify below and include a drawing of the Cross Section in Site Sketch Plans) -

Lane Width: 4.0 m.      Number of Lanes: 1 lane

Traffic Lane Crossfall: 3.0% (checked with Smart-level - varies btw 2.5% & 3.3%)

Shoulder Width: 2.0m LHS / 1.4m RHS. Shoulder Drop-off: 110 – 200mm

Shoulder Crossfall: varies 1.6% to 3.0% - smart level

Comments : Shoulder drop-off on LHS from end guardrail to Sunshine Motorway merge around 200m in length. Shoulder drop-off is near the batter hinge point.

- 1.82 Vertical Geometry – Crest Curve followed by Sag Curve (design plans – Appendix C)

Vertical Curve Radius 1: Crest curve = 3125m

Vertical Curve Radius 2: Sag curve = 3438m

Vertical Straight Grade: Varies along ramp 7.5m, 7.0m, 5.4m, 4.2m, 4.0m (Smart level)

- 1.83 Horizontal Geometry – Curve Left (design plans – Appendix C)

Curve Radius: 204 m.

- 1.84 Geometric Assessment – Is geometry in accordance with the RP&DM for the speed limit present: to be assessed and reported separately.

(A plan and/or workings showing an assessment of vertical/horizontal geometry and crossfalls must be included)

If "No": -(a) what is the geometric deficiency and what speed limit would the existing geometry cater for -

Geometric Deficiency:

Catering Speed:

(b) is an appropriate warning device in place?

**1.9 INJURIES AND PROPERTY DAMAGE**

1.91 Complete table below with the apparent severity of injuries sustained by persons and damaged sustained to vehicle property:

Unit Details (add/delete Units as necessary)	Severity Details				Property Damage Details  (Extent of Damage - Nil, Minor, Moderate-driveable, Moderate-towed away, Major-towed away, Extensive-unrepairable)
	Fatal (No.)	Hosp (No.)	Other Injury (No.)	OR PDO ("Y" if yes)	
<u>Unit 1</u> Driver, Rider or Pedestrian Passengers				Y	Unit Type: Car Damage Point: Right hand side Extent of Damage: Moderate-towed away
<u>Unit 2</u> Driver, Rider or Pedestrian Passengers				Y	Unit Type: Car Damage Point: Front left side Extent of Damage: Moderate-towed away
<u>Unit 3</u> Driver, Rider or Pedestrian Passengers	1#				Unit Type: Pedestrian Damage Point: Body Extent of Damage: Fatal injury
<u>Note #</u>	Unit 3 was driver of Unit 1. Unit 3 exited the Unit 1 prior to collision with Unit 2. As such Unit 3 is identified as a pedestrian (DCA 000 – Pedestrian Other)				

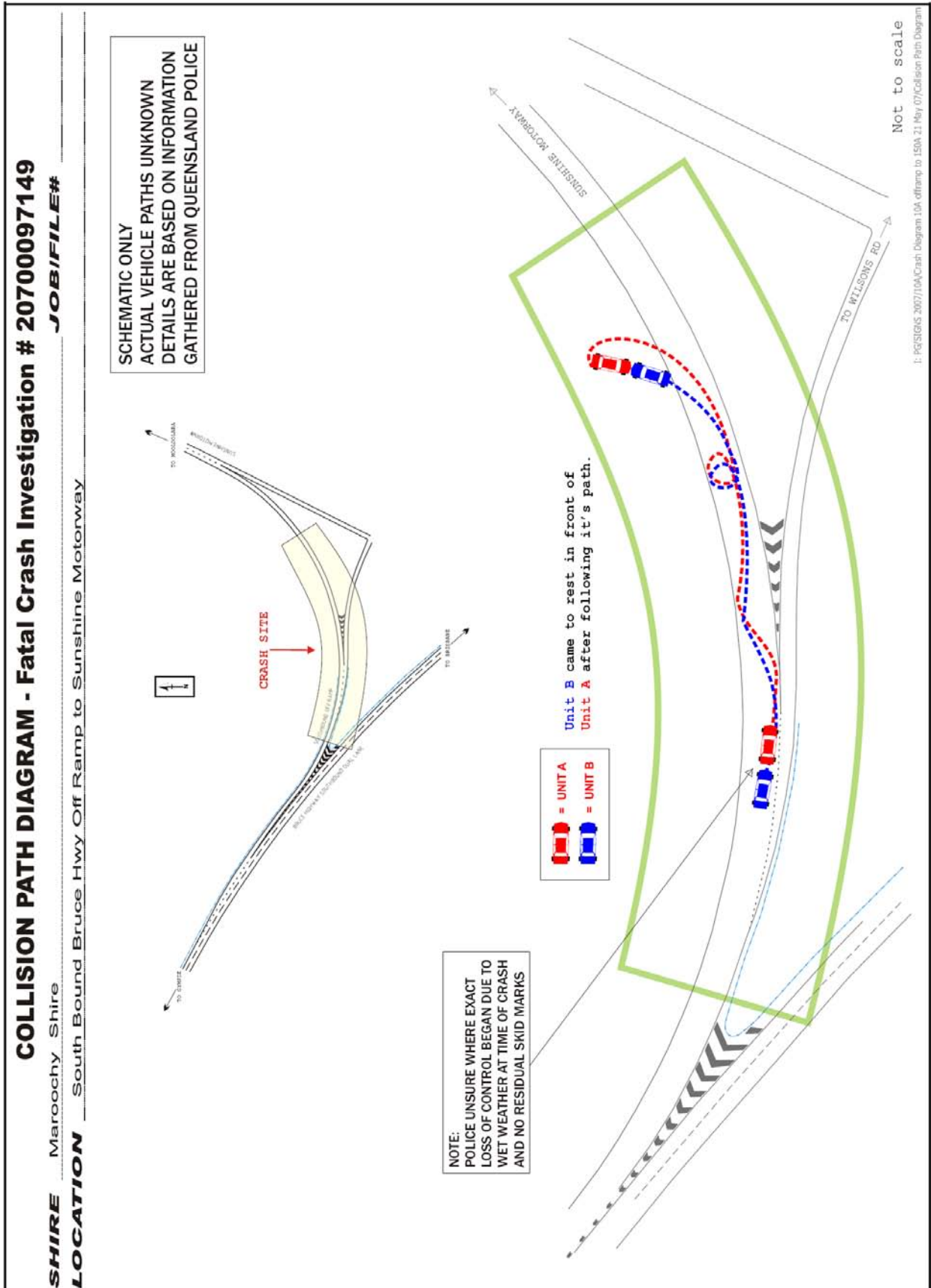
1.92 Is there any Damage to Main Roads' Infrastructure: Yes

If "Yes", describe damages: 4 guideposts have been knocked over

If "Yes", what is the estimated cost of damages: \$ 4000 (estimate includes traffic control)

# Site Investigation Sketch Plan(s)

Date of Site Investigation: 30/05/2007 – 31/05/2007

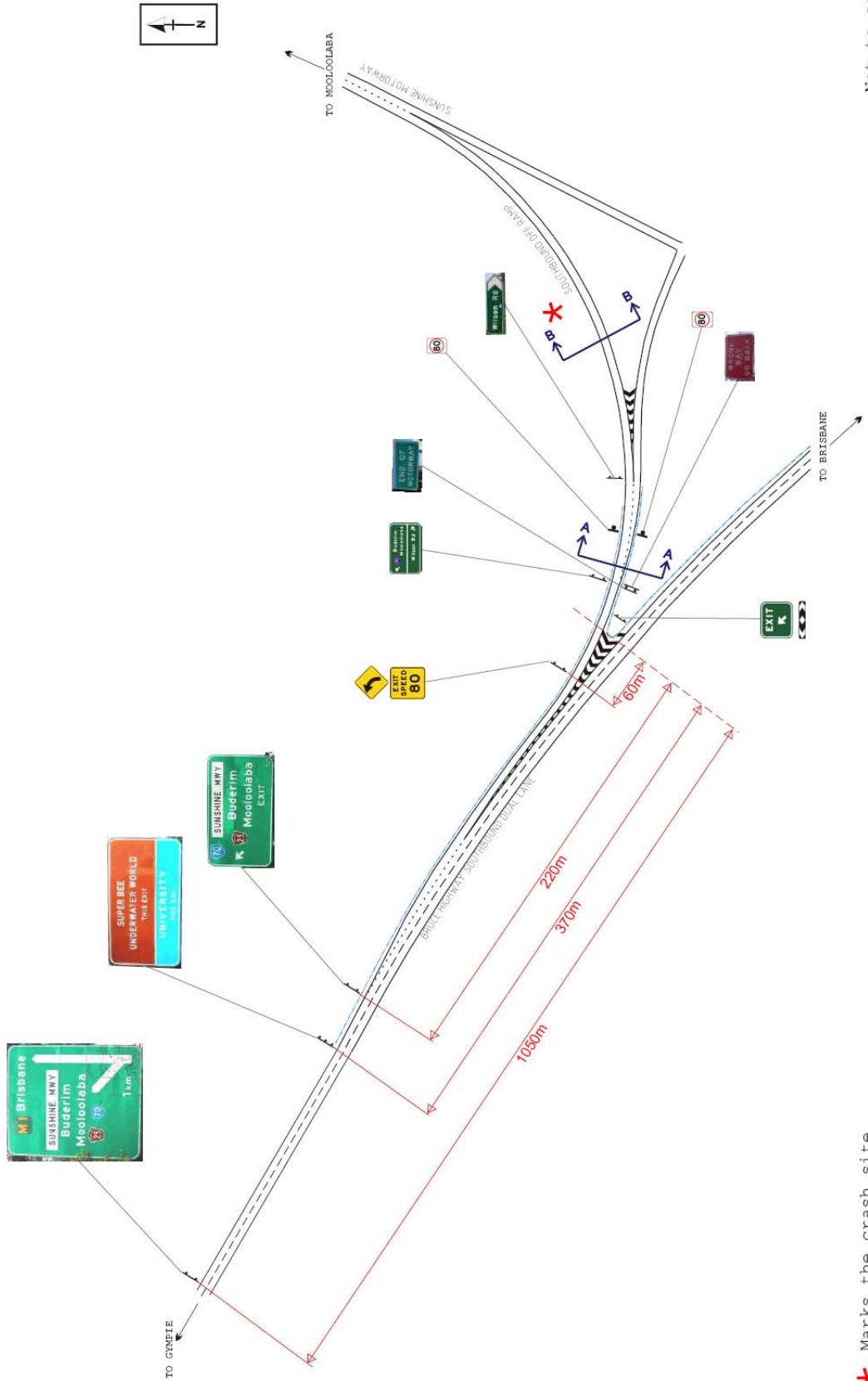


**EXISTING SIGNS DIAGRAM - Fatal Crash Investigation # 20700097149**

**JOB/FILE#**

**SHIRE** Maroochy Shire

**LOCATION** South Bound Bruce Hwy Off Ramp to Sunshine Motorway

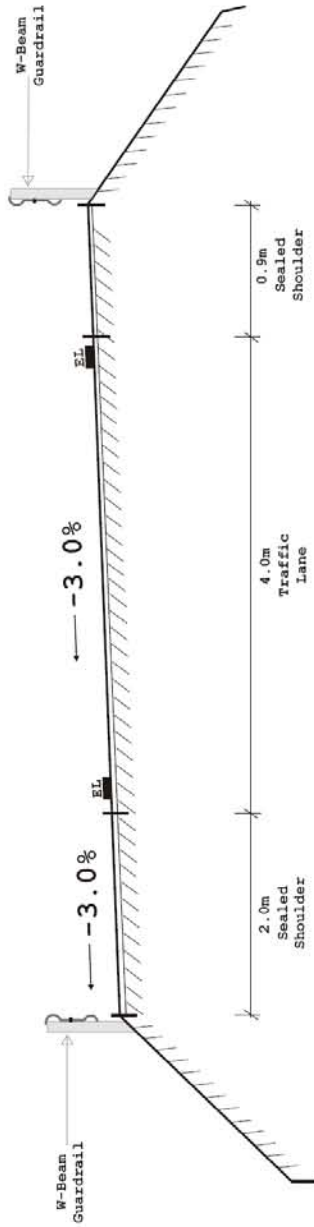


**X** Marks the crash site

Not to scale  
 I: PG/SIGNS 2007/10A/Crash Diagram 10A off-ramp to 150A.21 May 07/Existing Signs Diagram

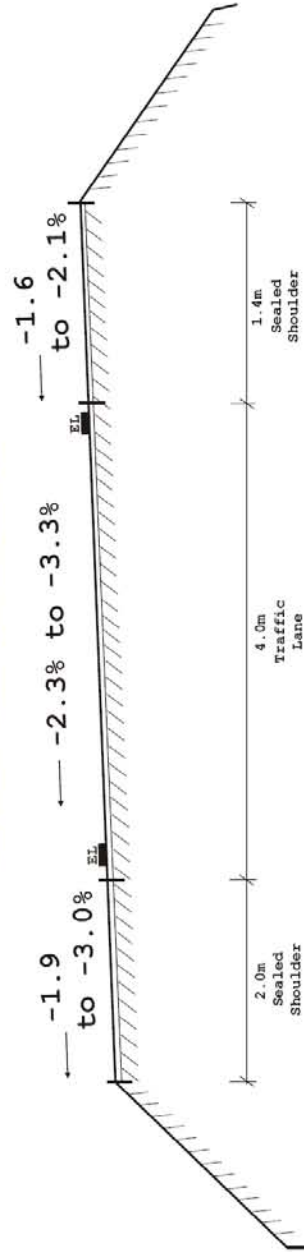
### CROSS SECTION A-A

APPROX. OVER 30M IN LENGTH



### CROSS SECTION B-B

APPROX. OVER 30M IN LENGTH



GEOMETRY BASED ON  
 SMART LEVEL READINGS

Not To Scale

I: PG\SIGNS 2007\10A\Crash Diagram 1GA.dwg Date: 15/04/21 May 07/Cross Fall Diagram

## Site Investigation Photographs



Photo 1 – Off-ramp approach



Photo 2 – Start off-ramp



Photo 3 – Off-ramp

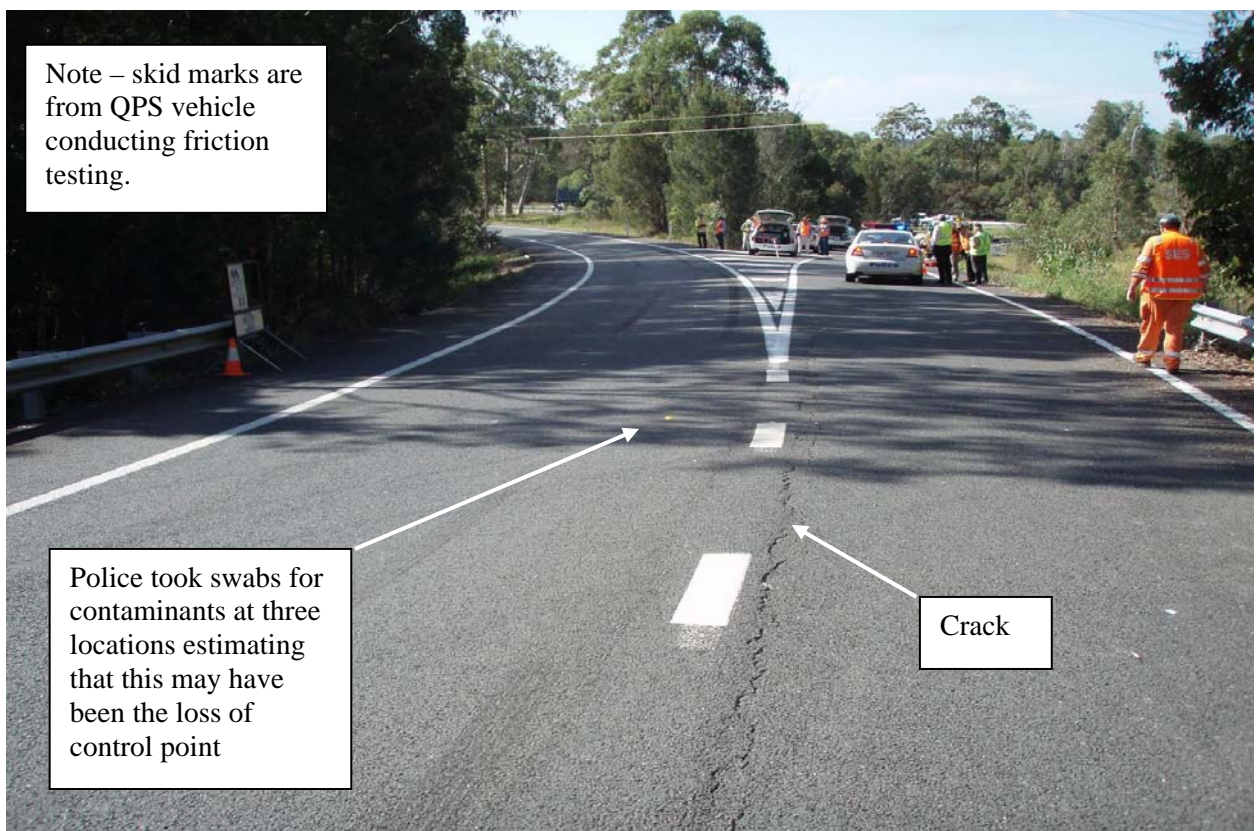


Photo 4 – Point were vehicle may have lost control



Photo 5 – View along ramp



Photo 6 – Reverse view along ramp

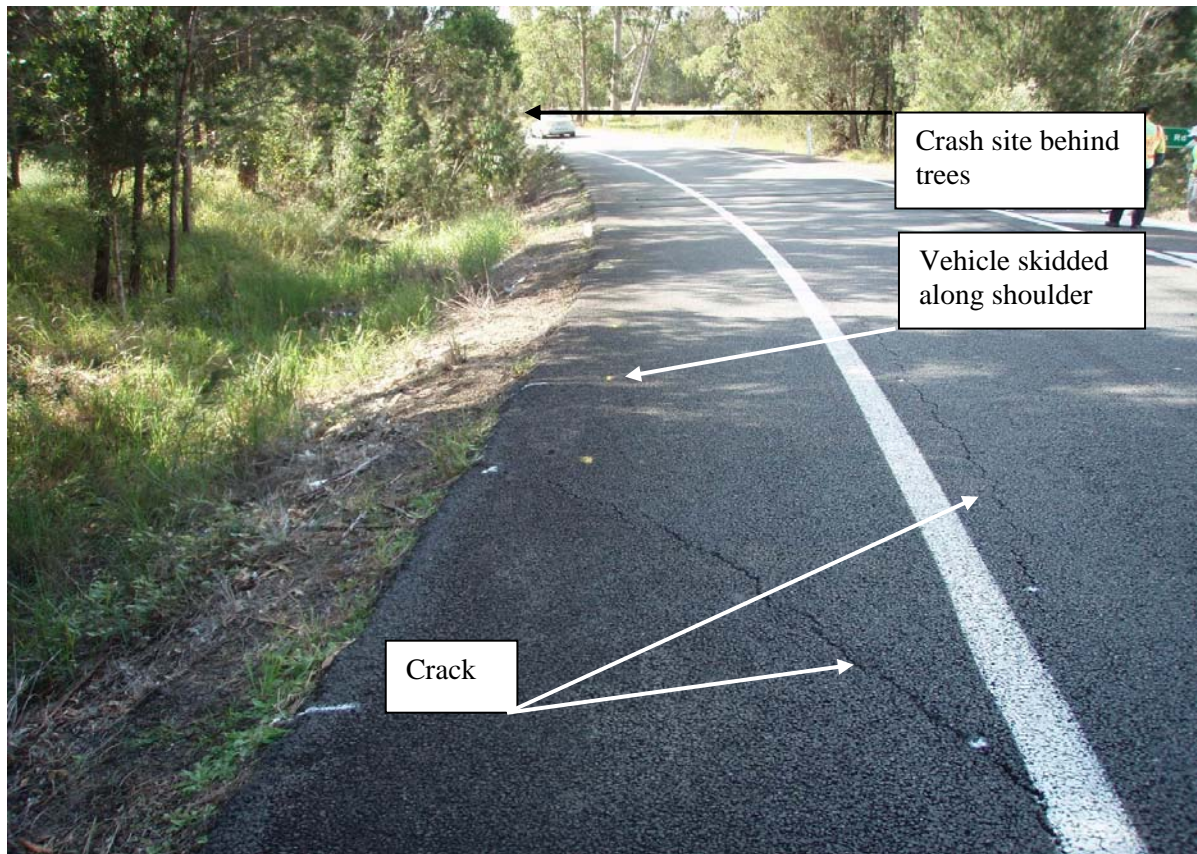


Photo 7 – View along shoulder where vehicle skidded



Photo 8 – Reverse view along shoulder



Photo 9 – Shoulder near crash site



Photo 10 – Crash site



Photo 11 – Settlement of road and environmental crack in pavement



Photo 12 – Settlement of road and environmental crack in pavement

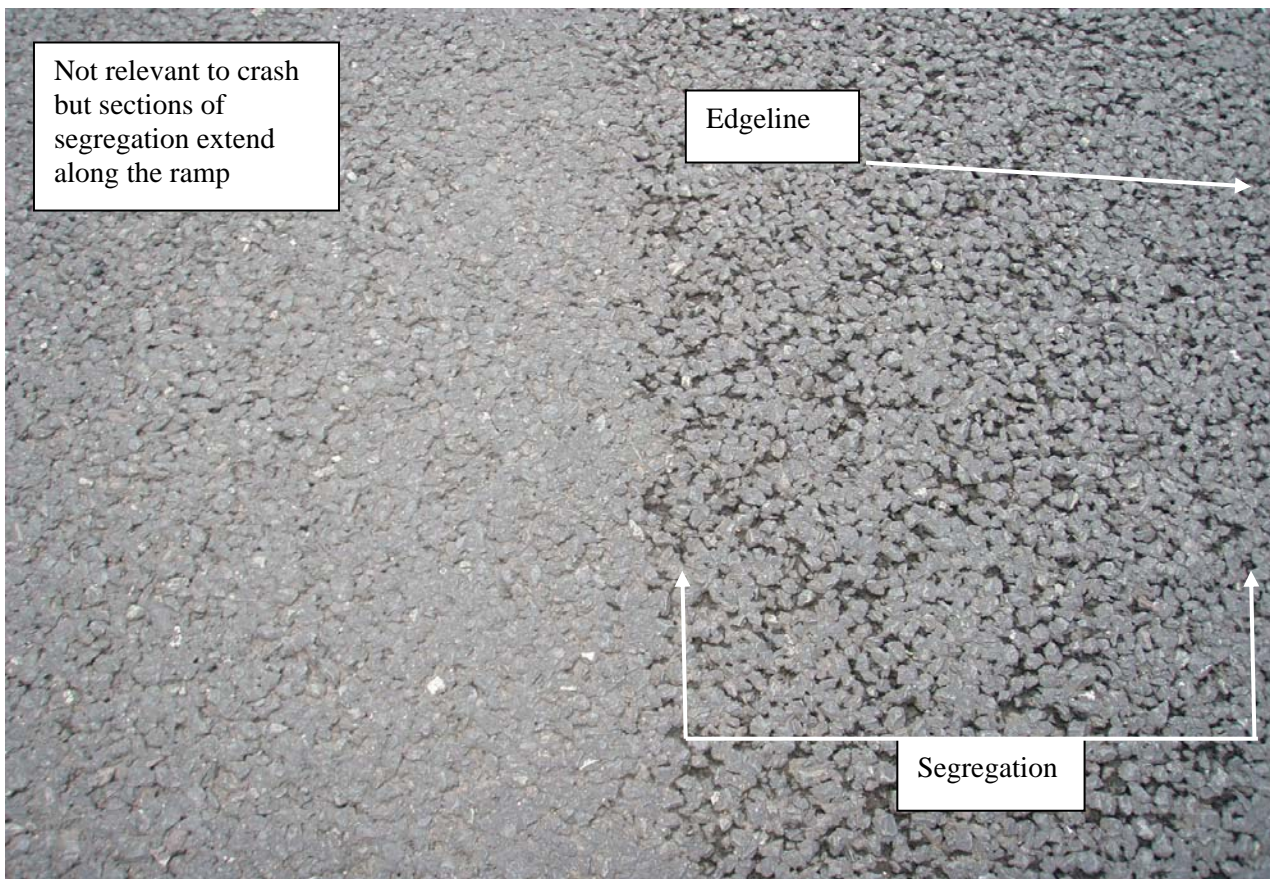


Photo 13 – Segregation of pavement near edgeline



Photo 14 – Small pothole starting to form near start of ramp

## Section 2 – Record of Interview with Police

**2.1** Name and Rank of Officer:

Name: [Stephen Knight](#)

Rank: [Senior Constable](#)

FCU: [Yes](#)

**2.2** Station Attached To: [Coolum](#)

**2.3** Discussion Date: [22/05/07 & 31/06/07](#)

Location: [Telephone and on-site](#)

**2.4** Others Present:

[Justin Valks](#)

**2.5** Did Police Officer attend crash:

[Yes](#)

Who were attending Officers:

Name

Station

[Unknown](#)

**2.6** State the apparent nature of injuries sustained by persons and damaged sustained to property:

[1 x fatal](#)

**2.7** Based upon discussion with Police, Main Roads' opinion as to possible cause of crash:

[Light rain making the road surface slippery. Driver of vehicle behind Unit 2 witnessed Unit 2 drive through a rainbow coloured patch on road surface underneath outer wheel path \(driver's side – right hand side wheel path of vehicle\) and subsequently saw the vehicle loose control. The rainbow coloured patch in the opinion of the witness is consistent with a substance such as oil or diesel. The witness did not loose control of vehicle. Police advise that Unit 2 was travelling at 70 km/h at the time of losing control. Visual assessment by police when they arrived at the scene did not reveal any contaminant on surface. Senior Constable Steve Knight and others walked the road on the approach to the crash site but could not detect any fuel deposits. He took three swabs of the road surface for further testing. He noted there were some minor deposits of soils/grits on the road surface that would normally wash off in the event of heavy rain.](#)

**2.8** Police preliminary opinion as to possible road contributing factors:

Slippery / wet road conditions

Possible combination of camber and tight radius curve.

**2.9** Police knowledge of any other crashes in vicinity:

No

**2.10** Police officers' preliminary opinions as to immediate needs for revised/additional signing or other minor works:

Nothing

**2.11** Police opinion as to other countermeasures that may be required:

Analysis of curve and camber

Skid resistance testing

### Section 3 – Additional Physical Features of Crash Site

#### 3.1 Details of **Pedestrian Facility** (if any pedestrians involved) – If no, refer to section 3.2

3.1.1 Crossing Type: **N/a** (Zebra, crossing etc)

Properly Marked: Yes/No

Condition of Marking:

Properly Signed: Yes/No

Extended Kerbs: Yes/No

Details:

Pedestrian Refuges:

Other facilities:

#### 3.1.2 If **School Crossing**:

Is this a supervised crossing: **N/a**

Was crossing supervised (by School Crossing Supervisor) at time of accident:  
Yes/No

Were all warning signs and flags displayed:

Condition:

Visibility:

#### 3.2 Details of **Traffic Signals** (if occurred at signalised intersection)

Type: **N/a**

Phasing – attach signal plan

Damaged: Yes/No

Details – attach log report

Functioning Correctly? Provide statement

Date of Last Maintenance Inspection (if available) – refer to ITS

Other Details (as necessary):

## Section 4 – Additional Testing/Checking Ordered

4.1	Further Investigation Required:		By Date
	(a) Geometrics – Survey	Yes	8 June 2007
	(b) Cross-fall – Measurements	Yes	8 June 2007
	(c) Visibility Distances – Measurements	Yes	8 June 2007
	(d) Roughness – Survey	Yes	8 June 2007
	(e) Speed Study	No	
	(f) Advisory Speed Study	Yes	8 June 2007
	(g) Skid Resistance/Surface Texture – Testing	Yes	8 June 2007
	(h) Pavement Drainage – Survey	No	
	(i) Further Investigation of Accident History	No	
	(j) Additional Traffic Data	Yes	8 June 2007
	(k) Pedestrian Movement Data	No	
	(l) Lighting – Maintained lux reading	Yes	8 June 2007
	(l) Other Special Investigation: Specify Here	No	
4.2	Details of Additional Investigation Completed:		
	<b>List of tests</b>	<b>Date</b>	<b>Appendix No</b>
	Advisory speed study	24 May 2007	D
	Lighting – Maintained lux readings	30 May 2007	E
	ROAR skid resistance testing	26/28 May 07	To be reported separately
	Surface texture depth test	31 May 2007	
	Sand patch test	31 May 2007	
	Laser Profilometer (texture depth and rutting)	25 May 2007	
	British pendulum test (surface friction wet/dry)	31 May 2007	

## Section 5 – Crash History and Analysis

### 5.1 Investigated Crash Incident

#### 5.1.1 Road Crash 2 CRASH INCIDENT REPORT

~4240732

\*\*\*\*\* ROAD CRASH DETAIL \*\*\*\*\* Run Date:  
22-MAY-2007 Page: 1

Crash Number : 20700097149

Police Division: MAROOCHYDORE DIVISION  
Reporting Division: MAROOCHYDORE DIVISION

Crash Date: 21-MAY-2007  
Day Of Week: MON  
Time: 15  
At: MAROOCHY (S) - EUDERIM

Street 1: BRUCE HWY OFF RAMP (SOUTHBOUND)  
Speed Limit: 80  
Landmark:  
Traffic Control: No Traffic Control  
Divided Road: N  
Road Feature: Interchange  
Horizontal: Curved-View open  
Vertical: Grade  
Nature: Hit parked vehicle  
On-Off C'way: 2  
Units: 3  
DCA: PED'N: HIT OTHER

Description:

-----  
UNIT 2 vehicle has taken the Sunshine Motorway exit from the Bruce Highway south bound to head east bound towards Mooloolaba. Unit 2 has slid out of control and crashed into a ditch to the left hand side of the road. A short time later Unit 1 has taken the same exit and has also slid out of control. The right side of Unit 1 vehicle has collided with the front and left hand side of Unit 2 vehicle causing Unit 2 vehicle to roll onto Unit 3 who was now standing behind Unit 2 vehicle. Unit 3 was transported to Nambour Hospital in a critical condition. It was raining at the time of the accident and the road surface was slippery and wet.

\*\*\*\*\* ROAD CRASH DETAIL \*\*\*\*\* Run Date:  
22-MAY-2007 Page: 2

Crash Number : 20700097149

1 DETAILS #	# UNIT
Unit Type:	4-wheel drive
Birthdate:	<input type="text"/>
Gender:	F
Persons in Unit:	2
Licence Type:	Open
Heading:	E on BRUCE HWY OFF RAMP (SOUTHBOUND)
Town of Origin:	FOREST GLEN

Page 1

~4240732

State of Origin: QLD  
 BAC : 94  
 Intended Action: Go straight ahead  
 Towing: Not Towing  
 Dangerous Goods: X  
 Communication Device: 98  
 Window Tint: 98  
 Cruse Control: 02  
 Bullbar: 02  
 Damage Point: Right rear door  
 Overall Damage: Moderate - towed away  
 Subsequent Incident: N

Contributing Circumstances:

ROAD - WET/SLIPPERY

Unregistered Trailers :

Trailer Number	Type of Trailer
=====	=====

Registered Trailers :

Trailer Number	Trailer Registration	Trailer State
=====	=====	=====

\*\*\*\*\* ROAD CRASH DETAIL \*\*\*\*\* Run Date:  
 22-MAY-2007 Page: 3

Crash Number : 20700097149

2 DETAILS #	# UNIT
Unit Type:	Car, Station Wagon
Birthdate:	
Gender:	
Persons in Unit:	0
Licence Type:	Not applicable
Heading:	E on BRUCE HWY OFF RAMP (SOUTHBOUND)
Town of Origin:	UNKNOWN
State of Origin:	QLD
BAC :	99
Intended Action:	Go straight ahead
Towing:	Not Towing
Dangerous Goods:	X
Communication Device:	98
Window Tint:	98
Cruse Control:	98
Bullbar:	02
Damage Point:	Front left fender
Overall Damage:	Major - towed away
Subsequent Incident:	Y

Contributing Circumstances:

~4240732

NOT APPLICABLE

Unregistered Trailers :

-----  
Trailer Number      Type of Trailer  
=====

Registered Trailers :

-----  
Trailer Number      Trailer Registration      Trailer State  
=====

\*\*\*\*\* ROAD CRASH DETAIL \*\*\*\*\*      Run Date:  
22-MAY-2007      Page:      4  
Crash Number :      20700097149

3 DETAILS #

# UNIT

Unit Type:                      Pedestrian  
Birthdate:                      02-JUN-1955  
Gender:                          F  
Persons in Unit:                      1  
Licence Type:                      Not applicable  
Heading:                          N on BRUCE HWY OFF RAMP (SOUTHBOUND)  
Town of Origin:                      UNKNOWN  
State of Origin:                      QLD  
BAC :                              93  
Intended Action:                      Remain stationary  
Towing:                              Not applicable to towing  
Dangerous Goods:                      X  
Communication Device:                      98  
Window Tint:                          99  
Cruse Control:                          99  
Bullbar:                              99  
Damage Point:                          Not applicable  
Overall Damage:                          Not applicable  
Subsequent Incident:                          N

Contributing Circumstances:

-----  
NOT APPLICABLE

Unregistered Trailers :

-----  
Trailer Number      Type of Trailer  
=====

Registered Trailers :

-----  
Trailer Number      Trailer Registration      Trailer State  
=====

# CASUALTY DETAILS #

Unit:      3      Occupant Number:      1      Gender:      F  
Birthdate:        
Severity:      Fatal  
Road User:      Driver/Rider/Controller  
Restraint:      Not Applicable

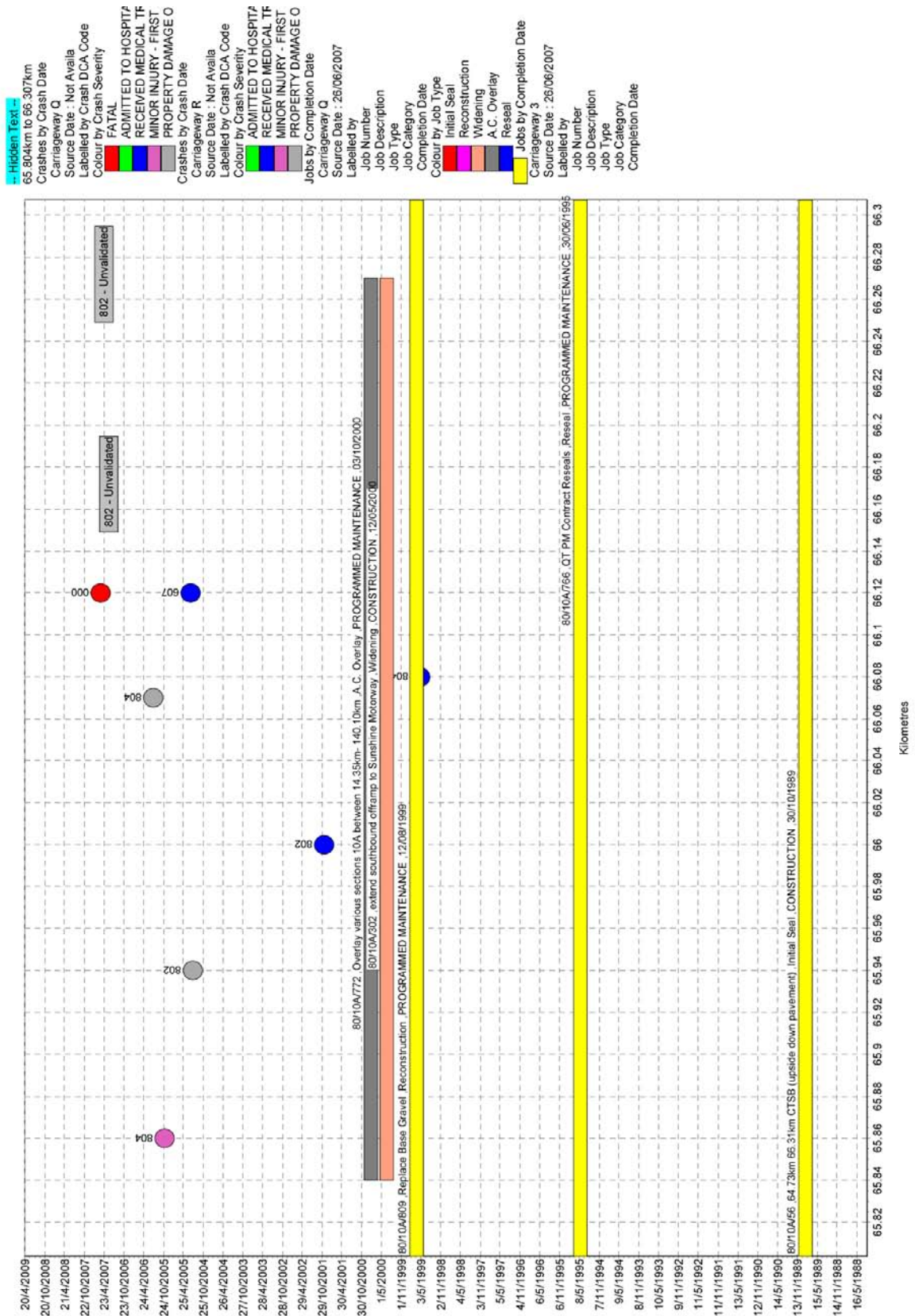
Helmet: Not Applicable ~4240732  
Airbag Description: Not applicable

## 5.2 Crash History in Vicinity of Crash Site

### 5.2.1 Chartview Plot and Road Crash 2 CRASH LISTING/DETAIL REPORTS (including reports of un-validated crash data)



Road Section 10A - BRUCE HIGHWAY ( BRISBANE - GYMPIE ) (135.9 km) from NORTH COAST HINTERLAND DISTRICT (MR) refreshed on 27 Jun 2007



**Road Crash 2  
 CRASH LISTING REPORT**



**Crash Types**  
 Crash Dates 01-OCT-2001 - 20-JUN-2007  
 Alignment: Vertical  
 Owner MIR DEPARTMENT OF MAIN ROADS  
 DCA Cod  
 Group  
 Feature  
 Traffic Ctrl  
 Speed Limit  
 Fatalities  
 Contrib Circ.  
 Severity  
 Unit Type  
 Nature  
 Risk Factor

**Area** LGA SLA Police Division

**Road Sections**  
 All Road Sections  Include Crashes or  Thru road Mid-block  Thru roads at Intersections  Intersecting roads at Intersection  
 Road Section 10A BRISBANE - GYMPIE  
 Oway RPC Q 18A 0.340 18A 0.770 65.840 66.270  
 Start Dist End Tdist  
 Number of Crashes  
 Injury 3  
 PDO 2  
 Total 6

**Intersections**  
 All Intersections





**Road Crash 2**  
**CRASH INCIDENT REPORT**

<b>Crash Types</b>	
Crash Dates	01-OCT-2001 - 20-JUN-2007
Owner	MR DEPARTMENT OF MAIN ROADS
DCA Code	
Group	
Fatalities	
Severity	
Nature	
Alignment:	Vertical
	Horizontal
	Feature
	Traffic Ctrl
	Speed Limit
	Contrib Circ.
	Unit Type
	Risk Factor
<b>Area</b>	LGA <input type="text"/> SLA <input type="text"/> Police Division <input type="text"/>
<b>Road Sections</b>	
All Road Sections	<input type="checkbox"/> Include Crashes on <input checked="" type="checkbox"/> Thru road Mid-block <input checked="" type="checkbox"/> Thru roads at Intersections <input checked="" type="checkbox"/> Intersecting roads at Intersections
Road Section	10A BRISBANE - GYMPIE
	Cway <input type="text"/> 18A <input type="text"/> 0.340 <input type="text"/> 18A <input type="text"/> 0.770 <input type="text"/> 65.840 <input type="text"/> 66.270 <input type="text"/> 6
	Start <input type="text"/> 18A <input type="text"/> 0.340 <input type="text"/> 18A <input type="text"/> 0.770 <input type="text"/> 65.840 <input type="text"/> 66.270 <input type="text"/> 6
	End <input type="text"/> 18A <input type="text"/> 0.340 <input type="text"/> 18A <input type="text"/> 0.770 <input type="text"/> 65.840 <input type="text"/> 66.270 <input type="text"/> 6
	Dist <input type="text"/> 18A <input type="text"/> 0.340 <input type="text"/> 18A <input type="text"/> 0.770 <input type="text"/> 65.840 <input type="text"/> 66.270 <input type="text"/> 6
	RPC <input type="text"/> 18A <input type="text"/> 0.340 <input type="text"/> 18A <input type="text"/> 0.770 <input type="text"/> 65.840 <input type="text"/> 66.270 <input type="text"/> 6
	Tdist <input type="text"/> 18A <input type="text"/> 0.340 <input type="text"/> 18A <input type="text"/> 0.770 <input type="text"/> 65.840 <input type="text"/> 66.270 <input type="text"/> 6
	Number of Crashes
	Fatal <input type="text"/> 1 <input type="text"/> 0 <input type="text"/> 3 <input type="text"/> 2 <input type="text"/> 6
	Injury <input type="text"/> 1 <input type="text"/> 0 <input type="text"/> 3 <input type="text"/> 2 <input type="text"/> 6
	PDO <input type="text"/> 1 <input type="text"/> 0 <input type="text"/> 3 <input type="text"/> 2 <input type="text"/> 6
<b>Intersections</b>	
All Intersections	<input type="checkbox"/>

**Road Crash 2  
 CRASH INCIDENT REPORT**



Crash No.	20010023699	Date	08-OCT-2001	Day	Mon	Hour	15	No. of Units	1	
Street/s	Bruce Hwy Off Ramp (Southbound)									
Landmark	30 ME of Bruce Hwy									
Road Section	10A Brisbane - Gympie									
Cway RPC	Q	18A	0.500	Dist	66.000					
Intersection										
Severity	3 RECEIVED MEDICAL TREATMEN									
SLA	4902 MAROOCHY (S) - BUDERIM									
DCA	802 OFF PATH-CURVE: OFF CWA									
Nature	07 Overtumed									
Feature	14 Interchange									
On/Off Cway	2								Divided Road	N
Lighting	Daylight									
Police Division	00124 MAROOCHYDORE DIVISIO									
Reporting Station	00124 MAROOCHYDORE DIVISIO									
Alignment	Vertical 2 Grade									
Horizontal	3 Curved-View open									
Traffic Control	99 No Traffic Control									
Direction	E								Speed Limit	100
Atmos Cond	Smoke/Dust									
Description	Unit 1 was driving South along the Bruce Hwy and has taken the exit ramp to Sippy Downs. As Unit 1 exited the back left tyre has blown causing the driver to lose control and the vehicle to go into a ditch off the side of the ramp. The vehicles tyres dug into the dirt and the force subsequently caused the vehicle to roll. The driver received a minor cut to the knee when he exited the vehicle. Nil breaches forthcoming									
Unit Details	Unit No.	1	Unit Type	01 Car, Station Wagon	Licence Type	01 Open	Damage Point	11 Turret		
	Birth Date		BAC	94	Danger	Goods	05 Major - Towed Away			
	Gender	M	Crash Heading	E on Bruce Hwy Off Ramp (So	Contrib Circ	502 Vehicle - Tyres (I.E. Low Tread, Puncture 998 Driver - Fatigue Related By Definition				
	No. of Occupants	1	Intended Action	01 Go Straight Ahead	Road User	01 Driver/Rider/Controller				
Casualty Details	Unit No.	1	Occupant	1	Gender	M	Severity	3 Received Medical Treatment		
	Nature of injury	099 Refer To Textual Description							Restraint	01 Fitted - Worn
									Helmet	99 Not Applicable

**Road Crash 2  
 CRASH INCIDENT REPORT**



Crash No.	20050001870	Date	25-JAN-2005	Day	Tue	Hour	12	No. of Units	1
Street/s	Bruce Hwy Off Ramp (Southbound) Bruce Hwy Off Ramp (Southbound)	Severity	5 PROPERTY DAMAGE ONLY						
Landmark	of	SLA	4902 MAROOCHY (S) - BUDERIM						
Road Section	10A Brisbane - Gympie	DCA	802 OFF PATH-CURVE: OFF CWA						
Cway RPC	Q 18A	Nature	07 Overtuned						
Dist	0.440	Feature	14 Interchange						
Tdist	65.940	On/Off Cway	2	Divided Road	N				
Intersection		Lighting	Daylight						
Description	The weather conditions at the time of the incident were raining and severe slippery conditions on the road. Unit 1 has exited the Bruce Highway onto the off ramp and due to the acute bend in the off ramp the driver has braked upon sighting the 80km/h sign. Being a front wheel drive vehicle and an inexperienced driver the vehicle has gone off the side of the road shoulder ending up on its roof. the driver has got out of the vehicle and has suffered nil injuries. No Braech Acti on will be forthcoming.								
Unit Details									
Unit No.	1	Unit Type	01 Car, Station Wagon						
Birth Date		Licence Type	02 Provisional						
Gender	M	BAC	0	Danger: Goods	X				
No. of Occupants	1	Crash Heading	E on Bruce Hwy Off Ramp (So						
		Intended Action	01 Go Straight Ahead						
		Damage Point	11 Turret						
		Overall Damage	05 Major - Towed Away						
		Contrib Circ	301 Road - Wet/Slippery 602 Driver - Inexperience/Lack Of Expertise						



**Road Crash 2  
 CRASH INCIDENT REPORT**

Crash No. 20050013624	Date 14-FEB-2005	Day Mon	Hour No. of Units 11	Police Division 00124 MAROOCHYDORE DIVISIO
Street/s Bruce Hwy Off Ramp (Southbound)	Severity 3 RECEIVED MEDICAL TREATMEN	SLA 4902 MAROOCHY (S) - BUDERIM	Reporting Station 00126 NAMBOUR DIVISION	Alignment: Vertical 2 Grade
Landmark 150 M W of Sunshine Motorway	Nature 06 Hit fixed obstruction or temporary	DCA 607 VEH'S ON PATH: TEMPORAR	Horizontal 2 Curved-View obscured	Traffic Control 99 No Traffic Control
Road Section 10A Brisbane - Gympie	Feature 14 Interchange	On/Off Cway 1	Direction E	Speed Limit 100
Intersection Q 18A	Dist 0.620	Tdist 66.120	Divided Road N	Atmos Cond Raining
Description	Information provided by the driver of unit 1 who states that he was proceeding along the Bruce highway and had taken the Sippy Downs exit to go onto the Sunshine Motorway. As he has negotiated the turn the front of his vehicle had come into contact with a large rock that was on the carriageway. This has resulted in the vehicle sliding to the right. The driver of unit 1 has attempted to regain control of the vehicle however the vehicle has left the carriageway and has spun three hundred and sixty degrees before coming into contact with a tree. The vehicle was extensively damaged as a result of the impact. The driver was conveyed to the Nambour General Hospital for treatment. Inquiries with witnesses confirmed that Unit 1 had in fact collided with a rock prior to leaving the carriageway.			
Unit No. 1	Unit Type 01 Car, Station Wagon	Licence Type 06 Cancelled, Disqual	Damage Point 01 Front	
Birth Date	BAC N/A	Danger X	Overall Damage 05 Major - Towed Away	
Gender M	Crash Heading E on Bruce Hwy Off Ramp (So	Intended Action 01 Go Straight Ahead	Contrib Circ 201 Atmospheric - Heavy Rain 301 Road - Wet/Slippery 311 Road - Temporary Object On Carriagewa	
No. of Occupants 1	Casualty Details			
Occupant 1	Birth Date	Gender M	Severity 3 Received Medical Treatment	Road User 01 Driver/Rider/Controller
Nature of injury	099 Refer To Textual Description		Restraint 01 Fitted - Worn	Helmet 99 Not Applicable



**Road Crash 2  
 CRASH INCIDENT REPORT**

Crash No. 20050025542	Date 12-OCT-2005	Day Wed	Hour No. of Units 13	Hour 1	Police Division 00124 MAROOCHYDORE DIVISIO
Street/s Bruce Hwy	Severity 4 MINOR INJURY - FIRST AID OR	SLA 4902 MAROOCHY (S) - BUDERIM	Reporting Station 00124 MAROOCHYDORE DIVISIO	Alignment: Vertical 2 Grade	
Landmark of	Nature 06 Hit fixed obstruction or temporary	Feature 14 Interchange	Horizontal 3 Curved-View open	Traffic Control 99 No Traffic Control	Direction S
Road Section 10A Brisbane - Gympie	On/Off Cway 2	Divided Road Y	Speed Limit 110	Atmos Cond Raining	
Cway RPC Q 18A	Dist 0.360	Tdist 65.860			
Intersection	Description U1 was travelling south down the Bruce Highway in heavy rain conditions. U1 attempted to make a left turn onto the off-ramp towards Chancellor Park. In so doing, U1 skidded and the offside portion of the truck collided and crushed the arm railing erected on the southern side of off-ramp intersection. Minor damage caused to U1 only. Driver received very minor scratch to lower right leg as a result of the collision.				
Unit Details Unit No. 1 Unit Type 03 Truck Licence Type 01 Open Damage Point 99 Not Applicable Birth Date [ ] BAC 94 Danger. Goods N Overall Damage 02 Minor Gender M Crash Heading S on Bruce Hwy Contrib Circ 201 Atmospheric - Heavy Rain No. of Occupants 1 Intended Action 04 Make Left Turn 301 Road - Wet/Slippery					
Casualty Details Unit No. 1 Occupant 1 Birth Date [ ] Gender M Severity 4 Minor Injury - First Aid Or No Nature of injury 916 Superficial Injury - Hip; Thigh; Leg; Ankle Road User 01 Driver/Rider/Controller Restraint 98 Unknown Helmet 99 Not Applicable					

**Road Crash 2  
 CRASH INCIDENT REPORT**



Crash No.	Date	Day	Hour No. of Units	Severity	Police Division
20060002126	27-JAN-2006	Fri	06	5 PROPERTY DAMAGE ONLY	00124 MAROOCHYDORE DIVISIO
Street/s				SLA	Reporting Station
Bruce Hwy Off Ramp (Southbound)				4902 MAROOCHY (S) - BUDERIM	00124 MAROOCHYDORE DIVISIO
Landmark				DCA	Alignment
15 MW of Sunshine Mwy				804 OFF PATH-CURVE: OFF CWA	Vertical 1 Level
Road Section				Nature	Horizontal
10A Brisbane - Gympie				06 Hit fixed obstruction or temporary	3 Curved-View open
Cway RPC				Feature	Traffic Control
Q	18A	Dist	Tdist	14 Interchange	99 No Traffic Control
		0.570	66.070	On/Off Cway	Direction
				2	E
Intersection				Lighting	Speed Limit
				Daylight	80
					Atmos Cond
					Raining
Description					
U1 was travelling south on the Bruce Highway from Nambour & took the eastern off ramp to join up with the Sunshine motorway. She can't recall her exact speed, but claims she was not speeding. approx half way round the bend to join the motor way, the driver of U1 has lost control of her vehicle, leaving the road on the southern side of the off-ramp, hit a tree & rolled down an embankment coming to rest on it's side. No injuries, No other vehicle involved. Police & QFRS officers inspected the road surface & whilst no visible substances were apparent, the road was considered slippery. At the time of this accident another car was reported to have lost control at the same point. Given the road conditions which have contributed to the accident, Police believe there is insufficient evidence of driver illegality to proceed further with this matter. Recommend no further action is taken.					
Unit Details					
Unit No.	Unit Type	Licence Type	Damage Point		
1	20 4-Wheel Drive	01 Open	11 Turret		
Birth Date		BAC	Danger. Goods	Overall Damage	
		N/A	X	05 Major - Towed Away	
Gender		Crash Heading		Contrib Circ	
F		E on Bruce Hwy Off Ramp (So		301 Road - Wet/Slippery	
No. of Occupants		Intended Action			
1		01 Go Straight Ahead			

**Road Crash 2  
 CRASH INCIDENT REPORT**



Crash No.	20700097149	Date	21-MAY-2007	Day	Mon	Hour	15	No. of Units	3
Street/s	Bruce Hwy Off Ramp (Southbound)								
Landmark	200 M E of Bruce Highway								
Road Section	10A Brisbane - Gympie								
Intersection	Cway	RPC	Dist	Tdist					
	Q	18A	0.620	66.120					
Description	U2 has driven south on the Bruce Hwy, Tanawha and taken the left hand exit ramp which leads onto the east/west arterial road of the Sunshine Mwy. The weather at this time was overcast and slightly rain-fog. This exit ramp is a long wide left slightly down-hill left hand bend. Half way through this bend there is a 'Y' shaped I/S. Just past the left hand side of the 'Y' I/S, U2 has, for an unknown reason at this stage, lost control which caused the Unit to complete								
	U2 has driven south on the Bruce Hwy, Tanawha and taken the left hand exit ramp which leads onto the east/west arterial road of the Sunshine Mwy. The weather at this time was overcast and slightly rain-fog. This exit ramp is a long wide left slightly down-hill left hand bend. Half way through this bend there is a 'Y' shaped I/S. Just past the left hand side of the 'Y' I/S, U2 has, for an unknown reason at this stage, lost control which caused the Unit to complete								

Unit Details	
Unit No.	1
Unit Type	20 4-Wheel Drive
Birth Date	
Gender	
No. of Occupants	2
Unit No.	2
Unit Type	01 Car, Station Wagon
Birth Date	
Gender	
No. of Occupants	0
Unit No.	3
Unit Type	10 Pedestrian
Birth Date	
Gender	F
No. of Occupants	1

Police Division	00124 MAROOCHYDORE DIVISIO
Reporting Station	00124 MAROOCHYDORE DIVISIO
Alignment: Vertical	2 Grade
	Horizontal 2 Curved-View obscured
Traffic Control	99 No Traffic Control
Direction	E
Speed Limit	80
Atmos Cond	Raining

Severity	1 FATAL
SLA	4902 MAROOCHY (S) - BUDERIM
DCA	000 PEDN: HIT OTHER
Nature	01 Hit parked vehicle
Feature	14 Interchange
On/Off Cway	2
Divided Road	N
Lighting	Daylight

Damage Point	04 Right Rear Door
Overall Damage	04 Moderate - Towed Away
Contrib Circ	301 Road - Wet/Slippery
Damage Point	07 Front Left Fender
Overall Damage	05 Major - Towed Away
Contrib Circ	099 Not Applicable
Damage Point	99 Not Applicable
Overall Damage	99 Not Applicable
Contrib Circ	099 Not Applicable


Queensland Government  
Department of Main Roads

Road Crash 2  
CRASH INCIDENT REPORT

Casualty Details

Unit No.	Occupant	Birth Date	Gender	Severity	Road User
3	1		F	1 Fatal	01 Driver/Rider/Controller
Nature of injury					Restraint
					99 Not Applicable
					Helmet
					99 Not Applicable

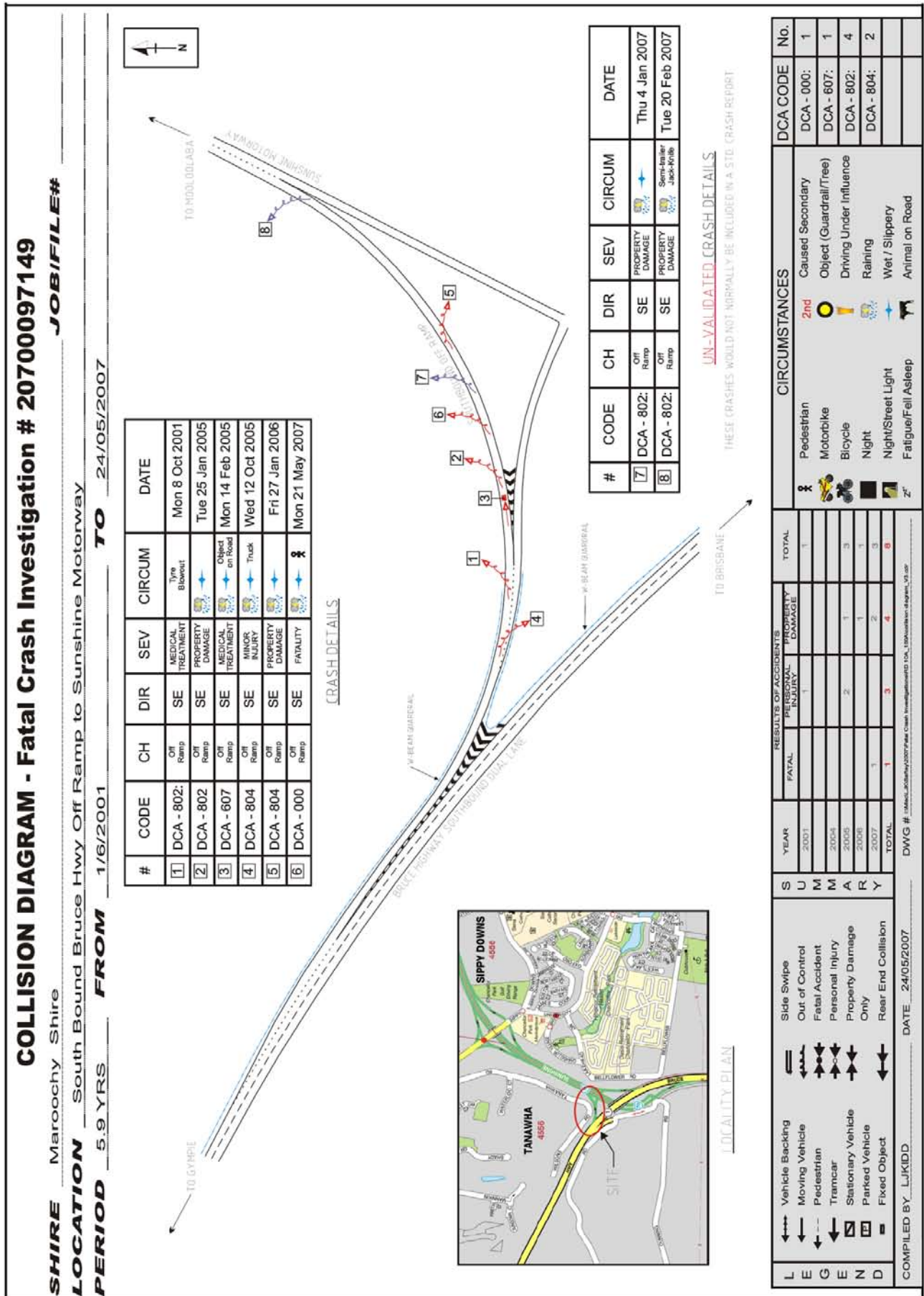
Un-validated crash no. 1

 <b>Major Incidents Response System</b>		Information Resource Management
Main Roads Department		Corporate Systems Branch
<a href="#">Close</a>   <a href="#">Next</a>   <a href="#">Prev</a>   <a href="#">Edit</a>		
<b>Document Author:</b> Greg J Roberts	<b>Date Composed:</b> 20/02/2007 10:05 AM	
<b>Division/Region:</b>	OFFICE OF THE DEPUTY DIRECTOR-GENERAL / DISTRICT:	
<b>Branch/District:</b>	NORTH COAST HINTERLAND	
<b>Date of Incident:</b>	20/02/2007	
<b>Time Incident Occurred:</b>	9:05 am	
<b>Location of Incident:</b>	Sunshine Motorway on ramp from Bruce Highway eastbound	
<b>Brief description of Incident:</b>	FIRST & FINAL NOTICE - Semi trailer jack knifed on the Bruce off ramp to the Sunshine Motorway travelling eastbound. Wet r the area at the time of incident.	
<b>Background Details:</b>	Semi trailer jack knifed southbound on the Bruce Highway off ra Sunshine Motorway to travel eastbound. The truck fully blocked ramp causing congestion. The trucks fuel tank ruptured spilling into nearby drains. Absorbant material was applied at scene to : the fuel on site.	
<b>Other groups:</b>	Tow Services	
<b>Details of Injuries/Fatalities:</b>	Police report no injuries	
<b>Impacts on Road Network (or other):</b>	The southbound off ramp from the Bruce Highway to the Sunshi Motorway was closed to all traffic from 9:05 am until 10:29 am. , caused congestion to eastbound traffic on the Sunshine Motorw Motorists were diverted by Police around the accident site.	
<b>Possible causes (if known):</b>	UNKNOWN	
<b>If yes, Give Details:</b>		

Un-validated crash no. 2

DESC_CRAS_NUMBER	CRAS_SEVE_IMAX	CRAS_DATE	CRAS_SLA_CODE	CRAS_POLD_CODE	CRAS_VALIDATION_STATU	CRAS_IN_SCOPE_STATUS	CRASH_DESCRIPTION
20700002392	5	04/01/2007	0	null	3	Y	UNIT 1 TRAVELLING SOUTH ALONG BRUCE HIGHWAY ENTERED OFF RAMP TO LEFT TO CONNECT WITH SUNSHINE MOTORWAY. VEHICLE HAS LOST CONTROL AND SPUN OFF THE ROAD WAY INTO BUSHLAND TO THE LEFT OF OFF RAMP. AT THE TIME OF DRIVING IT WAS RAINING AND THE ROAD WAS WET. POLICE ATTENDING THE SCENE OBSERVED THAT THE OFF/ON RAMP WAS EXTERMELY WET/SLIPPERY. THE CONDITION OF THE ROAD AND THE WEATHER CONDITIONS WERE A CONTRIBUTING FACTOR IN RELATION TO THE INCIDENT. THERE ARE NO WITNESSES TO PROVE IF SPEED WAS A FACTOR. THE DRIVER STATED THAT SHE WAS DOING THE SPEED LIMIT AT THE TIME OF THE INCIDENT. DUE TO THE WEATHER/ROAD CONDITIONS AND THE LACK OF ANY OTHER EVIDENCE IT IS RECOMMENDED THAT NO FURTHER POLICE ACTION BE TAKEN IN RELATION TO THIS MATTER.

5.2.2 Collision Diagram – all crashes in vicinity as contained in Section 5.2.1



**DEFINITIONS FOR CODING ACCIDENTS**

NOTE:- 1 = Key vehicle direction.  
 ie; The direction in which the key vehicle was travelling as it approached the crash location.

	00	10	20	30	40	50	60	70	80	90
	PEDESTRIAN on foot or in toy/pram	INTERSECTION vehicles from adjacent approaches	VEHICLES from opposing directions	VEHICLES from same direction	MANOEUVRING	OVERTAKING	ON PATH	OFF PATH ON STRAIGHT	OFF PATH ON CURVE	PASSENGERS & MISCELLANEOUS
1	000 OTHER	100 OTHER	200 OTHER	300 OTHER	400 OTHER	500 OTHER	600 OTHER	700 OTHER	800 OTHER	900 OTHER
2	001 NEAR SIDE	101 THRU • THRU	201 HEAD • ON	301 VEHICLES IN THE SAME LANE	401 LEAVING PARKING	501 HEAD • ON	601 PARKED	701 OFF CARRIAGEWAY TO LEFT	801 OFF CARRIAGEWAY RIGHT BEND	901 FELL IN FROM VEHICLE
3	002 EMERGING	102 RIGHT • THRU	202 THRU • RIGHT	302 LEFT REAR	402 PARKING	502 OUT OF CONTROL	602 DOUBLE PARKED	702 OFF CARRIAGEWAY TO RIGHT	802 OFF CARRIAGEWAY LEFT BEND	
4	003 FAR SIDE	103 LEFT • THRU	203 RIGHT • LEFT	303 RIGHT REAR	403 PARKING VEHICLES ONLY	503 PULLING OUT	603 CAR DOOR	703 LEFT OFF CARRIAGEWAY INTO OBJECT	803 OFF RIGHT BEND INTO OBJECT	903 HIT TRAIL
5	004 PLAYING WORKING, LIVING STANZING ON CARRIAGEWAY	104 THRU • RIGHT	204 RIGHT	304 U TURN	404 REVERSING IN TRAFFIC	504 CUTTING IN	604 HIT PERMANENT OBSTRUCTION	704 RIGHT OFF CARRIAGEWAY INTO OBJECT	804 OFF LEFT BEND INTO OBJECT	904 HIT RAILWAY • HIT FURNITURE
6	005 WALKING WITH TRAFFIC	105 RIGHT • RIGHT	205 THRU • LEFT	305 LANE SIDE SWIPE	405 REVERSING INTO FIXED OBJECT	505 PULLING OUT REAR END	605 HIT TEMPORARY ROADWORK	705 OUT OF CONTROL ON CARRIAGEWAY	805 OUT OF CONTROL ON CARRIAGEWAY	905 HIT ANIMAL OFF CARRIAGEWAY
7	006 FACING TRAFFIC	106 LEFT • RIGHT	206 LEFT • LEFT	306 LANE CHANGE RIGHT	406 LEAVING DRIVEWAY	506 OVERTAKING RIGHT TURN	606 HIT TEMPORARY ROADWORK	706 LEFT TURN	806 LEFT TURN	906 PARKED VEHICLE RAN AWAY
8	007 DRIVEWAY	107 THRU • LEFT	207 U TURN	307 LANE CHANGE LEFT	407 FROM LOADING BAY	507 FROM FOOTWAY	607 HIT TEMPORARY OBJECT ON CARRIAGEWAY	707 RIGHT TURN	807 RIGHT TURN	907 VEHICLE MOVEMENTS NOT KNOWN
9	008 ON FOOTWAY	108 RIGHT • LEFT	208 RIGHT TURN SIDE SWIPE	308 LEFT TURN SIDE SWIPE	408 FROM FOOTWAY	508 ACCIDENT OR BROKEN DOWN	608 MOUNTS TRAFFIC ISLAND	708 MOUNTS TRAFFIC ISLAND	808 MOUNTS TRAFFIC ISLAND	
0	009 STRUCK WHILE BOARDING OR ALIGHTING	109 LEFT • LEFT	209 PULLING OUT	309 PULLING OUT	409 ANIMAL	509 LOAD HITS VEHICLE	609 LOAD HITS VEHICLE			



**5.2.4** Are there any **trends** in the crash history at this location? **Yes**

If "Yes", describe trend: **Single vehicle loss of control crashes in the wet**

**5.2.5** Have any adverse crash trends been introduced since the most recent works at the site (Refer *Chartview* Plot and Crash Factor Matrix)? **Yes**

If "Yes", description of works and introduced trend:

**Stone Mastic Asphalt (SMA) was installed on the ramp in 2000. The ramp was surfaced with a bitumen spray seal prior to this.**

**There was 1 recorded crash on the ramp prior to the installation of SMA.**

**There are 6 recorded crashes on the ramp after SMA was installed (including the fatal crash outlined in this report). In addition 2 separate crashes have been identified which are yet to be validated (not yet formally communicated to Main Roads). These crashes are contained within the Queensland Transport Roadcrash system and the North Coast Hinterland – Traffic Incident Response system, respectively.**

**Closer analysis shows that 2 of the 6 recorded crashes can be discounted from analysis of road contributing factors (i.e, unrelated to most recent works) as follows:**

- DCA 607 involved a rock on the road**
- DCA 802 in the dry resulted from a blown tyre**

**The remaining 4 crashes were all single vehicle loss of control crashes in wet weather. The additional 2 (un-validated) crashes also involved single vehicle loss of control crashes in wet weather. Based on this additional information, it is reasonable to conclude that there is an emerging wet weather loss of control crash trend.**

**The average crash rate is 2 crashes/year of a particular type over a period of 3 years.**

## Section 6 – Remedial Treatments

**6.1** Did Police indicate opinion that immediate works were required? **No**

If "Yes", provide description: **N/a**

**6.2** Did initial site inspection indicate immediate works may be required? **Yes**

If "Yes", provide description:

(i) 80 km/h regulatory speed signs are B-size, but should be C-size (interim 70 km/h installed)

(ii) Wrong Way Go Back sign is faded

(iii) 80 km/h Ramp Speed sign is faded (interim 70 km/h installed)

(iv) Advisory speed study shows Ramp Speed should be 70 km/h

(v) Advisory speed study shows CAMS should be installed.

(vi) Bullnose terminal not installed to standard

(vii) Vegetation is obstructing visibility through curve

**6.3** Assessment of Immediate Remedial Works:

(i) MUTCD, Part 4, Clause 4.2.7, Table 4.2 – Reduction in speed limit over 20 km/h

(ii) MUTCD, Part 1, Clause 1.7.6 – Sign is faded / poor reflectivity

(iii) MUTCD, Part 1, Clause 1.7.6 – Sign is faded / poor reflectivity

(iv) MUTCD, Part 2, Clause 3.4.7 – Advisory speed = 70 km/h

(v) MUTCD, Part 2, Clause 3.4.9 – CAMS

(vi) Standard Drawings Roads Manual, Dwg. No. 1488

(vii) To be assessed separately by others.

**6.4** Recommendation for Immediate Remedial Treatment:

**a)** Crash Related

- N/a

**b)** Not Crash Related

- Replace 80 km/h regulatory speed signs with C-size (interim 70 km/h have been installed pending outcome of investigations)
- Replace Wrong Way Go Back sign
- Replace Ramp Speed sign with 70 km/h Ramp Speed (interim 70 km/h cover plate installed pending outcome of investigations)
- Install Chervon Alignment Markers around outside of curve

- Replace guardrail in gore area with slotted Thrie Beam Bullnose Terminal
- Clear vegetation obstructing visibility through curve.

**6.5** Assessment of Other (non-immediate) Improvements:

- (i) Some guide posts missing, MUTCD, Part 4, Clause 3.2.4.4
- (ii) Some delineators missing on guardrail in gore area, MUTCD, Part 4, Clause 3.2.5.4 (b)
- (iii) Height of guardrail is low – Standard Drawing Roads Manual, Dwg. No. 1474
- (iii) Some trees within clear zone - Road Planning and Design Manual, Chapter 8
- (iv) Road lighting at Wilson Road gore area and Sunshine Motorway merge does not satisfy point horizontal illuminance. Road lighting poles not installed along ramp between Wilson Road and Sunshine Motorway merge – AS1158.1.1:2005, Clause 3.2.2.5

**6.6** Recommendation for Other Improvements for consideration:

**a)** Crash Related

- N/a

**b)** Not Crash Related

- Replace missing guide posts.
- Replace missing delineators
- Consider raising guardrail height as part of guardrail replacement program.
- Consider road lighting improvements.
- Consider tree clearing as part of state-wide plan as a roadside hazard reduction initiative.

**Section 7 – Crash Investigation Officer's Statement**

The fundamental purpose of investigating accidents is to determine the circumstances and causes of the accident with a view to the preservation of life and the avoidance of accidents in the future; it is not the purpose to apportion blame or liability.

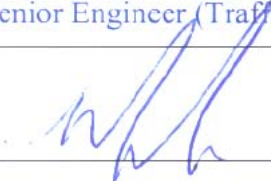
This Crash Investigation Report was carried out by the Traffic Area Officer, using observations and information made available to them. Every effort was made to ensure that all relevant safety issues were considered.

The above investigation findings and suggested actions are the opinion and judgement of the Crash Investigation Officer.

**Crash Investigation Officer**

Name: Martin Leja

Position: A/Senior Engineer (Traffic)


Signature: 

Date: 29/6/07

**The following officer has endorsed this document:**

Name Rowdy Goudens

Position Principal Engineer (Traffic)

Signature  Date 29/6/07

**Appendix A -  
Recommended Remedial  
Countermeasures -  
District Action Plan**

**RECOMMENDED REMEDIAL COUNTERMEASURES  
 DISTRICT ACTION PLAN**

**Meeting Date:** This report was presented at the Management Review Meeting held in Gympie District Office on "insert meeting date"

**Attendees:**

**Meeting Purpose:**

- Present Preliminary Crash Investigation Reports and discuss the findings with representatives of District Crash Committee.
- Determine if there are requirements for further investigations to be completed before finalising the report.
- Collectively formulate an agreed District Action Plan to address any recommended remedial countermeasures contained within the reports.

**Crash Investigation No:** 20700097149      **Crash Date:** 21 May 2007      **Road Name:** Bruce Hwy, Tanawha (Sippy Downs)      **Location:** Southbound off-ramp to Sunshine Motorway      **Ch:** 66.134

Ref No.	Recommended Remedial Treatment	Agreed Action	Action Officer	Target Completion Date	Comments
	<u>Items Related to Crash:</u>				
	N/a				
	<u>Items Not Related to Crash but Noted During Inspection:</u>				
	To be addressed in main report				

Approved by .....N/a.....N/a.....

Manager (Traffic Operations)

District Director (North Coast-Hinterland)

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## Appendix B - Media Articles

Sunshine Coast Daily, Tuesday 22 May 2007, p. 1 and 6

# WOMAN DIES IN FREAK CRASH

A WOMAN died last night in hospital after a freak accident on the Sunshine Motorway late yesterday. The woman was seriously injured when her car, which had been in a minor accident, was hit by another vehicle. **CONTINUED ON PAGE 6**

## Grazier helps victims of 'terrible' accident

FROM PAGE 1

POLICE said they believed the 52-year-old lost control of her car on a highway off-ramp at Tanawha and slid down an embankment just before 3pm. She was standing behind her vehicle on higher ground calling for help, when a four-wheel-drive also lost control on the wet road and slid down the same embankment.

The force of the Toyota Landcruiser hitting the woman's sedan was enough to send it up the embankment and on to the woman as she was speaking on her phone.

Her vehicle pinned her under a back wheel as it settled back down in the ditch.

Warren Lowe was driving behind the four-wheel-drive and saw the accident.

The Sippy Downs glazier immediately ran down to make sure the two occupants of the Landcruiser, a woman and a young child, were all right before checking on the pinned woman.

As the other driver called for help, Mr Lowe tried to take the car's weight off the woman. "I tried to lift the car up, but I couldn't and I didn't think I should move her, so I just went straight down and put my hand behind her back, so her head was resting on my arm," he said.

"I was just asking her her name, what she was doing, talking about having a drink together when she got out, anything to try to keep her from going into shock."

"She was fine at first - she was talking - but she was losing consciousness towards the end.



CRASH SCENE: Emergency crews work to free the woman in yesterday's crash while Warren Lowe, sitting, right, assists.

PHOTOS: MICHAELA GLEN/JASON DOUGHERTY

"But I just stayed there and kept talking to her while the crews tried to get her out, supporting her head while they worked. I figured if I was doing that then it was one less thing the medical guys had to worry about ..."

Mr Lowe was crouched down with the woman for more than an hour, while Buderim and Maroochydore firefighters used bricks, wood

and hydraulic equipment to lift the car.

Her mobile phone was thrown during the impact, but it rang throughout the rescue process, prompting Mr Lowe to ask someone to find it so he could relay messages to her.

"Her husband told her he loved her and he would meet her at the hospital," he said. "I just kept talking to her,

trying to calm her, but she was having trouble breathing

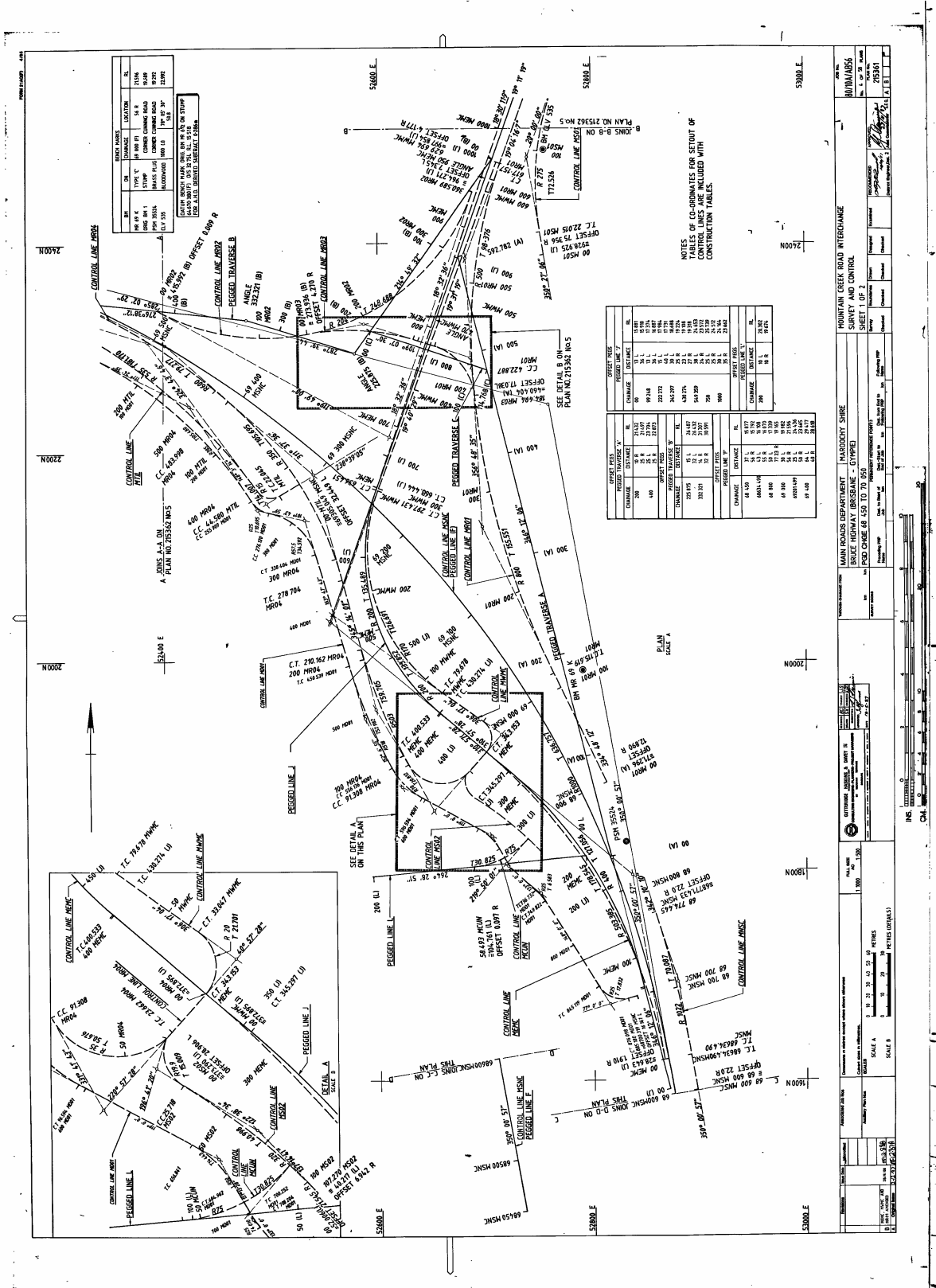
"She was just so unlucky. She was doing the right thing, standing back from the car, but the impact just pushed the car up the hill. It's terrible. Really, really terrible."

The woman was taken to Nambour General Hospital, in a critical condition just before 4pm. She died about 8pm.

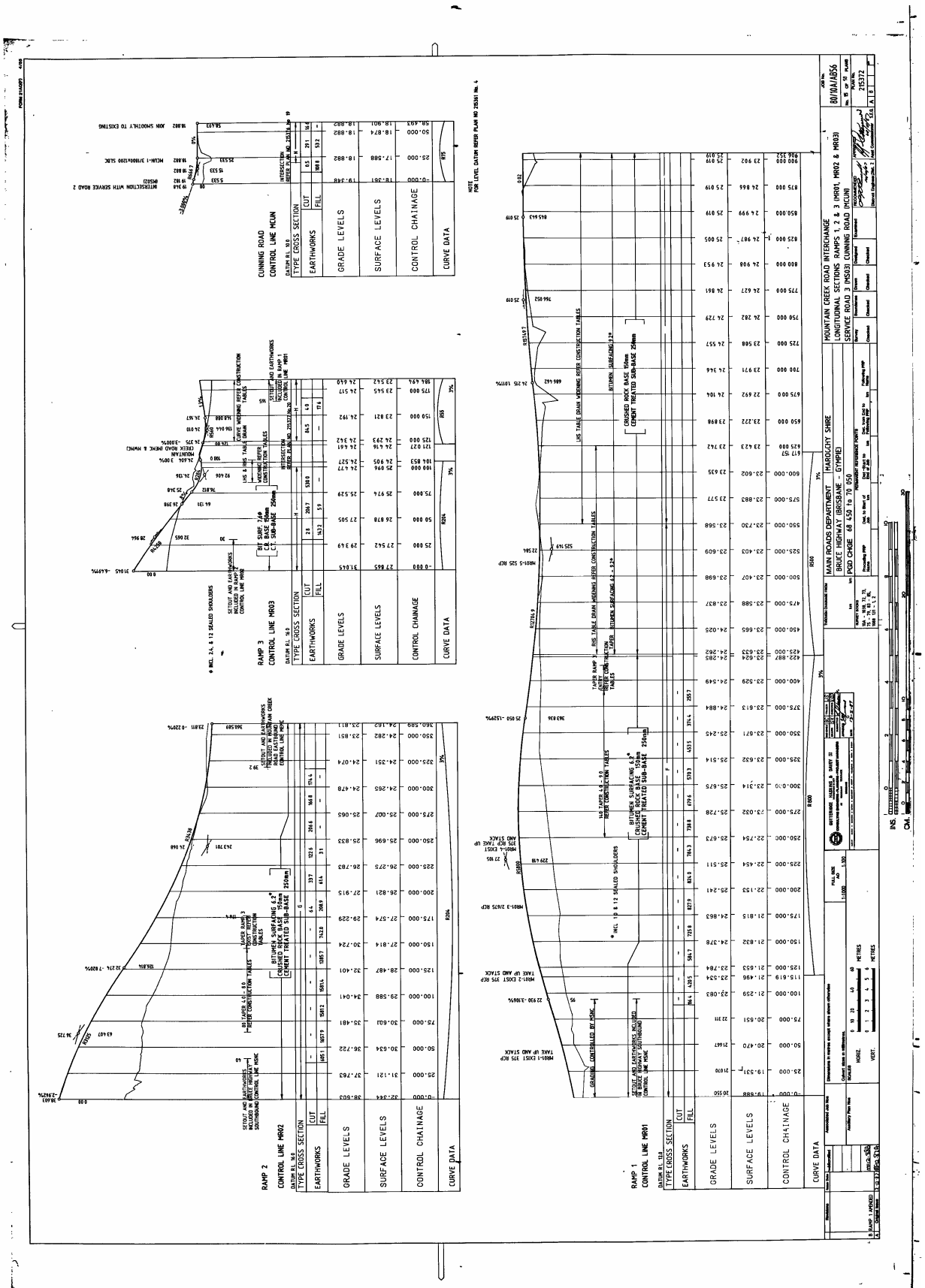
- AMY REMEKIS

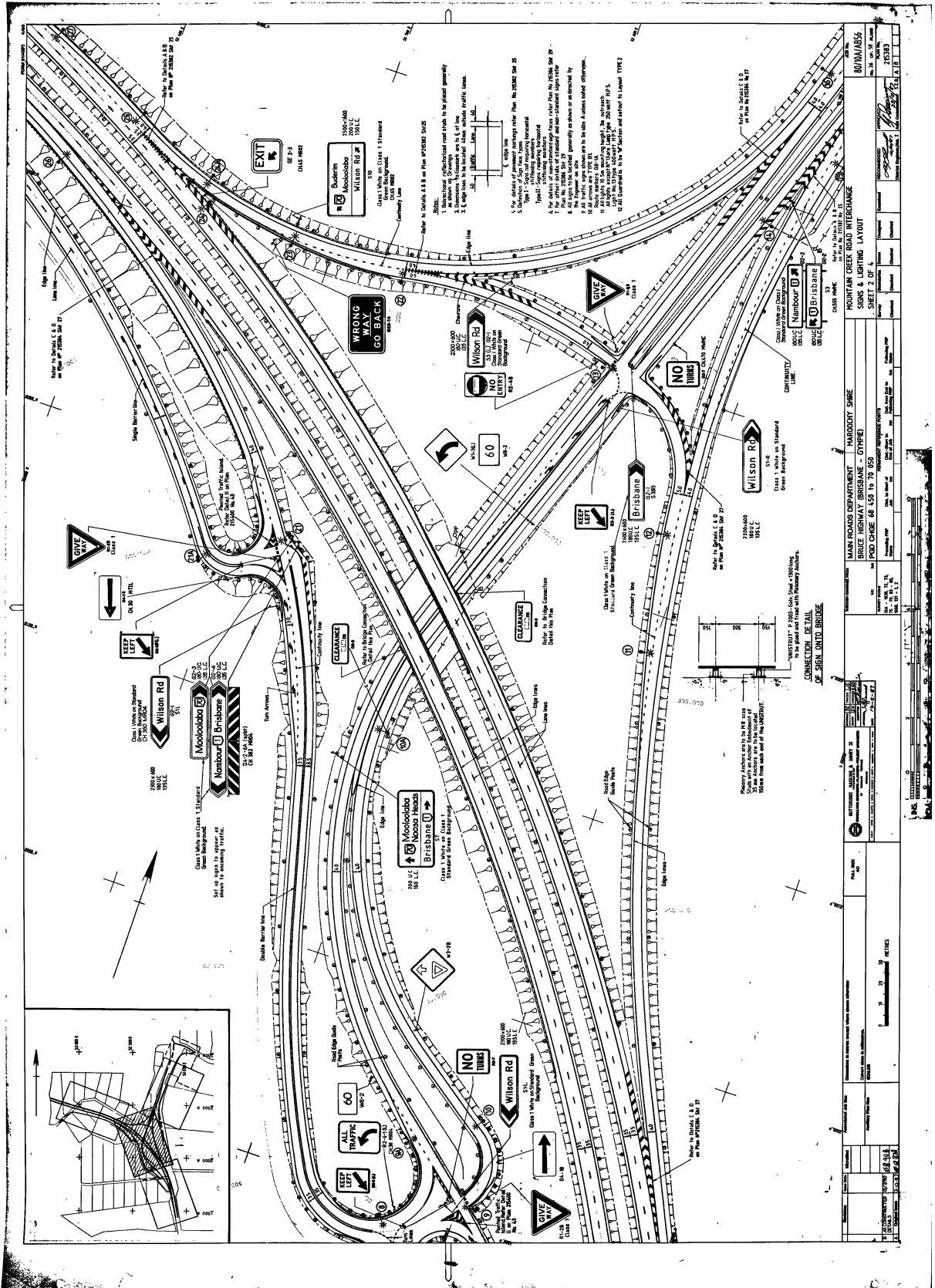


# Appendix C- Plan

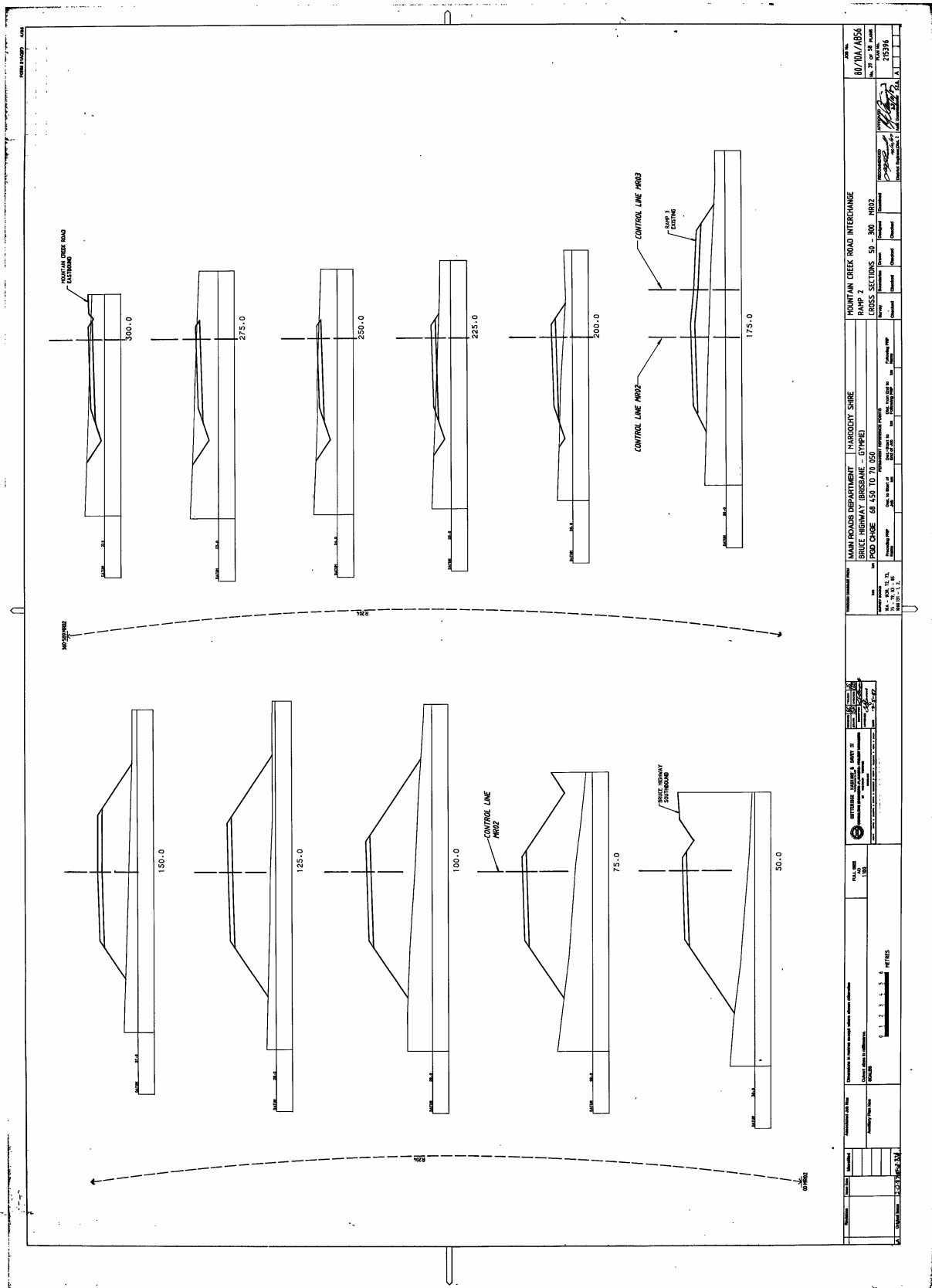












PROJECT NO. 80/004/0854 DATE 21/05/07 DRAWN BY 25396	
MOUNTAIN CREEK ROAD INTERCHANGE RAMP SECTIONS 59 - 300 - HR03 1:100 DATE 21/05/07 DRAWN BY 25396	
MAIN ROADS DEPARTMENT HARROLDY SHIRE BRUCE HWYWAY (BRISBANE - GYMNEY) ROAD CROSSING 58 450 TO 500 ROAD CROSSING POINT DATE 21/05/07 DRAWN BY 25396	
SHEET NO. 1 OF 1 SCALE 1:100 DATE 21/05/07 DRAWN BY 25396	
APPROVED BY DATE 21/05/07 DRAWN BY 25396	
CHECKED BY DATE 21/05/07 DRAWN BY 25396	
PROJECT NO. 80/004/0854 DATE 21/05/07 DRAWN BY 25396	









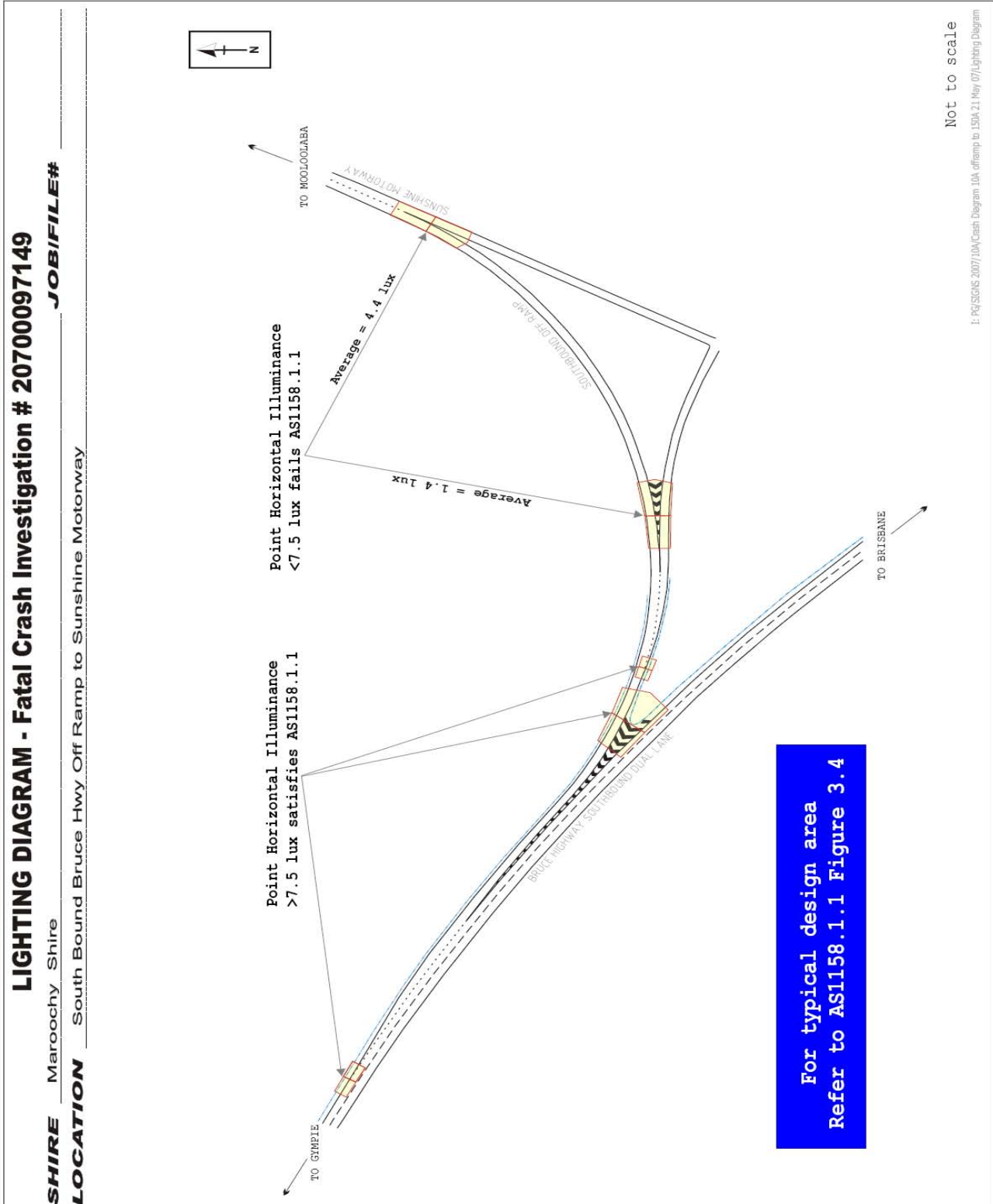
## Appendix D – Advisory Speed Study

Run Number (Toyota Camry)	Approach Speed (km/h)	Ball Bank Indicator Readings (degrees)	Advisory Speed (km/h)  <i>From: MUTCD Part2 Appendix E Figure E2</i>
1	60	8	72
2	70	11	70
3	70	11	70
4	80	13 to 16	72.5 to 66
5	80	15	67.5

Run Number (Ford Falcon)	Approach Speed (km/h)	Ball Bank Indicator Readings (degrees)	Advisory Speed (km/h)  <i>From: MUTCD Part2 Appendix E Figure E2</i>
1	60	7	75
2	60	8	72
3	70	12	66
4	70	9	75.5
5	70	11 to 12	70 to 66
6	80	13	72.5
7	80	15	67.5

- It is recommended that an Advisory Speed Sign of 70 km/h be installed.
- It is also recommended that Chevron Alignment Markers be installed on outside of curve according to the *MUTCD / Part 2 / Figure 3.6*.

# Appendix E – Assessment of Existing Lighting Levels



## **Appendix B – Geometric Assessment of Bruce Highway Southbound to Sunshine Motorway Eastbound Connection**

# Geometric Assessment of Bruce Hwy Southbound to Sunshine Motorway Eastbound Connection

## ***Background***

Detailed design of this connecting ramp from the southbound carriageway on the Bruce Highway to the eastbound carriageway on the Sunshine Motorway was completed by an external consultant in 1987. The detailed design closely reflected the concept design that had been developed within Main Roads. When this section of the Bruce Highway was built, the posted speed limit on the highway was 100km/h. The speed limit was increased to 110km/h in 1993. The exit terminal on the Bruce Highway for this ramp was lengthened in May 2000 in order to provide a greater deceleration length to the start of the R204m horizontal curve on the ramp proper.

Relevant geometric design guides at the time were:

- 1975 Main Roads Urban Road Design Manual (URDM), Ch 4 Freeways and Ch 6 Grade Separations and Interchanges. This covered mainly interchange layouts, turn types, merge and diverge geometry, sight distance at diverges, permissible ramp design speeds, gore area design, number of traffic lanes, ramp length, width and grade.
- 1980 NAASRA Interim Guide to the Geometric Design of Rural Roads. This covered the then current design parameters for horizontal curve design, sight distance and vertical alignment design. Some key parameters (side friction factors and deceleration rates) were different from those in the URDM. Importantly, this guide introduced the speed environment concept for establishing design speeds and gave for the first time, a clear definition of design speed, that is, the design speed had to be  $\geq$  the 85<sup>th</sup> percentile speed after the road was built. This also meant that the design speeds set out in Ch 6 of the URDM needed some "translation" to match the speed environment concept.
- The above NAASRA guide was supplemented by an internal Main Roads document that gave further guidance on the selection of superelevation for horizontal curves and for sight distance. This document was a paper by W.M. Rahmann (1981) titled "Design of Horizontal Curves Using Revised NAASRA Method – Side Friction Factors". However, it is not now known how well this paper was known/used by external consultants in 1987.
- 1984 AASHTO Policy on Geometric Design of Highways and Streets and 1984 NAASRA Grade Separated Interchanges Design Guide could be used as supplementary references.

The current Main Roads design guide is the 2000 Road Planning and Design Manual (RPDM), in particular

- Ch 4 Application of Design Principles and Guidelines
- Ch 6 Speed Parameters
- Ch 9, 10, 11 & 12 Sight distance and alignment
- Ch 16 Interchanges.

The RPDM has evolved from the design guides used in 1987 but contains updated design criteria and considerably more material based on Main Roads experience over the previous 20 years.

The interchange would now be classed as a "system interchange", being between two roads with motorway characteristics. This classification did not exist at the time. Strict adherence to the "system interchange" concept would now preclude some of the local road connections that have been provided within the interchange.

## ***Ramp Geometry***

- Horizontal Alignment (see Figure 1)
  - Starts off the back of a right hand R1000 on the southbound Bruce Hwy with 3% superelevation on a 3.04% down-grade
  - Reverse left hand R204 with 3% superelevation and with no spiral transition – initially there was no intervening tangent section. However, a 40m intervening tangent was introduced when the ramp terminal was revised in 2000 (see Figure 3).
  - 150m spacing to secondary diverge to Wilson Rd, off the R204 curve.
  - The far end of the R204 curve joins the Sunshine Motorway eastbound carriageway with branch connection geometry.
  - Limiting Curve Speed of the R204 curve with 3% superelevation is 84km/h. The limiting curve speed is defined in the design guides (NAASRA 1980, RPDM 2000) as the "speed at which a vehicle travelling on a curve of given radius and superelevation, will have a side friction demand equal to the absolute maximum recommended value" for that speed.
- Vertical Alignment (see Figure 2)
  - 3% down-grade
  - R3125 crest vertical curve 126.8m long
  - 7.02% instantaneous down-grade at the common tangent point between the preceding crest vertical curve and the following sag vertical curve
  - R3438m sag vertical curve 234m long
- Cross Section
  - 7m wide carriageway comprising –
    - 1m shoulder on right
    - 4m traffic lane (nil curve widening required according to Table 6.7 in NAASRA (1980).
    - 2m shoulder on left.

## ***Design Criteria adopted in 1987***

Since the design plans from 1987 do not show any design speeds or the speed environment, the following design speeds have been established from knowledge of the design guides and practices of the time. The speeds have been checked by "reverse engineering" from the radii and superelevation values that were adopted and the relevant criteria in the design guides.

The adopted Design speeds were:

- 100km/h exit speed from Bruce Highway. This would have been consistent with the requirement in para. 6-270 of URDM to assume vehicles leave the highway at the average running speed. Speed data shows that for a road like the Bruce Highway where the speed limit is 100km/h, the mean free speed is typically 100km/h and the 85<sup>th</sup> percentile speed is 110km/h.
- 80km/h for the ramp with possibly some checking for operation at 85km/h. This is predicated on:
  - Table 6-720 setting (for a high volume turning roadway with a through road design speed of 110km/h) a 90km/h desirable ramp design speed and 70km/h minimum design speed. Note that this was based on achieving turning radii in the range 465m down to 160m in accordance with Table 4-230.
  - However, by adopting, as required, the curve design parameters in NAASRA (1980), the R204m curve would be considered to be a curve that was suitable for an 85<sup>th</sup> percentile speed of 80 to 84km/h.
  - Also, by applying Figure 2.2 in NAASRA (1980), drivers would normally "read" a R204 horizontal curve and slow to about 85km/h from an approach speed of 100km/h. The 80km/h ramp advisory speed would have been considered to help ensure that drivers slowed to the assumed design speed of 80km/h or at least, help ensure that the 85<sup>th</sup> percentile speed did not exceed the limiting curve speed.
  - The R3125m crest being suitable for 85km/h.

The following key geometric design criteria conformed to the relevant design guides of 1987:

- Horizontal curve parameters – except possibly the superelevation and transition length (see below). It was known by the more experienced designers at the time that increasing the radius of a connecting roadway (that is, ramp) within an interchange would not ensure a significantly higher level of safety since drivers would simply drive the larger curve at its higher limiting curve speed.
- Vertical curve parameters
- Cross section widths
- Sight distance to the exit nose
- Development for superelevation for the secondary diverge to Wilson Rd.
- Pavement water flow depths – confirmed from recent survey because design water depths do not get recorded on the design plans.

The following geometric design criteria did not (at least in some way) conform to the relevant design guides of 1987:

- Superelevation of 3% - The preferred superelevation was 6% (from Rahmann 1981). However, the 3% superelevation that was used still ensured that the R204m curve still had a side friction demand that did not exceed the maximum value of 0.26 for 80km/h. As stated earlier, the curve had a limiting curve speed of about 84km/h.

- Transition Length - No spiral transition was provided on the entrance to the R204 curve. In 1980, it became normal practice to base transition curve length on the superelevation runoff length. For 80km/h the minimum runoff length is 27 (say 30m). In turn this would mean that a 30m transition would involve a 0.2m lateral shift which was small enough to eliminate the a transition. However, the preferred 6% superelevation would have required a 60m transition, which would not involve a small enough shift (<0.3m) for it to be able to be eliminated. Nevertheless, the 4m wide traffic lane still affords drivers room to make a suitable transition path when entering the curve. Even so, a separate entry transition element (50 to 60m long) would provide better guidance to drivers in this situation.
- Spacing between the R1000 and R204 curves – The use of 3% superelevation on the R204 curve was probably influenced by having a common tangent point between these curves.
- Ramp exit angle and consequent length of chevroned area.
- Sight distance over the barrier on the inside of the R204 curve - this may reduce the driver's ability to perceive the curvature of the ramp. However, guardrail has been provided on the outside of the ramp for the first 50m and this will provide some guidance.
- Maximum grade – The maximum down-grade of 7% exceeded the maximum value of 5% in Table 6-340 or the URDM. However, since the 7% down-grade only occurred instantaneously, it was probably considered that the average down-grade of 5% at this location effectively conformed.
- Coordination of the horizontal and vertical alignments. Overall, the horizontal and vertical alignments are coordinated. However, the R204 horizontal curve should have started before the R3125 crest vertical curve. This would have improved driver perception of the start of the R204 curve.

### ***Additional Criteria that would Apply to New Designs in 1987***

- Sight distance to 60m past nose (from 240m prior to nose in this case) as required in Table 6-310 in URDM. This criterion relates to driver perception of a diverge (together with the need to see the nose from at least 300m in this case). This criterion is often very difficult to achieve. At the distances involved, it is possible to "conform" by achieving the sight distance but not achieve the intent of making the situation more obvious to drivers. This criterion was relaxed with a number of interchanges built at the time because it was not a criterion specified in the 1984 AASHTO guide (and is still not in the 2004 AASHTO guide). That is not to say that the criterion is not used in the USA. Main Roads adopted the criterion from California around 1970. It is included in the 1984 NAASRA guide (but less onerous). The current Victorian guide only requires at least 60m of pavement past the nose to be seen from the start of the ramp taper. It is yet to be seen how the forthcoming Austroads project to standardise on this criterion across Australia and New Zealand deals with this issue.
- Traversable gore area 120m past the nose with maximum cross slope of 1 on 4 as required in para. 6-260 of URDM. This criterion is also often very difficult to achieve. It is a desirable criterion in the current RPDM but it is recognised that sometimes a barrier and crash cushion has to be used.

- A 1 in 15 diverge taper as required in Fig 6-250A of URDM. This allows better delineation and recognition of the off-ramp. The ramp exit was achieved by the use of the R204m curve, tangential to the highway alignment. In addition, only 45m of deceleration length was provided from the "ramp exit point" to the start of the R204 curve instead of the 115m that should have been provided in accordance with the table in Fig 6-250A of URDM. Note that the deceleration length was increased to about 104m in 2000 although a length of 170m (from Table 13.11 in RPDM) would now be provided. The consequences of the current deceleration length are:
  - Many drivers will slow down more than they normally would in the through highway lane before exiting.
  - Some drivers will decelerate harder than they normally would prior to the R204 curve and/or enter the R204 curve at a slightly higher speed than they normally would. Note that even though it is normal design practice to allow for drivers to decelerate to the curve operating speed prior to the curve (and this is necessary for trucks), it is known that car drivers approaching at the 85<sup>th</sup> percentile speed commonly start to decelerate from a point about 75m prior to the curve and do not fully decelerate to the curve operating speed until about 80m into the curve (see 7.3.1.1 of the current Austroads Rural Road Design Guide).

### ***Effect of 110km/h Speed Limit***

The main effect of the increase in speed limit to 110km/h on the Bruce Hwy after the interchange was built was an increase in the 85<sup>th</sup> percentile speed on the Bruce Hwy to about 120km/h. This meant that drivers had to make a larger speed reduction for the R204 curve – now up to a 40km/h reduction but at least on average, a 30km/h reduction.

Without any change in signing, drivers are less inclined to slow down to the 80km/h curve design speed for the R204 curve. The Speed Environment model (by extrapolation) shows that drivers would be inclined to slow to about 90km/h. This is above the limiting curve speed (for design) of 84km/h. However, Table 6-270 of URDM and Table 16-3 of RPDM show that drivers expect to slow down more when turning from one motorway to another compared to what they are prepared to slow for a curve of the same radius on the "through alignment" of a rural road (the Speed Environment model is based on rural road operation).

Even though the R204 curve has a limiting curve speed of about 84km/h, it does not mean that all, or even most, drivers taking the curve at 90km/h in the wet will lose control. What it does mean is that there is likely to be a slight increase in the single vehicle crash rate due to loss of control. This situation is explained as follows:

- From the universal curve design equation, the side friction factor is 0.28 for a R204 curve with 3% superelevation at 90km/h. A value greater than about 0.35 to 0.4 is needed before there is a chance of loss of control in the wet. It must be recognised that the friction factor used in the curve design equation is not the same as the friction value measured in skid testing. The friction factors used for design in Australia have been "back calculated" by the curve design equation from measured vehicle speeds on a wide range of curves.
- When drivers steer a horizontal curve they do not normally drive the curve as a single arc. This is especially the case with long curves and larger radii curves (this includes the R204 curve). Drivers tend to steer the curve as a series of disjoint arcs. When a steering correction is made, a higher side friction demand is made, but only for a short time. In being derived from actual driving practice, the curve design factors used in Australia do account for this phenomenon.

- Sometimes, drivers have to make a bigger steering correction on a curve because the initial line taken was wrong (possibly due to misjudging the curvature), the approach speed was too high, they were distracted, and so on. In these situations, a higher side friction demand may be made because of a greater steering correction being required. But usually, the steering correction is still sufficiently small and of short duration so that loss of control does not occur.
- Because there is a limit to the friction that is possible with the tyre-road interface, loss of control is more likely when it is necessary to brake in conjunction with a steering correction, or when vehicles accelerate heavily in conjunction with a steering correction.

The increase in operating speed on the Bruce Hwy meant an increase in the available deceleration length to the start of the R204 curve was required and was provided as explained earlier. At the same time, the guardrail at the gore area was moved back 20m to give a clearer gore area. The new shape of the guardrail probably helped to highlight and accentuate the curvature of the R204 curve.

### ***Current Operating Speeds***

The following speed data comes from a speed study conducted from 24 October 2006 to 9 November 2006. The data covers 42425 vehicles.

- 85.3km/h 85<sup>th</sup> percentile speed – which is consistent with the 84km/h limiting curve speed and not necessarily inconsistent with the 80km/h design speed assumed for the ramp.
- 77.1km/h mean speed.
- 91.1km/h 95<sup>th</sup> percentile speed.
- 35.6% of vehicles exceed the 80km/h speed limit – commonly this is close to 50% on "through alignments".

The above data does fit the expectation that drivers slow down more for a curve when turning from one motorway to another compared to what they are prepared to slow for a curve of the same radius on a "through alignment".

### ***Conformance with Current Design Guide (RPDM)***

Individually, the following key geometric design criteria still conform to the RPDM:

- Vertical curve parameters
- Cross section widths
- Sight distance to the exit nose (however, some small trees that have grown in the median at Ch 66.45km on the Bruce Highway will need to be cleared in order to maintain this sight distance).
- Development of the superelevation for the secondary diverge to Wilson Rd by means of a cross-over crown line.
- Pavement water flow depths – confirmed from recent survey because design water depths do not get recorded in the design plans.

However, Section 2.4.2 of the RPDM now warns that it is not acceptable practice to combine a number of minimum value design parameters.

The following geometric design criteria do not conform to the RPDM:

- Design speed of connector. The current version of Table 16-3 indicates a curve suitable for 100km/h (R400) should be used by virtue of the note at the bottom of the table. However, this is currently being revised and it is probable that a curve suitable for 90km/h (R300) will be adequate. The note at the bottom of the table does not properly reflect the intention of the original source of Table 16-3 (that is, AASHTO 1984).
- Lack of spiral transitions.
- Spacing and visibility to the second diverge (240m min for system interchange, 180m for service interchange). Note though, the RPDM is not specific on the sight distance needed to the second diverge.
- Spacing between the R1000 and R204 curves.
- Ramp exit angle and consequent length of chevroned area.
- Sight distance over the barrier on the inside of the R204 curve.
- Sight distance to 60m past primary diverge nose (from 290m prior to nose due to the 110km/h speed limit).
- Maximum grade – The maximum down-grade of 7% exceeds the maximum value of 5% in Table 16-6 of the RPDM. However, many designers would maintain that since the 7% only occurred instantaneously and that the average down-grade was 5% at this location, then it effectively conformed. This is where the check on the combination of minimum value parameters in Section 2.4.2 of the RPDM would intervene.
- Coordination of the horizontal and vertical alignments – The R204 curve should have started before the R3125 crest vertical curve in order to improve driver perception of the start of the R204 curve.

### ***Observations of “As Constructed” Survey***

RoadTek Surveys Nambour undertook a detailed feature survey of the highway diverge and the ramp during the week beginning 28 May 2007.

The following "as constructed" criteria has been checked for conformance with the original design and subsequent 1999 alteration to the highway diverge and gore area. This assessment does not consider the original design guidelines (discussed separately above), but rather investigates the accuracy of the construction.

#### **Horizontal Geometry**

The ramp curve has been constructed to the correct radius of 204m. No deviation from the design has been found.

#### **Vertical Geometry**

Vertical geometry conforms to the original design with due allowance for overlay undertaken in 2000.

## Flow Paths

Analysis of the sheet water flow paths has been undertaken. On the ramp proper, the longest flow path occurred at Chainage 160, being 38m long. The maximum flow depth for the design intensity of 50mm/h and a texture depth of 0.7mm was 1.4mm. This is **well below** the desirable maximum 2.5mm depth specified in Section 4.4.4.2 of the Road Drainage Design Manual. However, it does coincide with the area of maximum down-grade (which actually helps reduce water depth) and with an area of lower skid resistance.

This analysis of water depths on the ramp is consistent with observations made by the surveyor on Monday 28 June 2007 during heavy rain that no concentrated flows paths were evident and the surface appeared to be shedding water evenly.

There is also a flow path that achieves a depth of 1.9mm at the start of the R204 curve at about Chainage 50. Again, this is well below the desirable maximum 2.5mm depth specified in Section 4.4.4.2 of the Road Drainage Design Manual.

## Conclusion

The geometric design of the connecting ramp from the Bruce Hwy southbound to Sunshine Motorway eastbound at Sippy Downs did not fully conform with the geometric design guidelines of the time. However, it was largely consistent with common design practice of the era.

The RPDM released in 2000 superseded the previous URDM and NAASRA guides that date back to 1975. The RPDM captures Main Roads experience with building and operating motorway facilities for more than 30 years. Chapter 16 of the RPDM now more clearly sets out appropriate design criteria and practice, together with their technical foundation.

The main geometric issues are:

- 84m of sight distance to the road surface at a point 60m past the nose instead of the preferred 300m. The primary intent of this design requirement is to make it easier for drivers to see the exit and decide whether to exit, without having to rely upon signage. However, it also usually helps ensure that the start of the first curve on the ramp is visible. The following problems arise in this case because this criterion and alignment coordination at the start of the ramp has not been achieved -
  - Perception of the start of the R204 curve since it starts over a crest.
  - Perception of the size of the R204 curve since it starts over a crest.
- 104m of deceleration distance to the start of R204 instead of the preferred 170m. The available deceleration distance is such that –
  - Some drivers will slow down more in the through lane on the Bruce Highway.
  - Some drivers will decelerate at a higher rate than normal prior to the R204 curve.
  - Some drivers will enter the curve at a higher speed and therefore have to slow down more within the curve.

- No entry transition on the R204 curve instead of the preferred 60m transition. Even though there is room for drivers to make their own transition path, a 60m transition would have extended about 30m back into the exit terminal and improved perception of the start of the curve. It would also allow more superelevation to be applied on the curve.
- The combination of several minimum value design parameters at the same location, namely -
  - Horizontal curve of minimum radius for the 80km/h assumed design speed.
  - Down-grade of up to 7% (5% average). Note that there is a limitation with the universal curve design equation in that it does not take into account the effect of the combination of grade with horizontal curvature. Suitable design tools that take this into account are only starting to become available. However, this effect does show up in ball-bank testing of a horizontal curve. These tests (and the new vehicle dynamics modelling software) show that a steeper down grade like 5% does require a higher side friction demand than on a level grade if a curve is travelled at the same speed.
  - Sight distance restricted by safety barrier and vegetation on the inside of the curve.
  - 3% superelevation on the curve instead of 5% to 6%.
  - Short distance to secondary diverge to Wilson Road – this may increase the decision load for some drivers.
  - The need for a cross-over crown line at the secondary diverge – this has the effect of reducing the effective superelevation for a vehicle that runs wide on the R204 curve.
  - 38m long water flow path on the pavement surface (although the flow depth is only 1.4mm if the effective pavement texture depth is 0.7mm).

With respect to the road geometry being a contributing factor in loss of control crashes (especially in the wet), it is known that loss of control crashes are always the result of a combination of factors. The removal of any one factor may be sufficient to prevent the crash. In spite of the geometric issues identified, none are of a type that could be deemed to be a design error. And experience shows that none are of a type that would significantly increase crash rates.

Road design has always involved tradeoffs between competing design controls. It is not always possible to fully conform with all design parameters in order to obtain an optimum result. Chapter 2 of the RPDM formally recognises this. When this occurs, it is necessary to compensate with better than minimum values for other parameters and to adopt appropriate mitigating treatments. This does not mean however that an improvement of the ramp geometry does not need to be considered.

Possible short term geometric and related improvements are:

- Reducing the advisory speed or speed limit (speed limit reduced to 70km/h on 14 June 2007) and using chevron alignment markers around the curve.
- Improving the sight distance around the curve by clearing vegetation on the inside of the curve.
- Implementing clear zones.

Possible medium term improvements are:

- Reconstructing the ramp terminal on the Bruce highway to incorporate –
  - An intermediate curve to help reduce the approach speed to the R204 curve.

- An entry transition for the R204 curve.
- Increase in superelevation to 5% or 6%, but this would preferably require closing of the connection to Wilson Rd because of the cross-over crown line and the proximity to the main exit from the Bruce Hwy.
- Standard diverge angle and deceleration length.

In the longer term, increasing traffic volumes will probably make it necessary to reconfigure the interchange and remove some or all of the local road connections.

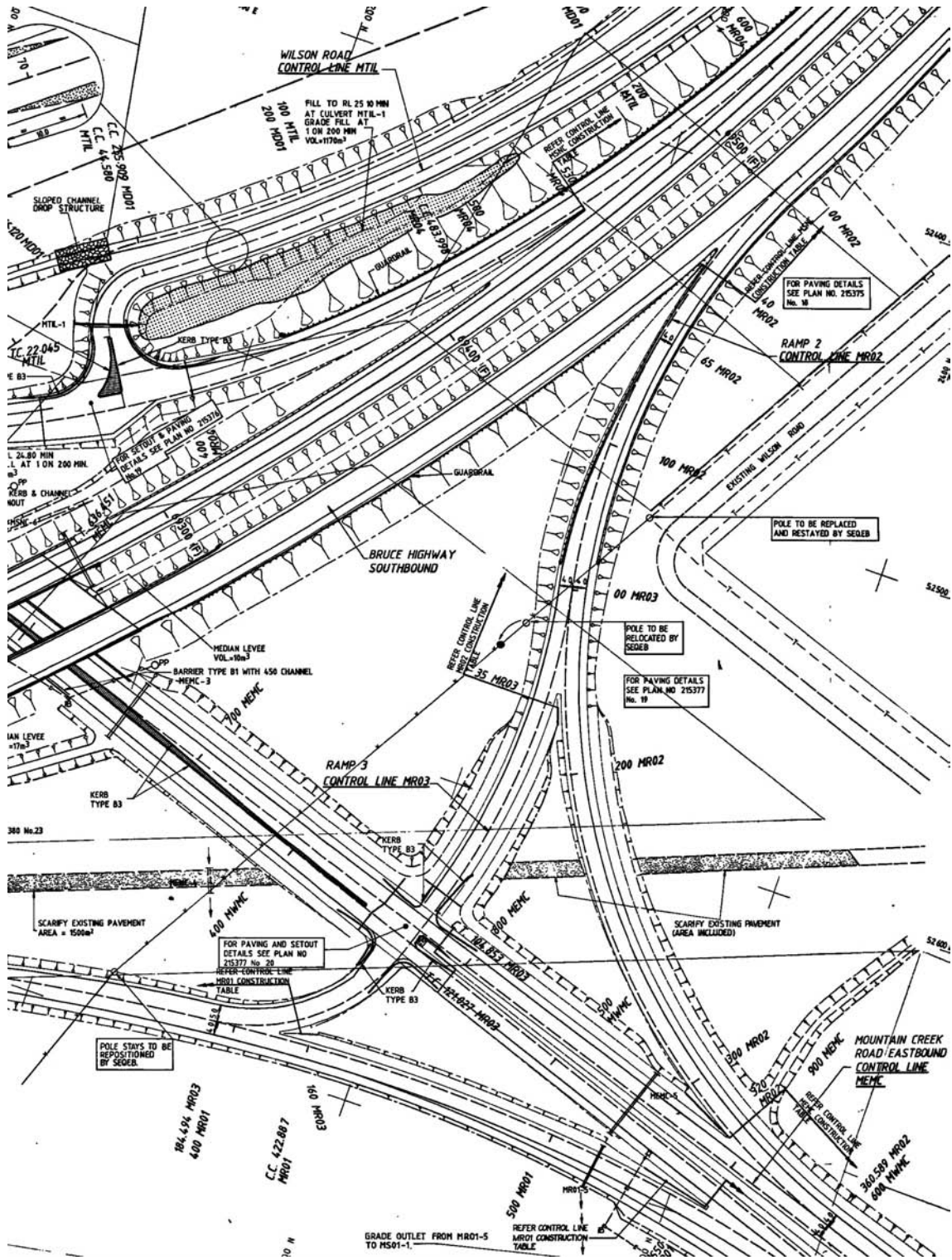


Figure 1 Original Ramp Layout

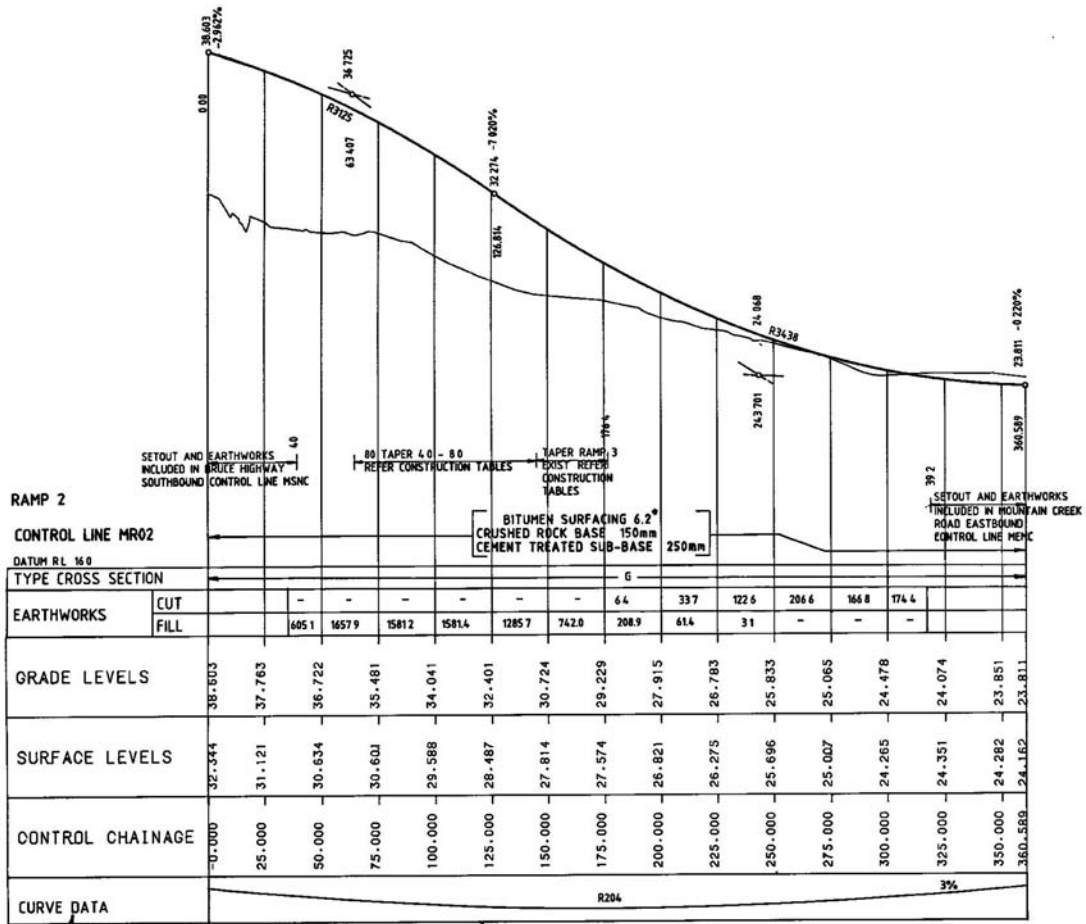


Figure 2 Ramp Vertical Alignment

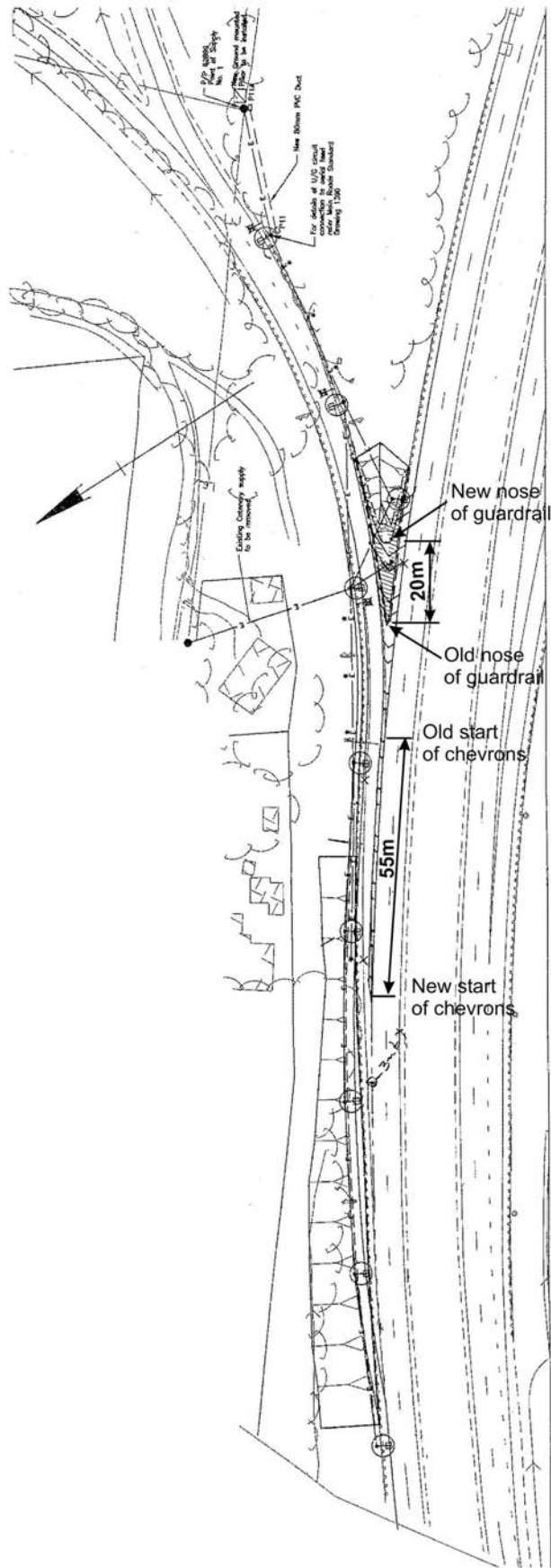


Figure 3 Revised Ramp Terminal

## **Appendix C – Summary of Pavement Surface Properties**



**Queensland  
Government**

Department of **Main Roads**

# **Bruce Highway Southbound off ramp to Sunshine Motorway**

## **Summary of Pavement Surface Properties**

Version 07\_06\_28

<b>Prepared by</b>	Pavements & Materials Branch
<b>Branch</b>	Pavements & Materials Branch
<b>Division</b>	Road Delivery & Performance Division
<b>Location</b>	35 Butterfield Street, Herston Qld 4006
<b>Date</b>	28 June 2007
<b>DMS ref. no.</b>	

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## Executive Summary

### Skid Resistance: A Brief Explanation

The term "skid resistance" is used to describe the friction force developed at the tyre-pavement contact area. In other words, skid resistance is the force that resists sliding on road pavement surfaces. Road pavement surface characteristics are part of the complex suite of factors which influence skid resistance. Additionally, skid resistance is a complex issue and is only one of many factors contributing to vehicle behaviour, which include:

- a) Driver behaviour
- b) Environment
- c) Vehicle characteristics
- d) Water film thickness
- e) Regulatory environments (delineation, signs, speed, constraint of driver behaviour)
- f) Road alignment and layout
- g) Maintenance regime
- h) Investment scenario determined from the asset management process.

Pavement surface properties cannot fully compensate for deficiencies in any of these above factors, and can only be developed and maintained within their context.

In relation to pavement surfacing, skid resistance is delivered through specifying the appropriate:

- a) Macro-texture (measured by texture depth) which:
  - i) Enables water to escape from beneath the tyre (in addition to the grooves in the tyre);
  - ii) Provides resistance through tyre deformation;
  - iii) Contributes to the provision of sufficient stress (along with micro-texture) between the tyre and the pavement asperities (generated by reducing the pavement surface areas with macro-texture and micro-texture) to enable a bond to develop between the tyre and the pavement surface.
- b) Micro-texture which:
  - i) Contributes to the provision of sufficient stress (along with macro-texture) between the tyre and the pavement asperities (generated by reducing the pavement surface areas with macro-texture and micro-texture) to enable a bond to develop between the tyre and the pavement surface.

Generally, macro-texture is the main contributor to skid resistance in the wet for high speed and micro-texture for low speed.

During service the micro-texture wears off (called polishing) and the texture depth can decrease (For reasons including: aggregate forced into the underlying surface, re-orientation, wear).

Road authorities typically use network tools such as SCRIM and ROAR to highlight specific areas of road surfacing requiring closer investigation. This may involve use of specific macro-texture and micro-texture test methods.

Establishing investigatory levels is challenging because it depends on multiple complex factors that cannot always be anticipated including traffic intensity and mix, skid demand during service, rate of wear of the different aggregates and so on.

### **Sippy Downs Accident Site**

At the Sippy Downs accident site the pavement surface was tested with:

- the network tool ROAR; and
- the Laser Texture Depth meter.

Selected sections have also been tested with:

- the Sand Patch texture depth test; and
- the British Pendulum test for micro-texture.

In summary, the results indicate that there has been increased wear on the aggregate in the central section of the curve.

## Contents

<b>EXECUTIVE SUMMARY .....</b>	<b>I</b>
SKID RESISTANCE: A BRIEF EXPLANATION .....	I
SIPPY DOWNS ACCIDENT SITE .....	II
<b>1 INTRODUCTION .....</b>	<b>1</b>
<b>2 ASPHALT MIX DESIGN DETAILS .....</b>	<b>1</b>
<b>3 POLISHED AGGREGATE FRICTION VALUE (PAFV) .....</b>	<b>1</b>
<b>4 SAND PATCH TEXTURE DEPTH .....</b>	<b>1</b>
<b>5 MULTI LASER PROFILOMETER TEXTURE DEPTH .....</b>	<b>2</b>
<b>6 MULTI LASER PROFILOMETER RUT DEPTH .....</b>	<b>2</b>
<b>7 MULTI LASER PROFILOMETER ROUGHNESS .....</b>	<b>2</b>
<b>8 SKID RESISTANCE TESTING USING BRITISH PENDULUM.....</b>	<b>2</b>
<b>9 SKID RESISTANCE TESTING USING ROAR.....</b>	<b>2</b>

**Appendix A Test Locations**

**Appendix B Approved Asphalt Mix Design Details**

**Appendix C Sand Patch Texture Depth**

**Appendix D Multi Laser Profilometer Texture Depth, Rut Depth and Roughness**

**Appendix E Skid Resistance Testing using British Pendulum**

**Appendix F Skid Resistance Testing using ROAR**

## 1 Introduction

This report is a compilation of pavement surface property test results for the asphalt surfacing on the Bruce Highway Southbound off ramp to the Sunshine Motorway at Sippy Downs.

This report includes:

- Asphalt mix design details
- Polished Aggregate Friction Value (PAFV) historic test results
- Sand patch texture depth testing
- Multi Laser Profilometer survey capturing texture depth, rut depth and road roughness
- Skid resistance testing using British Pendulum, and
- Skid resistance testing using Norsemeter Road Analyser and Recorder (ROAR).

It is understood water film thickness details will be reported by others.

The asphalt surfacing on this ramp is stone mastic asphalt (SMA) laid in October 2000.

A review of the project file and the scheme documents has identified the following:

- Contractor was Boral Resources
- Contract administrator was GHD
- Original design depth of SMA was 35mm, changed to 40mm as a variation.

An aerial photograph showing the site and test locations is attached in Appendix A.

## 2 Asphalt Mix Design Details

The mix used was an approved asphalt mix, number B:SM14/98/427(A5S), which at time of construction was approved for manufacture using Boral's mobile plant. Details of this approved mix design are attached in Appendix B.

## 3 Polished Aggregate Friction Value (PAFV)

For the approved mix design B:SM14/98/427(A5S) the approved aggregate source was the Moy Pocket quarry. Available PAFV results from Moy Pocket Quarry for the five years prior to 2000 are summarised below:

15/12/1995 - 45  
02/04/1998 - 46  
14/09/1998 - 45  
14/09/1998 - 45  
11/06/1999 - 46

The specified minimum value was 45.

## 4 Sand Patch Texture Depth

Sand patch texture depth testing, using test method Q705, was undertaken by RoadTek Consulting on 31 May 2007. Results are attached in Appendix C.

All the results, except one, are significantly greater than the typical texture depths for stone mastic asphalt and the investigation levels given in the *Austrroads* "Guide to the Selection of Road Surfacing". The one low result was located after the accident site. Additionally, the low value is only 0.01 mm less than the worst interpretation of the requirements in the above guide.

## **5 Multi Laser Profilometer Texture Depth**

Texture depth testing was undertaken by RoadTek using a Multi Laser Profilometer on 24 May 2007. Results are attached in Appendix D.

All the results are significantly greater than the typical texture depths for stone mastic asphalt and above the investigation levels given in the *Austrroads* "Guide to the Selection of Road Surfacing".

## **6 Multi Laser Profilometer Rut Depth**

Multi Laser Profilometer testing undertaken on 24 May 2007 was also used to estimate rut depths. Results are attached in Appendix D.

The typical shape requirements given in the *Austrroads* "Guide to the Selection of Road Surfacing" for older roads is 20 mm beneath a straight edge (or a rut of 20 mm).

The greatest rut depth indicated in the testing was 8 mm.

## **7 Multi Laser Profilometer Roughness**

Multi Laser Profilometer testing undertaken on 24 May 2007 was also used to estimate road roughness. Results are attached in Appendix D.

## **8 Skid Resistance Testing using British Pendulum**

Skid resistance testing using the British Pendulum (QDMR Test Method Q704) was undertaken by Engineering & Technology on 31 May 2007. Results are attached in Appendix E.

Neither QDMR nor *Austrroads* have standards for the interpretation of British Pendulum test results.

There are British investigatory standards for the Pendulum test but these apply to a country with a different environment, considerably greater loading intensities and with different materials. They cannot be directly applied to Queensland. However, using these as a ranking tool, there is support for other evidence that the middle sections of the curve have less micro-texture than the end sections.

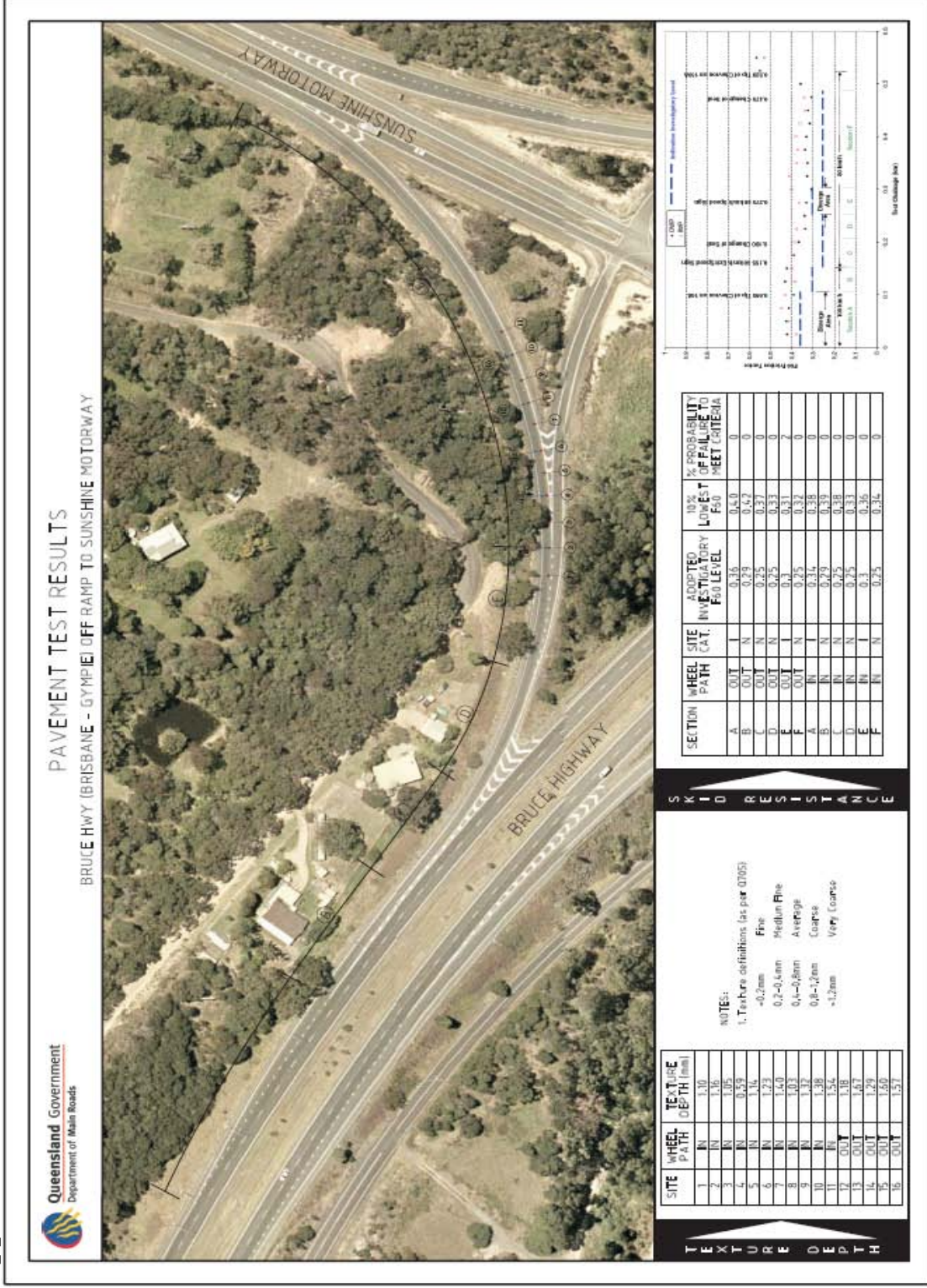
The British interpretation, corrected to 30°C, is attached in Appendix E.

## **9 Skid Resistance Testing using ROAR**

Skid resistance testing using ROAR was undertaken by RoadTek on 26 and 28 May 2007. Results are attached in Appendix F.

The results include the investigatory level as defined in the QDMR Skid Resistance Management Plan.

# Appendix A Test Locations



## Appendix B Approved Asphalt Mix Design Details



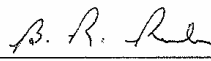
### APPROVED SUPPLIER CERTIFICATION

#### ASPHALT SUPPLY AND LAY

**COMPANY :** Boral Asphalt - Mobile Plants  
**APPROVAL NUMBER :** B080202  
**ORIGINAL ISSUE DATE :** 14/2/00  
**CURRENT ISSUE DATE :** 15/3/01  
**EXPIRY DATE :** 14/2/02

SPECIFICATION	APPROVED MIX DESIGNS	
MRS 11.30	Cloncurry B : DG14/96/324 Gympie B : DG10/98/444 B : DG14/98/419 B : DG20/01/605 Nanango B : DG7/98/437 B : DG10/98/428 B : DG14/98/435 Longreach B : DG10/96/319	Mackay B : DG14/96/301 Marburg B : DG10/99/514 B : DG14/99/519 Purga B : DG10/00/538 B : DG10/00/567 B : DG14/00/560 B : DG20/00/551 B : DG20/00/564 Mt Isa B : DG20/01/608
Northern District Supplementary Specification (3/00)	Charters Towers B : DG14/00/547 Class 1.2	Mt Isa B : DG14/01/607 Type 1.2
MRS 11.33	Gympie B : SM10/00/542 B : SM14/98/427	Marburg B : SM14/99/513 Purga B : SM14/00/535
MRS 11.34	Gympie B : OG10/98/443 B : OG14/00/558	

Approval Authority :

  
 Principal Chemist

Pavements, Materials & Geotechnical Division

## REPORT ON ASSESSMENT OF ASPHALT MIX DESIGN

Materials Centre  
35 Butterfield Street  
Herston 4006

REPORT NUMBER: A1883  
 COMPANY : Boral Mobile Operations (Gympie)  
 MIX TYPE: SM14 CODE NUMBER: B:IntSM14/98/427  
 SAMPLING METHOD: - DATE APPROVED: 1 June 1998  
 SAMPLED BY: Boral Personnel  
 SAMPLING DATE: -

Page 1 of 3

## RAW MATERIALS

SAMPLE NUMBER	COMPONENT	SOURCE	MIX PROPORTION (%)
A98/700	14mm Crushed Aggregate	Moy Pocket Quarry	40.0
A98/701	10mm Crushed Aggregate	Moy Pocket Quarry	35.0
A98/702	7/5mm Crushed Aggregate	Moy Pocket Quarry	4.0
A98/703	Crusher Dust	Moy Pocket Quarry	8.0
A98/704	Fine Sand	Mooloolah Sands	5.0
A98/705	Fly Ash	Pozzolanic Australia	8.0
A98/708	Fibre	Cellulose	0.3
A98/706	Class AB5 Binder	BP Australia	5.9

## PROPERTIES

TEST	SAMPLE NUMBER	RESULTS	SPEC. LIMITS
Flakiness Index (%) (Q201A)	A98-306 (14mm)	20*	Max 30
	A98-307 (10mm)	20**	
Ten Percent Fines Value (Wet) (kN) (Q205B)	A98-306	236#	Min 150
Polished Aggregate Friction Value (Q203)	A98-307	46##	Min 45
Voids in Dry Compacted Filler + (%) (AS 1141.17)	A98/705	40.0	Min 38

Variation to test method(s)/Remark(s):

- + Filler relates to the passing 75µm fraction of the combined aggregates/filler.  
 \* Refer to Soils Laboratory report number 9672.  
 \*\* Refer to Soils Laboratory report number 9673.  
 # Refer to Soils Laboratory report number 9671.  
 ## Refer to Soils Laboratory report number 9698.

Samples referenced in Soils Laboratory reports are representative of the Moy Pocket Quarry.

National Association of Testing  
Authorities, Australia

This laboratory is registered by the  
National Association of Testing Authorities,  
Australia. The tests reported herein have  
been performed in accordance with its  
terms of registration. This report may  
not be reproduced except in full.

Date : 22 May 1998

Checked By :

*S. Naidu*  
S Naidu

Signatory :

*I. Berghofer*  
I Berghofer

F:BAC 023/4

## Appendix C Sand Patch Texture Depth

Sample Number	Location	Texture Depth (mm)
07C0517-1	Ch.00 IWP – survey station "CN7"	1.10mm
07C0517-2	Ch.10 IWP – Police yellow mark, "expected start"	1.16mm
07C0517-3	Ch.20 IWP – 2.5m east of end of guard rail.	1.05mm
07C0517-4	Ch.30 IWP	0.59mm
07C0517-5	Ch.40 IWP	1.14mm
07C0517-6	Ch.50 IWP	1.23mm
07C0517-7	Ch.60 IWP – 2m east of survey station "STN4"	1.40mm
07C0517-8	Ch.70 IWP	1.03mm
07C0517-9	Ch.80 IWP	1.32mm
07C0517-10	Ch.90 IWP	1.38mm
07C0517-11	Ch.100 IWP – 9m west of survey station "CN9"	1.54mm
07C0517-12	Ch.10 OWP - Police yellow mark, "expected start"	1.18mm
07C0517-13	Ch.30 OWP	1.67mm
07C0517-14	Ch.50 OWP	1.29mm
07C0517-15	Ch.70 OWP	1.60mm
07C0517-16	Ch.90 OWP	1.57mm

RoadTek Consulting  
Caboolture Laboratory  
Beerburum Road, Caboolture

MAIN ROADS MOOLOOLABA Unit				
820	085	0	0	G
for info		for action		
PMV	13 JUN 2007			
RSG	for reply			
MPL				



40

### Report on Texture Depth

<b>Client :</b>	Paul Venz
<b>Road :</b>	Bruce Highway (South Bound) to Sunshine Motorway Ramp
<b>Job :Number</b>	80/489/204
<b>Requested By :</b>	P.Venz
<b>Request No :</b>	1687
<b>Testing Surface :</b>	Asphalt
<b>Tested By :</b>	G.Caulley & J. Roberts
<b>Date Tested :</b>	31/5/07
<b>Test Method :</b>	Q705

Sample Number	Location	Texture Depth (mm)
07C0517-1	Ch.00 IWP – survey station "CN7"	1.10mm
07C0517-2	Ch.10 IWP – Police yellow mark, "expected start"	1.16mm
07C0517-3	Ch.20 IWP – 2.5m east of end of guard rail.	1.05mm
07C0517-4	Ch.30 IWP	0.59mm
07C0517-5	Ch.40 IWP	1.14mm
07C0517-6	Ch.50 IWP	1.23mm
07C0517-7	Ch.60 IWP – 2m east of survey station "STN4"	1.40mm
07C0517-8	Ch.70 IWP	1.03mm
07C0517-9	Ch.80 IWP	1.32mm
07C0517-10	Ch.90 IWP	1.38mm
07C0517-11	Ch.100 IWP – 9m west of survey station "CN9"	1.54mm
07C0517-12	Ch.10 OWP - Police yellow mark, "expected start"	1.18mm
07C0517-13	Ch.30 OWP	1.67mm
07C0517-14	Ch.50 OWP	1.29mm
07C0517-15	Ch.70 OWP	1.60mm
07C0517-16	Ch.90 OWP	1.57mm

### Comments:

Chainage 00 = Survey station "CN7" all chainages increasing in easterly direction (with traffic).

OWP – Outer Wheel Path (passenger's side)

IWP – Inner Wheel Path (driver's side)

Texture definitions (as per Q705):-

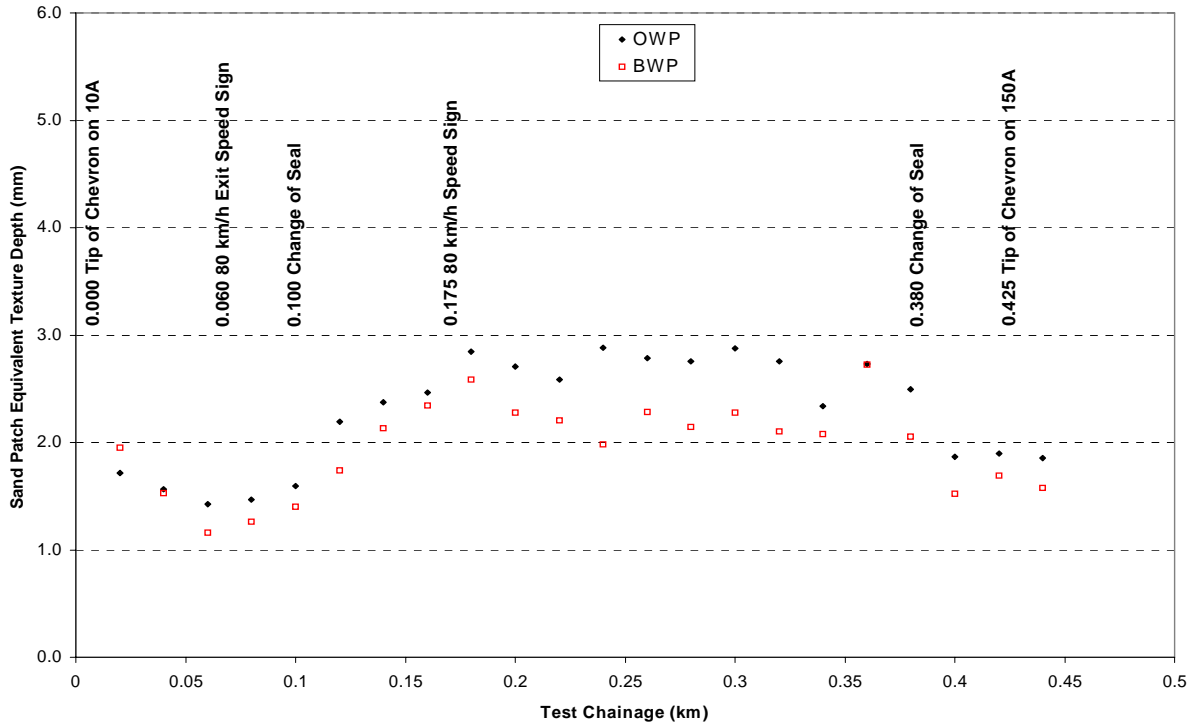
< 0.2mm	Fine
0.2 – 0.4mm	Medium Fine
0.4 – 0.8mm	Average
0.8 – 1.2mm	Coarse
>1.2mm	Very Coarse

Signatory :

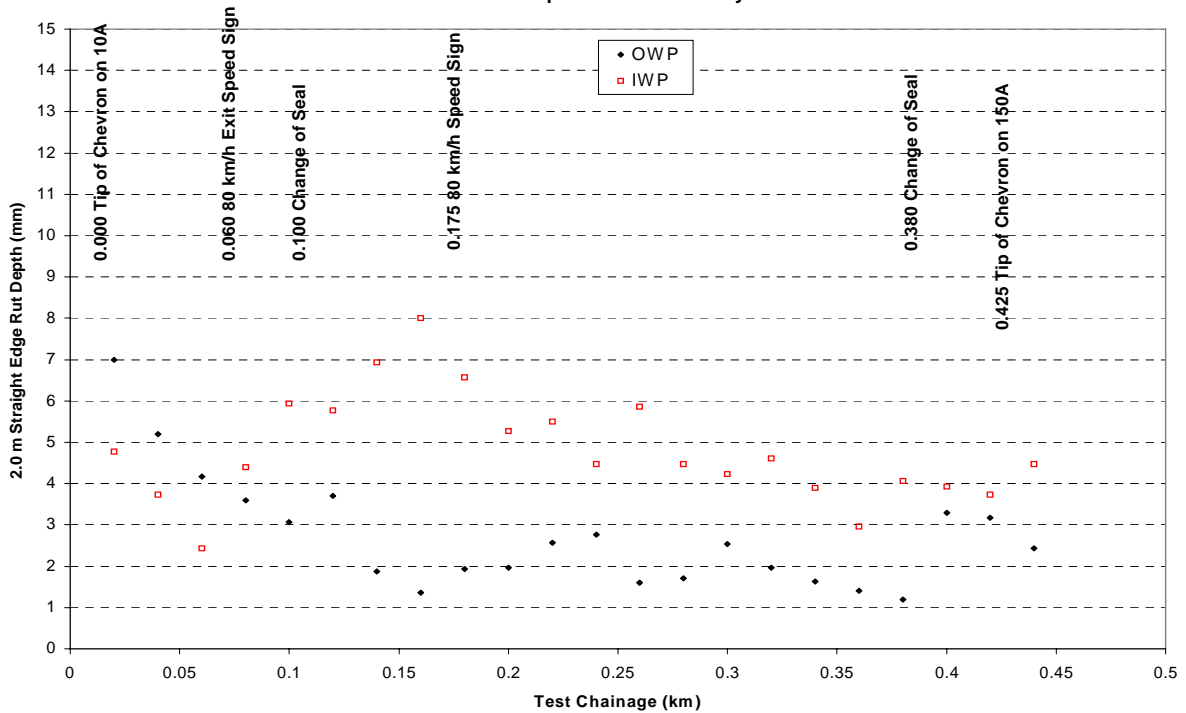
Date : 31/5/7

## Appendix D Multi Laser Profilometer Texture Depth, Rut Depth and Roughness

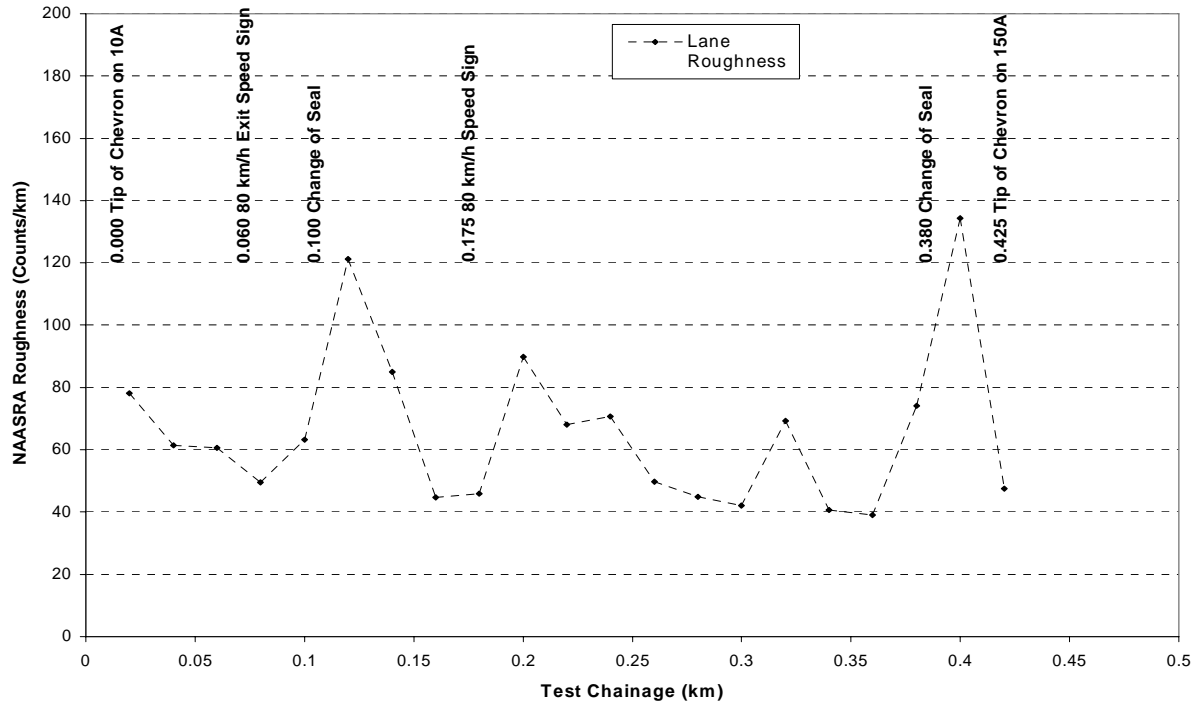
Bruce Highway Southbound Off Ramp Sippy Downs Accident Site  
Texture Depth - Tested 24 May 2007



Bruce Highway Southbound Off Ramp Sippy Downs Accident Site  
Rut Depth - Tested 24 May 2007



**Bruce Highway Southbound Off Ramp Sippy Downs Accident Site  
Lane Roughness - Tested 24 May 2007**



## Appendix E Skid Resistance Testing using British Pendulum

Road System & Engineering Group  
Pavements, Materials & Geotechnical Division  
35 Butterfield Street Herston Qld 4006



### REPORT ON SKID RESISTANCE AND TEXTURE DEPTH

**CLIENT:** Mr P. Venz  
North Coast Hinterland District

**REPORT NO.:** A5056  
**DATE:** 04/06/07  
**PAGE:** 1 of 2

<b>JOB NUMBER</b>	-
<b>SAMPLING DATE</b>	-
<b>SAMPLING METHOD</b>	-
<b>SAMPLER</b>	-
<b>DATE TESTED</b>	31/05/07
<b>TESTED BY</b>	M. O'Hara & E. Manouso

SAMPLE NUMBER	SITE / LOCATION	POSITION	SRV-Q704		TEXTURE DEPTH (mm) Q705
			DRY	WET - CORR TO 30°C	
A07/762	Station CN7	OWP	-	-	-
		BWP	-	-	-
		IWP	113	48	-
A07/763	Station CN7 + 10m	OWP	103	43	-
		BWP	-	-	-
		IWP	103	49	-
A07/764	Station CN7 + 20 m	OWP	-	-	-
		BWP	-	-	-
		IWP	104	50	-
A07/765	Station CN7 + 30m	OWP	105	47	-
		BWP	-	-	-
		IWP	105	52	-
A07/766	Station CN7 + 40m	OWP	-	-	-
		BWP	-	-	-
		IWP	109	53	-
A07/767	Station CN7 + 50m	OWP	102	44	-
		BWP	-	-	-
		IWP	104	51	-

*Variation(s) to Test Method(s) / Remark(s):*

**CHECKED BY:** M. O'Hara **SIGNATORY:** I. Berghofer

M. O'Hara

I. Berghofer

F:BAC005/2



Accreditation Number: 2302  
Accredited for compliance  
with ISO/IEC 17025

This document is issued in  
accordance with NATA's  
accreditation requirements.

Road System & Engineering Group  
Pavements, Materials & Geotechnical Division  
35 Butterfield Street Herston Qld 4006



### REPORT ON SKID RESISTANCE AND TEXTURE DEPTH

CLIENT: Mr P. Venz  
North Coast Hinterland District

REPORT NO.: A5056  
DATE: 04/06/07  
PAGE: 2 of 2

JOB NUMBER	-
SAMPLING DATE	-
SAMPLING METHOD	-
SAMPLER	-
DATE TESTED	31/05/07
TESTED BY	M. O'Hara & E. Manoussou

SAMPLE NUMBER	SITE / LOCATION	POSITION	SRV-Q704		TEXTURE DEPTH (mm) Q705
			DRY	WET - CORR TO 30°C	
A07/768	Station CN7 + 60m	OWP	-	-	-
		BWP	-	-	-
		IWP	104	49	-
A07/769	Station CN7 + 70m	OWP	99	41	-
		BWP	-	-	-
		IWP	103	47	-
A07/770	Station CN7 + 80m	OWP	-	-	-
		BWP	-	-	-
		IWP	108	50	-
A07/771	Station CN7 + 90m	OWP	106	45	-
		BWP	-	-	-
		IWP	101	52	-
A07/772	Station CN7 + 100m	OWP	-	-	-
		BWP	-	-	-
		IWP	99	49	-
		OWP			
		BWP			
		IWP			

Variation(s) to Test Method(s) / Remark(s):

CHECKED BY: M. O'Hara SIGNATORY: I. Berghofer

F:BAC005/2



Accreditation Number: 2302  
Accredited for compliance  
with ISO/IEC 17025

This document is issued in  
accordance with NATA's  
accreditation requirements.

**Guide to the Interpretation of Skid Resistance Values (British Pendulum Tester)<sup>1</sup>**

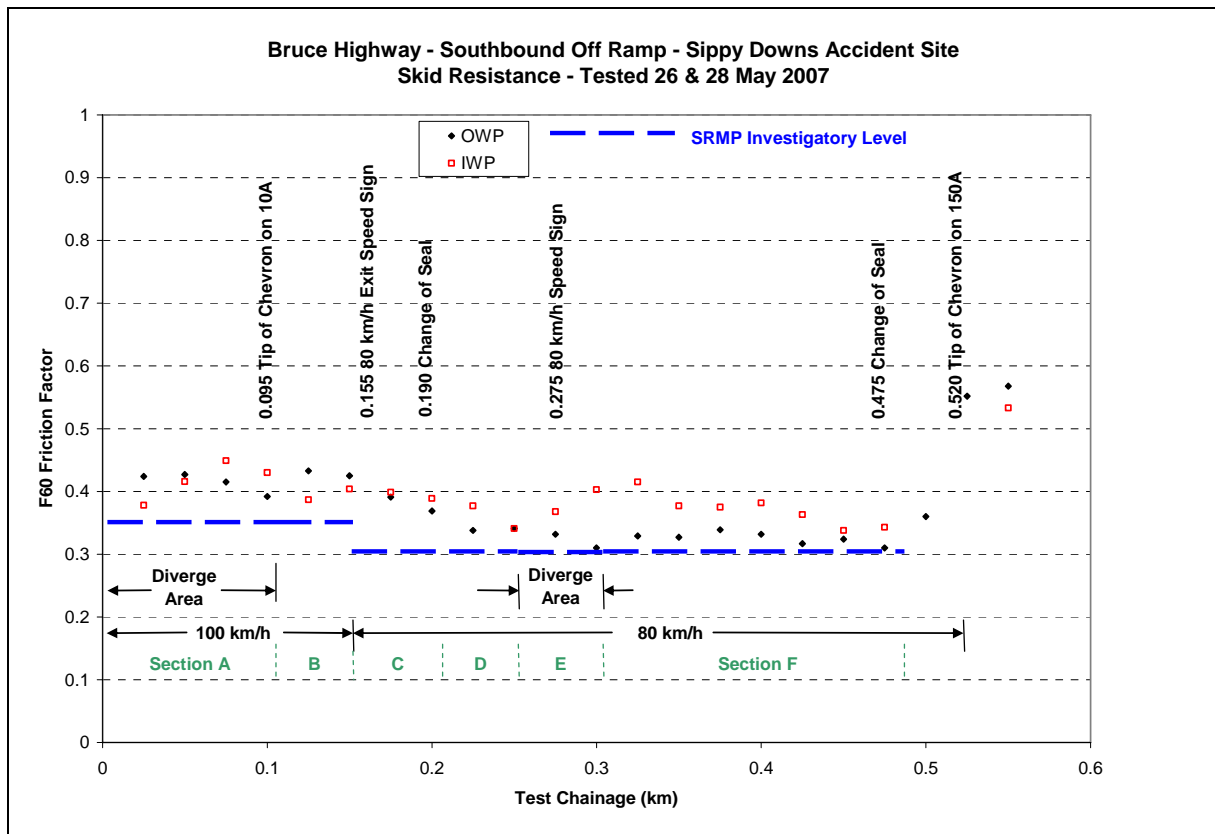
<b>Category</b>	<b>Type of Site</b>	<b>Wet Skid Resistance (Q704 at 30°C)</b>	<b>Standard of Skidding Resistance Represented</b>
A	Most difficult site such as: i) Roundabouts ii) Bends with radius less than 500 ft (150m) on derestricted roads; iii) Gradients, 1 in 20 or steeper, of length greater than 100 metres; iv) Approaches to traffic lights on derestricted roads.	Above 61	‘Good’ – Fulfilling the requirements even of fast traffic, making it most unlikely that the road will be the scene of repeated skidding accidents.
B*	General requirements: i.e. Roads and conditions not covered by categories A and C.	Above 52	‘Generally satisfactory’ – meeting all but the most difficult conditions encountered.
C*	Easy sites: Eg. Straight roads with easy gradients and curves and without junctions, and free from any features such as mixed traffic especially liable to create conditions of emergency.	Above 43	‘Satisfactory’ – but only in favourable circumstances.
D	All sites.	Below 43	‘Potentially slippery’

\* On smooth looking of fine textured roads in these categories, vehicles having smooth tyres may not find the ‘skid resistance’ adequate. For such roads, accident studies should be made to ensure that there are no indications of difficulties due to skidding under wet conditions.

Note: This guide is based on Road Note No. 27 Issued by the Road Research Laboratory (Great Britain) with appropriate modification of the skid resistance limits for testing at 30°C.

1. *Skid Resistance and the Impact of the New International Friction Index Parameters*, E. Baran, Technology Transfer Forum 1996.

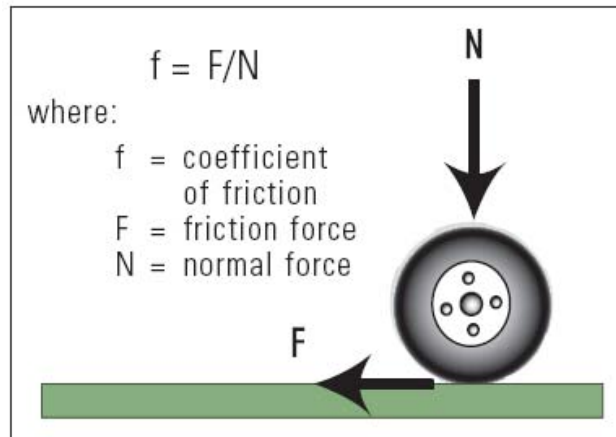
## Appendix F Skid Resistance Testing using ROAR



## Appendix D – QPS Vericom VC3000 (Accelerometer) Test Results

### Background

The PIARC Road Safety Manual (2003) defines friction as the resistance to motion between two surfaces in contact. Its magnitude is expressed by the coefficient of friction ( $f$ ) which is a ratio of two forces, one parallel to the surface of contact between two bodies and opposed to their motion (the friction force) and the other perpendicular to this surface of contact (the normal force). In the context of road transportation, the surface of contact is the road-tyre interface and the normal force is the wheel load (refer figure below). The coefficient of friction ranges from nearly 0 under icy conditions to greater than 1.0 under the best surface conditions.



Through the application of simple physics, it can be demonstrated that the coefficient of friction ( $f$ ) is in fact equivalent to the lateral and longitudinal coefficient of acceleration when a vehicle's tyres are skidding, expressed as a fraction of the acceleration due to gravity ( $g$ ).

### Equipment

The background discussion is important as the instrument recently acquired by QPS to measure friction supply and demand (a Vericom VC3000) measures acceleration on two axes (longitudinal and lateral) as a function of  $g$ . Consequently, the recorded longitudinal  $g$ -force co-efficient measured by QPS in a skidding vehicle is in fact equivalent to the coefficient of friction (which is used by Main Roads for road design purposes). The instrument used by QPS is depicted below.



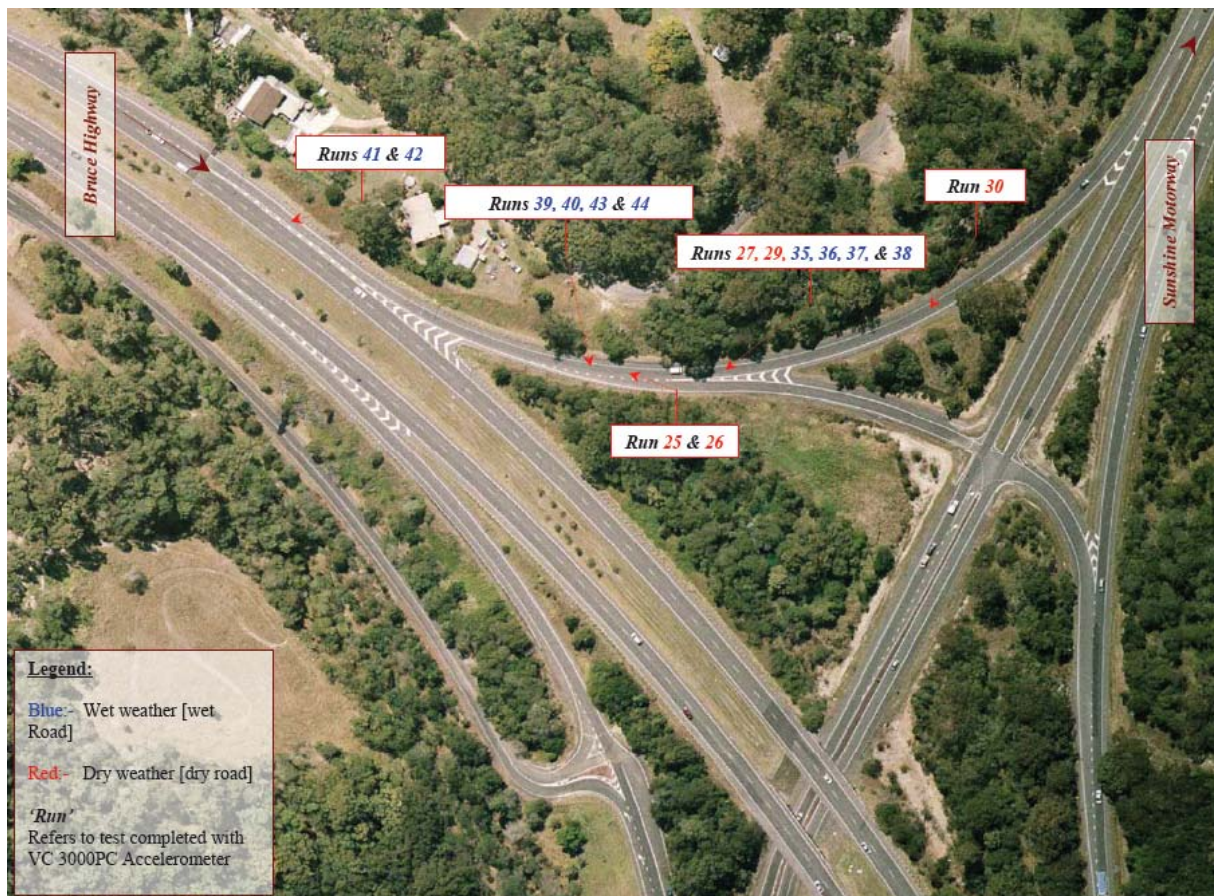
## QPS Testing

QPS Officers from the Forensic Crash Unit conducted skid resistance tests using a standard Holden sedan patrol vehicle fitted with a Vericom VC3000. The vehicle's anti-skid braking system was disconnected during the tests to allow the tyres to lock and slide. Skid testing on the ramp was undertaken as follows:

- 5 dry surface tests (at various points along the ramp) were conducted on 31 May 2007
- 10 wet surface tests (at various points along the ramp) were conducted on 5 June 2007

In addition to these skid tests, lateral acceleration tests were conducted during the following week. This involved driving the same vehicle through the curve at various speeds. Data was collected while the vehicle travelled at speeds of 60 km/h, 75 km/h and 80 km/h. A further test was conducted at a speed of 70 km/h, during which the brake was lightly applied within the curve.

The aerial photograph below shows the general locality at which the skid tests were conducted.



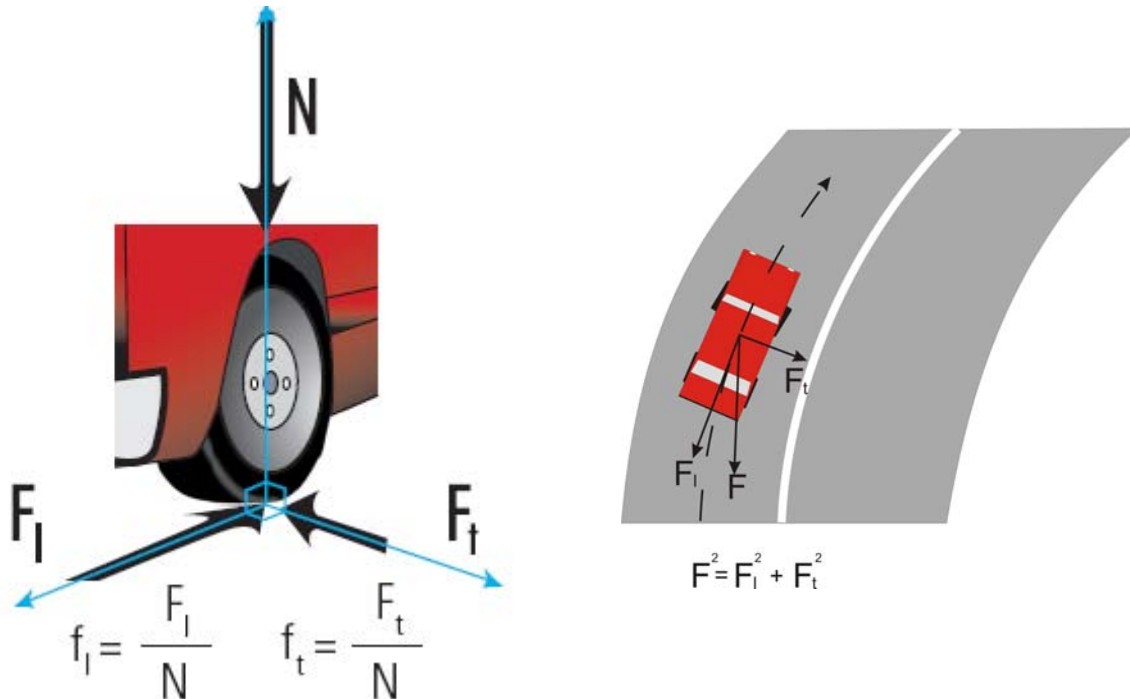
The friction factors determined from the various tests conducted at the site are shown in Table D1 on the following page and the results of the lateral acceleration tests are provided in Table D2. The results do not require adjustment for gradient since the device was calibrated at the respective test sites (and hence automatically adjusted for slope).

The graphed results (provided by QPS) are also attached.

<i>Drag Factor Test Results</i>					
<i>Run Number</i>	<i>Road Condition</i>	<i>Time (Sec)</i>	<i>Test Speed (km/h)</i>	<i>Average G (-)</i>	<i>Peak G (-)</i>
<i>Test Date: 31/05/2007</i>					
25	Dry	2.13	46	0.617	0.747
26	Dry	2.41	53	0.624	0.700
27	Dry	2.34	53	0.642	0.747
29	Dry	2.09	45	0.653	0.695
30	Dry	2.17	46	0.606	0.717
<i>Test Date: 05/06/2007</i>					
35	Wet	2.38	43	0.533	0.669
36	Wet	2.77	43	0.419	0.629
37	Wet	2.68	43	0.448	0.599
38	Wet	2.92	45	0.415	0.683
39	Wet	3.20	46	0.384	0.677
40	Wet	2.95	41	0.376	0.684
41	Wet	1.73	32	0.518	0.737
42	Wet	1.90	34	0.492	0.726
43	Wet	2.84	40	0.383	0.623
44	Wet	2.84	40	0.373	0.648

Table D1 – QPS Skid Test (Friction "Supply") Summary

On a curve, both lateral and longitudinal friction demands need to be considered. Longitudinal friction demand is a measure of acceleration or deceleration in the direction the vehicle is travelling, while the transverse friction demand is a measure in the direction perpendicular to the vehicle's direction of travel. The resultant total friction demand is the vector sum of lateral and longitudinal friction demands (as depicted in the following diagrams).



<i>Lateral Acceleration Test Results</i>					
<i>Test Date: 12/06/2007</i>					
<i>Run Number</i>	<i>Action</i>	<i>Speed (km/h)</i>	<i>Lateral G</i>	<i>Longitudinal G</i>	<i>Combined G</i>
2	Constant Speed	75	0.315	0.035	0.317
3	Constant Speed	80	0.343	0.038	0.345
4	Constant Speed	60	0.228	0.038	0.231
5	Constant Speed & Brake	70	0.200	0.396	0.444

Table D2 – QPS Lateral and Combined Lateral and Longitudinal Acceleration Test (Friction "Demand") Summary

*Bruce Highway  
- Sippy Downs  
Exit Ramp*

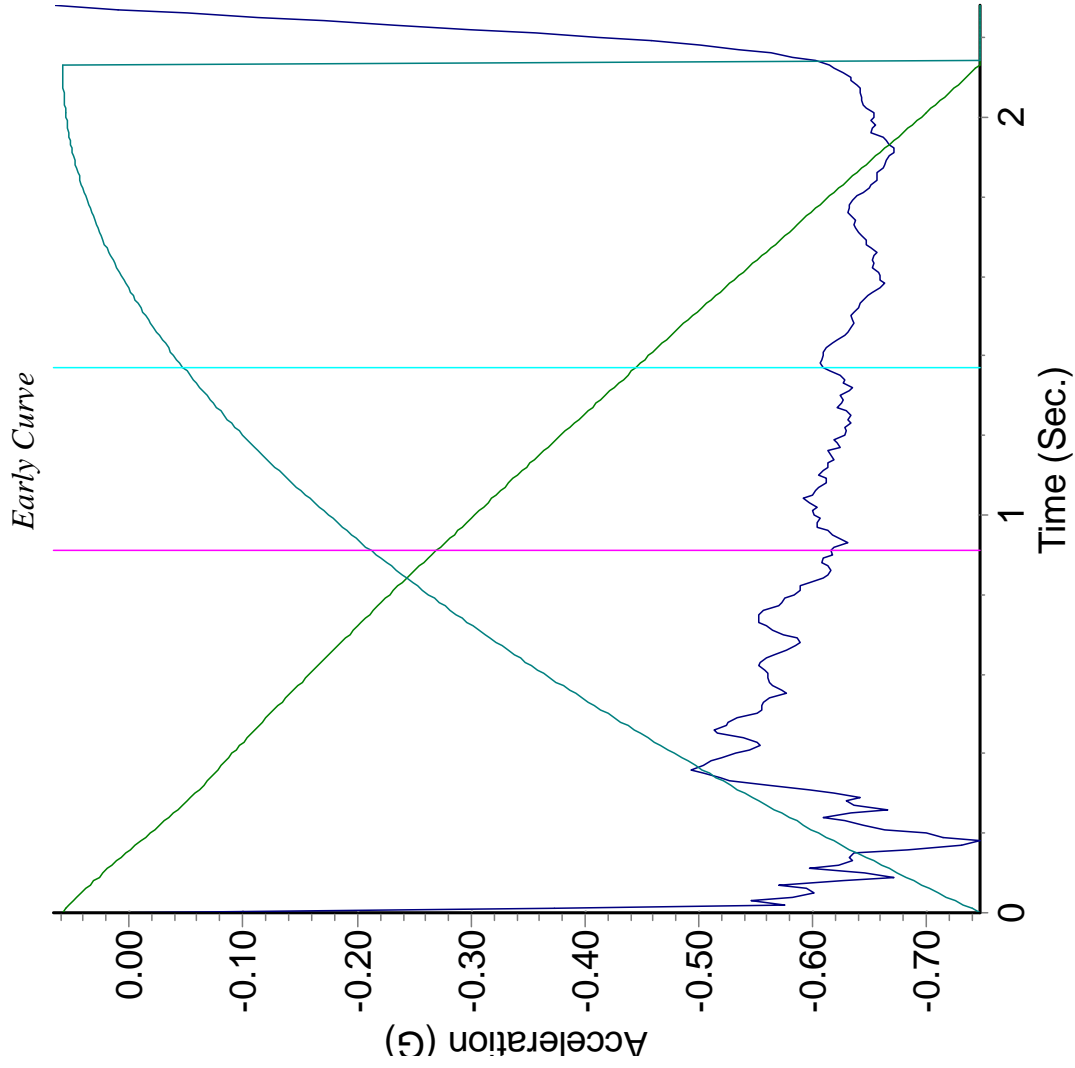


*Skid Resistance Testing Wet & Dry  
Roads*

- *Sippy Downs*

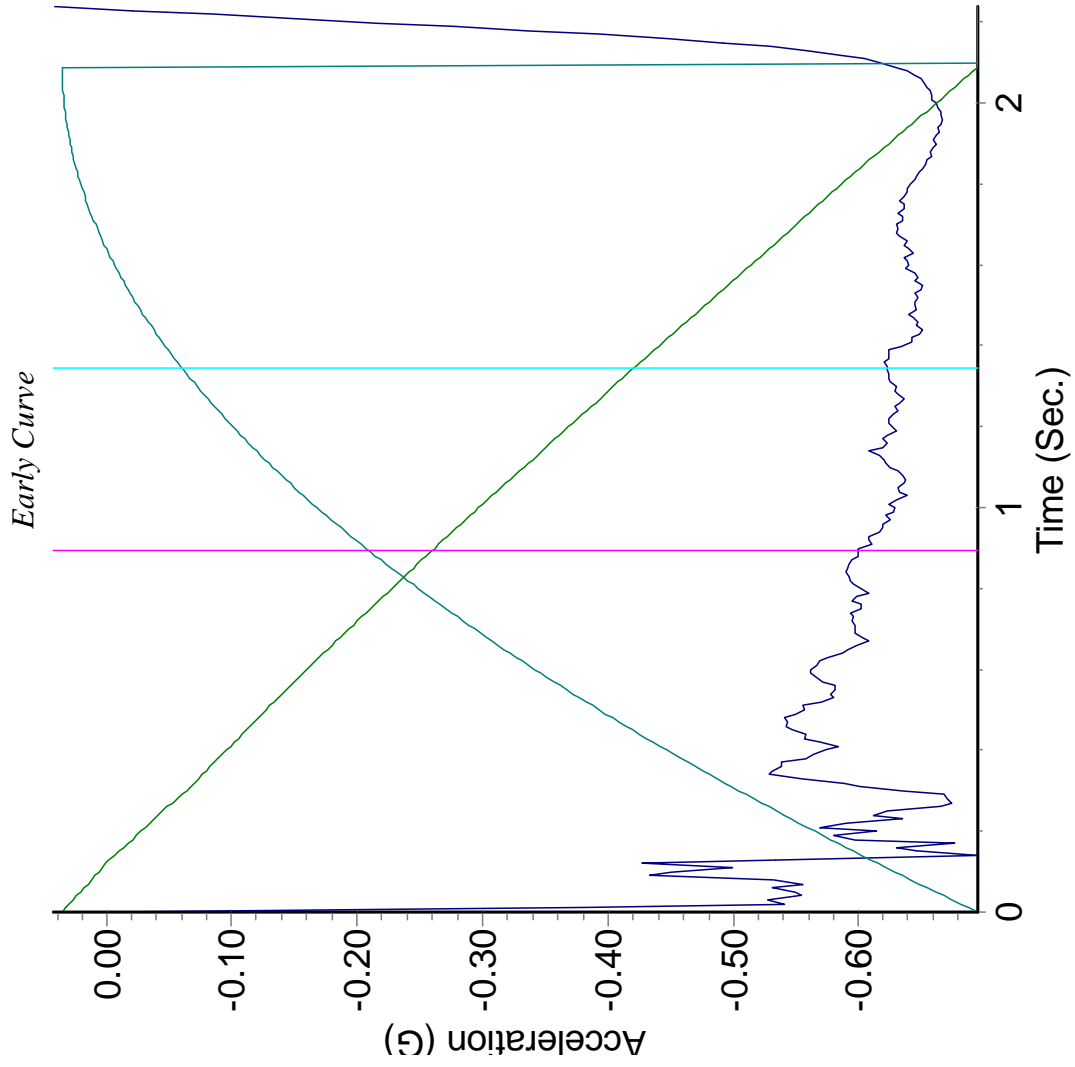
*Drag Factor Test – Dry Road*

Time 0.91 to 1.37  
648JDL 31/05/2007 25  
□ Avg Acceleration -0.617  
□ Avg Speed 22.313  
□ Avg Distance 10.775



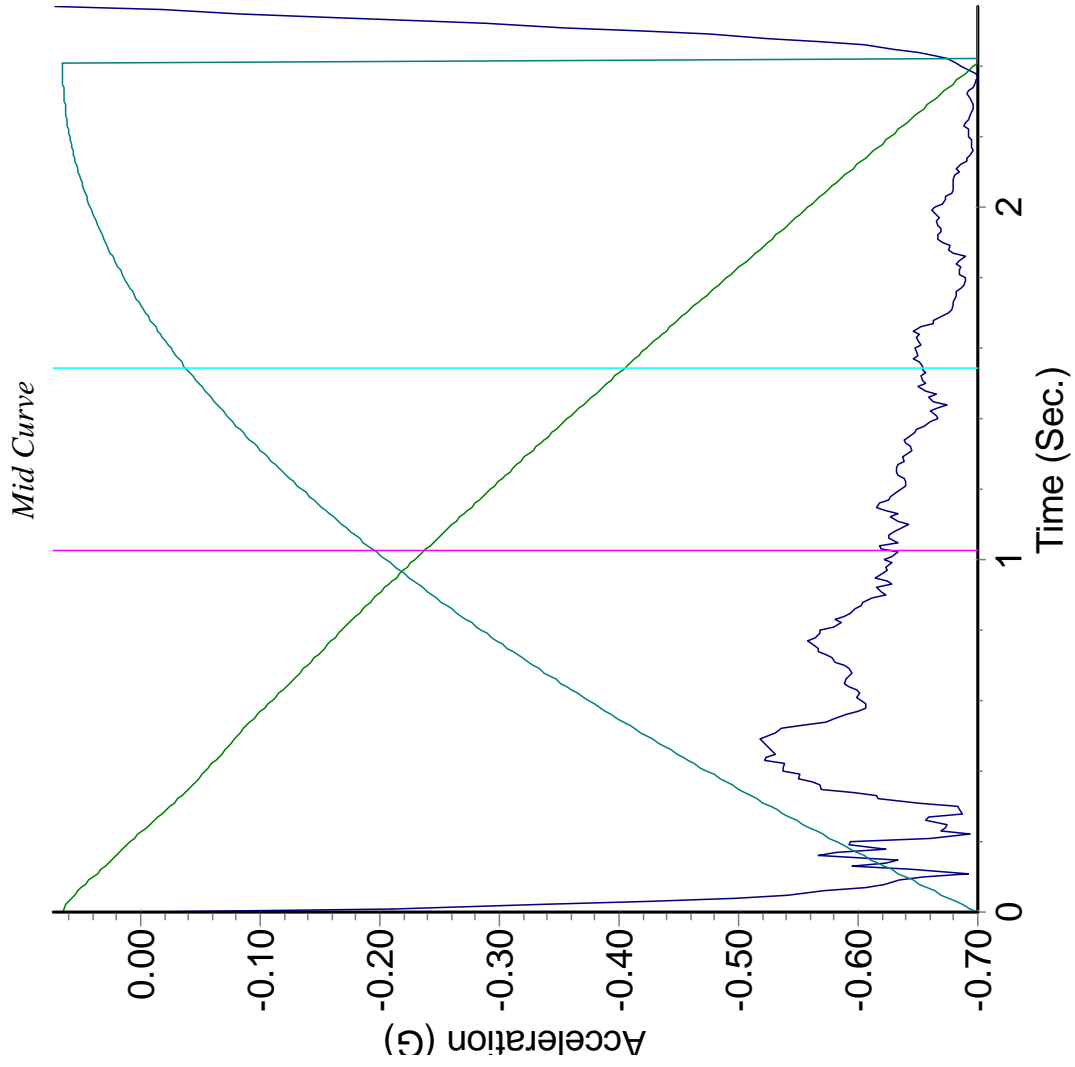
*Drag Factor Test – Dry Road*

Time 0.90 to 1.34  
648JDL 31/05/2007 29  
- Avg Acceleration -0.624  
- Avg Speed 21.943  
- Avg Distance 10.459



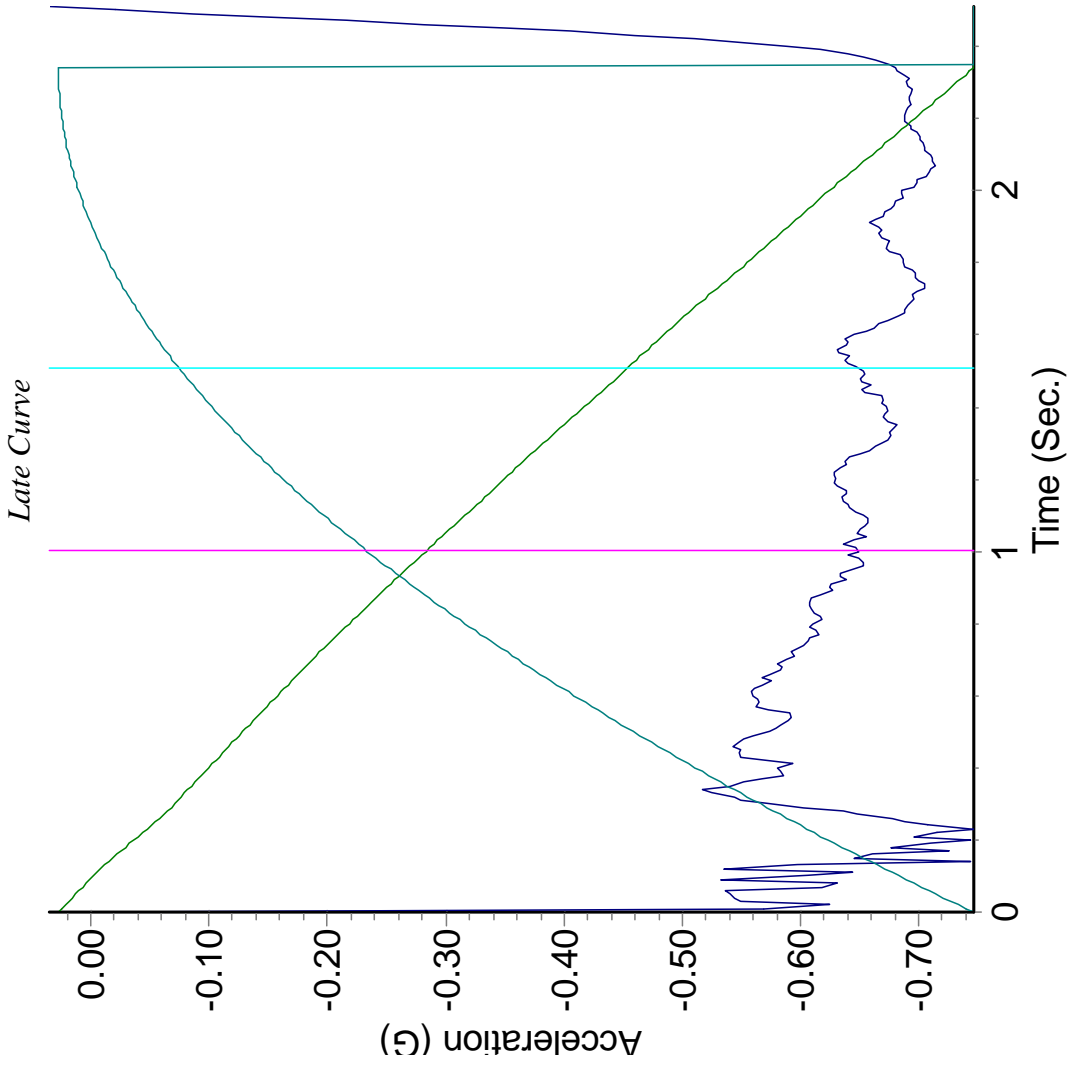
*Drag Factor Test – Dry Road*

Time 1.03 to 1.54  
648JDL 31/05/2007 26  
- Avg Acceleration -0.642  
- Avg Speed 26.694  
- Avg Distance 14.388



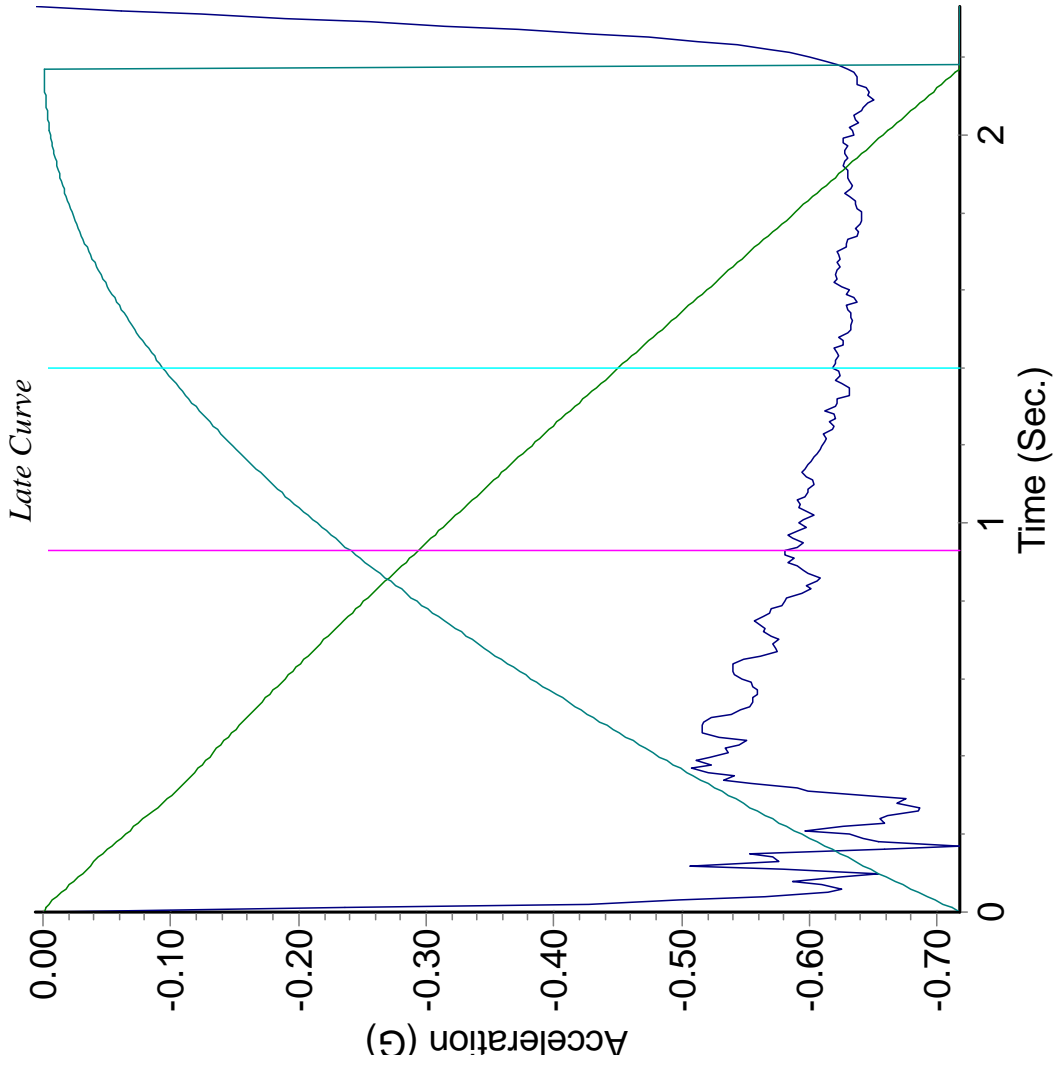
*Drag Factor Test – Dry Road*

Time 1.00 to 1.51  
648JDL 31/05/2007 27  
□ Avg Acceleration -0.653  
□ Avg Speed 25.945  
□ Avg Distance 13.766

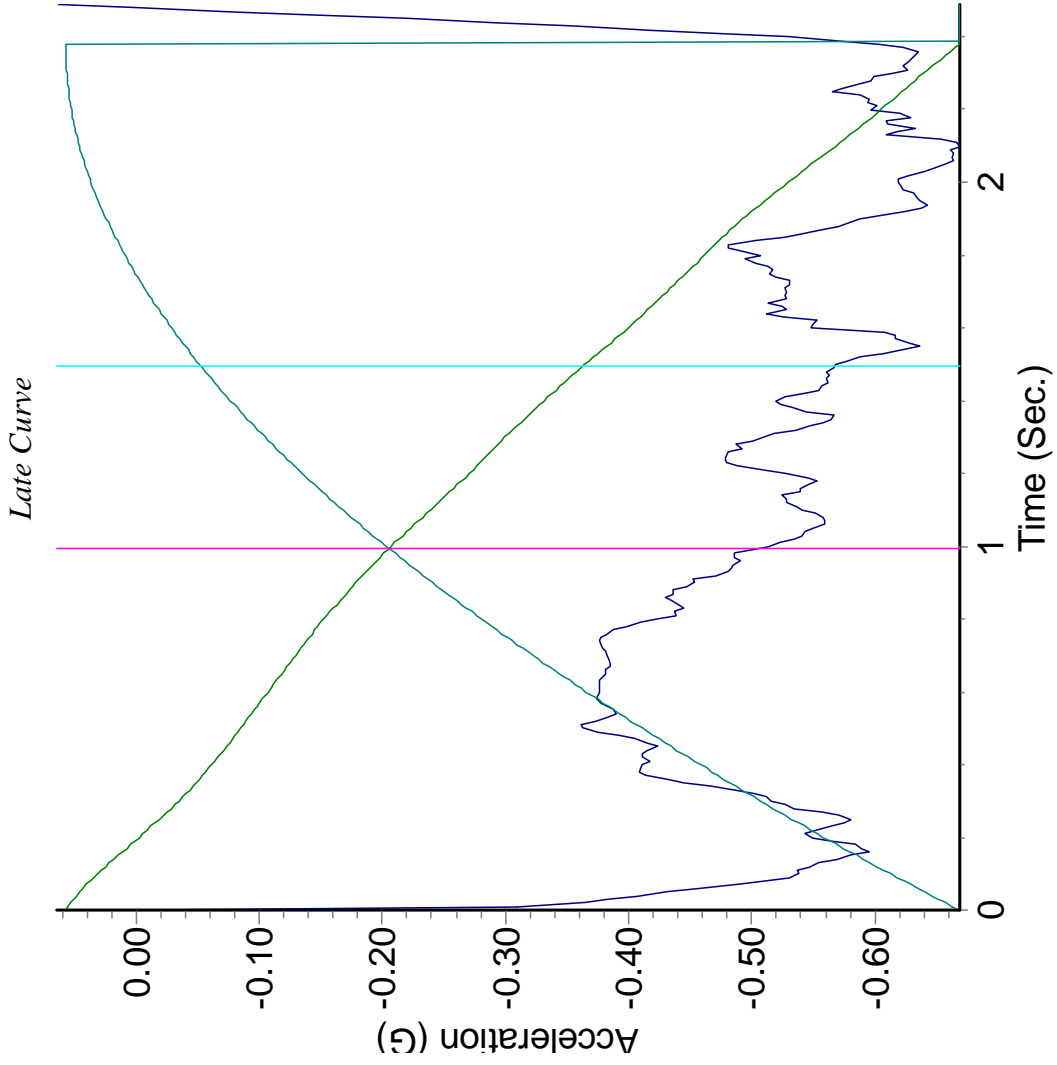


*Drag Factor Test – Dry Road*

Time 0.93 to 1.40  
648JDL 31/05/2007 30  
□ Avg Acceleration -0.606  
□ Avg Speed 22.254  
□ Avg Distance 11.018



Drag Factor Test – Wet Road – Light Rain

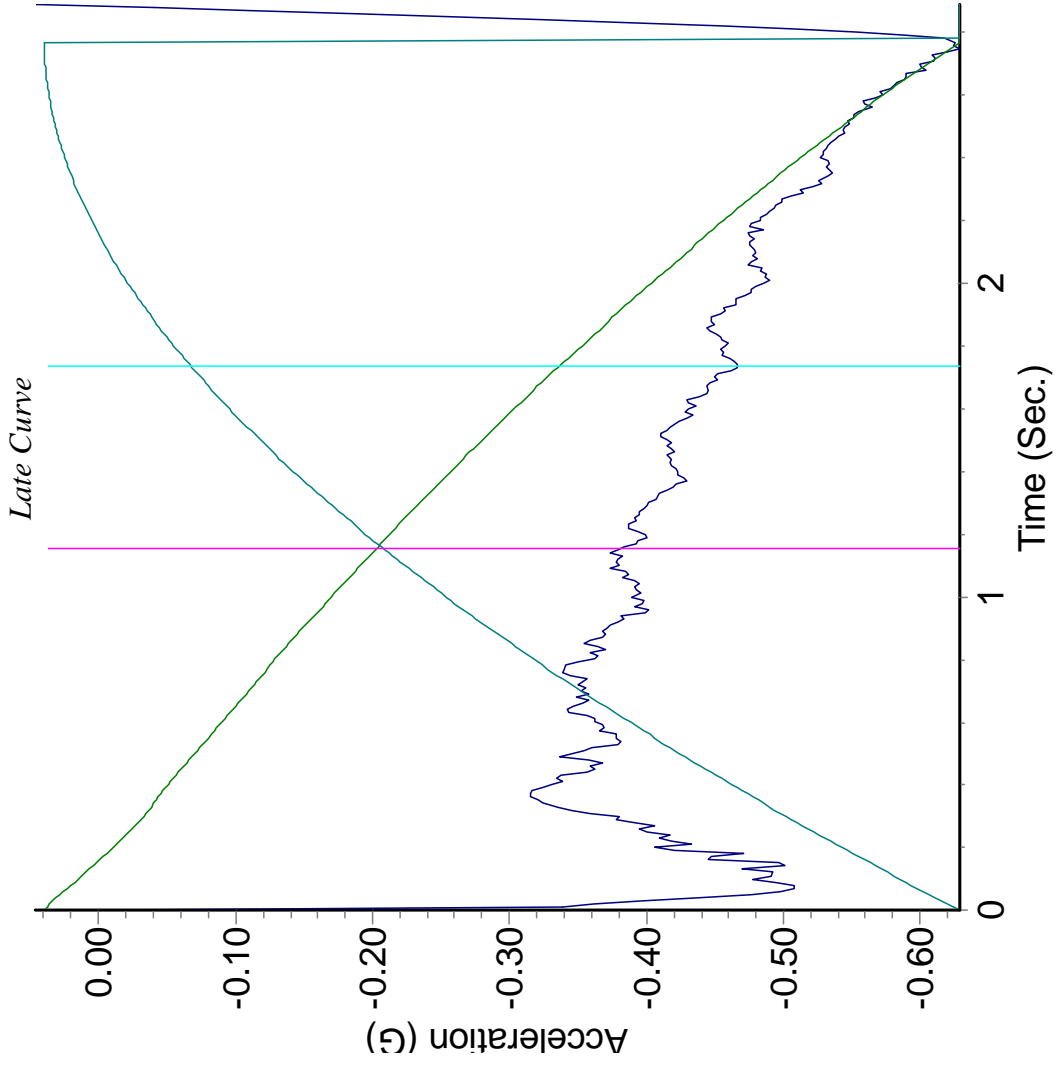


Time 1.00 to 1.49

648JDL 5/06/2007 35

- Avg Acceleration -0.533
- Avg Speed 23.106
- Avg Distance 11.495

Drag Factor Test – Wet Road – Light Rain



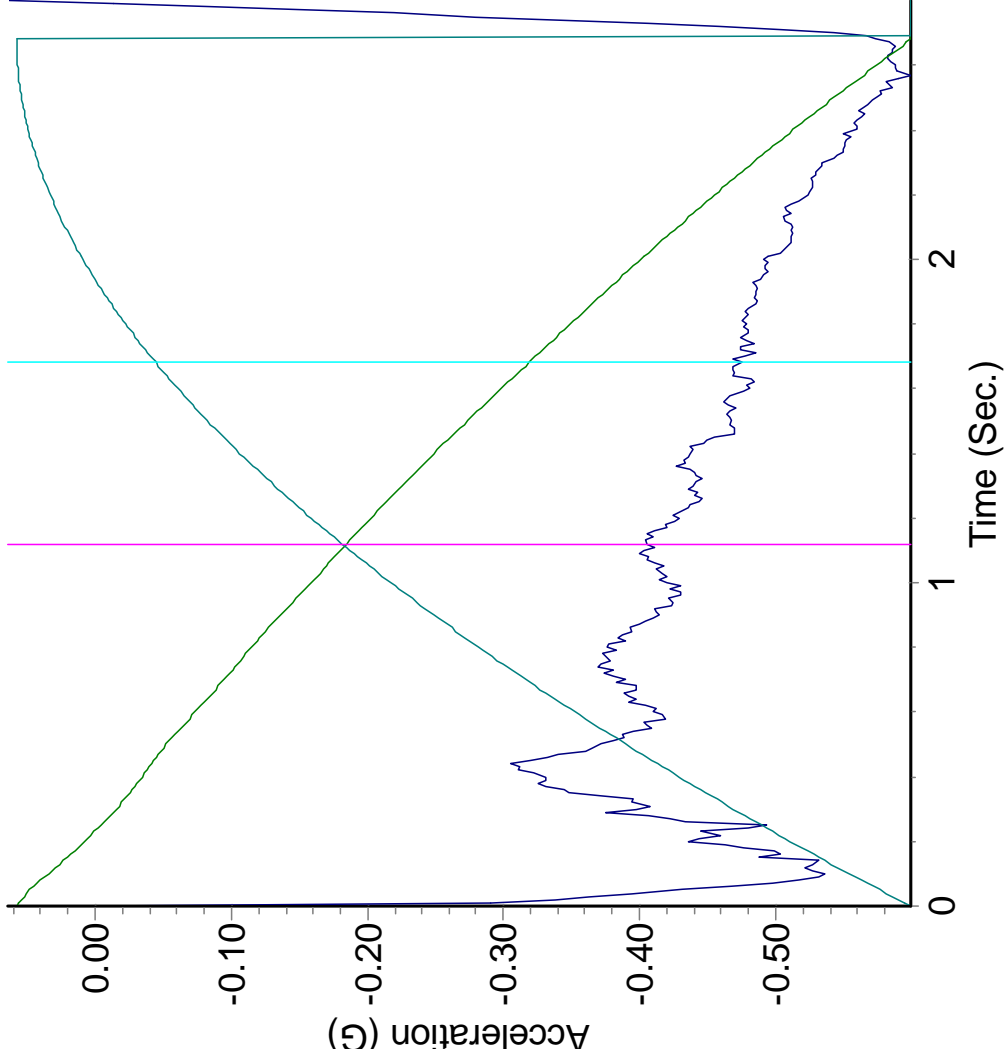
Time 1.16 to 1.73

648JDL 5/06/2007 36

- Avg Acceleration -0.419
- Avg Speed 23.192
- Avg Distance 13.201

Drag Factor Test – Wet Road – Light Rain

Late Curve

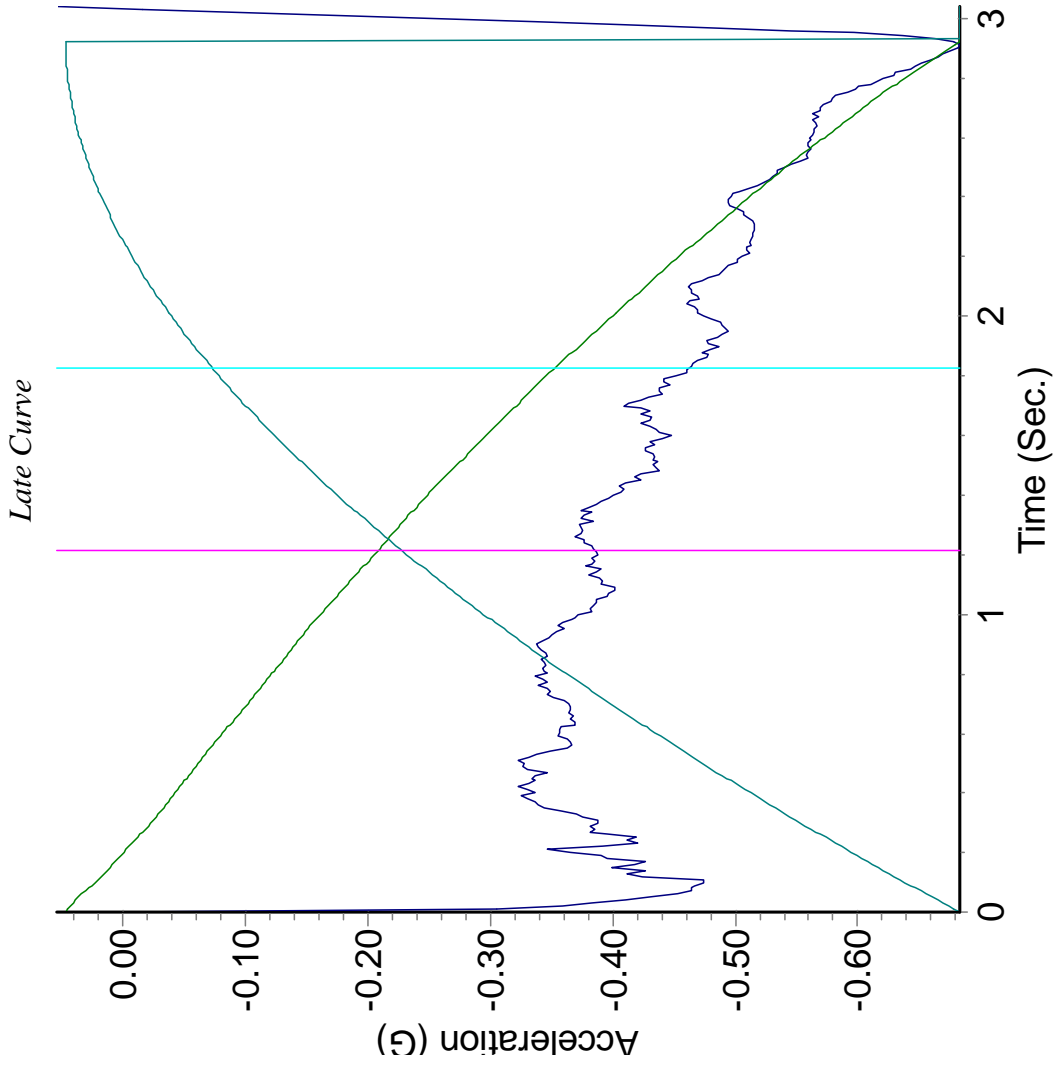


Time 1.12 to 1.68

648JDL 5/06/2007 37

□ Avg Acceleration -0.448  
□ Avg Speed 23.125  
□ Avg Distance 12.906

*Drag Factor Test – Wet Road – Light Rain*



Time 1.22 to 1.82  
648JDL 5/06/2007 38

□ Avg Acceleration	-0.415
□ Avg Speed	25.256
□ Avg Distance	14.903

Drag Factor Test – Wet Road – Light Rain

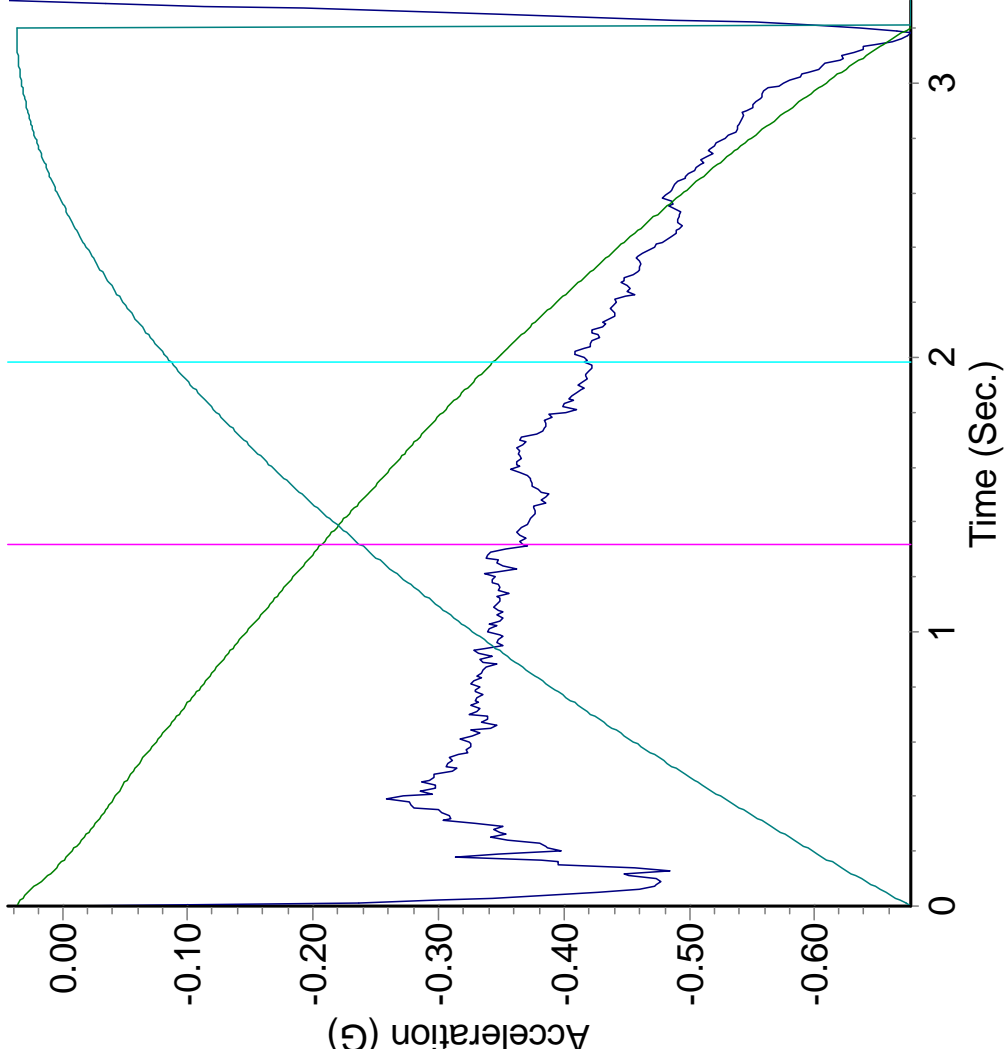
Early Curve

Time 1.32 to 1.98

648JDL 5/06/2007 39

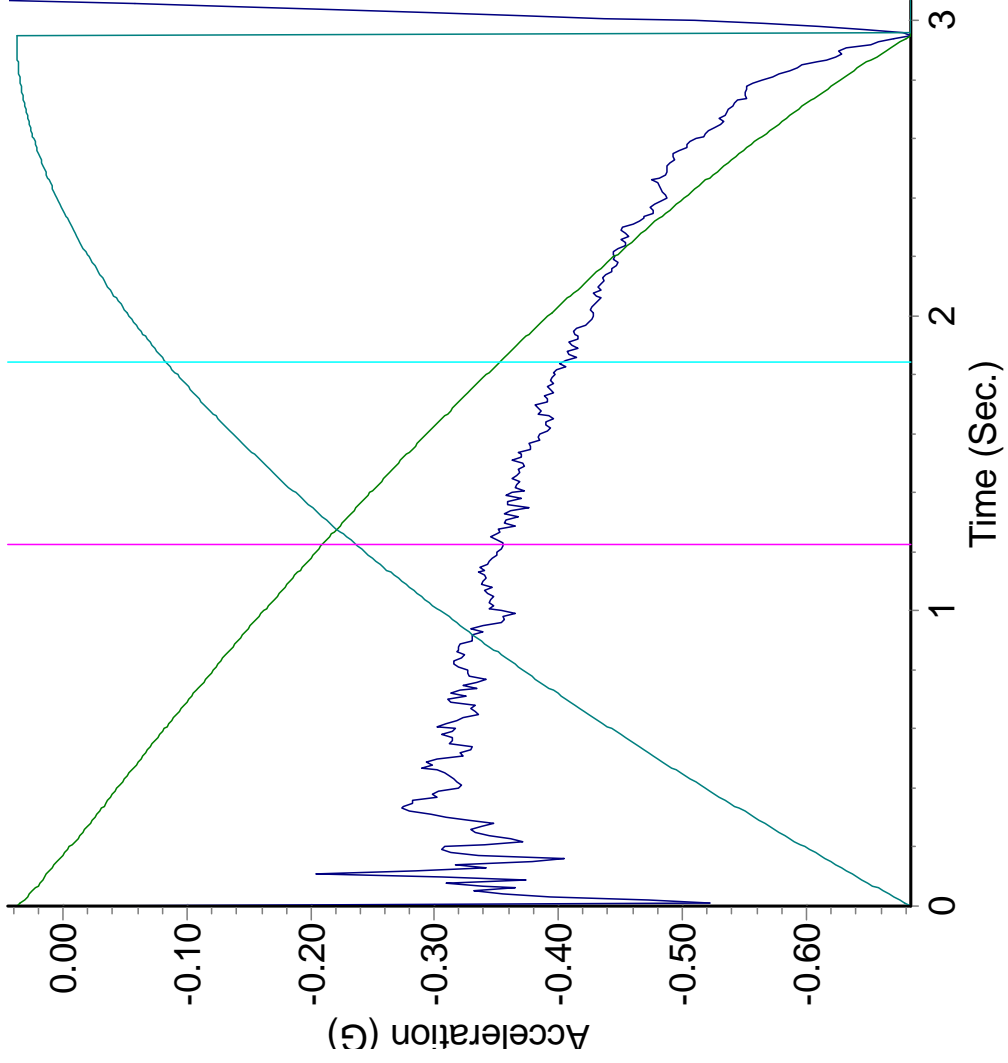
- Avg Acceleration
- Avg Speed
- Avg Distance

-0.384  
26.461  
16.758



Drag Factor Test – Wet Road – Light Rain

Early Curve



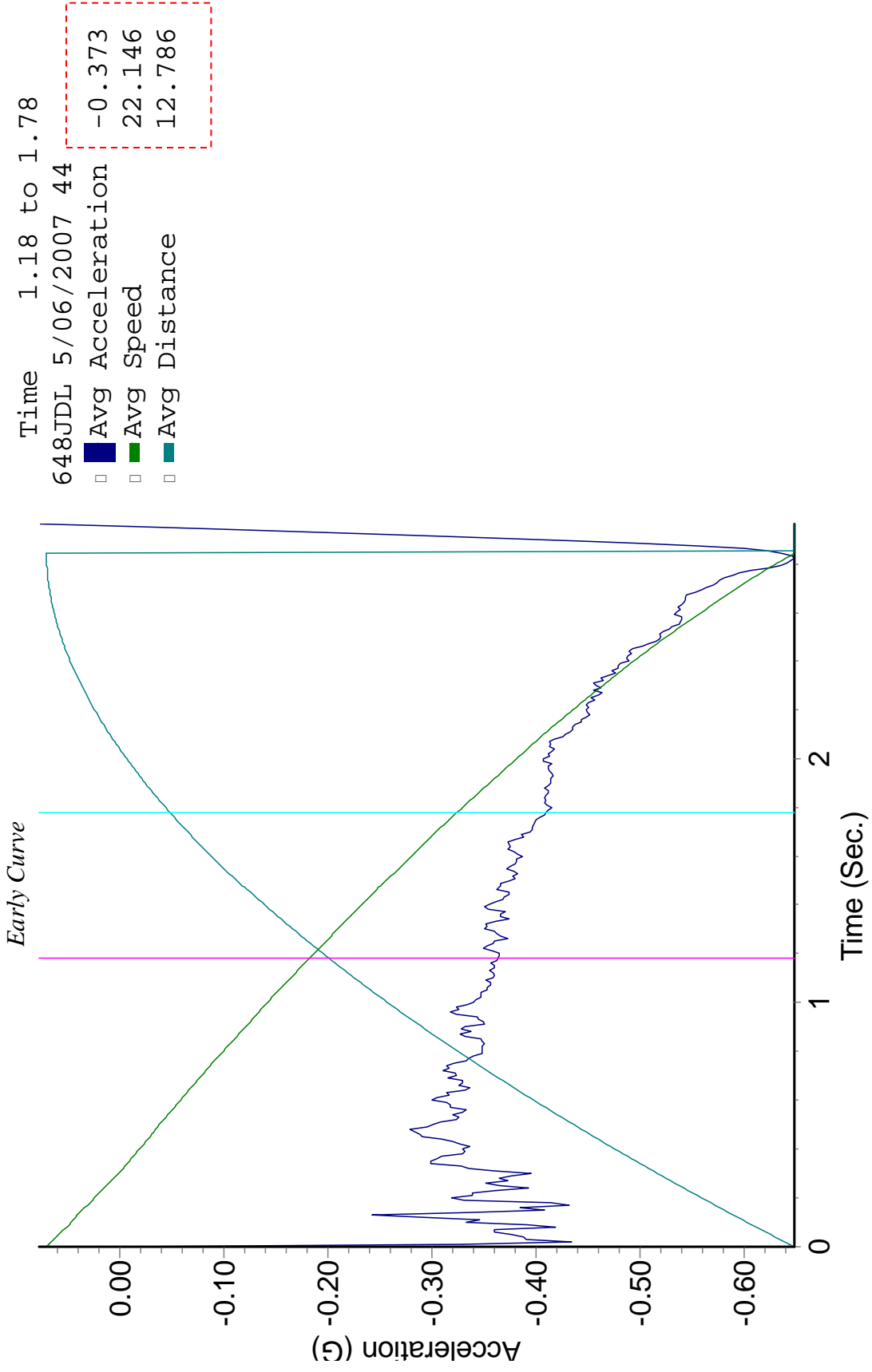
Time 1.23 to 1.84

648JDL 5/06/2007 40

- Avg Acceleration
- Avg Speed
- Avg Distance

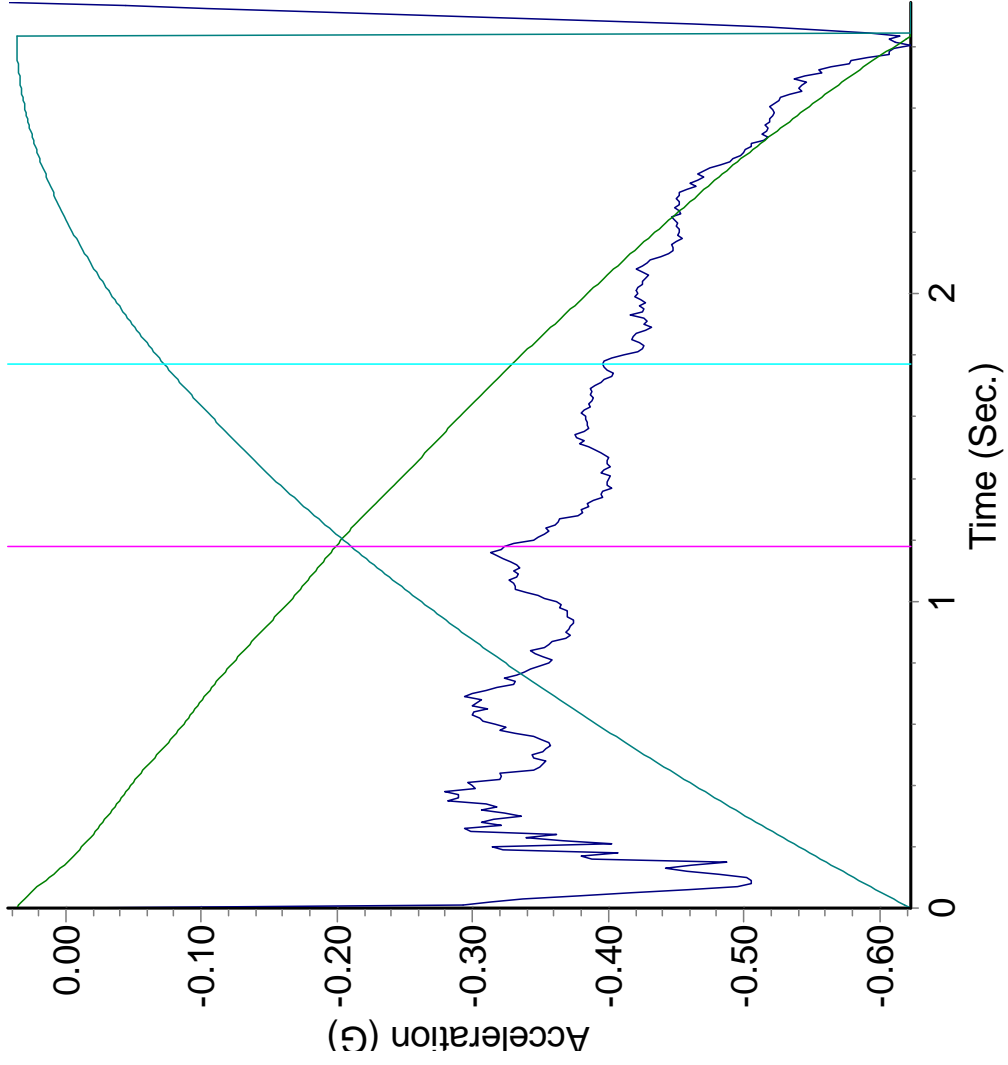
-0.376  
23.391  
13.895

*Drag Factor Test – Wet Road – Light Rain*



Drag Factor Test – Wet Road – Light Ran

Early Curve



Time 1.18 to 1.77

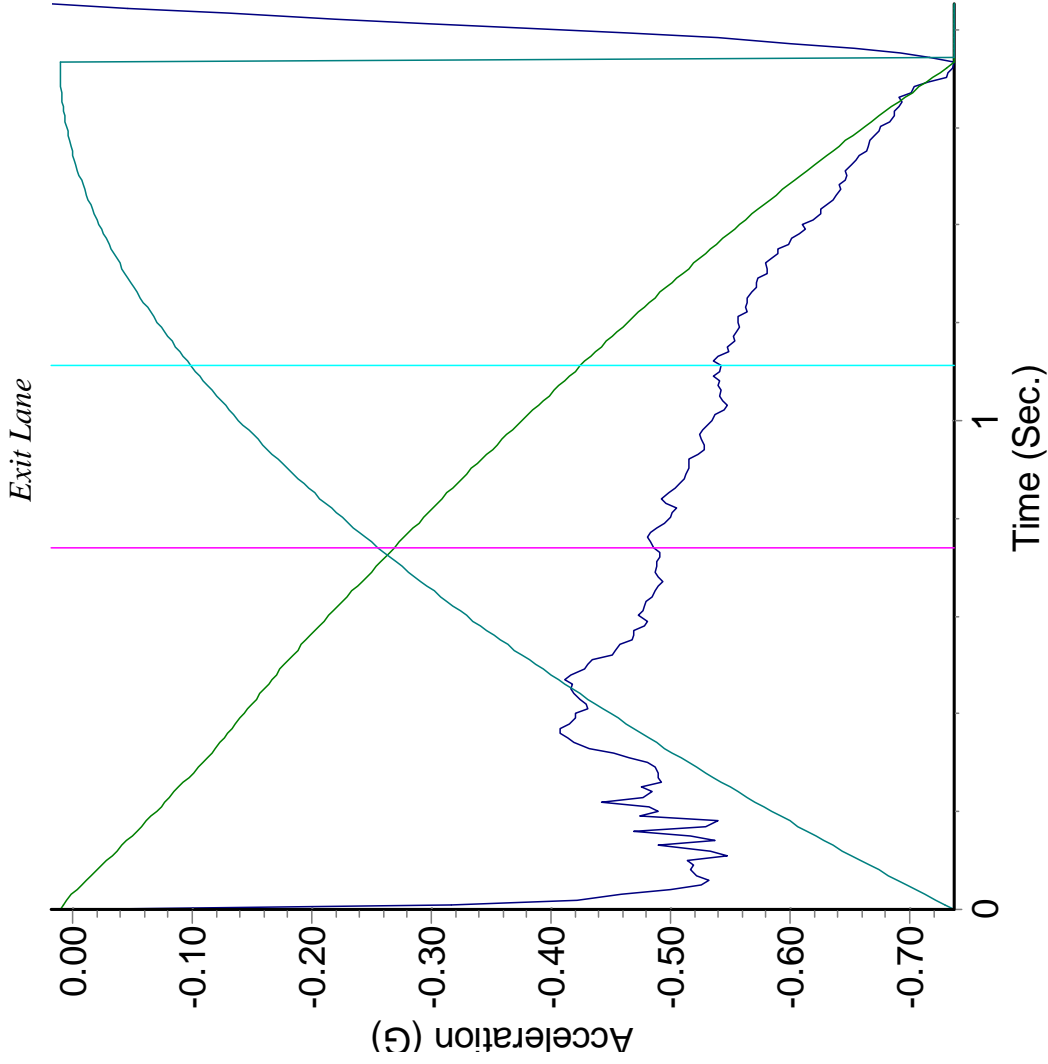
648JDL 5/06/2007 43

- Avg Acceleration
- Avg Speed
- Avg Distance

-0.383  
22.145  
12.790

Drag Factor Test – Wet Road – Light Ran

Time 0.74 to 1.11  
648JDL 5/06/2007 41  
Avg Acceleration -0.518  
Avg Speed 17.138  
Avg Distance 6.390



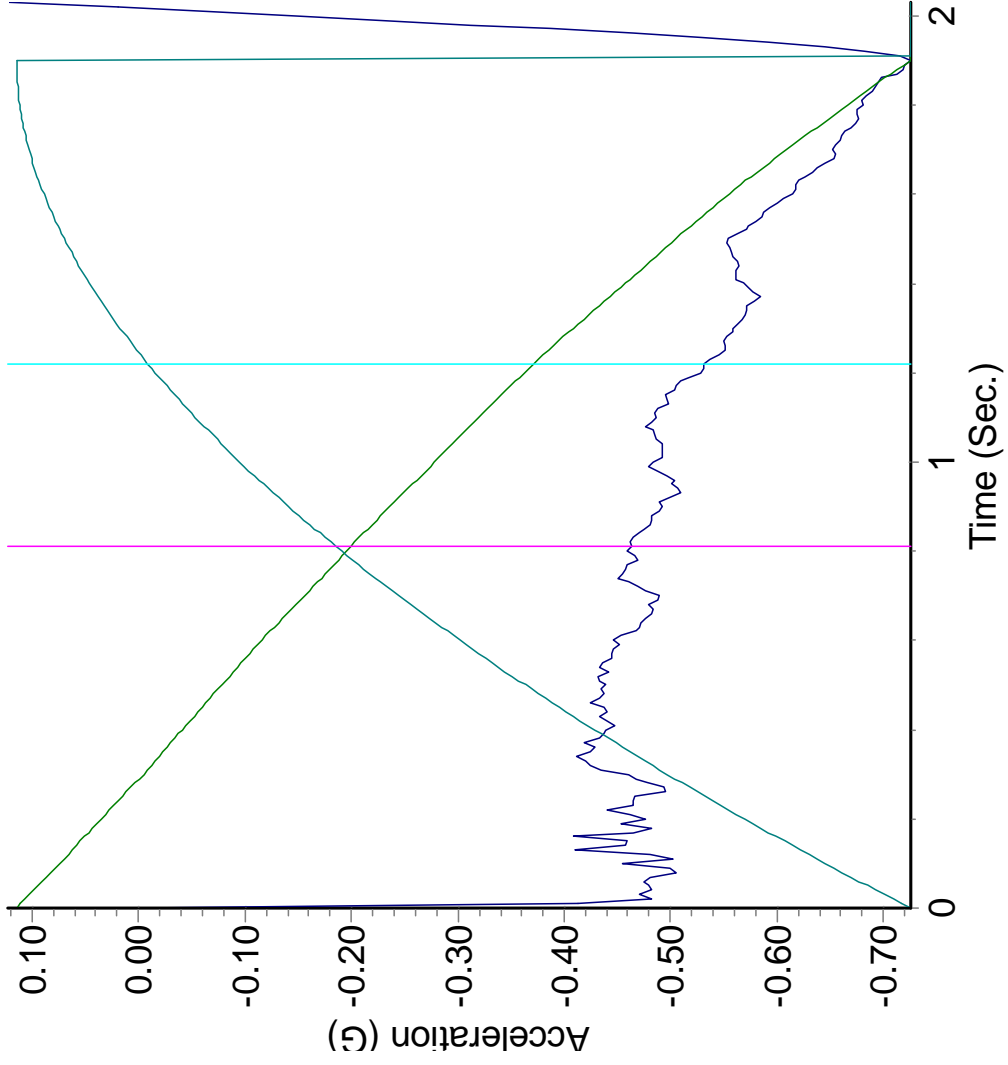
*Drag Factor Test – Wet Road – Light Ran*

Time 0.81 to 1.22

648JDL 5/06/2007 42

- Avg Acceleration -0.492
- Avg Speed 18.325
- Avg Distance 7.491

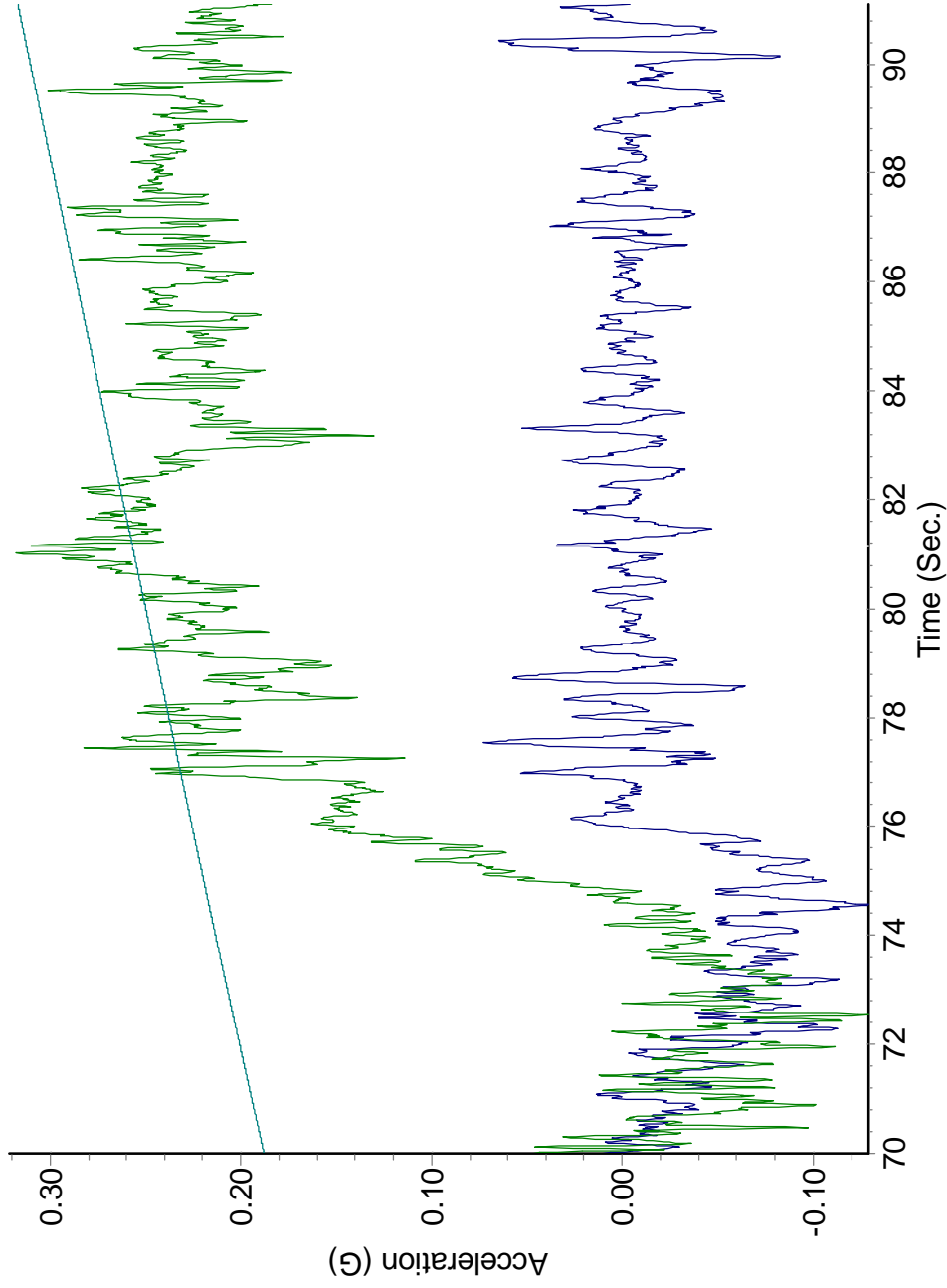
*Exit Lane*



*Lateral Acceleration Tests*

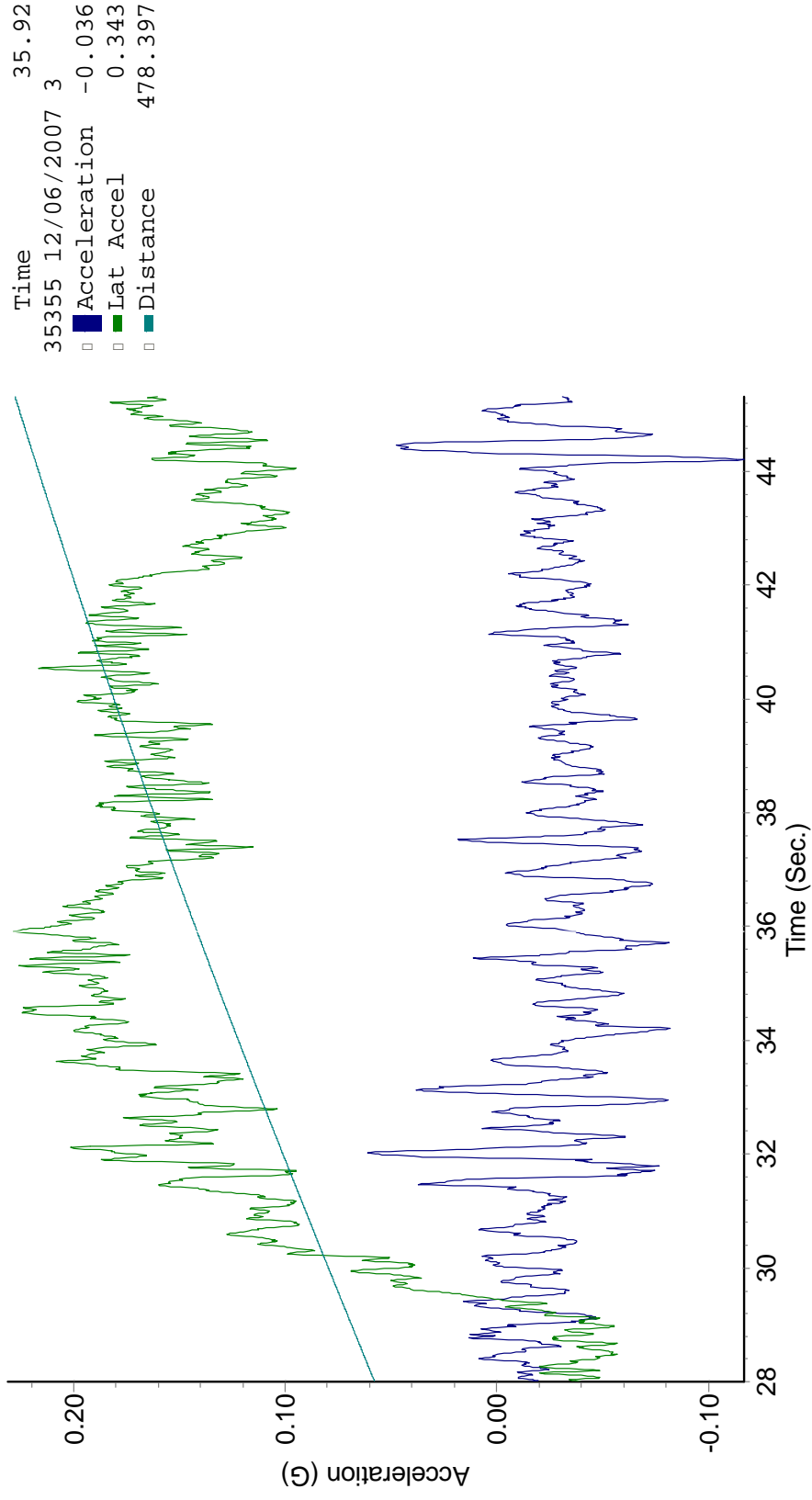
- *Sippy Downs*

*Lateral Acceleration – Constant Speed 75 km/h*

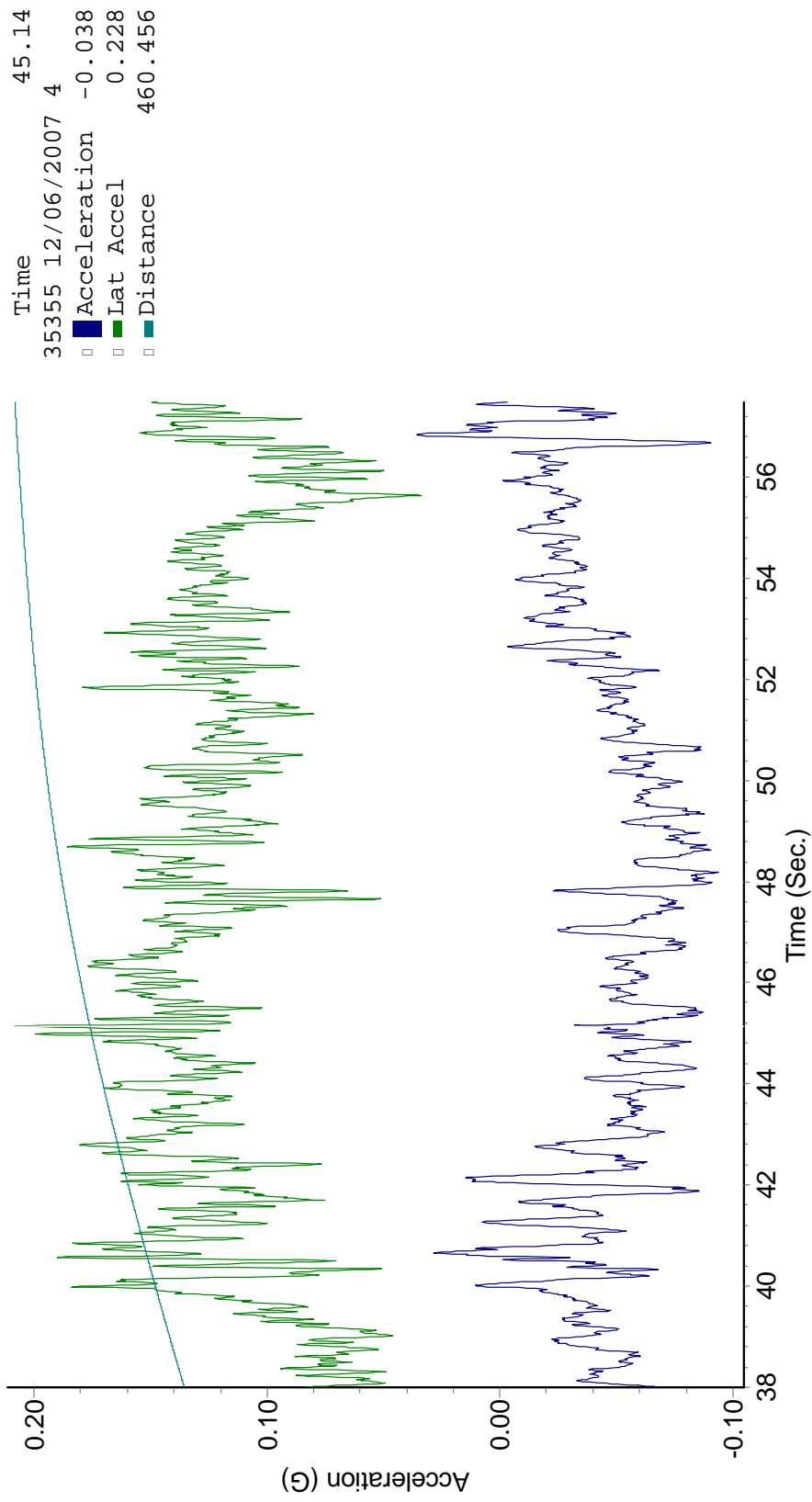


Time 81.16  
35355 12/06/2007 2  
Acceleration 0.035  
Lat Accel 0.315  
Distance 3,524.770

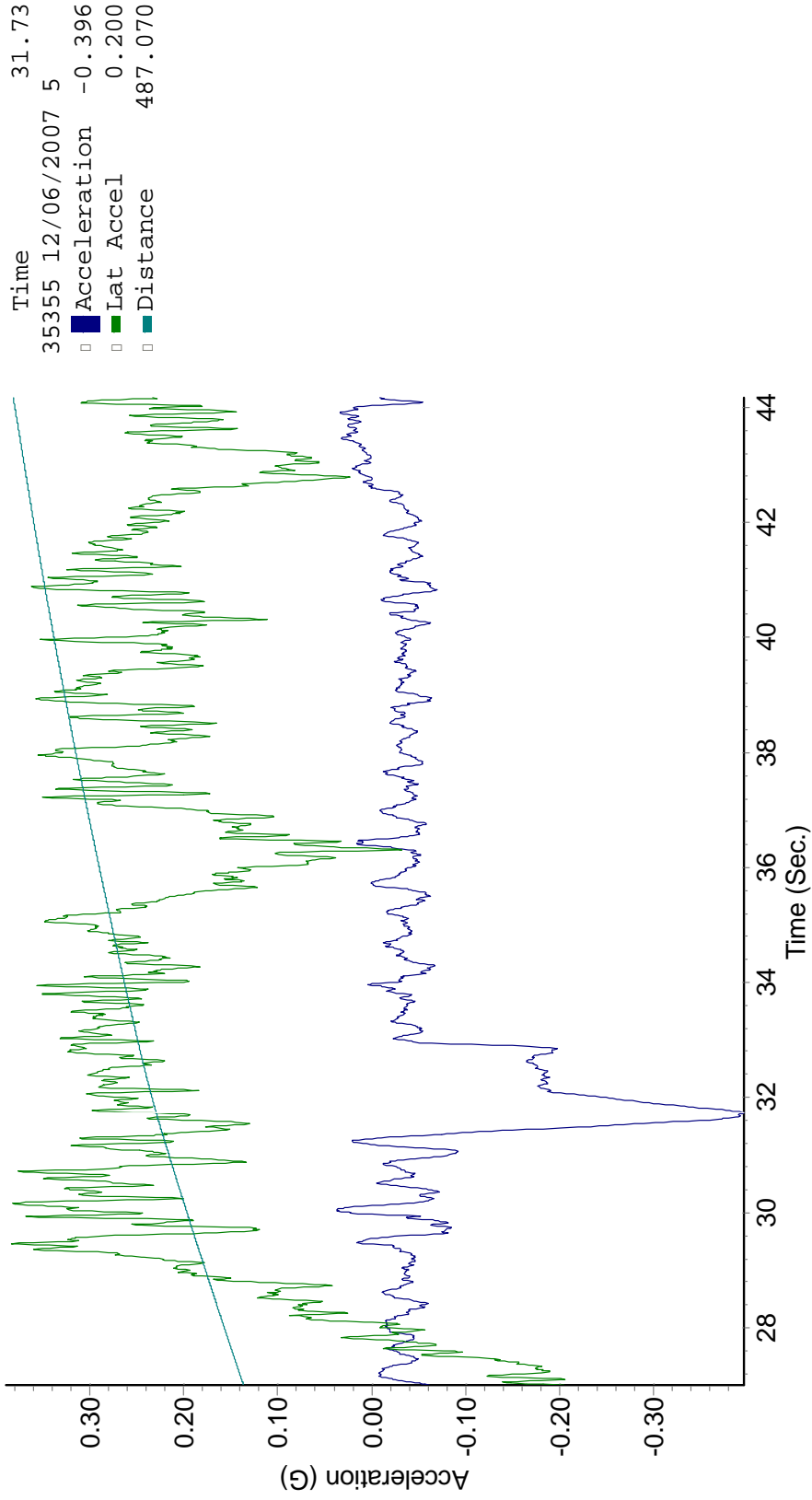
*Lateral Acceleration – Constant Speed 80 km/h*



*Lateral Acceleration – Constant Speed 60 km/h*



*Lateral Acceleration – Constant Speed @ 70 km/h With One Brake Application*



## **Appendix E – Calcined Bauxite High Friction Surfacing**



**Queensland  
Government**

Department of **Main Roads**

# Calcined Bauxite High Friction Surfacing

<b>Branch</b>	Pavements and Materials
<b>Division</b>	Roads and Bridge Technology
<b>Location</b>	Floor 2, 35 Butterfield Street, Herston Queensland 4006
<b>Version no.</b>	0.3
<b>Version date</b>	3 July 2007
<b>Status</b>	
<b>DMS ref. no.</b>	

## Contents

<b>1</b>	<b>Aim .....</b>	<b>3</b>
<b>2</b>	<b>Summary .....</b>	<b>3</b>
<b>3</b>	<b>Usage of High Friction Surfaces .....</b>	<b>4</b>
<b>4</b>	<b>Typical Treatment.....</b>	<b>6</b>
<b>5</b>	<b>Specifications.....</b>	<b>6</b>
<b>6</b>	<b>Noise .....</b>	<b>7</b>
<b>7</b>	<b>References.....</b>	<b>7</b>

# 1 Aim

The aim of this report is to briefly outline the nature, usage, types of and alternative ways to specify high friction surfacings.

# 2 Summary

*High friction surfacing* is the generic term used to describe pavement surfacing systems which use small size, high polish resistant aggregate with high micro-texture (such as calcined bauxite), which contributes to high skid resistance, held in place by a resin binder.

The surface friction of aggregate is tested by a variety of test methods such as:

- Polished Aggregate Friction Value (PAFV) which is used in all Australian jurisdictions except Victoria where Polished Stone Value (PSV) is used. These test also simulate the polishing of the aggregate surface when trafficked.
- British Pendulum Test that test the aggregate in the surface of the pavement.

Additionally, the surface friction of the pavement is tested by a variety of methods such as Sideways Force Coefficient Routine Investigation Machine (SCRIM) and Road Analyser and Recorder (ROAR). These test the influence of both the micro-texture (< 0.5 mm) and macro-texture (0.5 mm – 50 mm) with a controlled amount of surface water.

High friction surfacings were introduced into the UK in the 1960s to provide enhanced skid resistance for accident black-spots. In the UK, the systems proved successful and, since 1986, have been called up in Clause 924 of the UK Specification for Highway Works (Nichollas, 1998).

Some trials were undertaken in Melbourne in the 1970s. Although the trials were successful, the lack of local specialist contractors meant that interest largely waned. That situation has changed and local suppliers are now able to provide a range of products on demand (VicRoads, 2002), although costs are still relatively high compared with traditional surfacing treatments. The Roads and Traffic Authority of New South Wales has used calcined bauxite for about 25 years but currently mainly uses specific high micro-texture aggregates that have lower resistance to polishing, but are less expensive and adequate in many applications.

High friction surfacings are usually delivered as proprietary products.

The calcined bauxite aggregate typically has a Polished Stone Value (PSV) of around 75, compared to values of around 45 to 60 for aggregates from most naturally occurring stone sources. Calcined bauxite is also extremely hard and wear resistant (The resin based binder holds the aggregate firmly in place without the embedment of aggregates normally associated with heavy traffic and bituminous binders.). The combination of resistance to embedment and resistance to wear results in good macro-texture being retained, even with small nominal sized aggregates (5 mm or less) (VicRoads, 2002).

When tested using SCRIM, coefficients of friction (expressed as sideways force coefficient (sfc)) of around 0.75<sup>1</sup>, and more, have been measured (VicRoads, 2002). British pendulum testing on Rouen Road, Toowong, gave an average wet Skid Resistance Value (SRV) of 75 after two and a half weeks of traffic.

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<sup>1</sup> As a reference point, the highest VicRoads investigatory category for surface friction is a minimum of 0.55.

### 3 Usage of High Friction Surfaces

#### Main Roads, South East Queensland

Usage of high friction surfacings by Main Roads in South East Queensland is summarised in Table 2.1. Accident statistics are based on reported accidents known by Main Roads (i.e. received from the Queensland Police Service (QPS)).

**Table 2.1 Main Roads SE Qld Usage of High Friction Surfacing**

District	Product	Location	Date Laid	Comments	
Metropolitan District	Tyregrip 924 - HF supplied/installed by STS Applied Systems	Rouen Rd eastbound (Birdwood Tce to Vimy St), Toowong	8 February 2005	Refer note 1 below	
South Coast Hinterland District	Tyregrip 924 - HF supplied/installed by STS Applied Systems	Southport-Nerang Rd on westbound approach to Wardoo St (signals)	April 2005	No known rear end crashes since	
		Rockpave Hi Grip supplied/installed by Brick'nPave	Gooding Drv roundabout slip lane to Nerang-Broadbeach Road	November 2005	No known run offs since
			Southport-Nerang Rd on westbound approach to Cotlew St (signals) and Ashmore Rd (signals)	June 2006	No rear end crashes since
			Installed on Brisbane Rd on eastbound approach to Pine Ridge Road(signals)	February 2007	No known rear end crashes since
North Coast Hinterland District	TyreGrip	Bestman Rd Roundabout (on roundabout), Bribie Island	August 2005	Refer note 2 below	

Note 1: According to data in ARMIS there were six "off path – curve" incidents in the two years prior to treatment and none in the two years following treatment.

Note 2: Eight wet weather crashes in the 22 months prior to resurfacing and three in the 22 months following resurfacing

High friction surfacings used by Main Roads have performed satisfactorily to date in terms of durability. There are two exceptions to this:

- a At one site some moisture has entered the underlying asphalt and has affected the durability of both the asphalt and the high friction surfacing. This is an issue with the structural performance of the pavement and not a calcined bauxite issue.
- b At another site there has been some loss of stone from the surface. This occurs with all surfaces to varying degrees because bitumen reacts with oxygen (oxidises) and loses its resilience and cohesiveness.

### **VicRoads**

An investigation into the performance of calcined bauxite treatments on road surfaces with regard to the impact on traffic incident trends at twenty-nine treatment sites was reported by Simpson (2006).

The investigation showed calcined bauxite treatments provide a uniformly high level of skid resistance for at least five years after placement. The skid resistance of the treatments appeared to be independent of the visual condition of the surface.

Twenty-nine sites were analysed. These were located in Melbourne and Geelong and consisted of 20 'approaches' to signalised intersections, 4 curves, and 5 'approach and centre' of signalised intersection sites.

Twenty-eight sites were tested for skid resistance using SCRIM. At all sites, the results showed the calcined bauxite provided a highly skid resistant surface. Some low results at a number of sites were attributed to delaminated areas on the sites, where the underlying asphalt was exposed. Delamination is usually caused by poor surface preparation and / or excessive deterioration of the existing surface and is overcome by improved quality assurance.

Twenty-six sites were tested for surface texture (macro-texture). The results provided an average of 0.90mm, with most results within the range of 0.70 to 1.00mm. There appeared to be no major reductions in surface texture with time and traffic stresses.

### **RTA**

RTA has used calcined bauxite high friction surfacings for around 25 years with success. Good performance has been reported with some of the earlier sites still in satisfactory condition.

Due to the high cost of calcined bauxite treatments, RTA in recent years has mainly used specific high PAFV aggregates from selected NSW quarries (PAFV about 59) where high micro-texture is required. Calcined bauxite is still used in very difficult situations.

### **United Kingdom**

High friction surfacings are routinely used in the UK. On UK trunk roads, high friction surfacings are generally required for gradients (>50m long and >10%), approaches to roundabouts, traffic signals, pedestrian crossings, railway level crossings and similar. They may also be used on roundabouts and bends (< 100m) where there is no alternative aggregate supply with proven performance.

### **Brisbane City Council**

BCC has used high friction surfacings at several locations including:

- Ekibin Road, Annerley (on curve) early 2004

- Sinnamon Road, Jindalee (on curve) early 2004
- Winship Street, Redhill (very low traffic cul-de-sac with very steep gradient).

The product used for the above three locations was TyreGrip.

## 4 Typical Treatment

High friction surfacings should only be applied to sound pavements in good condition as they cannot account for structural inadequacies or irregularities in the existing pavement. Such treatments are not suitable for treatment of (VicRoads, 2002):

- rutted or unstable asphalt
- ultra thin open grade and open graded asphalts
- sprayed seals, whether flushed or not.

Literature and anecdotal evidence suggest that moisture in the underlying material is a key factor which may result in delamination of resin-based surfacings, and therefore presence of moisture must be avoided.

Surface preparation prior to application is also critical to ensure adequate bonding between the existing surface and the calcined bauxite surfacing.

Application in cool temperatures is possible but should be carried out in accordance with the manufacturer's recommendations.

The typical steps involved in the application of a high friction surfacing over an existing asphalt surface are:

- i Closure to traffic
- ii Preparation of the existing surface to remove dirt, grease and any excessive binder, and removal or masking of existing pavement markings
- iii Resin application by metered sprayer or by hand using buckets and rubber squeegee brushes
- iv Calcined bauxite chippings broadcast by hand
- v Curing period (typically around 4 hours)
- vi Vacuum brooming to remove loose chippings
- vii Opening to traffic.

## 5 Specifications

### Main Roads

Successful use of calcined bauxite depends on proper treatment of the existing surface, application in dry conditions with sufficient surface temperature, use of a specialist contractor with proven performance and good supervision.

### VicRoads

Specification is by VicRoads Standard Specification Section 430, High Friction Surface Treatments. The specification is based on achieving performance criteria rather than providing prescriptive measures (VicRoads, 2006).

### **RTA**

The resin-based surfacings used are specified in RTA specification R110 Coloured Surface Coatings for Bus Lanes and Cycle-ways.

### **UK**

Specification requirements in the UK are given in Clause 924 from the UK Specification for Highway Works (MCHW 1, 2002). HAPAS product approval is also required.

Following HAPAS approval, a certificate is issued to the supplier (and which is published on the BBA website) which includes details of the system. Perusal of a number of these certificates suggests the following:

- a Laying in extreme temperature conditions (typically less than 5°C or greater than 35°C, but product dependent) is not permitted.
- b Life expectancies for common applications are typically 5 to 10 years
- c Minimum binder application rates apply
- d Texture depths of the existing surface on which the high friction surfacing is laid of 0.5 to 2.0 mm (sand patch) are generally required.

## **6 Noise**

There does not appear to have been any significant study on the noise characteristics of high friction surfacings, and no data or studies could be identified.

## **7 References**

Nichollas, J.C. (1998), Trials of high-friction surfaces for highways, Transport Research Laboratory (TRL) Report 125, Crowthorne, United Kingdom.

VicRoads (2002), Skid Resistant Surfacing, Geopave Technical Note 60, May 2002.

VicRoads (2006), Performance of high skid resistant treatments, Geopave Technical Note 74, June 2006.

Simpson, C. (2006), Performance of high skid resistant treatments, 22<sup>nd</sup> ARRB Conference, Canberra, Australia.

## Appendix F – The Influence of Speed, Tyre Wear and Surface Water Depth on Vehicle Control

### 1. Reference: AA Article: “Get a Grip – Tyre, Road Surfaces and Traffic Accidents” (June 2005)

(Published by the AA Motoring Trust. Developed from a review of Research conducted by Hampshire County Council and managed by TRL on behalf of the AA Foundation for Road Safety Research and the County Surveyor’s Society.)

The following extracts are limited to findings regarding the contribution of tyres to wet weather crashes. The full article deals with other factors such as road surface characters, tyre pressure and data analysts.

#### **Crash Risk**

- *Worn tyres running on worn surfaces greatly increase crash risk, especially in the wet. The key factors to do with road-tyre interaction determining crash risk are well known, but bear repeating. They include:*
  - *Vehicle speed;*
  - *The road surface texture and skid resistance;*
  - *The road shape and geometry;*
  - *The properties of the tyre rubber and how it performs when hot;*
  - *The temperature and deformation of the tyre;*
  - *How much of the tyre is firmly in contact with the road;*
  - *The extent to which water is forced from the contact patch between the tyres and the road; and*
  - *The presence of any local contaminants on the road, such as oil or detritus.*
- *New tyres come with at least 7mm of tread. On a new road surface they can stop a car travelling at 60mph in less than 50 metres. But what about a typical car on a typical road? How confident can drivers be that they, and the cars behind, can pull up quickly in an emergency? The risks are many times greater if tread depths are close to the legal limit and the emergency is on a wet, worn-out road surface.*
- *The government should lead a review of the 1.6mm tread depth limit in the light of research evidence from real crashes.*

#### **Worn tyres**

- *Worn tyres are common. One in 10 cars has one or more tyres with a tread depth at or below the legal (1.6mm) limit. Research more than 30 years ago produced broadly similar results.*
- *Worn tyres reduce braking capability on wet roads and severely increase the risk of crashes.*
- *Tyres with less than 1mm tread depth have a braking friction in the wet that is just one-third that of tyres with the minimum legal tread depth of 1.6mm.*

#### **Tyres on wet roads**

- *Stopping distances in the wet are doubled.*
- *Worn tyres contribute to about one in 10 crashes in wet conditions, compared to one in 50 crashes on dry roads.*

- Grip on wet roads is markedly reduced when tread depth is less than 3mm.
- When there is a 2mm film of water on the road, even 2mm of tread may give no better stopping friction than a bald tyre.
- On wet roads, the risk of a crash trebles if the tread depth is at the 1.6mm legal minimum, and it increases seven-fold when the tread depth is less than 0.5mm.

### **Tyre imbalance**

- Different tread depths on front and rear tyres create handling problems.
- Vehicle handling is affected when the tread depth is substantially greater on the front tyres than on the rear tyres.

### **Crash risk**

- Vehicles of drivers found to be at fault in high-speed crashes were found to be six times more likely to have worn tyres than those of the other drivers involved.
- Drivers of vehicles with worn tyres may have other characteristics that increase crash risk for example; they may be younger and be driving older cars.

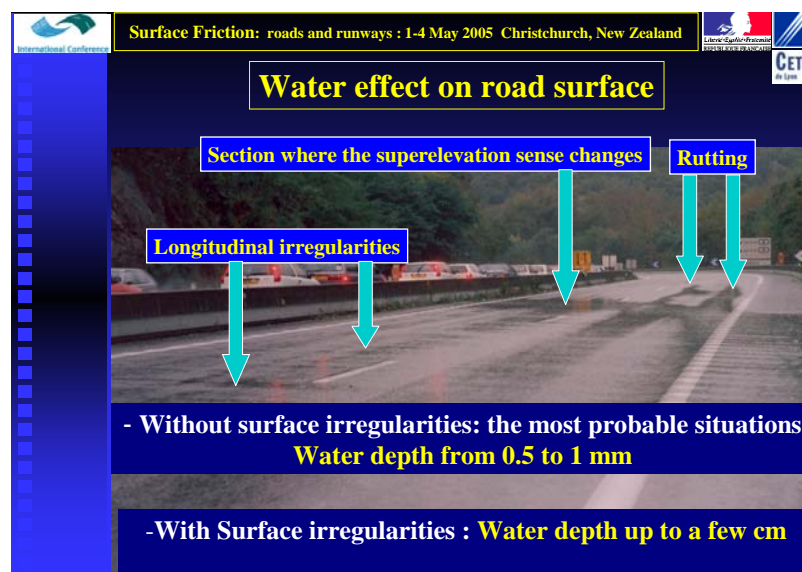
### **Surface texture**

- Road surfaces have both macro-texture (the overall roughness resulting from the number, type and size of the stone chippings) and micro-texture (the roughness of the individual chippings).
- The roughness of both the macro and micro-texture varies during the life of a surface.
- Crash rates increase markedly as the macro-texture roughness wears and smoothing of the micro-texture also decreases surface friction.

## 2. Reference: **Standardisation: input of the HERMES programme**

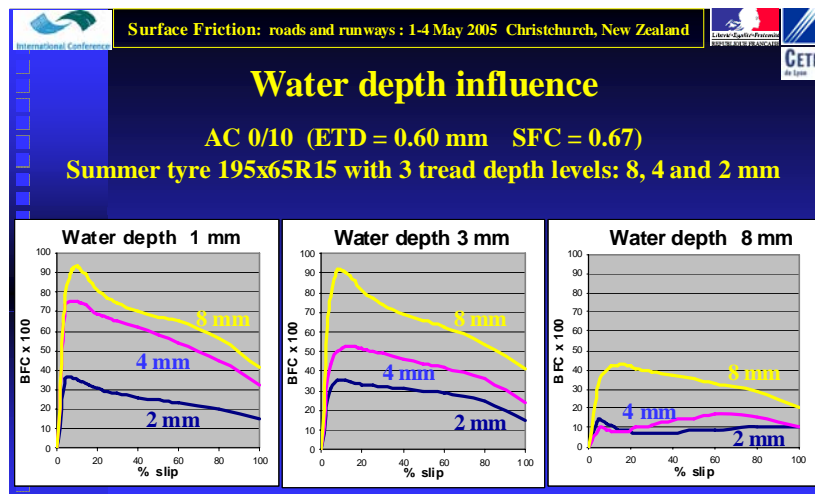
Michel Gothié, Research Director, LRPC de Lyon, France

- Water has to be drained by the surface
- And also by the tyre



- Skid resistance is directly proportional to the area of contact between the tyre and road surface. When even small amounts of water are present even new tyres experience a reduction in contact area and therefore a reduction in skid resistance. This is where partial aquaplaning mechanisms begin to influence skid resistance.

- A 'just legal' tyre experiences a significant reduction in contact area at 90 km/h and therefore a significant reduction in skid resistance.
- As water depth increases so does partial aquaplaning with a corresponding reduction in skid resistance.
- Tyre wear has a definite impact



Surface Friction: roads and runways : 1-4 May 2005 Christchurch, New Zealand

**Conclusions: rain effect on skid-resistance**

- Even on low rainfall intensity it is possible to find on a road surface some high water thickness (1 to 3 mm)
- At high speed, tyre (tread) and macrotexture functions are very important to eliminate this water and keep an acceptable skid resistance level. Between medium (WD 1mm, New tyre, ETD>0.9 mm) and bad conditions (WD 3 mm, Worn tyre, ETD<0.6 mm) stopping distances (locked wheel) can be multiplied by 7!
- Water depths on road surfaces during rain is dependent on rain intensity, slope, flow length and macrotexture. To predict water depth and skid resistance some models exist. But,
- These water depths are more dependent on surface irregularities such as super-elevation changes, rutting or megatexture.