



APRIL 2008



AUSTRALIAN  
AUTOMOBILE  
ASSOCIATION

# Comparing Risk Maps and Star Ratings

AusRAP Technical Working Paper

---

## Comparing Risk Maps and Star Ratings

### About this report

Since 2004, the Australian Automobile Association (AAA) has released a number of reports rating highways for risk using two protocols: Risk Mapping and Star Ratings. These reports can be viewed at [www.ausrap.org](http://www.ausrap.org).

AAA commissioned ARRB Group to investigate the relationship between the two protocols. This report presents the findings of that research, which was undertaken by Rob McInerney, Jarrod Harkness, Joseph Affum and Kerry Armstrong (ARRB) under the direction of John Metcalfe and Greg Smith (AAA).

### Contact details

For more information or copies of AusRAP reports or DVD, contact:

Australian Automobile Association  
216 Northbourne Avenue  
Canberra ACT 2601  
Email: [aaa@aaa.asn.au](mailto:aaa@aaa.asn.au)  
Web: [www.aaa.asn.au](http://www.aaa.asn.au)  
Phone: +61 2 6247 7311  
Or visit: [www.ausrap.org](http://www.ausrap.org)

Material in the publication maybe reproduced or quoted provided AAA and the Authors are acknowledged.

April 2008.

### Acknowledgements

The Australian Automobile Association acknowledges the Australian Government's financial support for AusRAP through the Australian Transport Safety Bureau.



**Australian Government**  
**Australian Transport Safety Bureau**

The Road and Traffic Authorities in the States and Territories provided data, software and technical support for the program.



Although the Report is believed to be correct at the time of publication, ARRB Group Ltd, to the extent lawful, excludes all liability for loss (whether arising under contract, tort, statute or otherwise) arising from the contents of the Report or from its use. Where such liability cannot be excluded, it is reduced to the full extent lawful. Without limiting the foregoing, people should apply their own skill and judgement when using the information contained in the Report.

[www.arrb.com.au](http://www.arrb.com.au)

---

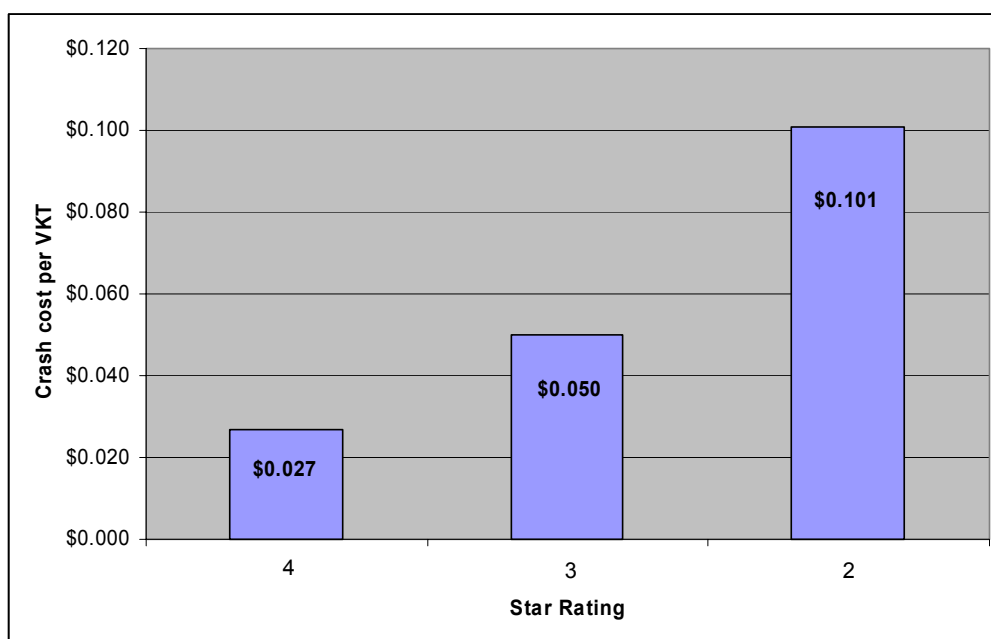
## Summary

The AusRAP Star Ratings initiative was launched by the Australian Automobile Association in October 2006 following over two years of research, development and assessment. The Star Rating results are based on an assessment of the engineering features of the road network and the calculation of a Road Protection Score (RPS).

This report details an investigation into the relationship between the Star Ratings / RPS and the crash costs on the road network. While the AusRAP model is not a crash prediction tool a link between the Star Ratings / RPS and crash outcomes is expected.

The study involved the comparison of crash data and Star Rating / RPS results on the Queensland AusLink network assessed as part of the 2006 report. The primary analysis of average crash costs per vehicle kilometre travelled and the Star Ratings revealed the following result:

- average crash costs of \$0.027 per vehicle kilometre travelled on 4 star roads;
- average crash costs of \$0.050 per vehicle kilometre travelled on 3 star roads; and
- average crash costs of \$0.101 per vehicle kilometre travelled on 2 star roads.



The analysis provides a strong indication of the improvement in crash costs that can be expected as a road network improves from two star to three star to four star and ultimately a five star road. These results are expected to assist in further work being undertaken during 2007/2008 to investigate the expected economic costs and benefits of raising the AusLink network to a four star standard.

---

## Contents

|                   |  |           |
|-------------------|--|-----------|
| <b>1</b>          | <b>Introduction.....</b>                                       | <b>4</b>  |
| 1.1               | Road Protection Score.....                                     | 6         |
| <b>2</b>          | <b>Research Philosophy .....</b>                               | <b>7</b>  |
| 2.1               | Research Methodology.....                                      | 7         |
| <b>3</b>          | <b>Research Outcomes .....</b>                                 | <b>10</b> |
| 3.1               | Crash cost per vehicle kilometre travelled by Star Rating..... | 11        |
| 3.2               | Crash cost per vehicle kilometre travelled by raw RPS.....     | 13        |
| 3.3               | Component RPS.....   | 15        |
| 3.3.1             | Run-off road RPS .....   | 16        |
| 3.3.2             | Head-on RPS .....  | 18        |
| 3.3.3             | Intersection RPS.....  | 20        |
| <b>4</b>          | <b>Conclusion .....</b>  | <b>22</b> |
| <b>5</b>          | <b>References .....</b>  | <b>23</b> |
| <b>Appendix A</b> | <b>Cumulative VKT vs Crash Cost per VKT Charts .....</b>       | <b>24</b> |
| <b>Appendix B</b> | <b>Alternate Research Methodologies.....</b>                   | <b>27</b> |

## 1 Introduction

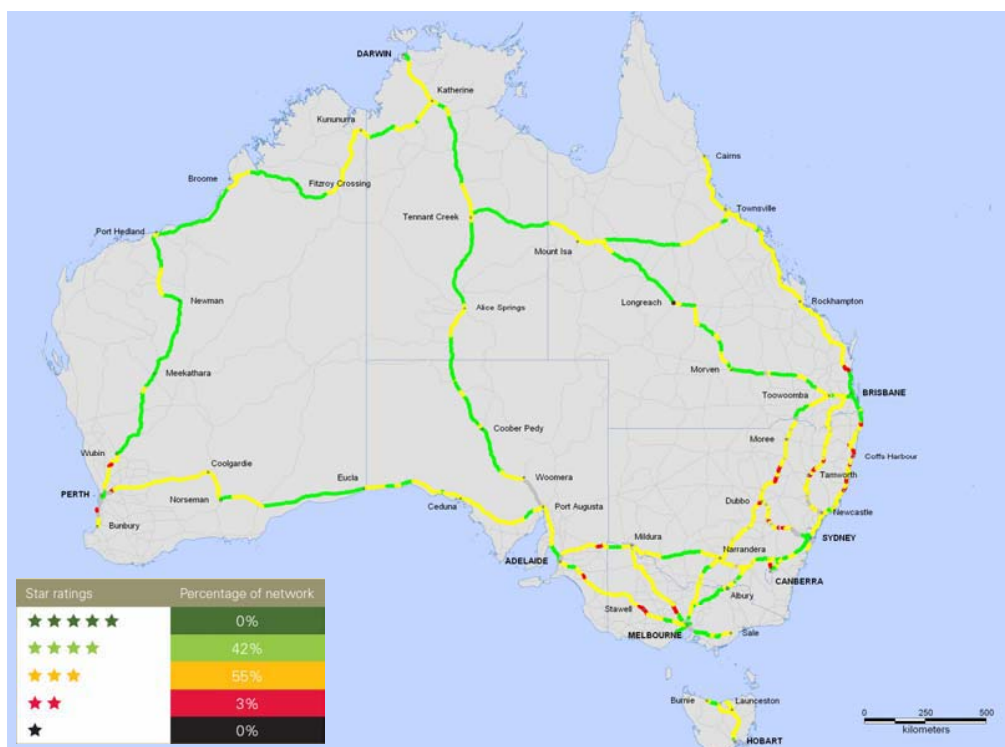
The Australian Road Assessment Program (AusRAP) is a sister program to the Australasian New Car Assessment Program (ANCAP), which crash-tests new cars and awards them stars for safety. AusRAP is based on the European equivalent, EuroRAP which produces maps showing the risk of road crashes that cause death and life-threatening injury and rates roads for safety. It highlights improvements that could be made to roads to reduce the likelihood of crashes — and to make those that do happen survivable.

AusRAP uses two methods — or protocols — to assess the safety of roads. AusRAP's first protocol, Risk Mapping, is based on a road's history of casualty crashes and traffic volume. Previous AusRAP reports, released in 2004 and 2005, used risk-maps to provide a measure of the safety performance of the AusLink National Network. Road crash fatalities on the AusLink network account for around 15 per cent of annual road fatalities in Australia.

The first AusRAP Star Ratings report was published in October 2006. The Star Ratings involve an inspection of a number of design elements such as lane and shoulder width and the presence of safety barriers, which are known to have an impact on the likelihood of a crash and its severity. Between one and five stars are awarded to road links depending on the level of safety which is 'built-in' to the road. The Star Ratings do not take into account a road's crash history.

The first report provided Star Ratings (from one star to five star) of the Australian AusLink network in all States and Territories except NSW and involved the assessment and rating of over 18,300 kilometres of road. In summary 2% of the network was rated two star, 51% of the network was rated three star and 47% of the network was rated four star.

In September 2007, a second report was published which included Star Ratings for the AusLink Network in NSW, which previously was not able to be rated. This took the total length of the rated AusLink network to 22,969km. The addition of the NSW ratings resulted in 3% of the network being rated two star, 55% rated three star and 42% rated four star.



State highways in Victoria, Western Australia and Queensland have also been Star Rated by the RACV, RACWA and RACQ respectively.

Following the release of the various reports, significant interest was generated into the extent of the relationship between the Star Ratings and Risk Maps. The obvious question was raised as to whether high risk roads identified in the Risk Mapping protocol correspond with high risk roads in the Star Rating protocol.

This AusRAP Technical Working Paper addresses this question by comparing the relationship between Risk Maps and Star Ratings. This analysis is based on research undertaken by ARRB for AAA. ARRB investigated different methodologies for researching this relationship and determined that crash costs, as opposed to Risk Maps *per se*, was the most appropriate measure for the comparison.

## 1.1 Road Protection Score

Star Ratings are based on a Road Protection Score (RPS) that measures the inherent safety of the road network as it relates to an individual road user. The RPS is based on three component measures that address the predominant crashes on open rural roads, namely:

- run-off road;
- head-on; and
- intersection.

A RPS is determined for each component and a total RPS is then calculated from these individual components. The RPS that determines the the Star Rating (one to five) and the typical roads represented by those ratings is detailed in Table 1 below.

**Table 1 RPS and Star Rating levels**

| RPS Score | Rating Scale | Typical road  |  |
|-----------|--------------|---|--|
|           |              | Divided Road  | Undivided Road   |
| < 1.05    | *****        | Straight with good line-marking, wide lanes and sealed shoulders, forgiving roadside and over- or under-pass intersections.   | No undivided roads can achieve a 5-Star Rating.  |
| 1.05-<4.0 | ****         | Minor deficiencies in some road features such as lane width, shoulder width, curves or roadside.  | Straight with good overtaking provision, good line-marking and forgiving roadside.   |
| 4.0-<10.0 | ***          | Major deficiencies in some road features such as poor median protection against head-on crashes, many minor deficiencies and/or poorly designed intersections at regular intervals. | Minor deficiencies in some road features such as bends and roadsides and/or poorly designed intersections at regular intervals.  |
| 10-<25    | **           | Many major deficiencies such as poor alignment, poor roadside and median protection and poorly designed intersections at regular intervals.   | Major deficiencies in some road features such as poor roadside environment and/or many minor deficiencies such as insufficient overtaking provision and narrow lanes, and/or poorly designed intersections at regular intervals. |
| 25+       | *            | Many curves, in mountainous terrain, narrow lanes and shoulders, severe roadside conditions and many major intersections.   | Many curves, in mountainous terrain, narrow lanes and sealed shoulders, poor line marking and severe roadside conditions.  |

---

## 2 Research Philosophy

The RPS is independent of traffic volume. This reflects the primary focus of the AusRAP Star Ratings on the safety of the infrastructure elements of the road and the impact of the road on an individual road user. The RPS model also accounts for both the likelihood and severity of a crash event.

Since the RPS relates to individual risk, it might be expected that there is a relationship between RPS and the measure of individual risk (crashes per vehicle kilometre travelled (VKT)) used for the Risk Maps.

We argue that the most appropriate means of testing the relationship is to convert the *individual risk* component of Risk Mapping to crash costs per vehicle kilometre travelled. The use of crash costs accounts for both the number and severity of crashes as relevant to an individual on the road.

Knowledge of the relationship between the RPS and actual crash costs per vehicle kilometre travelled is important for two reasons:

1. As a form of model validation, it is expected that the crash costs per vehicle kilometre travelled will increase on roads with a lower Star Rating (that is, a higher RPS). For example, we would expect that (after adjusting for traffic volume) a road with a one or two Star Rating to have more crashes than a road with a three or four Star Rating.

It should be emphasised however, that the AusRAP RPS model is not intended to be a crash prediction model. This is primarily because the model considers risk to an individual road user independent of exposure effects; intersection risk is modified slightly to measure quality relative to a best case condition; and the assessment technique involves the averaging of conditions over homogeneous sections.

2. To provide a knowledge of the crash cost savings that can be achieved through improvements in road infrastructure. This will allow clubs and authorities to understand the economic benefits to be achieved from improving the Star Rating of roads.

### 2.1 Research Methodology

For the purpose of the RPS and crash cost study, we used Queensland data to examine the relationship. This choice was made because of data availability and the extent of the road network (over 5,300 carriageway kilometres of road – refer to Figure 1 on page 9). An added advantage was the use of earlier video data (2003-2004) in the rating of the Queensland road network, since the data for this period will more accurately reflect the conditions that existed during the period over which the crash data has been sourced (1999-2004)<sup>1</sup>.

---

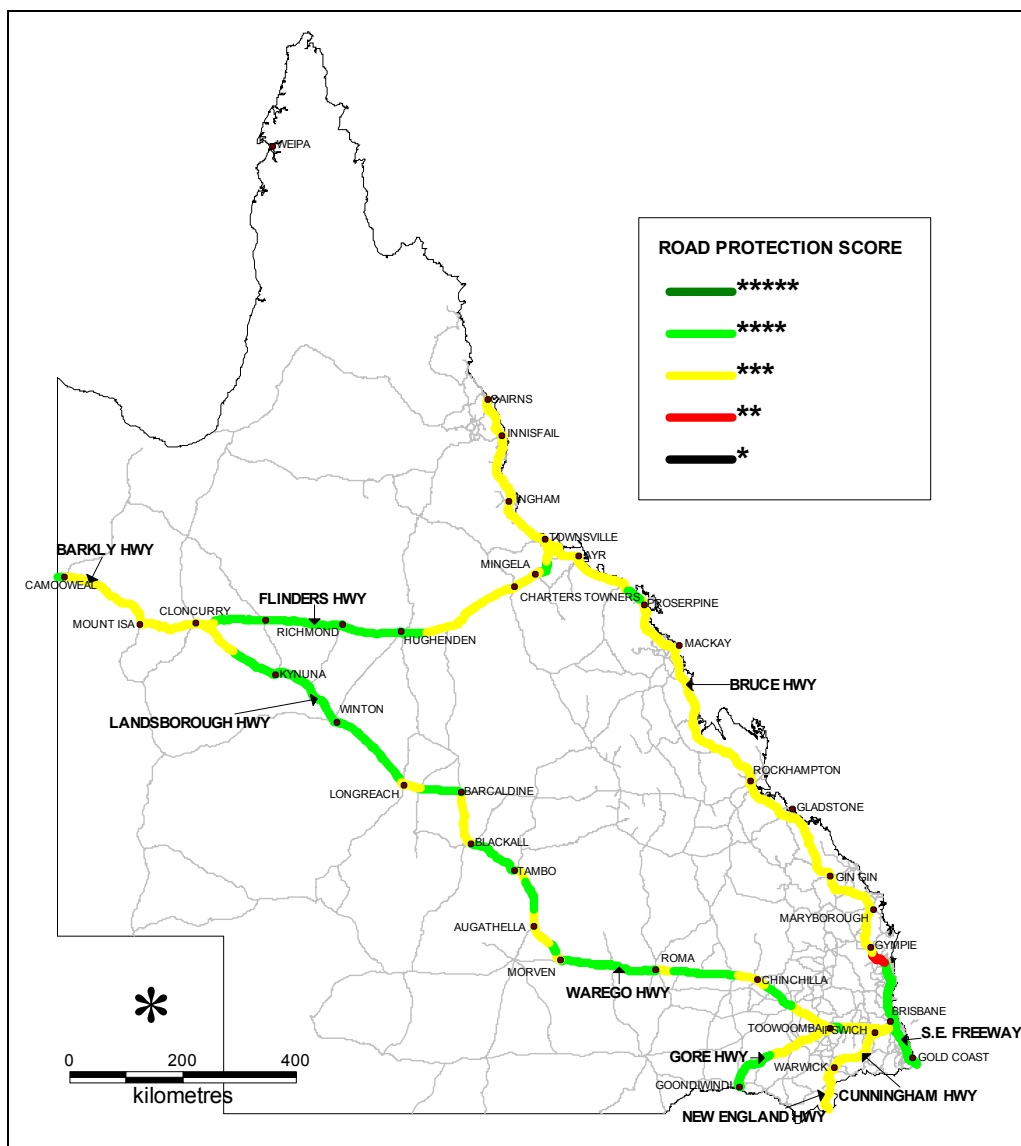
<sup>1</sup> It is noted that changes to the network may have occurred throughout the crash period. The AusRAP model cannot account for those changes as it relates to a snap-shot at a point in time. It is expected that those sections where changes have occurred are relatively small in length compared with the overall length of the network.

The tasks involved in the project included the following:

- Source traffic volume and crash data over the study period from 1999 to 2004.
- Assign crash and traffic data to each relevant homogeneous section identified during the rating of the Queensland network. This was based on the raw RPS results.
- Source crash cost data for use in the research and calculate the estimated crash costs for each section of road.
- Calculate the vehicle kilometres travelled for each road section.
- Calculate the crash cost per vehicle kilometre for each road section.
- Analyse and review the relationships identified.

The research activity involved the consideration of different methodologies prior to adopting the final approach described in the main body of this report. The final approach was selected following discussions with the EuroRAP research team and the outcomes of similar analyses being undertaken on the EuroRAP results. Further details on the non-preferred approaches are provided in Appendix B.

Figure 1 Queensland Star Ratings based on 2003/04 video data



### 3 Research Outcomes

The first stage of the project involved the sourcing of volume data for the Queensland road network and for each homogeneous section defined in the AusRAP Star Ratings.

The next stage involved obtaining crash data for the six years from 1999 to 2004 for the network. For the purpose of this evaluation, the severity outcome of the crash was critical to ensure that the crash costs were based on actual outcomes and not average outcomes (e.g. fatal crash as opposed to average crash costs by crash type).

The crash severity costs were based on those used by Queensland Main Roads.

**Table 2 QDMR crash costs<sup>1</sup>**

|                      |              |
|----------------------|--------------|
| Fatal Crash          | \$ 2,038,182 |
| Serious Injury Crash | \$ 500,741   |
| Minor Injury Crash   | \$ 29,598    |

<sup>1</sup> It is noted that a range of alternative values are available for the average crash cost severity (e.g. BTRE, ARRB). The QDMR figures were selected as the analysis is based solely on Queensland data.

Based on this information, the crash data was assigned to the relevant AusRAP homogeneous sections and the crash cost per VKT was calculated.

The data was then aggregated by the Star Rating calculated for that road section as part of the AusRAP assessment. All assessments were based on the Star Rating for each smaller homogeneous section (typically 200m – 20km) and not the longer lengths (>50km) presented in the final results. This allowed for greater sensitivity and changes in condition to be reflected in the analysis.

Further analysis was then conducted to compare the component RPS with each of the three component crash costs (that is, run-off road, head-on and intersection). Where possible, the RPS ranges were selected to ensure each one included a reasonable size sample of road (with a target minimum of approximately 100km of road length).

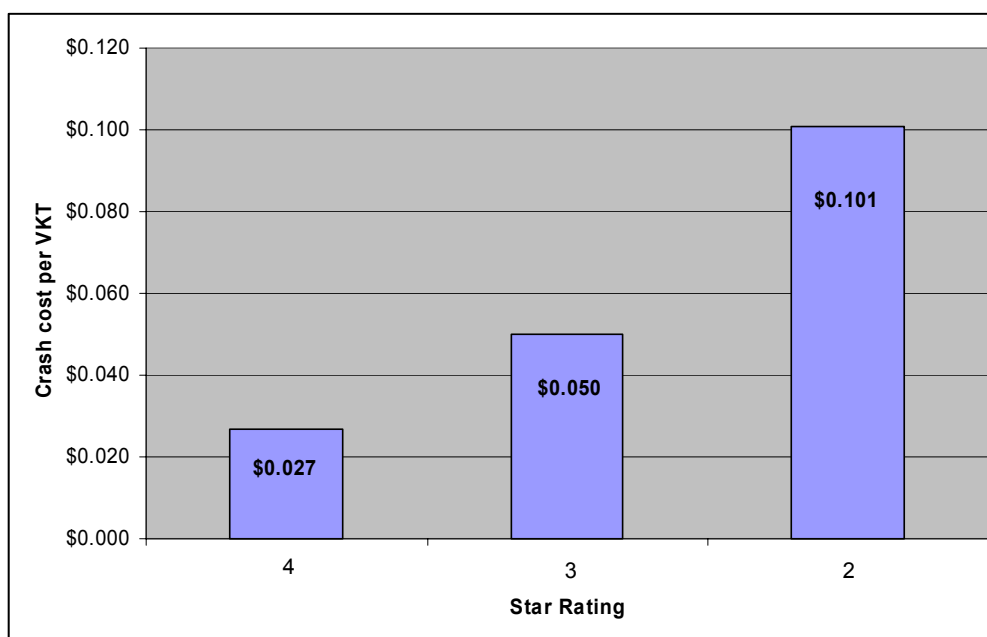
The results of the analyses undertaken are detailed in the sections below:

- Crash cost per VKT by Star Rating
- Crash cost per VKT by raw RPS
- Component RPS – run-off road RPS
- Component RPS – head-on RPS
- Component RPS – intersection RPS

### 3.1 Crash cost per vehicle kilometre travelled by Star Rating

Figure 2 shows the crash cost per VKT by Star Rating. The results show that a lower Star Rating is associated with a higher crash cost per VKT. The average crash cost is three cents per vehicle kilometre on a four star road; five cents per vehicle kilometre on a three star road and ten cents per vehicle kilometre on a two star road.

**Figure 2** Crash cost per VKT by Star Rating



The detailed results are provided in Table 3 below.

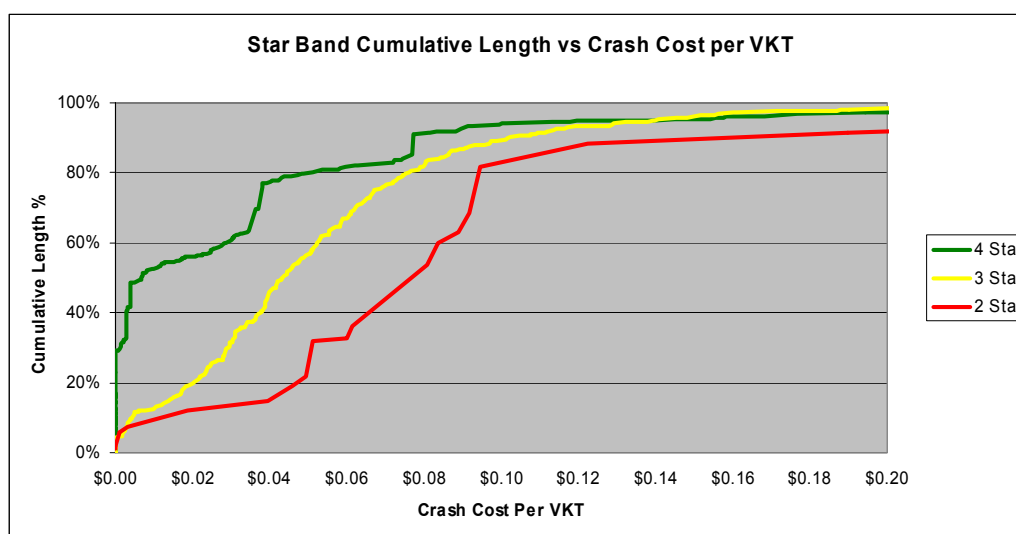
**Table 3** Crash cost per VKT by Star Rating

| RPS       | Star Band | Number of Records | Length of Road (km) | Annual VKT    | Annual Crash Cost (\$) | Crash Cost per VKT (\$) |
|-----------|-----------|-------------------|---------------------|---------------|------------------------|-------------------------|
| 1.05 to 4 | 4         | 237               | 2244                | 5,300,987,000 | \$ 144,814,332         | \$ 0.027                |
| 4 to 10   | 3         | 324               | 2713                | 3,453,578,692 | \$ 173,576,162         | \$ 0.050                |
| 10 to 25  | 2         | 24                | 101                 | 223,384,620   | \$ 22,470,566          | \$ 0.101                |

Note: insufficient / no data available for one and five star sections. Refer to Appendix A for the distribution of individual section results in relation to cumulative vehicle kilometres travelled.

A detailed review of the results highlighted a wide spread in actual crash costs for each small homogeneous section. This is to be expected as there are many short sections of road where no crashes have occurred (zero crash costs) and the increase in crash costs from this type of location to one where a single fatal crash may have occurred, is significant. To demonstrate this effect, the cumulative distribution curve for each Star Rating in relation to the length of road within each Star Rating band was generated and is provided in Figure 3.

**Figure 3** Distribution of homogeneous sections by Star Band and crash cost per VKT



The distribution curves reflect a higher proportion of four star road sections with zero crash costs compared to two and three-star roads. The two-star roads clearly have a higher proportion of road sections with higher crash costs than the three and four-star sections of road. Ideally the four-star curve should track above the three-star curve for the full distribution (up to 100%), although the results see the three-star distribution (yellow) cross the four-star distribution at approximately 14 cents per VKT.

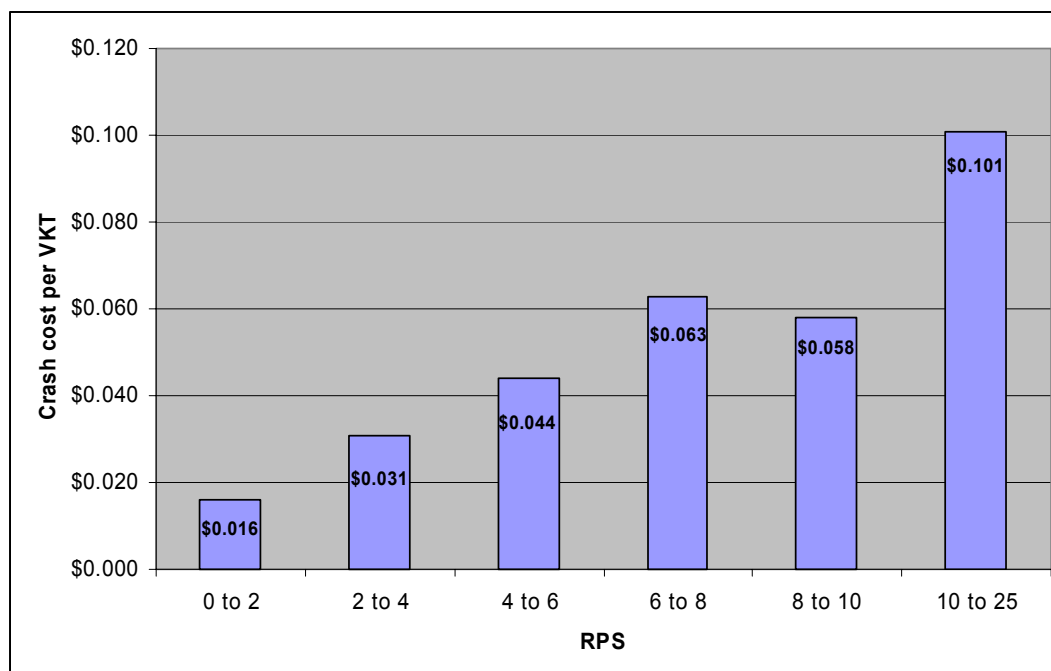
In reviewing these results, it is important to consider the step-based nature of the Star Ratings, such that some roads have RPS values close to the cut-off for a particular band. This may help explain the crossover of the three and four star-curves at 14 cents per VKT as some of the three and four-star sections will have an RPS close to the three/four star cut-off value.

### 3.2 Crash cost per vehicle kilometre travelled by raw RPS

As the majority of the Queensland road network has been assessed as being in the three or four-star category, further analysis was undertaken to determine if crash costs per VKT and the raw RPS had a relationship similar to that for the Star Ratings. For the purpose of this analysis, a greater number of RPS ranges were selected in the three and four-star range (between 1.05 and 10) with verification checks undertaken to ensure sufficient length of roads were available within each segment.

Figure 4 shows the crash cost per VKT by RPS. The chart indicates an increasing trend in crash costs per VKT as the RPS increases. There is some movement away from the trend on road sections where the RPS values are between 8 and 10.

**Figure 4** Crash cost per VKT by RPS



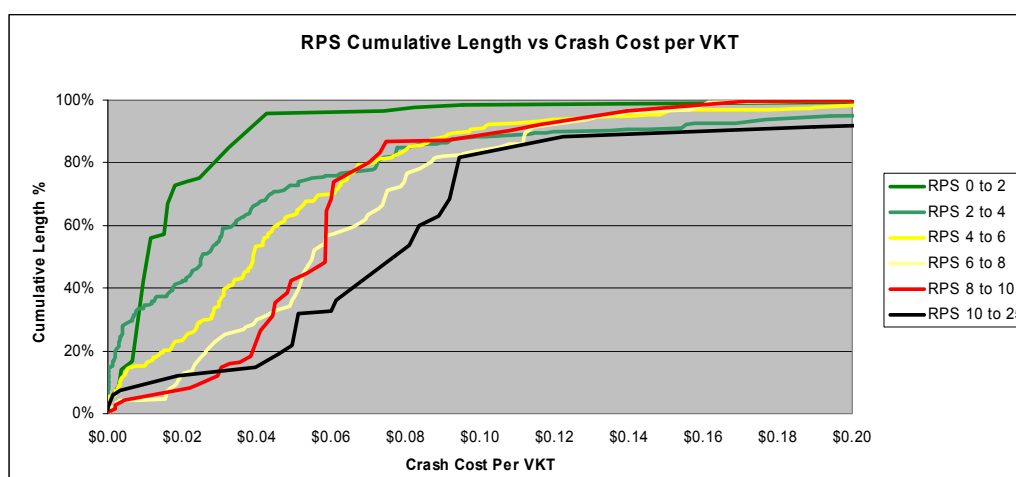
The detailed results are provided in Table 3 below.

**Table 4** Crash cost per VKT by RPS

| RPS      | Number of Records | Length of Road (km) | Annual VKT    | Annual Crash Cost (\$) | Crash Cost per VKT <sup>1</sup> (\$) |
|----------|-------------------|---------------------|---------------|------------------------|--------------------------------------|
| 0 to 2   | 18                | 91                  | 1,172,622,339 | \$ 18,869,893          | \$ 0.016                             |
| 2 to 4   | 222               | 2155                | 4,158,900,170 | \$ 127,687,974         | \$ 0.031                             |
| 4 to 6   | 211               | 1992                | 2,232,884,973 | \$ 98,741,005          | \$ 0.044                             |
| 6 to 8   | 80                | 497                 | 834,757,934   | \$ 52,449,645          | \$ 0.063                             |
| 8 to 10  | 33                | 223                 | 385,935,784   | \$ 22,385,512          | \$ 0.058                             |
| 10 to 25 | 24                | 101                 | 223,384,620   | \$ 22,470,566          | \$ 0.101                             |

<sup>1</sup> It is important to note that the selection of "break-points" in viewing the data does influence the results. Refer to Appendix A for the distribution of individual section results in relation to cumulative vehicle kilometres travelled.

The cumulative distribution curve for each RPS range in relation to the length of road within each category was generated and is provided in Figure 5.

**Figure 5** Distribution of homogeneous sections by RPS and crash cost per VKT

The distribution highlights the following:

- in general, roads with lower RPS scores (higher Star Ratings) have a higher proportion of road lengths with no crashes recorded; and
- the remainder of the road lengths with lower RPS scores have lower crash costs per VKT compared to roads with higher RPS scores (and lower Star Ratings).

The cumulative distribution for RPS values between 8 and 10 (red line) is the one most noticeably different from what might be expected. The distribution curve indicates a significant proportion of the road length with crash costs of approximately 6 cents per VKT. The distribution suggests roads with an RPS of 8 to 10 have a lower proportion of road lengths with crash costs greater than 6 cents per VKT compared to roads with an RPS of 6 to 8 (light yellow line). The distribution for the RPS in the range 8 to 10 is also approximately similar to those for the distributions in the RPS ranges of 2 to 4 (light green) and 4 to 6 (dark yellow), where 20-30% of road sections have crash costs greater than 6 cents per VKT.

It is noted that there is only 223 kilometres of road in the RPS 8 to 10 range and one section of road (Bruce Highway between Maryborough and Gin Gin) was over 32 kilometres long with an average crash cost of 6 cents per VKT. Extension of the analysis to other parts of the Australian network, which would generate a greater sample size on which to base the analysis, would provide a better basis for assessing this issue.

### 3.3 Component RPS

To further assist in understanding the relationship between the Star Rating / RPS and crash costs, the individual component RPS values and crash costs were analysed. Within the Star Rating model, the RPS is calculated for each of three key crash types: run-off road, head-on and intersection crashes. The scores are based on a range of design elements which are weighted according to the relative contribution that each design element makes to the likelihood of a crash. The scores are further adjusted according to the likely severity of a crash should one occur.

The final RPS is determined by combining the run-off road RPS, head-on RPS and intersection RPS for sections of road that are generally homogeneous. These sections can be as short as 200 metres or as long as 100km, depending on the frequency of changes in the road's design.

The analysis in this study focussed on a comparison between the crash cost percentage for each component type and the weighted contribution that each component makes to the overall RPS.

The results can be summarised as follows:

- 58% of the annual crash cost is associated with run-off road crashes, and the VKT weighted run-off road RPS values account for 64% of the total RPS.
- 22% of the annual crash cost is associated with head-on road crashes, and the VKT weighted head-on RPS values account for 15% of the total RPS.
- 21% of the annual crash cost is associated with intersection crashes, and the VKT weighted intersection RPS values account for 21% of the total RPS.

Table 5 displays the detailed results and component crash costs and VKT weighted RPS contributions for each crash type.

**Table 5** Crash cost comparison with RPS contribution by RPS component

| Component     | Annual Crash Cost (\$) | Annual Crash Cost (%) | VKT Weighted RPS Contribution | VKT Weighted RPS Contribution (%) |
|---------------|------------------------|-----------------------|-------------------------------|-----------------------------------|
| Run-off       | \$ 144,383,271         | <b>58%</b>            | 23,569,867,260                | <b>64%</b>                        |
| Head-on       | \$ 54,108,637          | <b>22%</b>            | 5,581,507,674                 | <b>15%</b>                        |
| Intersections | \$ 52,133,172          | <b>21%</b>            | 7,598,503,430                 | <b>21%</b>                        |

Based on this analysis the current AusRAP methodology closely reflects the contribution of the various component crash types used to calculate the overall RPS.

The following section compares each of the individual component RPS values against the crash costs per VKT for crashes related to that component. The aim of this was to determine if a particular component was responsible for the trends seen in Figures 3 and 5, or whether the results are a combination of all three component risks (run-off, head-on and intersection).

### 3.3.1 Run-off road RPS

The run-off road RPS was grouped into ranges and the crash costs associated with run-off road crashes only were determined for each homogeneous section. The results of the analysis are detailed in Figure 6 and Table 6 below.

**Figure 6 Run-off road crash cost per VKT by run-off RPS**

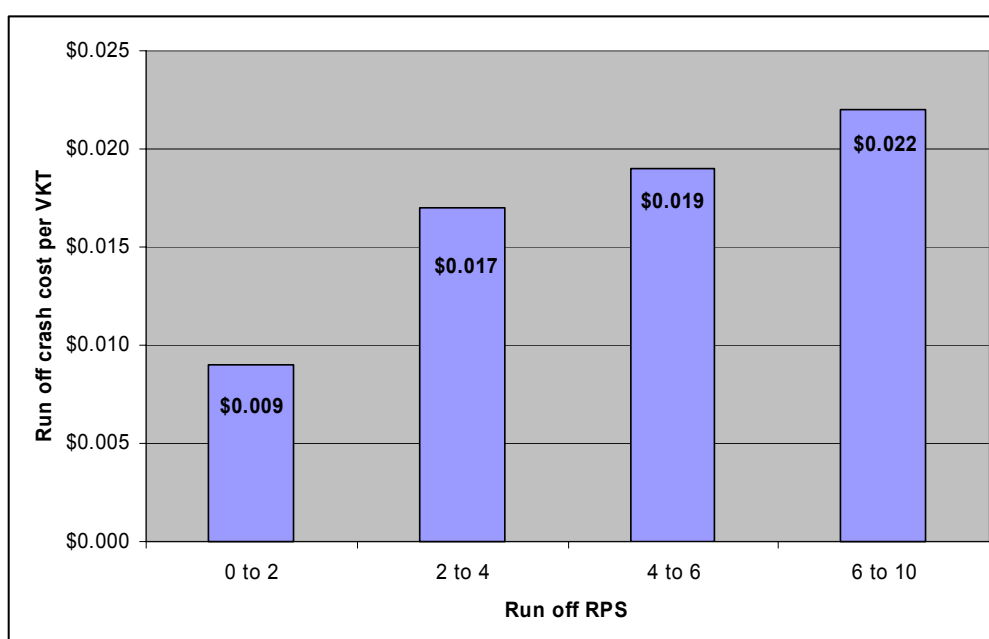


Figure 6 shows the run-off road crash cost per VKT by run-off road RPS. The figure indicates an increasing trend in run-off road crash costs per VKT as the run-off road RPS increases. The analysis has identified that the average run-off road crash cost for run-off road RPS scores between zero and two is 0.9 cents per vehicle kilometre travelled; between two and four is 1.7 cents per vehicle kilometre travelled; between four and six is 1.9 cents per vehicle kilometre travelled; and between six and ten is 2.2 cents per vehicle kilometre travelled (see Table 6).

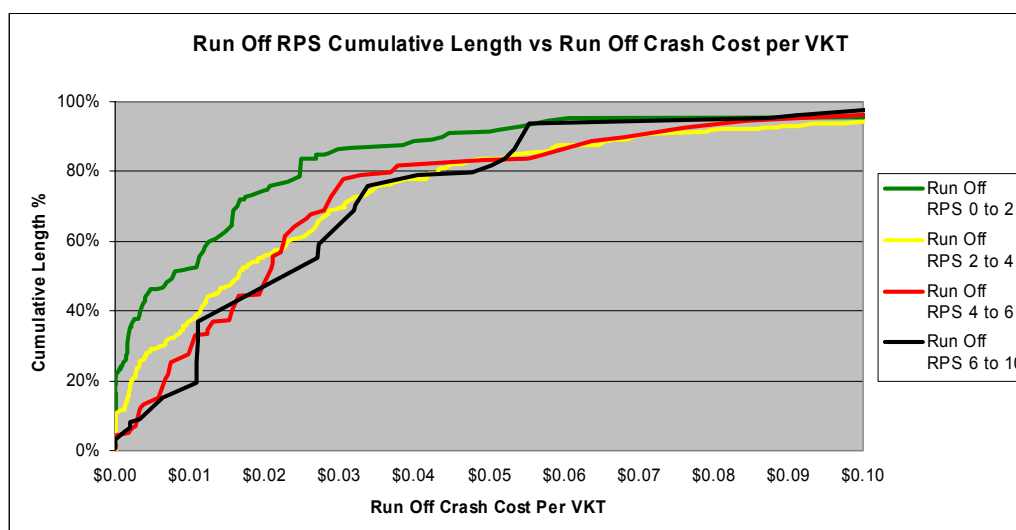
**Table 6 Run-off road crash cost per VKT by run-off RPS**

| RPS     | Number of Records | Length of Road (km) | Annual VKT    | Annual Crash Cost (\$) | Crash Cost per VKT (\$) |
|---------|-------------------|---------------------|---------------|------------------------|-------------------------|
| 0 to 2  | 144               | 822                 | 1,948,267,212 | \$ 17,535,521          | \$ 0.009                |
| 2 to 4  | 361               | 3664                | 5,180,347,280 | \$ 89,784,566          | \$ 0.017                |
| 4 to 6  | 57                | 395                 | 1,394,025,350 | \$ 26,374,511          | \$ 0.019                |
| 6 to 10 | 26                | 179                 | 485,845,979   | \$ 10,688,673          | \$ 0.022                |

Note: refer to Appendix A for the distribution of individual section results in relation to cumulative vehicle kilometres travelled.

The distribution of results in relation to road length is detailed in Figure 7 below. The results generally indicate:

- a higher proportion of road length with no run-off road crashes on roads with lower run-off road RPS; and
- the higher run-off road crash costs are experienced on the roads with a higher run-off road RPS.

**Figure 7 Distribution of homogeneous sections by run-off road RPS and run-off road crash cost per VKT**

The distributions for run-off road RPS scores between two and ten (black, red and yellow) do intersect with each other, making the distinction between the distributions less obvious. A stronger link might have been expected although the result may highlight the specific difficulty in rating roadside hazards and the highly variable outcomes that may occur when vehicles run-off the road. A review of the model outcomes suggested the following:

- Run-off road RPS scores of zero to two are typically locations where no hazards exist and where crashes are not likely to involve serious injury. These locations can be rated consistently.

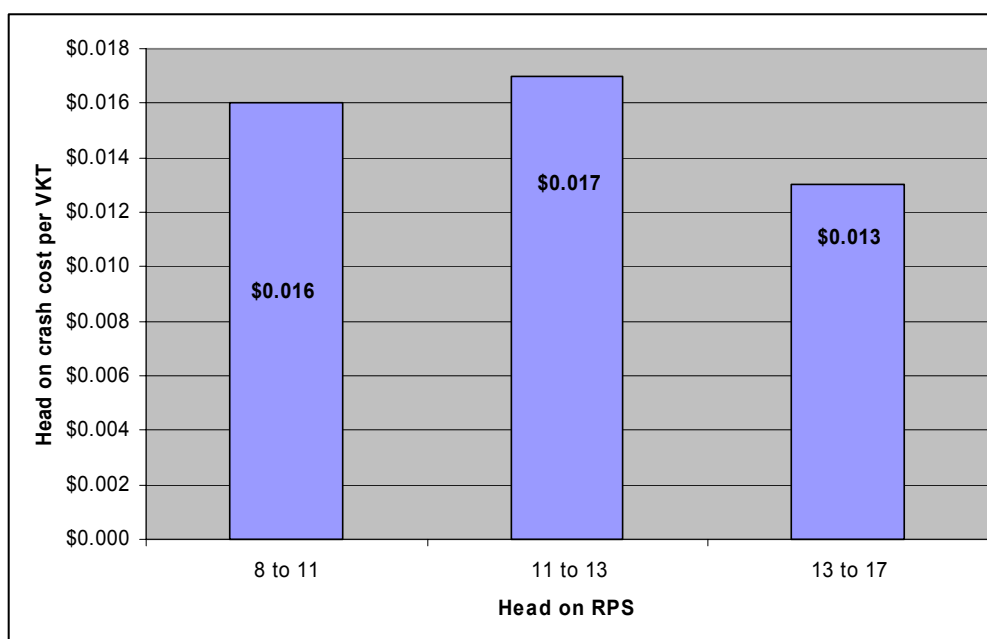
- Run-off road RPS scores of two and above are generally present when there is some form of hazard in the roadside and the outcome of an errant vehicle may be impacted more by the exact location of the run-off road crash and the circumstances of the crash (e.g. did the vehicle roll, vehicle type, seat-belts and exactly where a vehicle struck an object).

AusRAP has recently decided to make changes to the Star Rating model which are expected to better define roadside hazards in relation to run-off road RPS. These changes include a move from homogeneous rating to continuous rating<sup>2</sup> and the inclusion of a specific rating category for steel safety barriers. A review of the relationship between any adjusted RPS and crash costs is recommended following any subsequent rating of the AusLink networks.

### 3.3.2 Head-on RPS

The head-on road RPS was grouped into ranges and the crash costs associated with head-on road crashes only were determined for each homogeneous section. The results of the analysis are detailed in Figures 8 and Table 7 below.

**Figure 8 Head-on crash cost per VKT by head-on RPS**



There were no roads in the 0 to 8 category as the minimum score possible for head-on RPS is greater than 8.2. It is noted that the head-on RPS equals zero for divided carriageway roads.

The head-on RPS category between 13 and 17 is expected to exhibit the highest head-on crash cost per vehicle kilometre travelled. However, the results indicate that the

<sup>2</sup> The homogeneous rating method requires raters to segregate roads into sections that are of consistent design along their length (eg all divided). These sections are then individually rated. The continuous rating approach means roads are simply segregated at 100m intervals and then these short sections are rated separately. This continuous rating method is likely to produce more reliable and repeatable ratings than the homogeneous method.

lowest head-on crash cost per vehicle kilometre travelled was recorded on sites with the worst head-on RPS.

Following this result the individual records for each homogeneous section were reviewed to identify a possible explanation for this relationship. It was discovered that roads in the 13 to 17 range for head-on RPS typically had poor alignment with poor overtaking opportunities and medium to high volume. Therefore a possible explanation could be that overtaking facilities are so poor that motorists do not attempt to overtake and therefore the head-on crash cost is less than expected. This outcome requires review in relation to the desired purpose of the AusRAP model (as a communication tool and not a crash prediction tool), and whether changes in the model are warranted.

**Table 7 Head-on crash cost per VKT by head-on RPS**

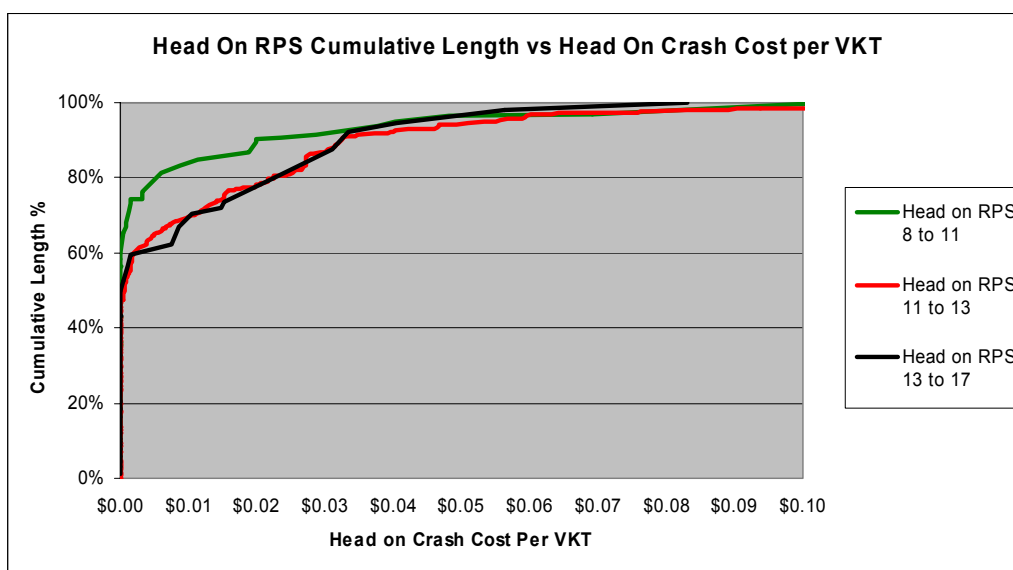
| RPS      | Number of Records | Length of Road (km) | Annual VKT    | Annual Crash Cost (\$) | Crash Cost per VKT (\$) |
|----------|-------------------|---------------------|---------------|------------------------|-------------------------|
| 8 to 11  | 80                | 568                 | 416,637,677   | \$ 6,483,962           | \$ 0.016                |
| 11 to 13 | 366               | 3599                | 2,588,833,291 | \$ 45,140,143          | \$ 0.017                |
| 13 to 17 | 36                | 221                 | 190,192,595   | \$ 2,484,532           | \$ 0.013                |

Note: refer to Appendix A for the distribution of individual section results in relation to cumulative vehicle kilometres travelled.

In terms of the length of road within the various RPS categories (refer Figure 9), the lowest head-on RPS range of 8 to 11 exhibited the highest proportion of road length (approximately 60%) where no head-on crashes were observed (refer figure 8 below).

With significant sections with no head-on crash costs the results are heavily influenced by the magnitude of crash costs per VKT occurring on a relative low proportion of the length (and cumulative VKT). Locations accounting for 3% of the VKT accounted for 25% of the crash costs per VKT for the RPS range. As a result, the distributions – and thus the general result - can alter significantly with only a relatively small change in the number of head-on crashes.

**Figure 9 Distribution of homogeneous sections by head-on RPS and head-on crash cost per VKT**

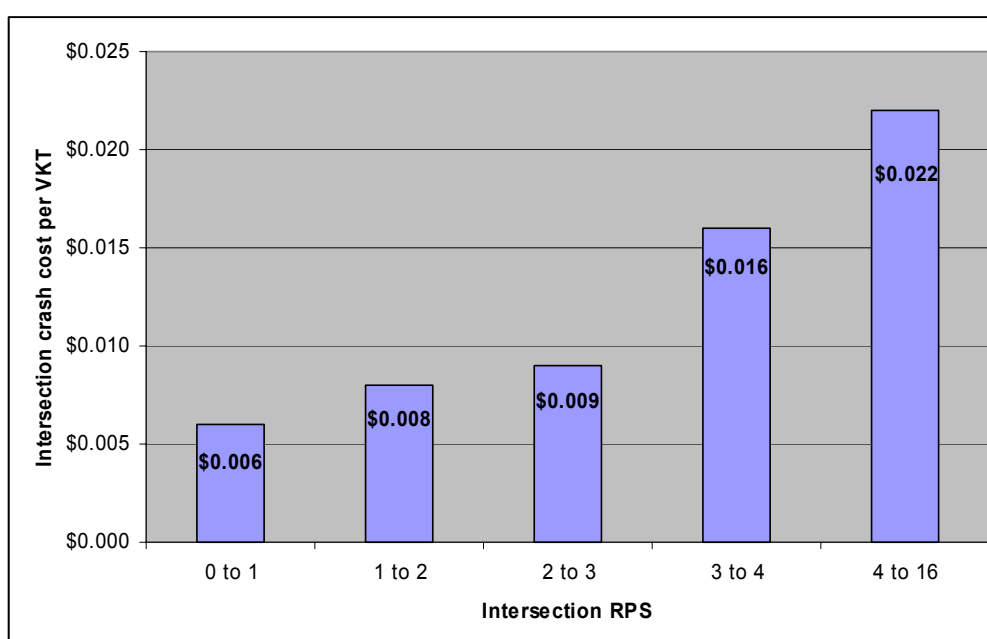


### 3.3.3 Intersection RPS

For the purpose of this study the intersection RPS refers to the total RPS attributable to intersections within a homogeneous section. That is, they are not individual intersection RPS values but the collective intersection RPS within each homogeneous section. This RPS is then related to the sum total of intersection crash costs within the homogeneous section being considered.

Figure 10 shows the intersection crash cost per VKT by intersection RPS. The graph shows that as the intersection RPS increases the intersection crash cost per VKT also increases.

**Figure 10** Intersection crash cost per VKT by intersection RPS



The detailed results are provided in Table 8 below.

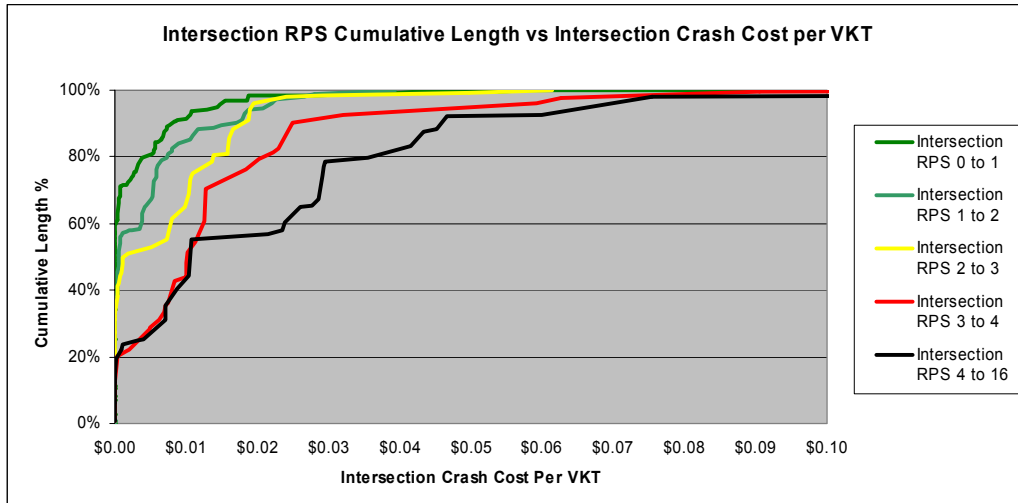
**Table 8** Intersection crash cost per VKT by intersection RPS

| RPS     | Number of Records | Length of Road (km) | Annual VKT    | Annual Crash Cost (\$) | Crash Cost per VKT (\$) |
|---------|-------------------|---------------------|---------------|------------------------|-------------------------|
| 0 to 1  | 161               | 1986                | 3,501,188,368 | \$ 22,165,489          | \$ 0.006                |
| 1 to 2  | 89                | 711                 | 1,256,232,331 | \$ 10,139,384          | \$ 0.008                |
| 2 to 3  | 56                | 337                 | 576,319,778   | \$ 5,212,877           | \$ 0.009                |
| 3 to 4  | 35                | 185                 | 432,437,111   | \$ 6,741,639           | \$ 0.016                |
| 4 to 16 | 38                | 173                 | 352,863,102   | \$ 7,873,784           | \$ 0.022                |

Note: refer to Appendix A for the distribution of individual section results in relation to cumulative vehicle kilometres travelled.

The general shape of the cumulative distributions (see Figure 11) align with expectations with a higher proportion of road sections with no intersection crashes (zero cost) on road sections with lower intersection RPS values. In general, the road sections with higher RPS contributions from intersections experienced higher intersection crash costs.

**Figure 11** Distribution of homogeneous sections by intersection RPS and intersection crash cost per VKT



## 4 Conclusion

The analysis undertaken confirms our expectation of a relationship between the Star Ratings and crash costs per VKT. The primary analysis revealed the following result:

- average crash costs of \$0.027 per vehicle kilometre travelled on 4 star roads;
- average crash costs of \$0.050 per vehicle kilometre travelled on 3 star roads; and
- average crash costs of \$0.101 per vehicle kilometre travelled on 2 star roads.

There was also a relationship between crash costs per VKT and Road Protection Score (RPS), as well two of the three RPS components. There was particularly marked relationship for the run-off road RPS which is the most significant contributor to the overall RPS.

It is noted that many aspects influence a crash outcome (including road conditions, driver, vehicle, speed, enforcement and emergency response issues) whereas the AusRAP RPS model focuses only on the road features. However, while the AusRAP model is not designed to be a crash prediction model, with the focus of the AusRAP model on measurement of the inherent safety of the engineering features of the road, the results nonetheless provide some validation of the safety ratings using the RPS.

Overall, the analysis provides a strong indication of the improvement in crash costs that can be expected as a road network improves from two star to three star to four star and ultimately a five star road. These results are expected to assist in further research being undertaken by AAA to investigate the expected economic costs and benefits of raising the AusLink network to a four star standard. AAA regards AusLink highways that are rated less than 4 stars as being unacceptable. The extension of the study to State road networks may also provide the opportunity to test the relationship further for two star and possibly one star roads.

## 5 References

McInerney, R., Affum, J., Callaghan, L., Taylor, S., Wix, R., Hansen, L. and Barlow, S. (2006) *AusRAP Star Rating and Road Protection Score Methodology* (QC71711 - Report 3), ARRB Group Brisbane.

Metcalf, J. and Smith, G. (October 2006). *Star Ratings: Australia's National Network of Roads*, Australian Automobile Association, Canberra.

Metcalf, J. and Smith, G. (October 2006). *Safer Roads Save Lives: Star Ratings For The AusLink National Network in NSW*, Australian Automobile Association, Canberra.

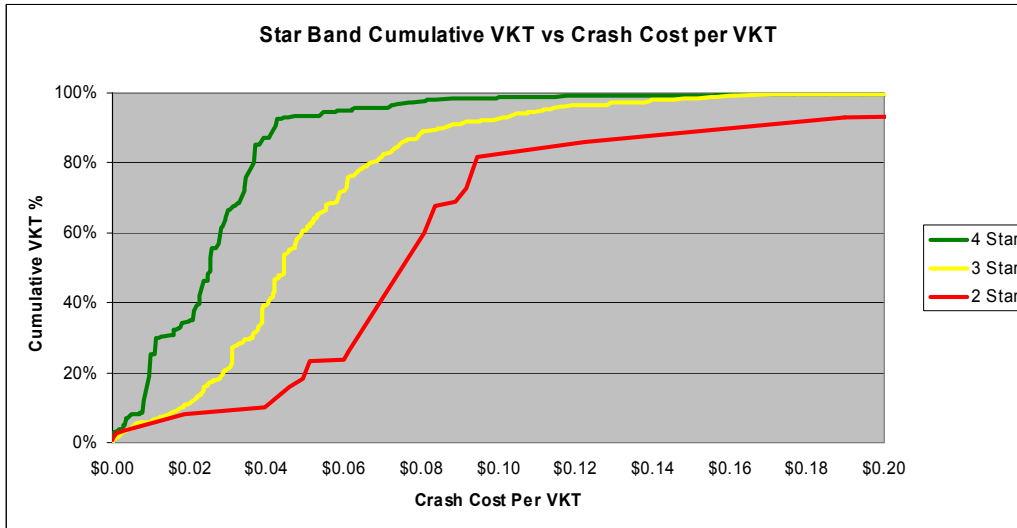
Metcalf, J. and Smith, G. (March 2005). *How safe are our roads? Rating Australia's National Highways for Risk*, Australian Automobile Association, Canberra.

Metcalf, J. and Smith, G. (November 2005). *How safe are our roads? Rating Australia's National Network for Risk*, Australian Automobile Association, Canberra.

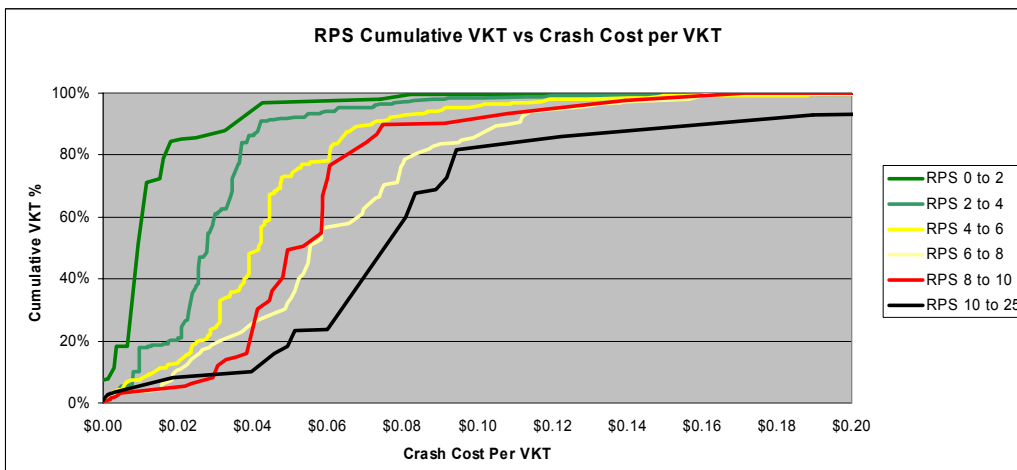
Metcalf, J. and Smith, G. (July 2007). *How safe are our roads? Rating Australia's National Network for Risk*, Australian Automobile Association, Canberra.

## Appendix A Cumulative VKT vs Crash Cost per VKT Charts

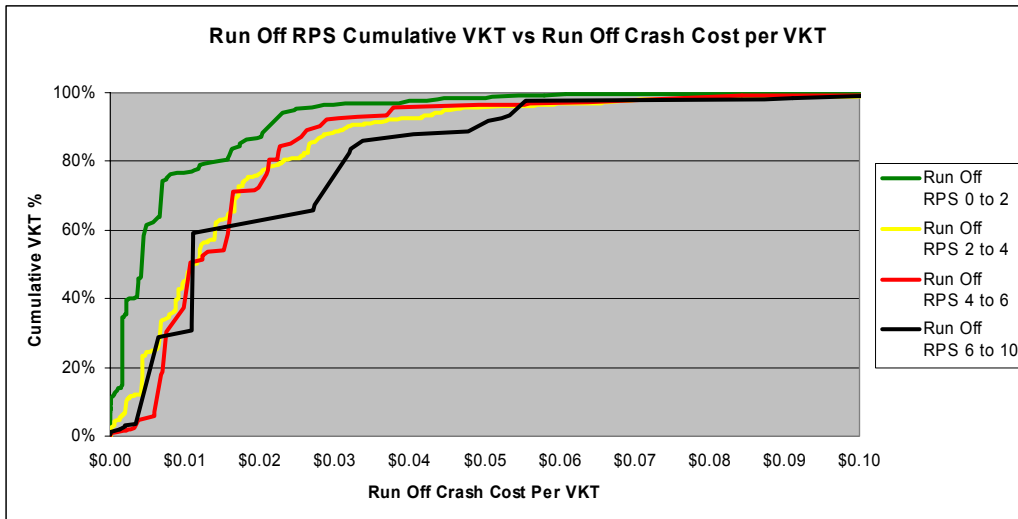
**Figure A1 Star Rating cumulative VKT vs crash cost per VKT**



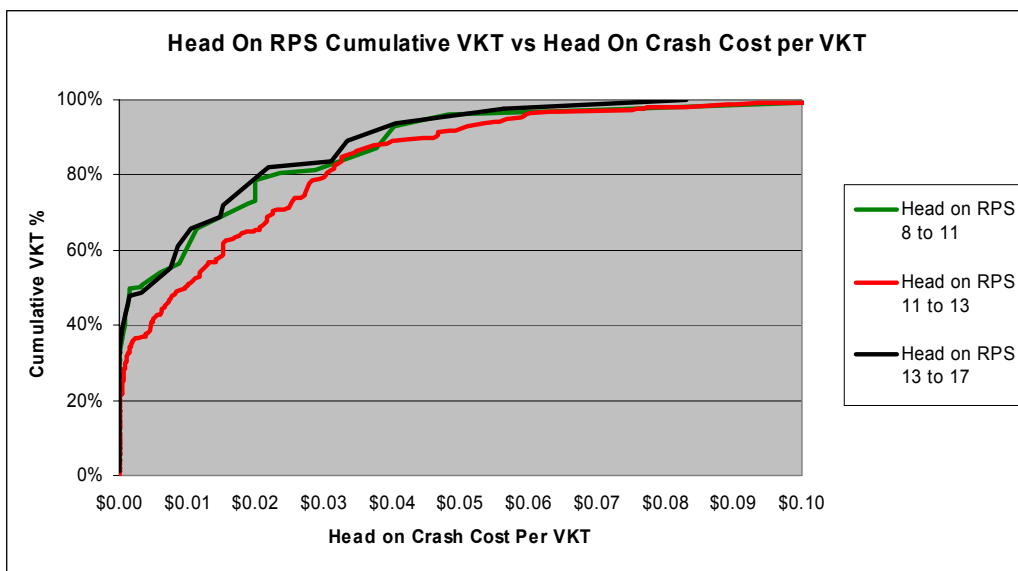
**Figure A2 RPS cumulative VKT vs crash cost per VKT**



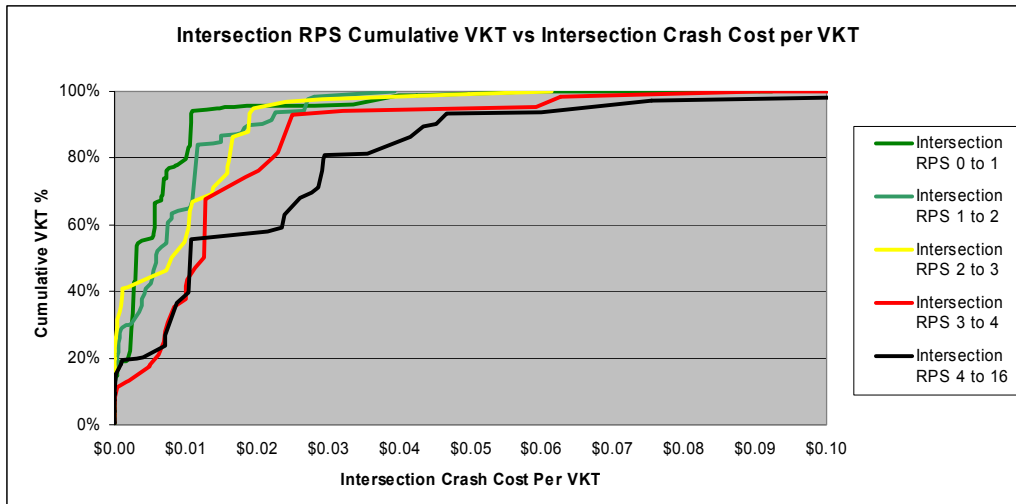
**Figure A3 Run-off road RPS cumulative VKT vs run-off road crash cost per VKT**



**Figure A4 Head-on RPS cumulative VKT vs head-on crash cost per VKT**



**Figure A5 Intersection RPS cumulative VKT vs intersection crash cost per VKT**

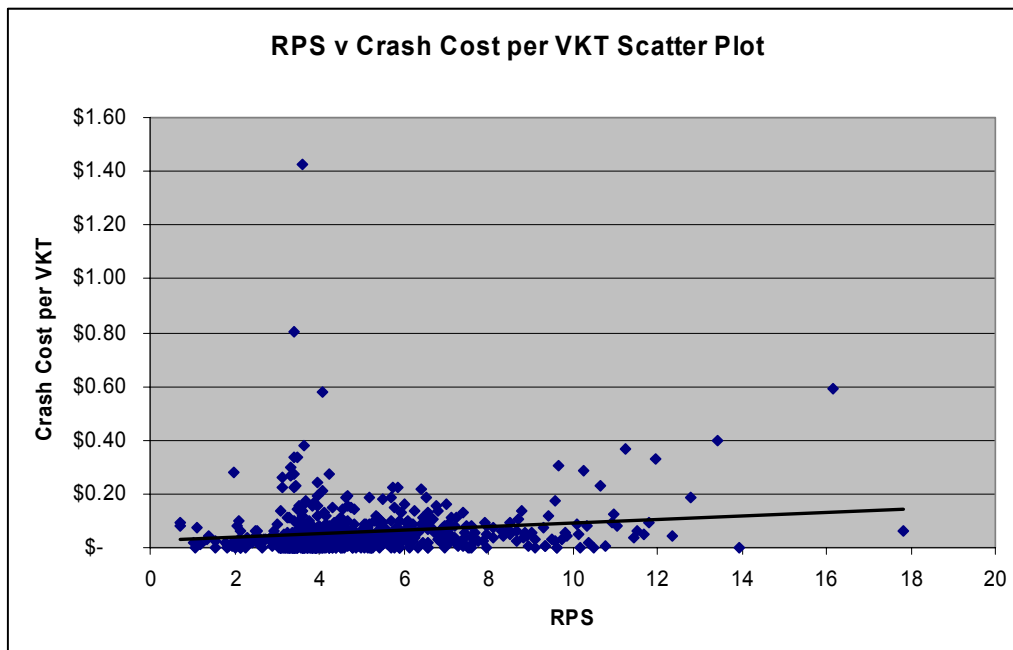


## Appendix B Alternate Research Methodologies

The ARRB research team undertook a detailed regression analysis to investigate the direct relationship (if any) between the RPS and crash costs. The approach focused on examining the relationship between RPS and crash costs per vehicle-kilometre travelled (VKT). This is based on the notion that any relationship between the RPS and crash outcomes is expected to be with crash costs per vehicle kilometre travelled as it accounts for both the number and severity of crashes as relevant to an individual road user.

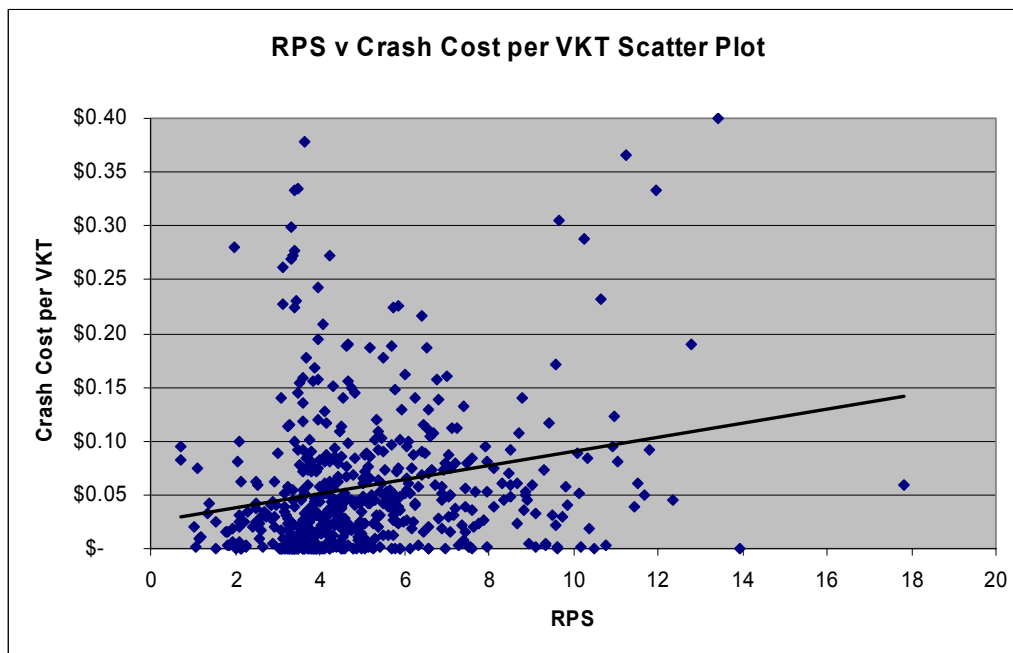
The analysis was undertaken on the data-set described in Section 2 of the report. The initial investigation focussed on the direct relationships between the raw RPS scores and crash costs per vehicle kilometre travelled on each homogeneous section. The scatterplot of the results is detailed in Figure B1 below.

**Figure B1 Relationship between cost of crashes per VKT and RPS (full data set)**



A closer examination of the data adjusting the Y-axis to a maximum crash cost per VKT of \$0.40 is detailed in Figure B2.

**Figure B2 Relationship between cost of crashes per VKT and RPS (part data set)**



A regression analysis on the data set was deemed inappropriate as there is a wide variation in the actual results from road section to section. This reflects the true nature of a crash event as a random multi-variable infrequent event. There is also a large number of individual sections where there is no crash history and as a result there is zero crash costs per VKT.

The project team reviewed the methodology following discussions with the EuroRAP teams where the approach has been to compare crash costs and RPS results over larger aggregated samples (such as the Star Rating bands). This approach forms the basis of the main body of this report. The cumulative distribution charts were added to the analysis to demonstrate the range of crash cost outcomes evident within each range of RPS values.