
# Identification and Evaluation of Engineering Solutions to Accident Reduction in North Queensland

**Lal Wadhwa**

*Associate Professor*
*James Cook University*

**Brian Handy**

*Civil Structural Engineer*
*BHP Engineering*

Abstract:

This study is directed towards the design of cost-effective engineering solutions for reducing accidents which have been identified to have been mainly caused by adverse road conditions Using the Queensland Department of Transport database PHYLAK, accident frequency, severity and circumstances (RUM numbers) have been analysed for all declared rural roads within the three northern Queensland districts of Townsville, Cairns and Mackay. Priority for remedial measures has been based on the road contributing accidents/km of link. A benefit/cost ratio has been calculated for each remedial measure for the selected links for each district. These measures have been ranked in descending benefit/cost ratio for funding priority.

Contact author:

Associate Professor L C Wadhwa
Department of Civil and Systems Engineering
James Cook University
TOWNSVILLE QLD 4811

Telephone (077) 814290 Fax: (077) 75 1184

## Introduction

It has been reported that road accidents in Australia cost the community an estimated six billion dollars annually (BTCE,1988). This figure is based on the financial cost of loss of life, emergency and recuperative services for the injured, pain and suffering of victims and families, property damage, and lost productivity. A reduction in accidents results in a direct benefit to the community, and it is therefore, important to implement effective measures for accident reduction. In order to reduce road accidents it is necessary to establish trends in accident location and circumstances surrounding the accidents so as to design the most effective strategies for reducing accidents and thus provide maximum benefit to the community in general.

The principal objectives of this study are as follows:

(i) identify sections of rural roads that have above average accident concentrations,
ii) determine trends in location or circumstance surrounding these accidents,
iii) design measures which may be implemented to reduce accidents along those sections,
iv) determine benefit/cost ratios in order to determine priority for implementation of remedial measures.

This study has been carried out for the Queensland Department of Transport districts 9, 11 and 8 based respectively in Townsville, Cairns and Mackay. The district boundaries are shown in Figure 1. The entire period for which data is available in the Department of Transport accident database is used in this study. This covers four years and eleven months from July 1984 to May 1989.

## Methodology

### Accident Classification

Many attempts have been made to devise a useful system for classification of accidents. This is a difficult task as a variable describing an accident must be able to

i) identify the vehicle manoeuvres that were indicated by the drivers
ii) describe factually what the vehicle manoeuvres actually were
iii) reflect directions of impacts received by vehicle or vehicles.

This is achieved by means of the Road User Movement (or RUM) system of numbers (Hutchinson, 1987) which uses 85 categories to describe the nature of an accident. These categories consist of ten groups of related circumstances. Major classification of RUM numbers are shown in Table 1.

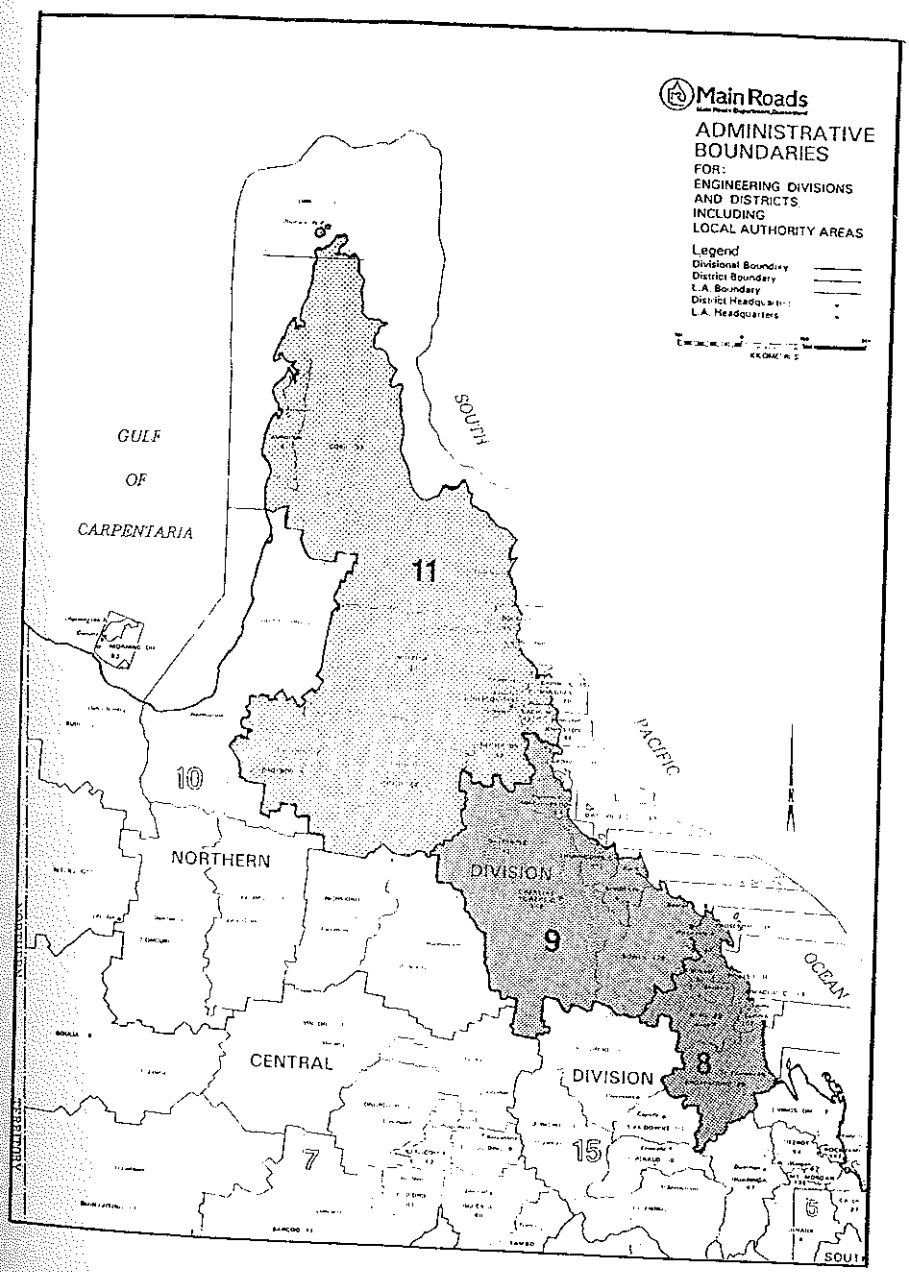


Figure One: District Boundaries

**Table 1 Accident classification by RUM numbers**

| | Accident category | RUM numbers |
|---|---|---|
| 1. | Pedestrians (on foot, in toy or pram) | 00 -> 09 |
| 2. | Vehicles from adjacent directions (intersections only) | 10 -> 19 |
| 3. | Vehicles from opposing directions | 20 -> 29 |
| 4. | Vehicles from same directions | 30 -> 39 |
| 5. | Manoeuvring | 40 -> 49 |
| 6. | Overtaking | 50 -> 59 |
| 7. | On Path | 60 -> 69 |
| 8. | Off Path on Straight | 70 -> 79 |
| 9. | Off Path on Curve | 80 -> 89 |
| 10 | Passengers and Miscellaneous | 90 -> 99 |

The complete list of RUM number classifications is shown in Appendix A.

PHYLAK database and dBASE III Plus

PHYLAK is an accident information database system developed for the Queensland Department of Transport by consultants Cameron McNamara in 1988. The system provides a convenient repository of all information on accidents reported by the Police Department. The road accident data feeding PHYLAK is obtained from police accident records (Police forms PT51) which are computerised by the Australian Bureau of Statistics (ABS). One of the distinguishing features of PHYLAK is the accurate location of each accident. This is done by specifying the link in the road section where the accident occurred and the distance from the beginning of the link to the exact accident location (+/- 10m). This degree of accuracy enables useful information to be generated about the road system and assists in designing road improvement strategies (engineering solutions) to reduce accidents.

dBASE III Plus, a general-purpose spreadsheet program, is used to manage the stored data on traffic accidents. It enables data to be retrieved, displayed, rearranged, and analysed. This allows considerably more flexibility for data analysis than that available with PHYLAK. Data for each accident is contained in one record with 99 fields of information e.g. accident number, time, true date, severity, ARP (accident reference point), RUM number, etc. Fields of particular interest can be selected and displayed on the screen or printed. Searches can be carried out for either a particular field expression (e.g. YEAR = "1988"), or combined with logical expressions for a more detailed analysis (e.g. YEAR = "1988" AND STREET 1 = "BRUCE" AND SEVERITY = "DEAD"). Useful also is the facility where records can be simply summed, averaged, or counted, rather than just displayed, for a particular search condition.

## Accident concentration

When undertaking any type of accident research, it is important to examine accident location and concentration. The most useful way to describe accident location is generally in terms of links and more specifically in terms of distance from the start of a link. Determining accident concentrations along a link is more complex due to differences in the length of each link and the traffic volumes using them. These factors are combined in terms of vehicle kilometre (vkm) where

vehicle kilometre/day on a link = vehicles/day * link length (km)

This enables accident intensity to be represented in terms of travel task undertaken e.g. number of accidents/$10^8$ vkm. Another useful measure of accident concentration is the number of accidents per km of link. In both cases, links have been ranked in order of decreasing accident concentration and plotted onto maps to show the areas where accidents are concentrated. These maps have been adapted from the Queensland Department of Transport district maps.

## EPDO

Equivalent Property Damage Only (EPDO) is a method of weighting accidents of different severity (death, injury, property damage only). The relevant factors upon which the weightings are calculated are:

| | | |
|---|---|---|
| Minor Damage | = | 1 |
| Treatment | = | 2 |
| Hospitalisation | = | 3 |
| Death | = | 4 |

Total EPDO and EPDO/$10^8$vkm have been calculated to indicate the severity of accidents on each link.

## Road conditions and accidents

A useful parameter in the PHYLAK database identifies whether or not road conditions may have been the major cause of an accident.

A statistical analysis was carried out to determine whether or not the accidents where road conditions were not a contributing factor fall within the limits expected by chance. That is, to ascertain whether a hypothesis of randomness of these accidents can be rejected. The analysis of each section consisted of two tests:

i) the number of accidents/km of link above and below the average for the section

ii) the number of runs up and down.

If non-random influences are found to exist, a more detailed inspection of these accidents is necessary in order to identify recurring trends in accidents which are not related to the condition of the road. This is beyond the scope of study reported in this paper.

Remedial measures, costs and benefits

Remedial measures and their costs, projected benefits and effectiveness have been determined for those links which have greater than 1.5 times the average number of road contributing accidents/km of link. The proposed action is based upon the common groups of RUM numbers and/or recurring accident locations, which can be targeted by an engineering solution. Table 2 shows the expected service life for remedial measures employed, their initial and maintenance cost, as well as their service life.

The cost of accidents has been researched in detail by the Bureau of Transportation and Communication Economics (BTCE) and the Federal Office of Raod Safety (FORS). Their methods have been employed to update accident cost estimates for 1990. These estimates are shown in Table 3. Benefits for each remedial measure have been based upon the number of accidents targeted, cost of accidents (a function of severity) reduced, effectiveness of remedial measures and the time period for which measure is effective.

**Table 2 Estimated costs and expected life of remedial measures**

| Remedial measure | Service life (yrs) | Initial cost ($) | Maintenance cost ($/yr) |
|---|---|---|---|
| Signage | 5 | 600 | 30 |
| Street lighting | 10 | 30 000 | 6 000 |
| Railway crossing lights | 10 | 35 000 | 6 000 |
| Turning lanes | 10 | 15 000 | 1 500 |
| Intersection reconstruction | 10 | 100 000 | 10 000 |
| Lane widening (/km) | 20 | 200 000 | 25 000 |
| Dual carriageway construction (/km) | 30 | 1 800 000 | 54 000 |
| Bridge reconstruction | 30 | Varies | Varies |

**Table 3 Cost estimates for rural road crashes**

| Crash severity | Cost ($) |
|---|---|
| Fatality | 514 000 |
| Admitted to/treated at Hospital | 115 000 |
| Minor injury | 13 800 |
| Property damage only | 3 300 |

The effectiveness of the remedial measure is expressed as a percentage of accidents reduced based on Sanderson et al (1985). A discount rate of 8% has been adopted to determine the net present benefit of each remedial measure.

Application of the proposed methodology

Figure 2 shows a flowchart of the methodology followed. This methodology has been applied to analyse accident occurrences in the three districts in Northern Queensland and to propose cost-effective engineering solutions for reducing accidents on declared rural roads in these districts. The next three sections describe this application.

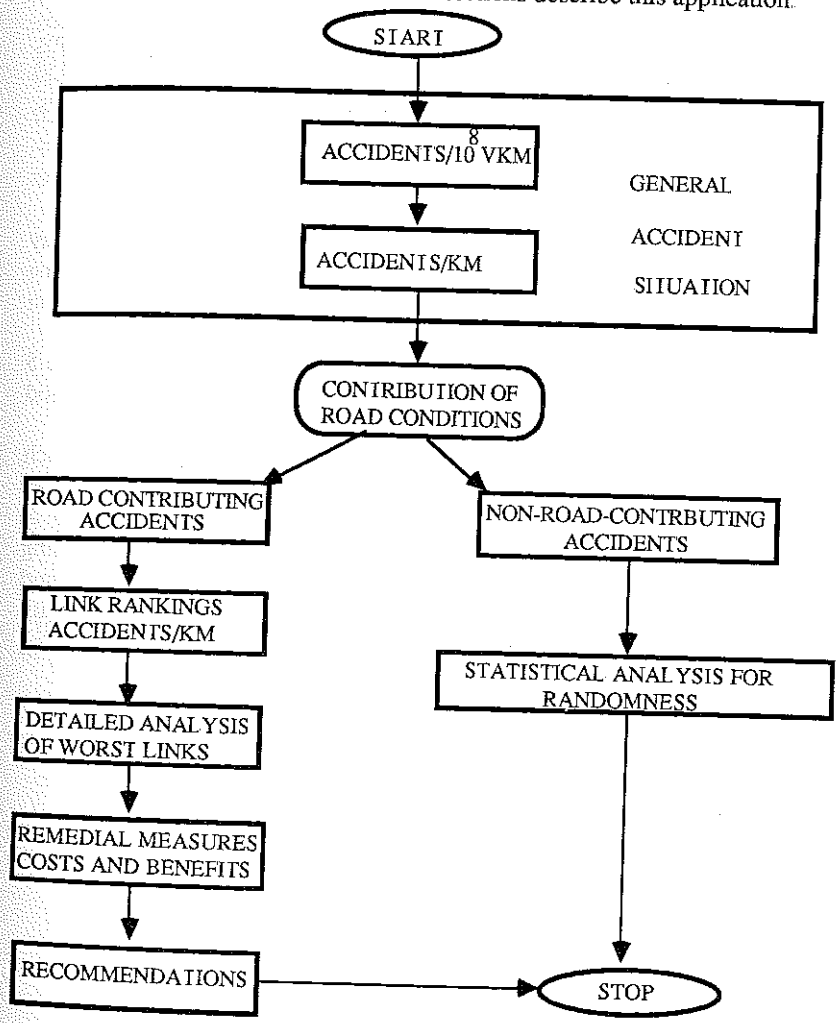


**Figure 2 Methodology used in this study**

Engineering solutions are proposed for each site (with accident intensity greater than 1.5 times the district average) based on an analysis of the nature and recurrence of accident types as revealed by the RUM number distribution. For example, the obvious engineering solution for a site with predominance of right rear accidents (RUM 32) would be the provision of a right turn lane.

## Accident analysis and engineering solutions for Townsville district

Townsville district (Queensland Transport district 9) includes eight local authorities covering an area of 59,100 sq.km. These are Bowen, Dalrymple, Burdekin, Hinchinbrook, and Cardwell Shires and three cities of Charters Towers, Townsville and Thuringowa.

Major roads in this district include the Bruce Highway, Flinders Highway, Gregory Developmental Roadand Bowen Developmental Roads. This amounts to 450 km of National Highways, 463 km. of National Arterials and 539 km. of Rural Arterials

### Accident analysis

The annual number of accidents in the district has varied from 319 to 365 during the study period. The majority of accidents resulted in only minor injury or property damage. One in four accidents resulted in hospitalisation and one in twenty was fatal. This is shown in Figure 4.

Accident circumstances, described by RUM numbers are classified in Figure 5 which shows that over 44 per cent of accidents that occured during the study period involved vehicles travelling off the path (or pavement) on either straights or curves.

The randomness of non road attributable accidents is shown in Figure 6 which clearly demonstrates that there is no evidence to reject the hypothesis of a random distribution of non road contributing accidents over the 60 links on the Bruce Highway in the Townsville district. Accident concentrations on various links were analysed by using EPDO/$10^8$ vkm and accidents/km. The first measure relates accidents to travel task and the second to length of the link. A summary of the analysis, showing the ten links with the highest concentration, is given in Table 4.

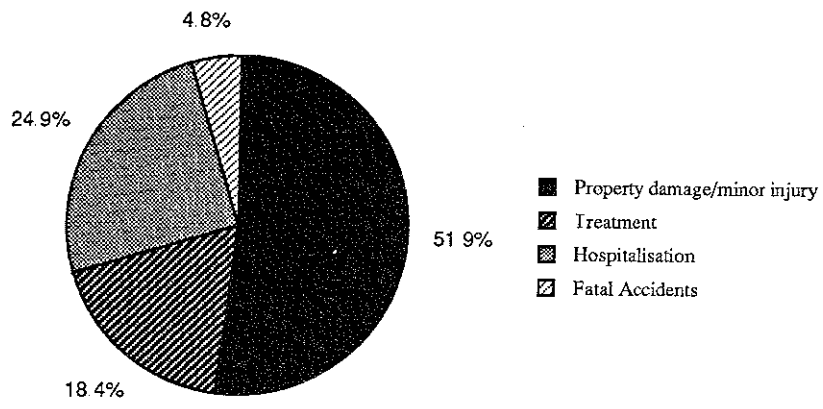


**Figure 4 Accident severity in the Townsville district**

Engineering solutions and their evaluation

Based on the circumstances surrounding road-related accidents (as shown by RUM number distribution for each link), engineering solutions have been proposed and evaluated for all links with an accident intensity of greater than 1.5 times the district average of 0.77 road contributing accidents per km. of link. It will be noticed that no solution has been proposed for link 010K/03 (a 6.8 km link of Bruce Highway between Bowen and Ayr). This is due to the fact that no single road characteristic appears to be the dominant cause of accidents as evidenced by the accidents' RUM numbers, and, therefore, no single solution is likely to be cost effective. Table 5 shows the ranking of various engineering solutions applicable in the Townsville district based on benefit/cost ratio. Eight solutions have benefit/cost ratio of greater than one.

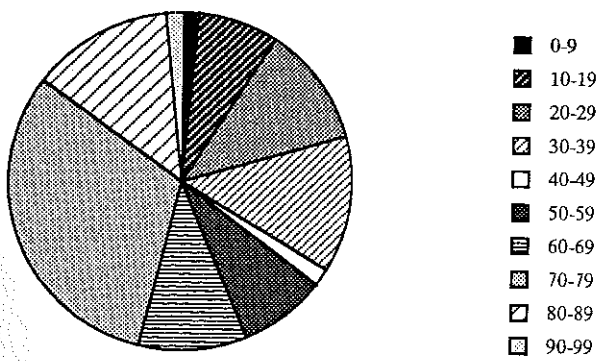


**Figure 5 Accident circumstances (RUM numbers) in the Townsville district**

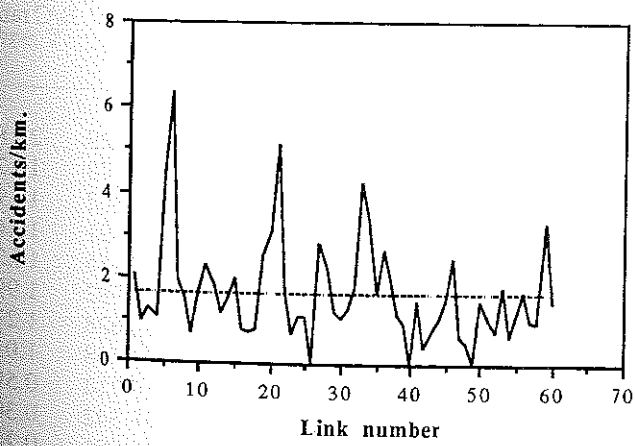


**Figure 6 Randomness of non-road-contributing accidents in the Townsville district**

**Table 4 Links with high accident rates in Townsville district**

| Rank | Accidents/$10^8$vkm | | | Accidents/km | | |
|---|---|---|---|---|---|---|
| | Link | Acc./$10^8$vkm | Severity ratio | Link | Acc./km | Intensity |
| 1 | 6106/01 | 385.51 | 2.22 | 010K/01 | 5.82 | 7.56 |
| 2 | 088B/01 | 306.72 | 1 83 | 010K/01 | 5.63 | 7.31 |
| 3 | 5407/07 | 248.37 | 1.89 | 014A/11 | 3.75 | 4.87 |
| 4 | 083A/05 | 201.77 | 2.20 | 010L/01 | 1.95 | 2.53 |
| 5 | 5407/02 | 193.54 | 2.00 | 010N/06 | 1.77 | 2.30 |
| 6 | 010N/01 | 167.44 | 1.50 | 010K/06 | 1.62 | 2.10 |
| 7 | 014A/11 | 158.33 | 2.25 | 010K/03 | 1.32 | 1.71 |
| 8 | 010K/02 | 145.46 | 1.57 | 010N/04 | 1.26 | 1.64 |
| 9 | 5407/06 | 144.22 | 2.00 | 010N/15 | 1.22 | 1.58 |
| 10 | 5407/03 | 114.61 | 1.60 | 010K/04 | 1.18 | 1.53 |

## Accident analysis and engineering solutions for Cairns district

Cairns district (Queensland Transport district 11) includes twelve local authorities covering an area of 122,600 sq.km. These are Douglas, Mareeba, Atherton, Eacham, Herberton, Johnstone, Mulgrave, Etheridge, Croyden, Cook and Torres shires and the city of Cairns.

**Table 5 Engineering solutions for Townsville district**

| Link | Action | Cost ($) | Accidents targetted | Effectiveness (%) | Benefits ($) | B/C ratio |
|---|---|---|---|---|---|---|
| 010L/01 | Stop sign | 750 | 2 | 65 | 17 129 | 22.8 |
| 010K/01 | Intersection reconst. | 200 000 | 9 | 40 | 3 248 978 | 16.2 |
| 010N/06 | Bridge reconst. | 1 480 000 | 7 | 100 | 4 032 362 | 10.9 |
| 010M/04 | Right turn lane | 30 000 | 2 | 40 | 317 491 | 10.6 |
| 010L/01 | Intersection reconst. | 200 000 | 7 | 40 | 2 032 155 | 10.2 |
| 014A/11 | Lane widening | 3 010 000 | 22 | 25 | 5 974 992 | 1 99 |
| 010K/06 | Lane widening | 1 680 000 | 7 | 25 | 2 132 628 | 1.27 |
| 010N/15 | Lane widening | 840 000 | 3 | 25 | 846 768 | 1 01 |
| 010K/02 | Right turn lane | 30 000 | 2 | 64 | 17 714 | 0.59 |
| 010K/02 | Flash Lights | 95 000 | 2 | 64 | 28 342 | 0.30 |
| 010K/04 | Lane widening | 2 240 000 | 6 | 25 | 622 681 | 0.28 |

Major roads in this district include the Bruce Highway, Captain Cook Highway, Palmerston Highway, Kennedy Highway, Gulf Developmental Road, Burke Developmental Road, parts of Gregory Developmental Road and the Kennedy Developmental Road. This amounts to 105 km of National Highways, 333 km of National Arterials and 334 km of Rural Arterials.

## Accident analysis

The annual number of accidents in the district has varied from 359 to 489 during the study period. The majority of accidents resulted in only minor injury or property damage. One in four accidents resulted in hospitalisation and one in twenty was fatal. This is similar to accidents in the Townsville district. This is shown in Figure 7.

Accident circumstances, described by RUM numbers are classified in Figure 8 which shows that over 42 per cent of accidents that occured during the study period involved vehicles travelling off the path (or pavement) on either straights or curves.

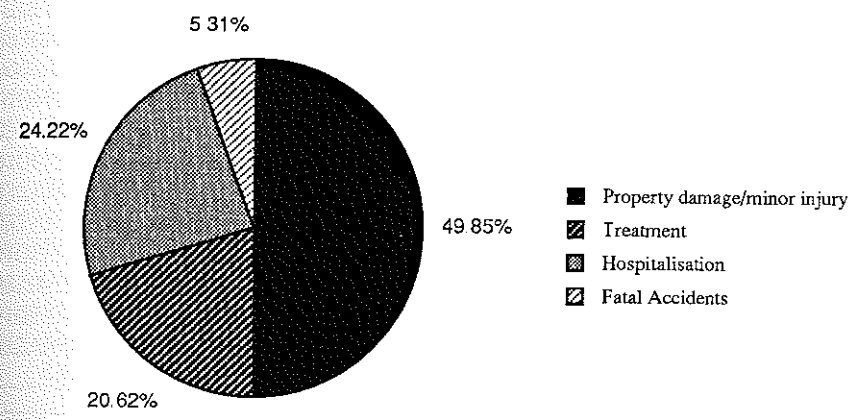


**Figure 7** Accident severity in the Cairns district

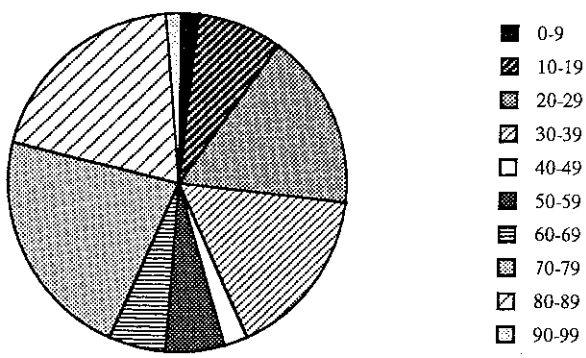


**Figure 8** Accident circumstances (RUM numbers) in the Cairns district

Accident concentrations on various links were analysed by using EPDO/$10^8$ vkm and accidents/km. The first measure relates accidents to travel task and the second to length of the link. A summary of the analysis, showing the ten links with the highest concentration, is given in Table 6.

Engineering solutions and their evaluation

Based on the circumstances sorrounding road-related accidents (as shown by RUM number distribution for each link), engineering solutions have been proposed and evaluated for all links with an accident intensity of greater than 1 5 times the district average of 1 44 road contributing accidents per km. of link

**Table 6 Links with high accident rates in Cairns district**

| Rank | Accidents/$10^8$vkm | | | Accidents/km | | |
|---|---|---|---|---|---|---|
| | Link | Acc./$10^8$vkm | Severity ratio | Link | Acc./km | Intensity |
| 1 | 092B/01 | 632.94 | 2.25 | 020A/05 | 13.33 | 9.24 |
| 2 | 6471/02 | 525.79 | 2.20 | 0647/06 | 7.53 | 5.22 |
| 3 | 091A/02 | 524.38 | 2.57 | 032A/07 | 7.20 | 4.99 |
| 4 | 090C/01 | 501.65 | 2.11 | 032A/02 | 6.60 | 4.57 |
| 5 | 090D/03 | 498.56 | 1.71 | 010P/17 | 5.44 | 3.77 |
| 6 | 090D/01 | 484.34 | 2.00 | 032A/03 | 5.20 | 3.60 |
| 7 | 0627/03 | 481.85 | 2.57 | 032A/04 | 4.41 | 3.60 |
| 8 | 0653/05 | 386.12 | 2.38 | 010P/08 | 4.21 | 2.92 |
| 9 | 0204/12 | 352.15 | 3.25 | 032A/01 | 3.86 | 2.68 |
| 10 | 092B/07 | 350.16 | 2.33 | 010P/07 | 3.83 | 2.65 |

Table 7 shows the ranking of various engineering solutions applicable in the Cairns district based on benefit/cost ratio. Twelve solutions have benefit/cost ratio of greater than one and six of these have a benefit/cost ratio greater than four

## Accident analysis and engineering solutions for Mackay district

Mackay district (Queensland Transport district 8) includes seven local authorities covering an area of 43,700 sq.km. These are Broadsound, Nebo, Mirani, Sarina, Mackay, Poineer and Proserpine shires

Major roads in this district include the Bruce Highway, Peak Downs Highway, Sutter and Fitzroy Developmental Roads, and Shute Harbour Road. This amounts to 340 km. of National Highways, 313 km. of National Arterials and 577 km. of Rural Arterials.

**Table 7 Engineering solutions for Cairns district**

| Link | Action | Cost ($) | Accidents targetted | Effectiveness (%) | Benefits ($) | B/C ratio |
|---|---|---|---|---|---|---|
| 020A/07 | Signage | 750 | 6 | 35 | 921 121 | 1228 |
| 020A/05 | Right turn lane | 30 000 | 5 | 40 | 1 243 393 | 41.4 |
| 0647/06 | Right turn lane | 30 000 | 5 | 40 | 643 838 | 21.5 |
| 032A/04 | Right turn lane | 30 000 | 2 | 40 | 617 268 | 20.6 |
| 020A/07 | Light instl. | 90 000 | 4 | 30 | 701 069 | 7.79 |
| 020A/07 | Lane widening | 1 000 000 | 5 | 25 | 4 349 197 | 4.35 |
| 032A/01 | Lane widening | 250 000 | 5 | 25 | 614 582 | 2.46 |
| 010P/08 | Lane widening | 2 000 000 | 15 | 25 | 3 679 391 | 1.84 |
| 032A/11 | Lane widening | 900 000 | 7 | 25 | 1 453 250 | 1.61 |
| 0663/03 | Lane widening | 1 100 000 | 9 | 25 | 1 652 057 | 1.50 |
| 010N/24 | Lane widening | 600 000 | 5 | 25 | 862 967 | 1.44 |
| 032A/04 | Lane widening | 500 000 | 7 | 25 | 622 681 | 1.25 |
| 010P/17 | Reconstruct hwy | 7 040 000 | 15 | 25 | 2 900 447 | 0.41 |
| 032A/03 | Reconstruct hwy | 6 160 000 | 13 | 25 | 1 671 350 | 0.27 |
| 032A/07 | Reconstruct hwy | 16 720 000 | 28 | 25 | 2 732 566 | 0.16 |
| 010P/16 | Reconstruct hwy | 6 600 000 | 11 | 25 | 973 252 | 0.15 |
| 032B/15 | Reconstruct hwy | 10 560 000 | 3 | 25 | 1 034 611 | 0.10 |
| 010P/07 | Reconstruct hwy | 12 760 000 | 20 | 25 | 1 238 981 | 0.10 |
| 032A/02 | Reconstruct hwy | 2 068 000 | 30 | 25 | 929 400 | 0.04 |

## Accident analysis

The annual number of accidents in the district has varied from 214 to 278 during the study period. Almost one half of accidents resulted in only minor injury or property damage. A higher rate of accidents resulted in hospitalisation in Mackay district (29 per cent) compared to Cairns and Townsville districts. One in twenty accidents was fatal. This is shown in Figure 9.

Accident circumstances, described by RUM numbers are classified in Figure 10 which shows that a large proportion of accidents 46 per cent) that occured during the study period involved vehicles travelling off the path (or pavement) on either straights or curves.

Accident concentrations on various links were analysed by using EPDO/$10^8$ vkm and accidents/km. The first measure relates accidents to travel task and the second to length of the link. A summary of the analysis, showing the ten links with the highest concentration, is given in Table 8

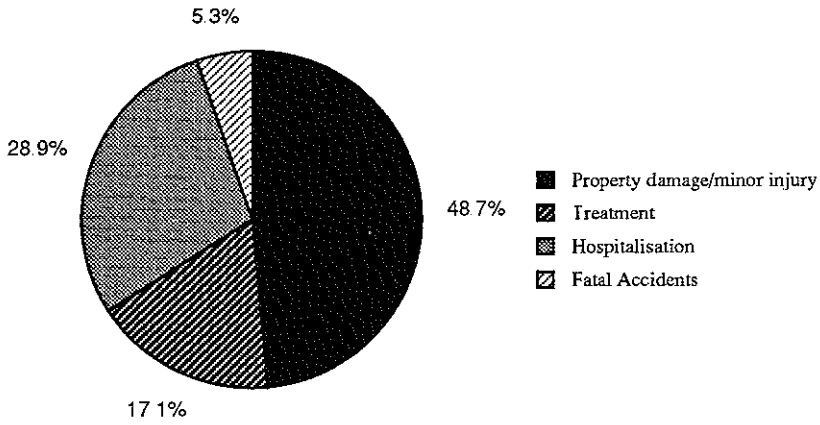


**Figure 9 Accident severity in the Mackay district**

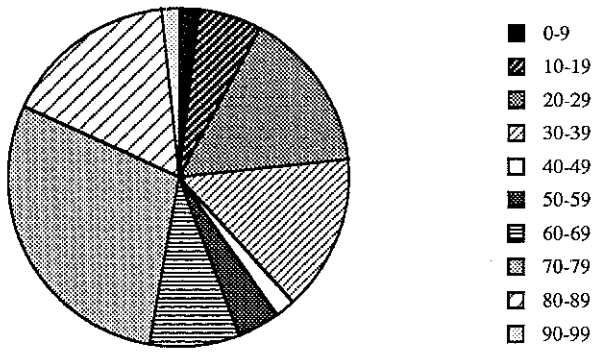


**Figure 10 Accident circumstances (RUM numbers) in the Mackay district**

Engineering solutions and their evaluation

Based on the circumstances sorrounding road-related accidents (as shown by RUM number distribution for each link), engineering solutions have been proposed and evaluated for all links with an accident intensity of greater than 1.5 times the district average of 0.88 road contributing accidents per km. of link. This occured on six links. It will be noticed that no solution has been proposed for link 0106/21 ( a 760m link of Bruce Highway between St Lawrence and Mackay). This is due to the fact that no single road characteristic appears to be the dominant cause of accidents as evidenced by the accidents' RUM numbers, and, therefore, no single solution is likely to be cost effective

**Table 8 Links with high accident rates in Mackay district**

| Rank | Accidents/$10^8$vkm | | | Accidents/km | | |
|---|---|---|---|---|---|---|
| | Link | Acc./$10^8$vkm | Severity ratio | Link | Acc./km | Intensity |
| 1 | 5307/03 | 441.90 | 2.20 | 0851/04 | 9.49 | 10.76 |
| 2 | 010H/14 | 427.36 | 1.43 | 010H/11 | 3.72 | 4.22 |
| 3 | 8509/02 | 323.95 | 2.13 | 0857/04 | 2.67 | 3.03 |
| 4 | 5307/05 | 181.96 | 1.40 | 010G/21 | 2.63 | 2.98 |
| 5 | 010H/18 | 150.37 | 2.33 | 0851/05 | 1.85 | 2.10 |
| 6 | 085C/06 | 128.12 | 1.14 | 033B/15 | 1.73 | 1.96 |
| 7 | 0516/01 | 119.31 | 2.17 | 010J/03 | 1.30 | 1.47 |
| 8 | 0851/04 | 101.98 | 2.74 | 010H/04 | 1.24 | 1.41 |
| 9 | 082A/03 | 101.85 | 1.00 | 010H/07 | 1.23 | 1.39 |
| 10 | 010H/11 | 98.92 | 1.52 | 010H/16 | 1.14 | 1.30 |

Table 9 shows the ranking of various engineering solutions applicable in the Mackay district based on benefit/cost ratio. Four solutions have benefit/cost ratio of greater than two.

**Table 9 Engineering solutions for Mackay district**

| Link | Action | Cost ($) | Accidents targetted | Effectiveness (%) | Benefits ($) | B/C ratio |
|---|---|---|---|---|---|---|
| 0857/04 | Lane widening | 350 000 | 3 | 25 | 1 277 761 | 3.65 |
| 0851/04 | Lane widening | 1 900 000 | 23 | 25 | 4 755 400 | 2.50 |
| 033B/15 | Lane widening | 250 000 | 5 | 25 | 588 810 | 2.36 |
| 010H/11 | Lane widening | 1 500 000 | 18 | 25 | 3 476 167 | 2.32 |
| 0851/05 | Lane widening | 33 000 000 | 12 | 25 | 2 649 934 | 0.08 |

## Discussion and conclusions

The objective of this study has been to design cost-effective engineering solutions for reducing accidents which have been identified to have been mainly caused by adverse road conditions. Using the Department of Transport database PHYLAK, accident frequency, severity and circumstances (RUM numbers) have been analysed for all declared rural roads within the three northern Queensland districts of Townsville, Cairns and Mackay. Links involving accidents in which the major cause may have been due to

road conditions have been ranked in terms of accidents/km of link in order to determine priority for links where action to reduce the high accident concentrations is necessary. It was decided that road contributing accidents/km of link was the most useful parameter on which to establish priority for remedial action. Accidents/$10^8$ vkm was not considered when determining remedial action priorities as this parameter would place undue emphasis on links with low traffic volumes and thus the benefits derived from remedial action would be enjoyed by relatively few. The district average for road contributing accidents/km of link was calculated over all links in the district. The intensity factor for each link was then calculated to determine accident intensity relative to the district as a whole. A more detailed analysis listing trends, remedial measures and costs was then carried out on those links with an intensity factor greater than or equal to 1.5. Costs include initial costs plus maintenance costs over the expected service life. The ex-post approach has been adopted to determine benefits from remedial measure implementation. A benefit/cost ratio has been calculated for each remedial measure for the links identified in accident analysis for each district. These measures have been ranked in descending benefit/cost ratio for funding priority.

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## Appendix A

RUM Number Classifications