"LEE Colin \(ENERGEX\)" <colinlee@energex.com.au>
21/01/2009 09:30 AM

To <mike.z.nenes@mainroads.qld.gov.au>
cc <karen.l.low@mainroads.qld.gov.au>
bcc
Subject Managing the Safety Risk of Power Poles

History: This message has been forwarded.

Hi Mike,

Please find the latest version of the report.

I have made changes to Sections 4 onwards. I have also include a flow chart showing the process.

<<Managing the Safety Risk of Power Poles in Road Corridors V3.doc>>

Regards,

Colin

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- Managing the Safety Risk of Power Poles in Road Corridors V3.doc

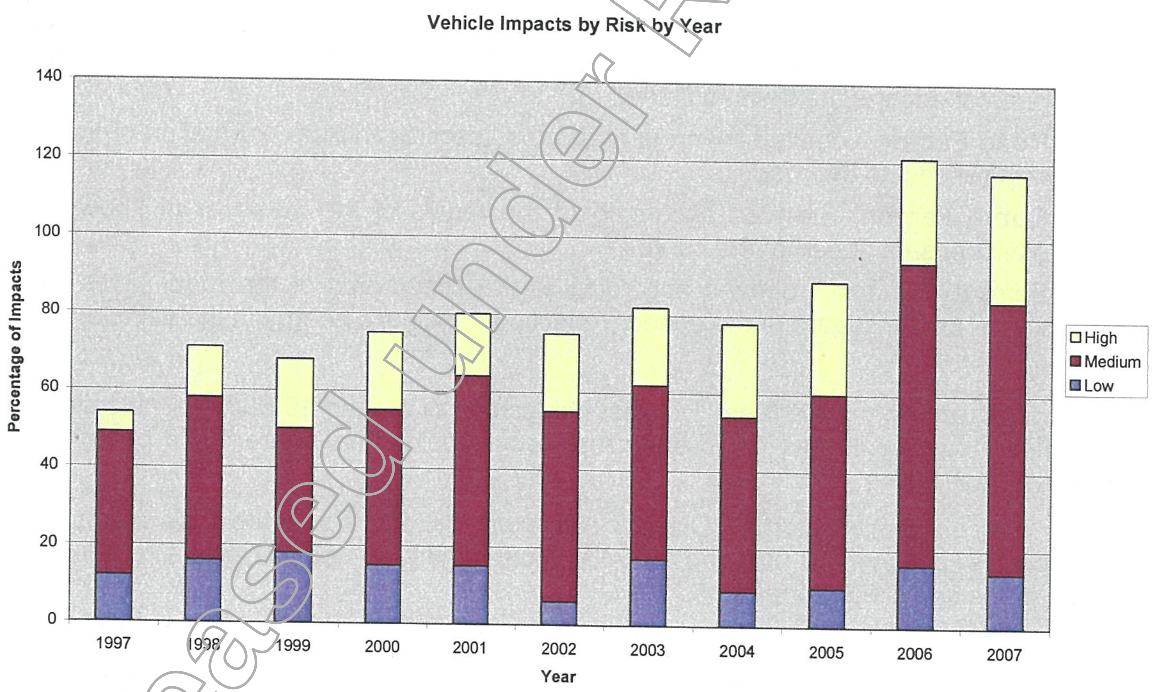
MANAGING THE SAFETY RISK OF POWER POLES IN ROAD CORRIDORS

1 BACKGROUND

The Queensland Department of Main Roads (DMR) and ENERGEX have embarked on a project to manage the risk associated with power poles located on DMR controlled road corridors.

The risk methodology adopted for the project is covered in the "Roadside Utility Poles – Road Design Note RDN 3-31" (RDN) issued by the Victorian Department of Main Road (VicRoads). This document provides a framework for the assessment of risk of poles to vehicle collision under a range of criteria. RDN further provides criteria for the determination of the cost-benefit of remedial measures against all the avoided costs of collision.

There has been observed an increasing trend with the number of vehicles impacting on power poles. An analysis of the number of vehicles which cause a high voltage (HV) outage on the ENERGEX has found an increasing trend over the last 10 years.



Note: The vehicle impacts do not take account of impacts on low voltage only poles or on HV poles which do not cause an outage.

Figure 1 Vehicle Pole Impacts which cause HV outage by Year

To address this increasing trend, DMR and ENERGEX have trialled the Vic Roads RDN on a number of pilot projects to assess how easy the methodology is to use, determine whether the risk levels are applicable for roads in south east Queensland and identify appropriate mitigation strategies to lower the risk.

DMR and ENERGEX are also endeavouring to obtain funding for this project as a significant road safety initiative in future programs of work.

2 RISK ASSESSMENT METHODOLOGY

The Victorian Department of Main Road (VicRoads) has developed a risk assessment methodology in the "Roadside Utility Poles – Road Design Note RDN 3-31" (RDN). The (RDN) defines a "Clear Zone" within which no poles or other obstructions should ideally be positioned. This ideal situation will not be met in practice in many situations, particularly urban situations.

The risk assessment procedure involves the determination of a number of factors which are applied to a formula to arrive at a *Risk Score* for the site. These factors are:

- **Daily** 2-way traffic volume
- **Offset Factor** – derived from a) the road speed limit and b) the offset which is the distance from the side of the pole nearest the road and the white line marking the nearest edge of the travelled lane
- **Road Factor** – derived from the road cross-section and the orientation of the pole with respect to the road
- **Curve Factor** – derived according to the radius of the curve or (if known) the advisory safe speed of the curve
- **Severity Factor** – derived according to the speed limit of the road. This factor varies as the square of the speed (reflecting the kinetic energy in the vehicle)

RDN goes further to state (Item 3.2) that risk scores of around 10 000 are indications of high risk, however it goes on to state that scores below this figure could benefit from improvement work.

There is also a process in the RDN for dealing with situations with high risk scores. The risk score of between 10 000 and 50 000 recommends the use of barriers or relocation of the poles to a Clear Zone.

Risk scores of greater than 50 000 suggest that undergrounding could be an option.

The Cost Benefit analyses of options to reduce risk are based on avoided cost of crashes against the cost of the remedy.

3 PILOT PROJECTS WHERE THE RISK ASSESSMENT WAS APPLIED

The risk assessment methodology was applied to 5 pilot projects involving 163 poles. The survey areas include sections of:

- Route 904, Lytton Road, Hemmant
- Route 904, Port Road, Lytton
- Route U19, Sandgate Road Clayfield
- Route U88, Sandgate Road Nundah
- Sandgate Road Albion (BCC owned road)

Bar charts showing the range of risk scores for the above roads are given in Appendix 1.

The surveys carried out and risk calculations revealed relatively low risk scorings (majority well below 10 000) on the sections of Route 904, which comprised suburban type roadways with relatively generous clearances and relatively minor work requirements if the criteria set in RDN were to be met.

Scorings on Routes U19 and U88 were considerably higher (with some poles above 40 000), being of high density, highly developed inner-city urban roadways with minimal clearances. The types of roadways potentially represent considerably greater costs and different options for treatment, up to and including undergrounding of overhead electrical systems.

These results suggest that a cost-benefit exercise for treatment options should be carried out on the higher-risk poles in the survey and the potential financial impact on DNR and ENERGEX be assessed.

4 RISK MANAGEMENT PROCESS

The risk management approach adopted for the high risk poles follows the process stages set out in AS/NZS 4360:2004 Risk Management (section 2) and ISO/DIS 31000-Risk Management (section 6) and illustrated in Figure .

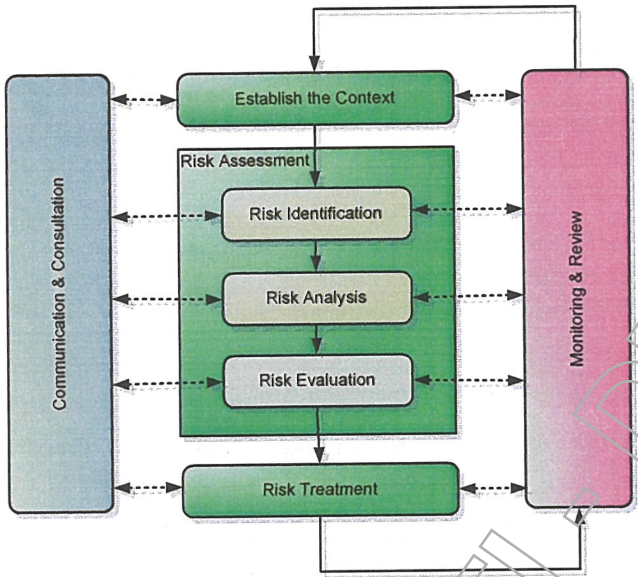


Figure 2 - Risk Management Process

Risk Analysis

In the AS/NZS 4360 framework, a Quantitative Risk is conducted by assessing the Consequence and Likelihood and then multiplying these 2 terms (QR = Consequence x Likelihood = C x L).

For the assessment of safety risk for vehicle impacts on power poles, a range of Likelihood and Consequence values needs to be identified.

The Vic Roads Risk Assessment methodology arrives at a risk score based on a number of factors with most affecting the Likelihood of an event. These factors are:

- Traffic Density
- Offset Factor
- Road Factor
- Curve Factor

The one factor which impacts on Consequence of the event is the Severity Factor or speed limit on the road.

The Vic Roads risk score has been correlated with the probability of a casualty crash and the range of Likelihood values are given in Table 1.

Table 1 – Range of Likelihood Values

Likelihood	Probability of Casualty Crashes	Vic Roads Risk Score
1	Once per 50 years	10,000

2	Once per 20 years	30,000
3	Once per 10 years	60,000

Using only the Vic Roads Severity Factor as the Consequence, the proposed mitigation actions to address the different levels of risk for the impact on power poles is given in Table 2.

Table 2 – Proposed Range of Mitigation Actions

Vic Roads Risk Score	Mitigation Action
< 30,000	No action considered
> 30,000 < 60,000	Derive BCR using simplified approach and monitor
> 60,000	Derive BCR using detailed approach and prioritise

It should be noted that the Consequence of a vehicle impact on a pole could range from a minor injury to a fatality. The factors which influence these Consequences are:

- Speed limit on road (severity factor from Vic Roads risk methodology)
- Size of the object (diameter of pole)
- Characteristic of the pole (frangible or slip base poles lower risk)

The size of the object and characteristic of the pole are not factored in the Vic Roads risk methodology. These factors however are factored in the more detailed Risk and BCR calculator which has been developed by the Main Roads – this will be discussed later.

4 MITIGATION ACTIONS AND CRASH REDUCTION FACTORS

The main mitigation actions to reduce the risk of the power poles have been identified as:

(1) Relocation of pole
(2) Installation of barrier
(3) Undergrounding a section of line

Relocating a pole outside the clear zone will allow 85% of errant drivers to recover control. There is still a risk of impact on the pole and the risk assessment methodology can assess the crash reduction factor for this mitigation treatment. Although pole relocations are a viable option, on most roads, there is not much scope for a relocation outside the clear zone unless the road authority is going through a process of property resumption on the same side of the road corridor as the poles.

The installation of a barrier can cause a reduction in casualty crashes by around 50% for a steel beam type guardrail to up to 90% for a wire rope barrier. The crash reduction factor for a barrier is the result of a reduction in the severity of the crash compared to that of a crash with a solid object such as a pole.

A crash reduction factor of almost 100% can be used if the lines are placed underground. However, because there are other roadside hazards, the undergrounding treatment will generally cause a crash reduction factor of 95%

Other long term measures which can be considered for reducing the risk of vehicle impacts are:

- Rationalize the number of poles on the road reserve (eg underground low voltage only so that the span lengths between poles can be increased)
- Road re-alignment (to reduce curve) and selective line marking and shoulder rumble strips

5 BENEFIT TO COST RATIO FOR TREATMENT OPTIONS – SIMPLIFIED PROCEDURE

The cost effectiveness of the various treatment options can be assessed using a Benefit to Cost Ratio (BCR). In the Vic Roads RDN (Appendix 3) there is a basic procedure outlined for determining the BCR which is given in Equation 1.

BCR = CC/yr * $CC * CRF * PWF / C ....Eqn 1

Where:

CC = the number of Casualty Crashes

$CC = weighted unit Cost of Casualty Crashes

CRF = Crash Reduction Factor

PWF = Present Work Factor

C = Cost of Treatment

Appendix 2 provides some worked examples of how the BCR can be applied to one of the pilot projects (Sandgate Road between Adelaide St East to East West arterial) for each of the main treatment options. In the example the following input was used:

CC = 0.1 (1 every 10 years)

$CC = $150,000 for 60 km/hour zone

CRF = 0.5 for pole relocation, 0.5 for barrier and 0.95 for undergrounding

PWF = based on 40 year life for pole relocation, 20 year life for barrier and 40 year life for undergrounding

C = $100,000 for pole relocation, $20,000 for barrier and $250,000 for undergrounding

The BCR for the various treatment options were 1.06 for pole relocation, 4.13 for barrier and 0.8 for undergrounding.

The Vic Roads Design Note suggests that when the BCR ratio is above 2.0, there is justification for road safety expenditure. Based on the BCR's for Sandgate Road, there is only one option which would appear to have a value above 2.0 and this is the installation of barriers.

It should be noted however, that it is not practical to install barriers on the poles or to relocate the poles on this section of Sandgate Road. This is because the poles are hard up against the kerb and there is no space in the footpath or a resumption in place on Sandgate Road to allow a relocation.

Since the BCR for an undergrounding option is well below 2.0, no treatment option is thus recommended for this road.

6 DETAILED RISK AND BENEFIT TO COST CALCULATOR

The Main Roads has an in-house developed program for calculating the Risk associated with vehicle impacts on power poles along with the Benefit to Cost ratios for various treatment options. This BCR calculator ……………………..

7 PROCESS FOR MANAGING SAFETY RISK OF POWER POLES

The process for managing the safety risk associated with power poles is shown in Figure 3.

MANAGING SAFETY RISK OF POWER POLES

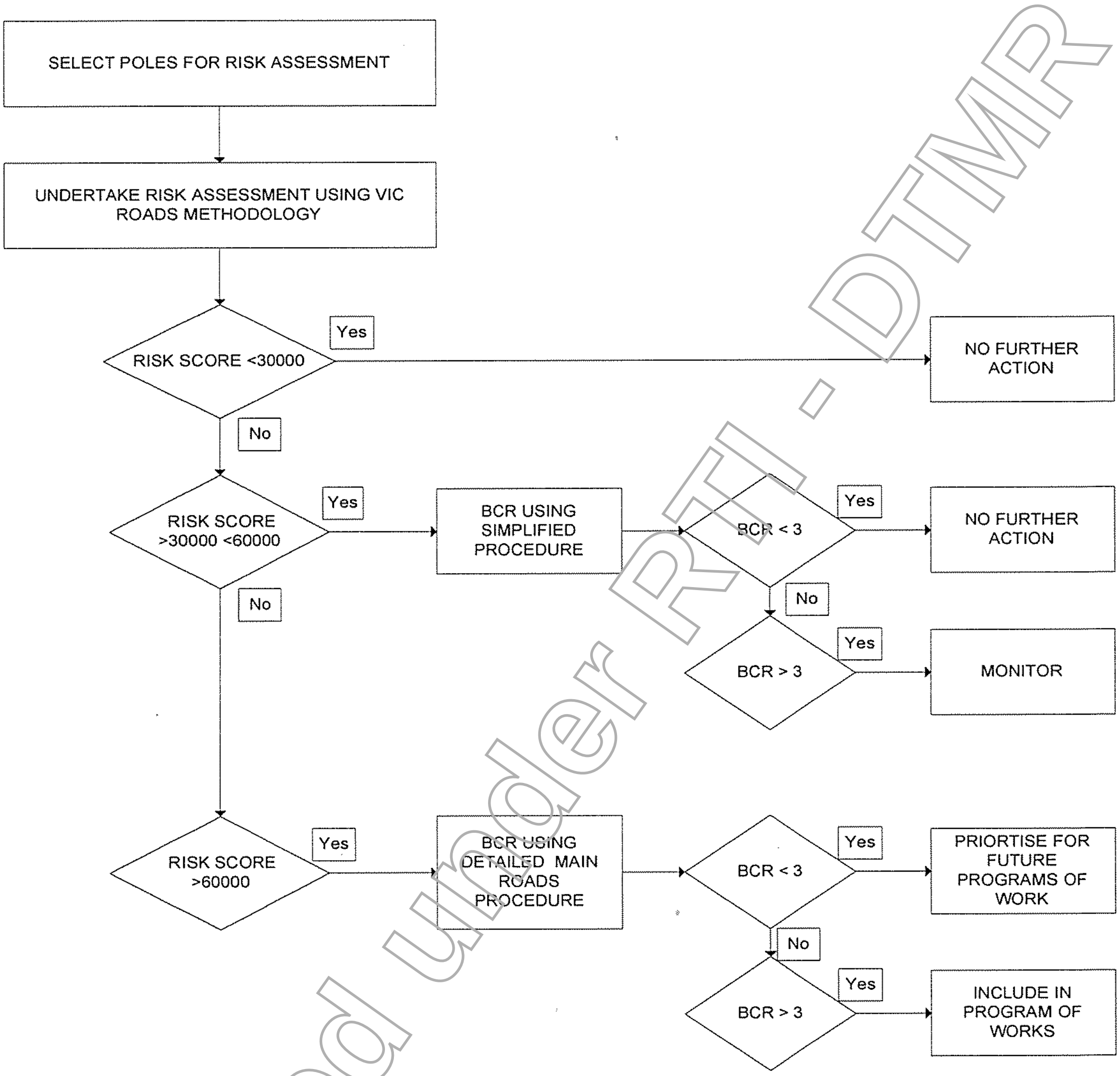


Figure 3 - Flowchart showing the Risk Assessment and Decision Process

8 GUIDELINES FOR THE PLACEMENT OF POLES IN DMR CONTROLLED ROAD CORRIDORS

The investigation into the safety risk associated with power poles have identified a number of opportunities for siting power poles to reduce the risk of impacts. These opportunities include:

(1) Poles should ideally be located outside the clear zones

(2) Poles should ideally be straight and not leaning towards the road side

(3) Poles should ideally be located away from where two lanes join into one

(4) The number of poles installed in the road corridor should be minimized by the use of long spans

(5) Where there are significant curvatures on the road, the poles should ideally be located on the inside of the curve

Based on these improvement opportunities, guidelines have been produced for the siting of new poles on DMR controlled road corridors. These guidelines are outlined in Appendix 3.

9 CONCLUSIONS AND RECOMMENDATIONS

The Vic Roads Risk Assessment Methodology outlined in the "Roadside Utility Poles – Road Design Note RDN 3-31" (RDN) has been trialled successfully on 5 pilot projects in the Main Roads Metropolitan area. The risk scores are primarily governed by the Traffic Density and are modified by a number of factors, such as:

- Separation of pole from running lane
- Speed of road
- Curvature of road

The risk scores on 4 of the pilot projects were generally well below 30,000. The project with the highest risk score (in the range of 40,000 to 45,000) was the section of Sandgate Rd from Adelaide St East to the East West Arterial road. On this section of road, there are a number of timber poles which carry low voltage conductors.

Based on the risk scores, it is initially suggested that in South East Queensland any power poles which have a risk score below 30,000 there is no further action required. A risk score of 30,000 corresponds to a casualty crash of once every 20 years.

For risk scores in the range of 30,000 to 60,000 it is recommended that a simplified BCR be undertaken using the Vic Roads Methodology. Based on the BCR, there is either no further action required or the situation is monitored an reassessed in 3 to 5 years.

For risk scores above 60,000 it is recommended that these poles be prioritized for mitigation treatment.

The major mitigation treatments to reduce the risk of the power poles have been identified as:

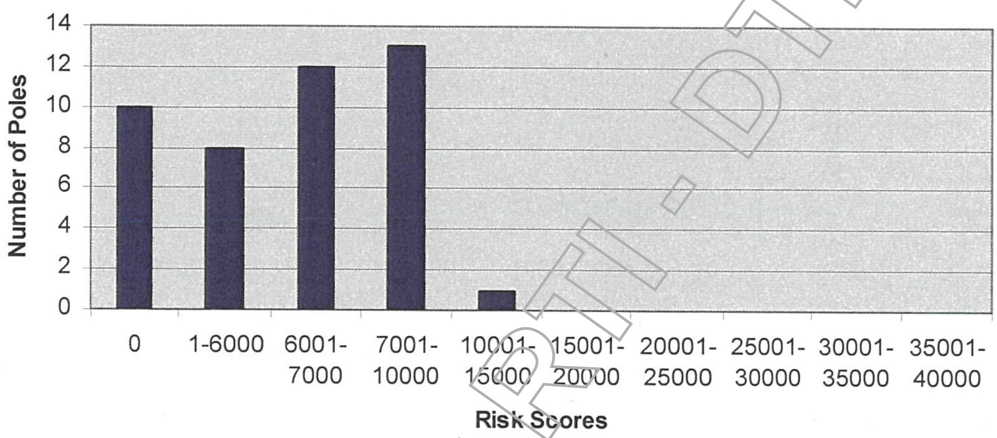
- Pole relocation
- Installation of barrier
- Undergrounding

It is proposed to use the more detailed Main Roads Risk and Benefit to Cost Ratio program to priortise the projects and treatment options.

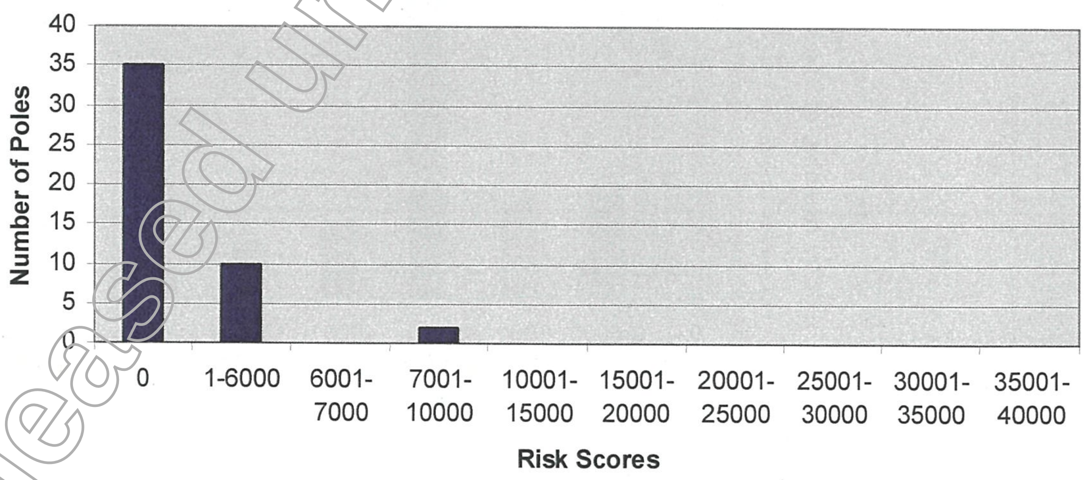
APPENDIX 1 – RISK SCORES FOR PILOT PROJECTS

Lytton and Port Roads

Route 904 Lytton Road
Doboy Bridge to Aquarium Ave - 44 Poles

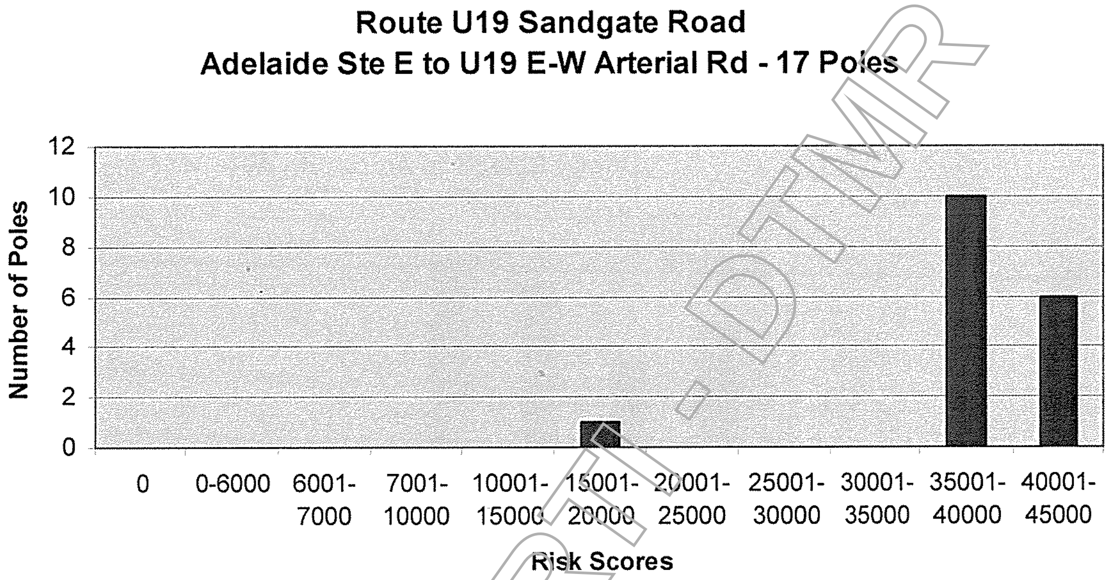


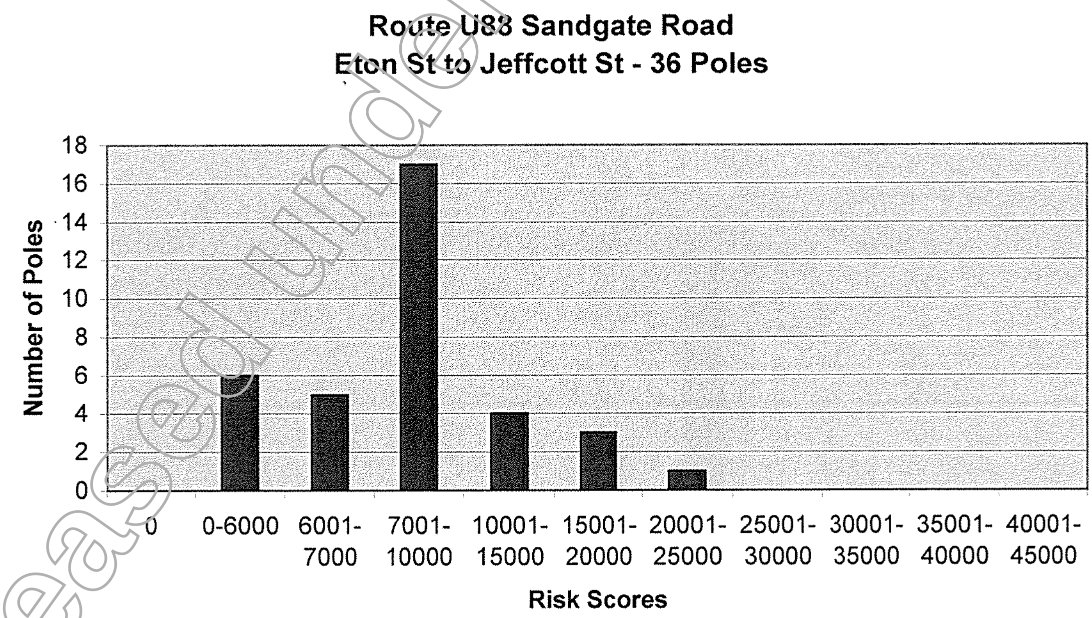
Route 904 Port Road
Pritchard St to Howard Smith Drive - 47 Poles



Lytton Road shows risk scores 10000 and lower, with the exception of one pole. Port Road shows little or no risk, with two poles scoring in the 7001-10000 range.

Sandgate Road





The two areas of Sandgate Road score much higher than Lytton or Port Roads, being highly developed and urban, with poles at the edge of the footpath.

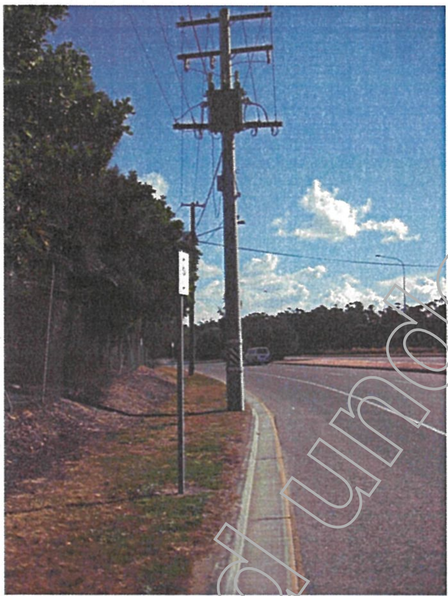
The section of U19 shows risk scores consistently in excess of 35000, whereas the section of U88 shows a range of scores, centring around a score of 7001-10000.

Lytton and Port Roads

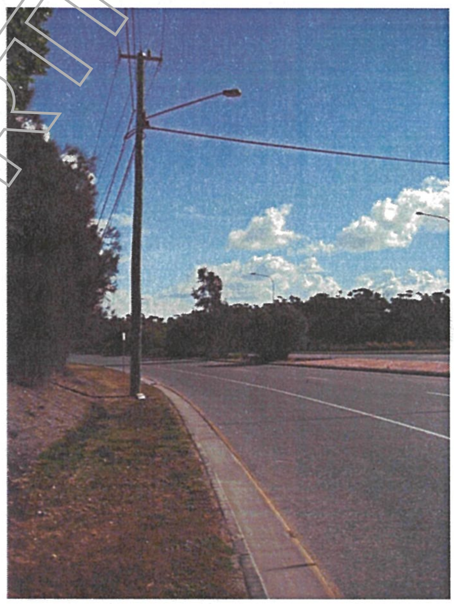
According to RDN, both roads show a low risk scoring generally. If a highest acceptable risk score of 10000 were to be adopted as a guideline, then 2 poles would require some sort of treatment, on the Lytton Road section. The Port Road section would require no treatment.

According to RDN correction of the 2 poles in Lytton Road would require the installation of barriers.

Example photos are attached:



Pole 389753 Lytton Rd
Photo 148
Risk Score 12804

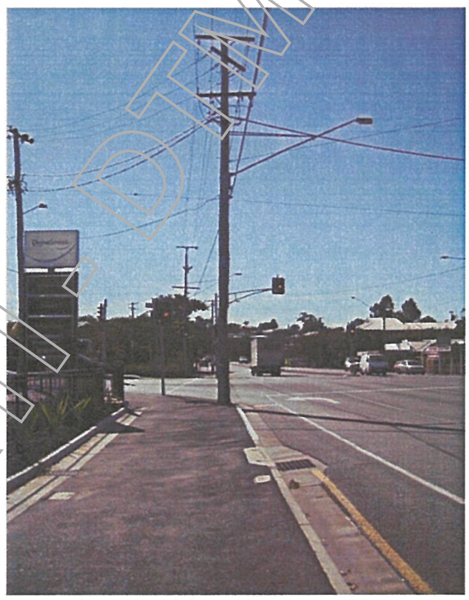


Pole 376240 Lytton Rd
Photo 150
Risk Score 8536

Routes U19 & U88 - Sandgate Road

The sections of U19 and U88 which were surveyed are representative of much of the inner-city urban areas of Brisbane or any similar city in Australia. Practically every main traffic route which traverses older areas will be in a similar situation with regard to risk.

Pole 21670 Sandgate Rd Route U19
Route U88
Photo 269
Risk Score 41598



Pole 42728 Sandgate Rd

Photo 301 (Corner Rode Rd)
Risk Score 14436

Some of the poles requiring treatment may be corrected through installation of barriers or pole relocation. However examination of the photos suggests that in the majority of cases, barriers would not provide an acceptable solution, a consideration being the narrow footpath and pedestrian traffic.

Relocation of poles back from the roadway would not be feasible unless some resumption of property were to be contemplated.

Although the RDN recommends consideration of undergrounding for risk scores in excess of 50000, it is considered that the cost benefit of undergrounding the sections involved should still be investigated.

APPENDIX 2 – WORKED EXAMPLES OF BCR FOR TREATMENT OPTIONS

Benefit Cost Ratio for Pole Relocation

CC/yr	Casualty crashes per year	0.1	
$CC	Cost of Casualty	150000	
CRF	Crash Reduction Factor	0.5	
PWF	Present Work Factor	14.14	
C	Cost of Treatment	100,000	Treatment of a number of poles

Benefit Cost Ratio: 1.06

Weighted Crash Costs

Speed Limit	Weighted CC Cost
60 km/hr or less	120,000
70,80,90 km/hr	200,000
100,110 km/hr	300,000

Present Worth Factor

n years	PWF
5	4.13
10	7.18
15	9.4
20	11.01
25	12.19
30	13.05
40	14.14
50	14.72

Benefit Cost Ratio for Barrier

CC/yr	Casualty crashes per year	0.1	
$CC	Cost of Casualty	150000	
CRF	Crash Reduction Factor	0.5	
PWF	Present Work Factor	11.01	
C	Cost of Treatment	20000	For 3 poles

Benefit Cost Ratio: 4.13

Weighted Crash Costs

Speed Limit	Weighted CC Cost
60 km/hr or less	120,000
70,80,90 km/hr	200,000
100,110 km/hr	300,000

Present Worth Factor

n years	PWF
5	4.13
10	7.18
15	9.4
20	11.01
25	12.19
30	13.05
40	14.14
50	14.72

Benefit Cost Ratio for Undergrounding

CC/yr	Casualty crashes per year	0.1	
$CC	Cost of Casualty	150000	
CRF	Crash Reduction Factor	0.95	
PWF	Present Work Factor	14.14	
C	Cost of Treatment	250000	For 0.5 km of u/g cable

Benefit Cost Ratio: 0.81

Weighted Crash Costs

Speed Limit	Weighted CC Cost
60 km/hr or less	120,000
70,80,90 km/hr	200,000
100,110 km/hr	300,000

Present Worth Factor

n years	PWF
5	4.13
10	7.18
15	9.4
20	11.01
25	12.19
30	13.05
40	14.14
50	14.72