

Chapter 21

Railway and Cane Railway Level Crossings

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2	21.2	Figure 21.1 - cross reference to Standard Drawing 881 for alternative designs.	Steering Committee	March 2002
	21.6	Section number -correct number to 21.6.1.		
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	21A.4	Vehicle size - Table 21.4 - change length of Type 2 Road Train to 53.5m.		
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Chapter 21

Railway and Cane Railway Level Crossings

21.1 Introduction

This chapter discusses the requirements for the design, signing and control of railway and cane railway level crossings of roads. The horizontal and vertical alignment of the road at railway crossings is critical to the safety and comfort of the crossing. Apart from the effect of the alignment on visibility, the relationship of the alignments of the road and rail at the crossing determine the comfort of the crossing. If the crossing does not occur with minimal impact on the vehicle, safety will be compromised, as control of the vehicle at speed will be more difficult.

This chapter also outlines a procedure for identifying the appropriate protection device to use at an 'at grade' railway/road level crossing and a means of prioritising crossings for treatment.

Criteria for 'sign only' (passive) control are derived from first principles, utilising known site conditions and relationships between road geometry and vehicle characteristics (e.g. sight distance, stopping distance, vehicle/train speed). Criteria for higher levels of control (i.e. active crossing devices) are developed from vehicle/train exposure measures and benefit cost analysis (BCA) methods.

The guidelines have been developed for typical situations. They are intended to aid but not replace sound engineering judgement based on particular local conditions. They indicate the order of magnitude of parameters at which various control devices are considered suitable. The traffic control devices referenced are specified in the Manual of Uniform Traffic Control Devices (Qld) Part 7.

21.1.1 Notation

The following symbols are used in this Guide:

- a Average acceleration of vehicle in starting gear (general case assumption = 0.5m/sec^2 , refer to Table 21.4, Appendix A).
- C_T Clearance or safety margin from the vehicle stop or holding line on the departure side of the crossing (general case assumption = 5m).
- C_V Clearance from the vehicle stop or holding line to the nearest rail (general case assumption = 3.5m).
- d Coefficient of longitudinal deceleration, refer to Table 1, Appendix A (AUSTROADS 1990).
- G Grade, negative for downhill, positive for uphill (%).
- G_S Grade correction factor, refer to Table 21.3, Appendix A.
- J Sum of the perception time and time required to depress clutch (general case assumption = 2 sec.) (Federal Highway Administration 1986).
- L Length of road vehicle (m), refer to Table 21.2, Appendix A.
- L_d Distance from the driver to the front of the vehicle (general case assumption = 1.5m).
- R_T Perception/reaction time (general case assumption = 2.5 sec).
- S_1 Minimum distance of an approaching road vehicle from the nearest rail when the driver of the vehicle can see an approaching train (m).

- S₂ Minimum distance of an approaching train from the point of impact with a road vehicle, when the driver of the road vehicle first sees a train approaching (m).
 - S₃ Minimum distance of an approaching train from the point of impact with a road vehicle, when the driver of a stationary road vehicle at the crossing must first see an approaching train in order to safely cross the tracks (m).
 - S_{2L} Minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a road vehicle first sees a train approaching from the left (m).
 - S_{2R} Minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a road vehicle first sees a train approaching from the right (m).
 - S_{3L} Minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a stationary road vehicle at the crossing must first see a train approaching from the left in order to safely cross the track from a stationary position (m).
 - S_{3R} Minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a stationary road vehicle at the crossing must first see a train approaching from the right in order to safely cross the track from a stationary position (m).
 - T Train volume, which is the average number of trains per week at the level crossing. On lines with high seasonal train traffic it may be appropriate to use the average number of trains per week during the high periods of use (trains/week).
 - V Vehicular volume, which is the measured or estimated annual average daily traffic (AADT) at the level crossing (vehicles/day).
 - VT Vehicular-train exposure at the level crossing = V x T (vehicles/day x trains/week).
 - V_T The speed of the train approaching the crossing (the allowed operating speed of trains, as advised by QR) (km/h).
 - V_V The 85th or 15th %ile road vehicle speed in the vicinity of the crossing. The road speed limit plus 10% is a reasonable approximation where the 85th %ile speed is not known, while the 15th %ile speed can be approximated by .75 x 85th %ile speed (Lay 1990:407) (km/h).
 - W_R Width of the travelled way (portion of the roadway allocated for the movement of the vehicles) at the crossing (m).
 - W_T Width, outer rail to outer rail, of the rail tracks at the crossing (1.1m for single track, 5.1m for double track).
 - X_{1L} Vehicle driver viewing angle measured from distance S₁ on the road centre line, where a driver must first see a train approaching from the left at distance S_{2L} from the crossing (degrees).
 - X_{1R} Vehicle driver viewing angle measured from distance S₁ on the road centre line, where a driver must first see a train approaching from the right at distance S_{2R} from the crossing (degrees).
 - X_{2L} Vehicle driver viewing angle from a stopped position to a train approaching from the left at distance, S_{3L} from the crossing (degrees).
 - X_{2R} Vehicle driver viewing angle from a stopped position to a train approaching from the right at distance, S_{3R} from the crossing (degrees).
 - Z Angle between the road and the railway at the crossing (degrees).
- Note: For selected parameters, the values nominated in the general case assumptions will vary to assist in prioritising sites for treatment with respect to both, approach and crossing visibility.

21.2 Alignment at Level Crossings

The horizontal and vertical alignments of both the road and rail have to be considered when designing the level crossing. If necessary, realignment of either or both of the road and rail should be considered to produce a satisfactory result.

Horizontal Alignment

The most desirable angle of crossing is a right angle. This will usually produce the best sight distance for both road and rail and the most easily handled vertical geometry. However, it is often the case that a skewed crossing will be necessary to accommodate the needs of both facilities.

Where a skewed crossing is required, the angle should be limited to the values in 21.6.3.1 (not greater than 110° to the left of the crossing and 140° to the right of the crossing).

A skewed crossing will always be required where the crossing is the result of a road parallel to the rail changing from one side to the other and using reverse horizontal curves to effect the change. In addition to limiting the angle of skew, it is necessary to ensure that the curve radii are suitable for the speed environment of the crossing. To achieve all of the necessary conditions, it may be essential to change the approach geometry of the road. It is essential that there is not a significant change in the 85th percentile speed of the curves at the crossing to avoid accidents resulting from loss of control of the vehicle.

If the conditions require a significant change in the approach speed, the alignment should be designed to effect a gradual reduction in the operating speed as the crossing is approached. The methods for gradually reducing the radii of curves to effect this change are the same as those described in Chapters 13 and 14 for the approach to intersections and roundabouts.

Vertical Alignment

At open level crossings it is essential for smooth running at the operating speed, that the levels of the pavement fit perfectly with the levels of the rails. If the road is straight at the crossing, and the road grade matches the level difference of the rails, any variation of the pavement crossfalls to match the railway grade presents no difficulty and, provided the change of crossfalls length, or rate of rotation, is adequate, produces the desirable smooth crossing at speed. For notes on the permitted rate of change of crossfalls, or rate of rotation refer Chapter 11, Horizontal Alignment.

When the road is curved it is rare for the grade of the rails to match the standard superelevation on the curve and the superelevation usually has to be modified to suit the rails. If this variation of superelevation is too great the curve becomes hazardous.

The following rules must be adhered to on road curves:-

- (a) The variation in superelevation on the curve must not be greater than the maximum value given in Table 21.1 for the design speed.
- (b) The value of the coefficient of side friction for the reduced superelevation on the curve, calculated at the rails chainage for the design speed, must not be greater than the maximum value given in Table ?? for the design speed.
- (c) The general superelevation on the curve should desirably not be nil.

Note that a greater variation is permitted at the lower design speeds. The design speed should be realistic for the site and if there is any doubt about the safety of the crossing, the test specified in (b) above should be made for a speed 15 km/h greater than the design speed.

Table 21.1 Railway Level Crossings Variation in Superelevation

Design Speed km/h	Maximum Variation %
50	5
60	4
70	3.5
80	3
100	2
110	1
120	0.5

As the value of (e+f) for the curve is constant, the above figures, when expressed as a decimal, also represent the permitted variation in f.

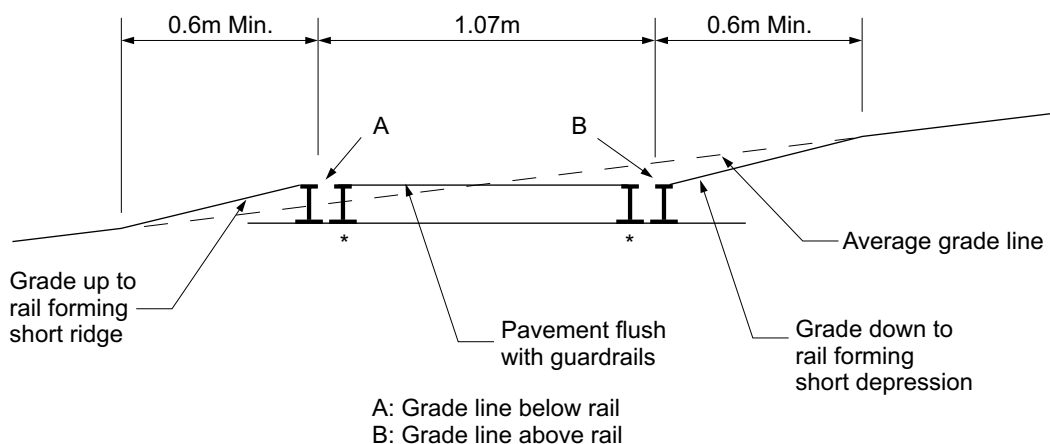
Where the normal road grade does not match the levels of the rails, it becomes necessary to vary the grade to provide at least for uniformity in levels at the crossing. The minimum standards of vertical curvature shall be the absolute minimum provided in Section 5, and as it happens that the type of grading applicable to the situation may often resemble that at floodways, the rules for floodway grading will often be permitted here. However, this represents the minimum standard allowed and would be permitted on minor roads only. As importance increases, so must the standard, even to the extent of relocating the road and/or rail.

In grading to the rails it is always desirable that the grade line coincide with the tops of the rails but cases arise where this produces an impossible grade, something not even to minimum standard. By grading through points respectively just above and below the two rails, an otherwise impossible grade may be converted to a possible and, taking this further, an otherwise minimum grade may be improved to something more in conformity with the importance of the road. The maximum variation above and below the rails is a function of the difference in grade between the adopted road grade and the grade of the rails. Permitted variations are given in Table 21.2 and the method is illustrated in Figure 21.1.

Table 21.2 Railway Level Crossings Permitted Variations in Grade between Road and Rails

Design Speed km/h	Maximum Variation %
80 and less	4
100	2
110	1
120	0

When there are two (or more) tracks at such levels that it is impossible to provide even a minimum standard grade line it is an indication that one of



* See Standard Drawing 881 for alternative details.

Figure not to scale

Note: Refer Table 21.1 for maximum variation permitted.

Figure 21.1 Railway Level Crossings. Method of grading above and below rails in difficult situations

the tracks should be regraded to permit the required road grading. This expense is usually warranted only on important roads and in other cases adequate warning signs have to be resorted to. It is desirable also in such cases to reduce the alignment standard as a means of reducing the speed over the crossing.

When the rails are curved and superelevated it is usually desirable that the road approach be skew as this often allows a satisfactory crossing design to be made, where a square crossing would be impossible.

It should be noted that the railway crossing must be individually designed and full details presented on job plans.

Refer also to Chapter 21 for standards of visibility at open level crossings.

21.3 Minimum Requirements for Signaling Level Crossings

21.3.1 General

Railway crossings may be treated with a hierarchy of control which will vary with the prevailing conditions. The hierarchy of control available is:

- (i) position markers with or without advance warning signs,
- (ii) STOP sign control with advance warning of the control sign;
- (iii) signal control;
- (iv) signal with half boom gate control; and
- (v) grade separation.

21.3.2 Signs

The sign type and location for railway level crossings shall be in accordance with the Manual of Uniform Traffic Control Devices (MUTCD), Part 7: Railway Crossings (Queensland).

21.4 Sight Distance Requirements

To determine the suitable control devices at a crossing, the site conditions of the crossing should first be examined as detailed in Section 21.6. Calculation of sight distances S_1 , S_2 and S_3 are necessary to determine the distances required for assessment of the sight triangles.

For each approach, the 85th percentile vehicle speed, maximum train speed, and measured distances from a site survey are to be determined in order to calculate distances S_1 , S_2 and S_3 from the equations below (refer Appendix A for Sight Distance derivation).

The minimum distance of an approaching road vehicle from the nearest rail when the driver of the vehicle can see an approaching train (m):

$$S_1 = \frac{R_T V_V}{3.6} + \frac{V_V^2}{254(d + \frac{G}{100})} + L_d + C_v$$

For the motorist to decelerate and safely stop at the stop or holding line, the train would have to be sighted at a minimum distance, S_2 from the crossing:

$$S_{2L(i)} = \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} (R_T + \frac{V_V}{35.3d})$$

$$S_{2R(i)} = \frac{V_T}{3.6} (R_T + \frac{V_V}{35.3d})$$

Alternatively, for the vehicle to proceed and clear the crossing within an adequate safety margin, the minimum distance of an approaching train from the crossing when the driver of the road vehicle can first see the approaching train subsequently becomes:

$$S_{2L(ii)} = \frac{0.5W_R}{\sin Z} + \frac{V_T}{V_V} \left(\frac{R_T V_V}{3.6} + \frac{V_V^2}{254(d + \frac{G}{100})} \right) + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L$$

$$S_{2R(ii)} = \frac{V_T}{V_V} \left(\frac{R_T V_V}{3.6} + \frac{V_V^2}{254(d + \frac{G}{100})} \right) + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L$$

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Stationary vehicles at a STOP sign require sufficient sight distance to establish that they have sufficient time to safely cross the railway before the train arrives.

Equations for the minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a road vehicle must first see a train approaching in order to safely cross the track from a stopped position at the holding line (m) are:

$$S_{3L} = \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} (J + \frac{(\frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L)}{a})^{1/2}$$

$$S_{3R} = \frac{V_T}{3.6} (J + \frac{(\frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L)}{a})^{1/2}$$

21.5 Guidelines for Control Devices

21.5.1 Introduction

Traffic control devices are depicted in the hierarchy of control in Section 21.3.1. Installation of a device should be considered at a crossing when lower order devices appear unsuitable, as detailed in this Section.

If the survey of sight distance assessment warrants the installation of higher order devices, the appropriate protection devices should be recommended and advised for respective ranking.

It may be more appropriate to take remedial action on approach and crossing visibility etc., to enable the use of lower order (and less expensive) control devices. The process of determining the desirable order of device is summarised in Figures 21.4 and 21.5.

21.5.2 Position Markers and Advance Warning Signs

Position markers with advance warning signs are usually adequate unless one of the following conditions exists for either approach.

- (i) inadequate approach visibility exists, i.e. the sight triangle formed by the road and the rail at distances S_1 and S_2 from the vehicle and train respectively to the crossing. (Figure 21.2).
- (ii) inadequate crossing visibility exists, i.e. the sight triangle formed by the road and the rail at distances 5m and S_3 from the vehicle and train respectively to the crossing. (Figure 21.3).
- (iii) for curved crossings, field measurement of approach visibility angles X_{1L} and X_{1R} exceed the maximums permitted (95° to the left and 110° to the right).
- (iv) VT is greater than 300,000 for urban areas or 50,000 for rural areas.

Where the minimum sight triangle requirements as calculated above cannot be met, before recommending stop control or flashing lights consider:

- clearing of obstructions to achieve visibility (e.g. removal of vegetation, large signs, buildings, embankments, etc).
- methods to reduce vehicle speeds
- the possibility of reducing train speed
- in conjunction with QR, the viability of the line (closure of the crossing may be an option)
- construction of a new crossing alignment (rail or road or both - horizontally or vertically).

21.5.3 Stop Sign Control

Permanent Stop Signs

Control by STOP signs (R1-1) should be considered at every level crossing where position markers (i.e. a GIVE WAY assembly) with or without advance warning signs are inadequate (Section 21.4).

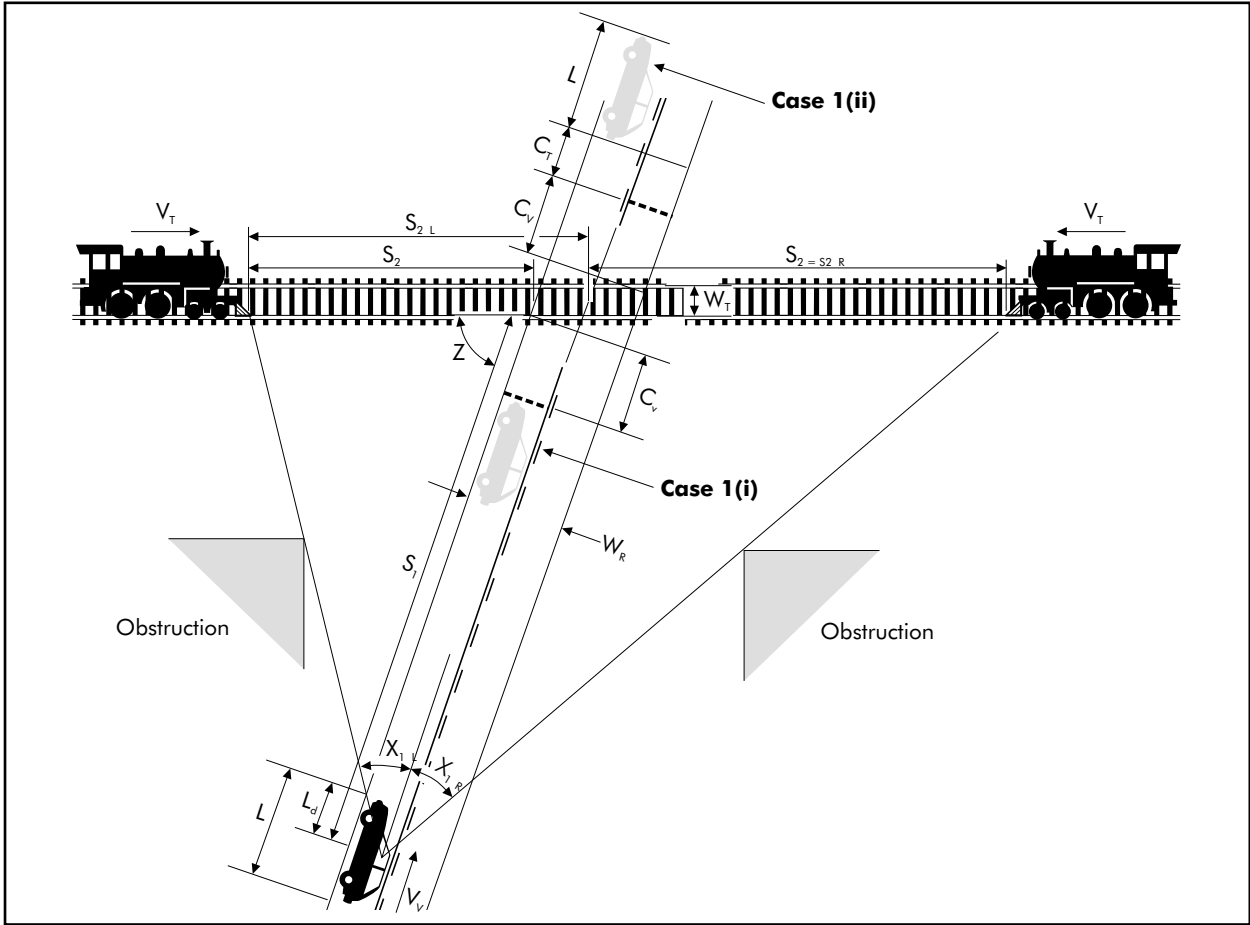
Control by STOP signs may be inappropriate where V is greater than 500 (urban) or 300 (rural), due to delays at the crossing and the increased chance of rear-end collisions.

Control by higher order devices (see 2.1 (iii) to (v)) should be considered where:

- (i) adequate crossing visibility is not available (Figure 21.3).
- (ii) adequate stop sign visibility is not available and a “stop sign ahead” sign (W3-1) is unsuitable for the location where increased vehicle/vehicle accidents may result.
- (iii) a stop sign is judged to be inappropriate (for example at some rural locations with high speeds and where a crossing is unexpected).
- (iv) field measurement of visibility angles X_{2L} and X_{2R} exceed 110° to the left or 140° to the right.

Temporary Stop Signs

Stop signs may be used as a temporary measure whilst the site is listed for higher order treatment in priority order of assessed need. Consideration should be given to the possibility of more frequent and/or severe accidents occurring as a result of the introduction of a temporary sign. For example, at some rural sites, and other areas where the road geometry provides inadequate advance warning for an unexpected stop sign, the probability of vehicle/vehicle collisions increases.



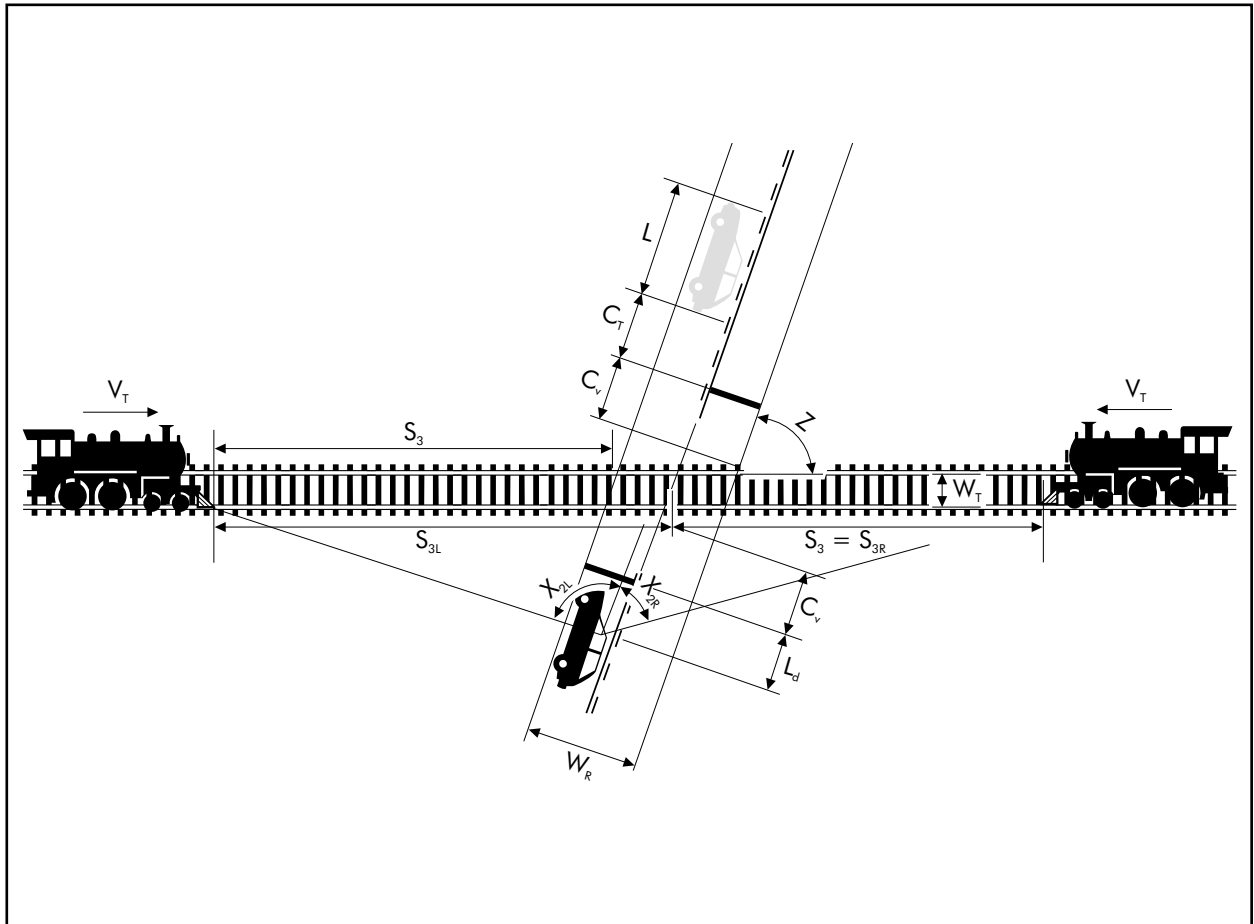
Case 1 (i) Motorist approaching crossing sights train, decelerates and stops at the stop or holding line.

Case 1 (ii) Motorist approaching crossing sights train, proceeds and safely clears the crossing.

Notation (units and/or general case assumptions are shown in brackets):

- S_1 Minimum distance of an approaching road vehicle from the nearest rail when the driver of the vehicle can see an approaching train (m).
- S_2 Minimum distance of an approaching train from the point of impact with a road vehicle, when the driver of the road vehicle first sees a train approaching (m).
- S_{2L} Minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of the road vehicle first sees a train approaching from the left (m).
- S_{2R} Minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of the road vehicle first sees a train approaching from the right (m).
- V_T The speed of the train approaching the crossing (the allowed operating speed of trains, as advised by QR) (km/h).
- V_V The 85th or 15th %ile road vehicle speed in the vicinity of the crossing. The road speed limit plus 10% is a reasonable approximation where the 85th %ile speed is not known, while the 15th %ile speed can be approximated by $.75 \times 85\text{th \%ile speed}$ (Lay 1990:407) (km/h).
- C_V Clearance from the vehicle stop or holding line to the nearest rail (general case assumption = 3.5m).
- C_T Clearance or safety margin from the vehicle stop or holding line on the departure side of the crossing (general case assumption = 5m).
- L Length of road vehicle (m), refer to Table 21.2 (Appendix A).
- L_d Distance from the driver to the front of the vehicle (general case assumption = 1.5m).
- W_R Width of the travelled way (portion of the roadway allocated for the movement of the vehicles) at the crossing (m).
- W_T Width, outer rail to outer rail, of the rail tracks at the crossing (1.1m for single track, 5.1m for double track).
- X_{1L} Vehicle driver viewing angle measured from distance S_1 on the road centre line, where a driver must first see a train approaching from the left at distance S_2 from the crossing.
- X_{1R} Vehicle driver viewing angle measured from distance S_1 on the road centre line, where a driver must first see a train approaching from the right at distance S_2 from the crossing.
- Z Angle between the road and the railway at the crossing (degrees).

Figure 21.2 Approach Visibility at Open Level Crossings



Case 2 Motorist stopped at crossing requires adequate time to accelerate and safely clears the crossing.

Notation (units and/or general case assumptions are shown in brackets):

- S_3 Minimum distance of an approaching train from the point of impact with a road vehicle, when the driver of the road vehicle must first see an approaching train in order to safely cross the tracks.
- S_{3L} Minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a road vehicle must first see a train approaching from the left in order to safely cross the track from a stopped position at the stop or holding line (m).
- S_{3R} Minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, to enable the driver of a road vehicle must first see a train approaching from the right in order to safely cross the track from a stopped position at the stop or holding line (m).
- V_T The speed of the train approaching the crossing (the allowed operating speed of trains, as advised by QR) (km/h).
- L Length of road vehicle, refer to Table 21.2 (m) (Appendix A).
- L_d Distance from the driver to the front of the vehicle (general case assumption = 1.5m).
- C_v Clearance from the vehicle stop or holding line to the nearest rail (general case assumption = 3.5m).
- C_T Clearance or safety margin from the vehicle stop or holding line on departure side of the crossing (general case assumption = 5m).
- W_R Width of the travelled way (portion of the roadway allocated for the movement of the vehicles) at the crossing (m).
- W_T Width, outer rail to outer rail, of the rail tracks at the crossing (1.1m for single track, 5.1m for double track).
- X_{2L} Vehicle driver viewing angle measured from at the STOP line to a train approaching from the left at distance, S_3 from the crossing.
- X_{2R} Vehicle driver viewing angle measured from at the STOP line at the road centre line to a train approaching from the right at distance, S_3 from the crossing.
- Z Angle between the road and the railway at the crossing (degrees).

Figure 21.3 Crossing Visibility at Open Level Crossings

21.5.5 Signal Control

Signal control should be considered at level crossings where all lower order devices are inadequate. The existing exposure levels for upgrading from passive to active protection are set at:

VT > 300,000 urban

VT > 50,000 rural

These values should be treated as a guide only and full BCA analysis undertaken on a site specific basis using costs and user benefits as set down in the Department's BCA manual. Where the number of mainline tracks at the crossing is greater than one, and active protection is required half boom gate control should be used.

21.5.6 Signals and Half Boom Gate Control

Signals with half boom gates should be considered at level crossings where the need for signals exists, and where the vehicle/train accident rate at a signalised level crossing is sufficiently high to give a benefit/cost ratio based on accident cost exceeding 1.5.

21.5.7 Grade Separation

Where delays to vehicles are high or where train and vehicle volumes are large, level crossings may be unsuitable and grade separation deemed to be an option where funds are available.

21.5.8 Sub-standard Crossings

Sub-standard crossings are those not controlled by flashing lights or boom gates, where the crossing visibility is below the requirements of the guide. If the motorists cannot see an approaching train at the critical decision point (whether or not to cross the railway) an accident is highly probable. All factors being considered, neither the train driver nor the motorist is at fault.

21.6 Evaluation of Site Conditions

21.6.1 Introduction

In order to apply the guidelines in Section 21.5 it is necessary to quantify the relevant site conditions as detailed below.

21.6.2 Level Crossing Environment

- (i) the crossing environment is classified as either urban (built-up) or rural (no abutting built development), an urban environment generally having a speed limit of 70 km/h or lower and 80 km/h or higher in a rural environment.
- (ii) the existing level of control is noted:
 - (a) position signs (i.e. GIVE WAY assembly) with or without advance warning signs
 - (b) stop sign control with stop sign ahead
 - (c) flashing lights (signals)
 - (d) boom gates
- (iii) the number of railway tracks within distance S_2 , left and right of the crossing which could be used at the one time is noted.
- (iv) the vehicle volume V , the signed speed limit and the 85th percentile speed V_V are measured by field survey or approximated by appropriate means (e.g. $V_V = 110$ km/h posted speed limit).
- (v) the average weekly train volume T and the maximum operating train approach speed V_T are obtained in writing from Queensland Rail.
- (vi) the vehicle/train accident rate at the crossing is noted.
- (vii) the road surface type (sealed or gravel) and condition is noted.

(viii) the maximum grade, G , should be measured within the braking zone. This is approximately

$$\frac{V_V^2}{254(d)} \text{ (m)}$$

measured from the crossing.

(ix) other items in accordance with the field survey procedure.

21.6.3 Level Crossing Geometry

Approach Visibility

The approach visibility is deemed to be adequate, when an area of unrestricted visibility exists for each approach, refer Figure 21.2. Approach visibility is adequate when the following conditions are met:

The driver of an approaching vehicle, travelling at the 85th%ile speed (V_V) can see a train travelling at maximum operating speed (V_T), when the vehicle and the train are at distances S_1 and S_2 respectively from the crossing, such that the vehicle can either safely stop short of the crossing, or clear the crossing before the train reaches it. Appropriate values of V_T should be obtained from Queensland Railways.

For a given vehicle, the approach visibility must be adequate for trains approaching from either direction. The approach visibility angle must not exceed 95° to the left of the crossing and 110° to the right of the crossing.

Note that in considering approach visibility, occasional obstructions such as posts, small trees, sparse vegetation can be considered acceptable if it is clear that they are of a size and spacing that would not obscure vision to a train.

Crossing Visibility

Crossing visibility is deemed to be adequate, when an area of unrestricted visibility exists for each approach, refer Figure 21.3. Crossing visibility is adequate when the following conditions are met:

The driver of a stationary vehicle, positioned at the stop or holding line, has a clear view of approaching trains to a distance S_3 along the tracks, such that a train appearing in the driver's field of view, at the point where the vehicle begins to move, would reach the crossing after the vehicle cleared the crossing.

For the purpose of calculating the visibility triangle, the following figures are used:

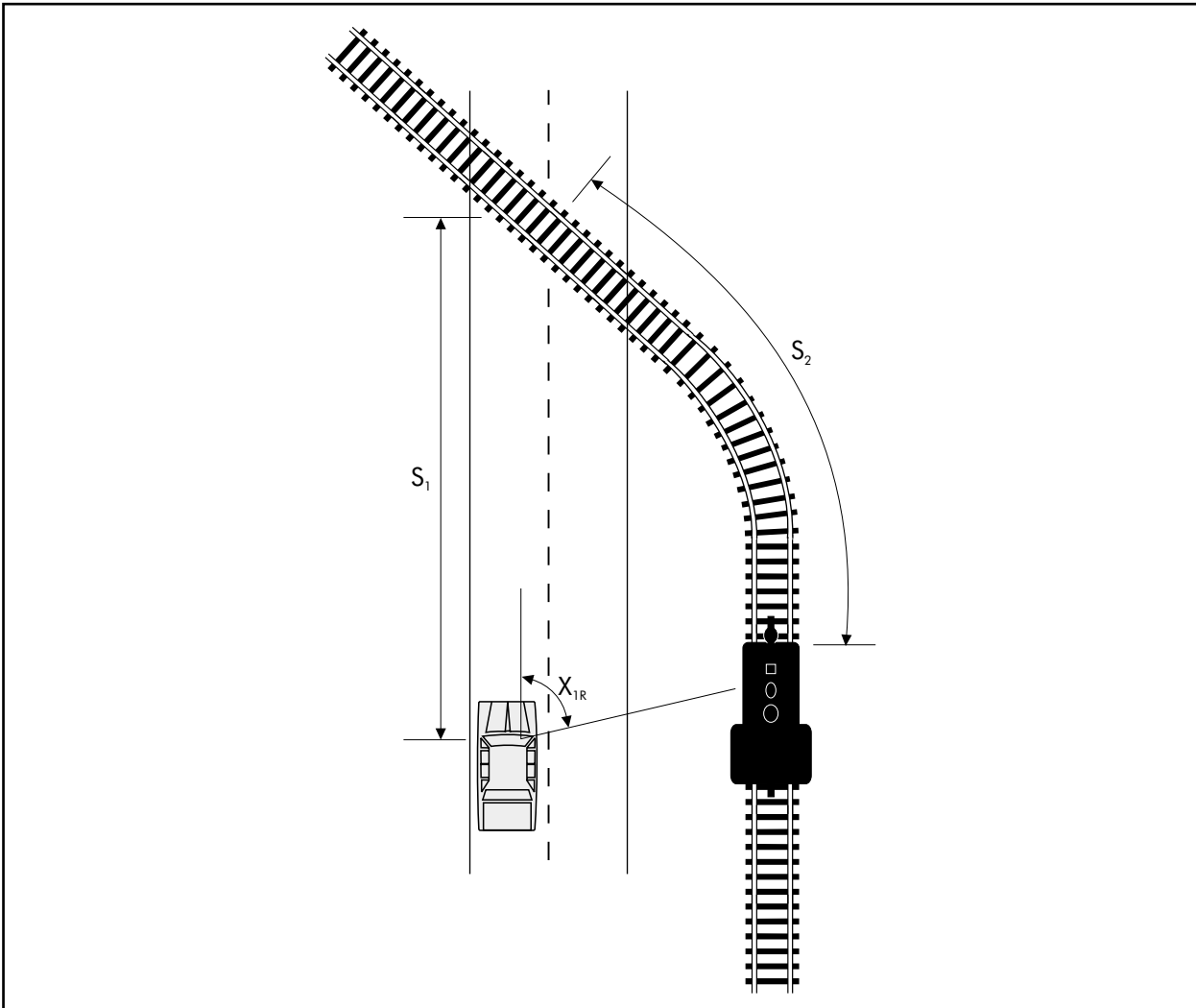
- Distance from the driver's eye to the rail, whilst at standstill is 5.0 m.
- Height of driver's eye above road is 1.15m.
- Height of train above rails is 2.3m.

For a given vehicle, the crossing visibility must be adequate for trains approaching from either direction. The crossing visibility angle must not exceed 110° to the left of the crossing and 140° to the right of the crossing.

Parallel Roads and Crossings on Side Roads

Many railways run parallel to adjacent roads and motorists on such roads may be unaware of a train travelling just behind the vehicle in the same direction. In these cases where the road then crosses the rail or a side road crosses the rail, distances S_1 and S_2 must be checked (unless there is stop control on the crossing with advance warning signs) at the design speed of the main road. It is essential that the visibility angles for S_1 and S_2 fall within the prescribed limits (ie. angles X_{1L} and X_{1R}).

Figure 21.4 provides an example of a road parallel to a railway line that then crosses the road.



Note: The vehicle driver viewing angles X_{1L} and X_{1R} should be checked for both 85 and 15 percentile vehicle speeds.

Figure 21.4 Road Parallel to Railway Line Before Crossing

With regard to a crossing on a side road a short distance from the continuing road, the road vehicle speed (V_V) will be relatively low and therefore the required distance S_1 reduced.

15th Percentile Vehicles

Motorists who drive slower than the 85th percentile speed, will be closer to the railway line at the time they need to detect an approaching train. It follows that the visibility angle for slower drivers will be increased. It is therefore necessary to check that for the 15th percentile road speed (taken as 0.75×85 th percentile) visibility angles are within the prescribed limits.

21.6.4 Sight Triangle Obstructions

There are many ways in which the sight triangle can be obstructed and consequently many interpretations can be made on the safety impact of a particular obstruction.

The proposed procedure divides a substandard sight triangle for both approach and crossing visibility into four zones. A four zone system has been chosen to provide a real measure of segregation between the worst case (where an accident is almost inevitable) and the case where the exact requirements of sight triangle are not available but the practical impact on safety level is minor.

Both the visibility angle and the sight triangle need to be considered for the scoring process. In order to determine the corresponding zones representing the available approach or crossing visibility at individual crossings, both requirements need to be met.

To assist in the ranking procedure, the variables $S_1(A)$, $S_1(B)$, $S_2(A)$, $S_2(B)$, $S_3(A)$ and $S_3(B)$ have been introduced in order to determine limits of the four zone system.

Sight distances S_1 , $S_1(B)$, $S_1(A)$, S_2 , $S_2(B)$ and $S_2(A)$ are calculated from the same corresponding equations with two variable factors. Those being perception/reaction time, R_T and coefficient of deceleration, d . The adopted values are as follows:

S_1, S_2 $R_T = 2.5$ sec (general case assumption), and the coefficient of deceleration, d .

$S_1(B), S_2(B)$ $R_T = 2.5$ sec (general case assumption), and the coefficient of deceleration, $2d$.

$S_1(A), S_2(A)$ $R_T = 0.8$ sec and the coefficient of deceleration, $2d$.

Accordingly, for sight distances S_3 , $S_3(B)$ and $S_3(A)$, the general S_3 equation is applied with several variable parameters. The concerning factors are as follows:

S_3 $J = 2$ sec (general case assumption), vehicle length $L =$ refer to Table 21.2, clearance $C_T = 5$ m, average vehicle acceleration $a = 0.5$ m/sec².

$S_3(B)$ $J = 1.5$ sec, vehicle length $L = 19$ m, clearance $C_T = 2.5$ m, average vehicle acceleration $a = 0.6$ m/sec².

$S_3(A)$ $J = 0.8$ sec, vehicle length $L = 5$ m, clearance $C_T = 2.5$ m, average vehicle acceleration $a = 0.9$ m/sec².

21.7 Practical Application

The practical application of the warrants is explained in the detailed survey instructions (Appendix B) and the decision tree figures for level crossing control selection, Figures 21.5 and 21.6 (lower level control and higher level control respectively).

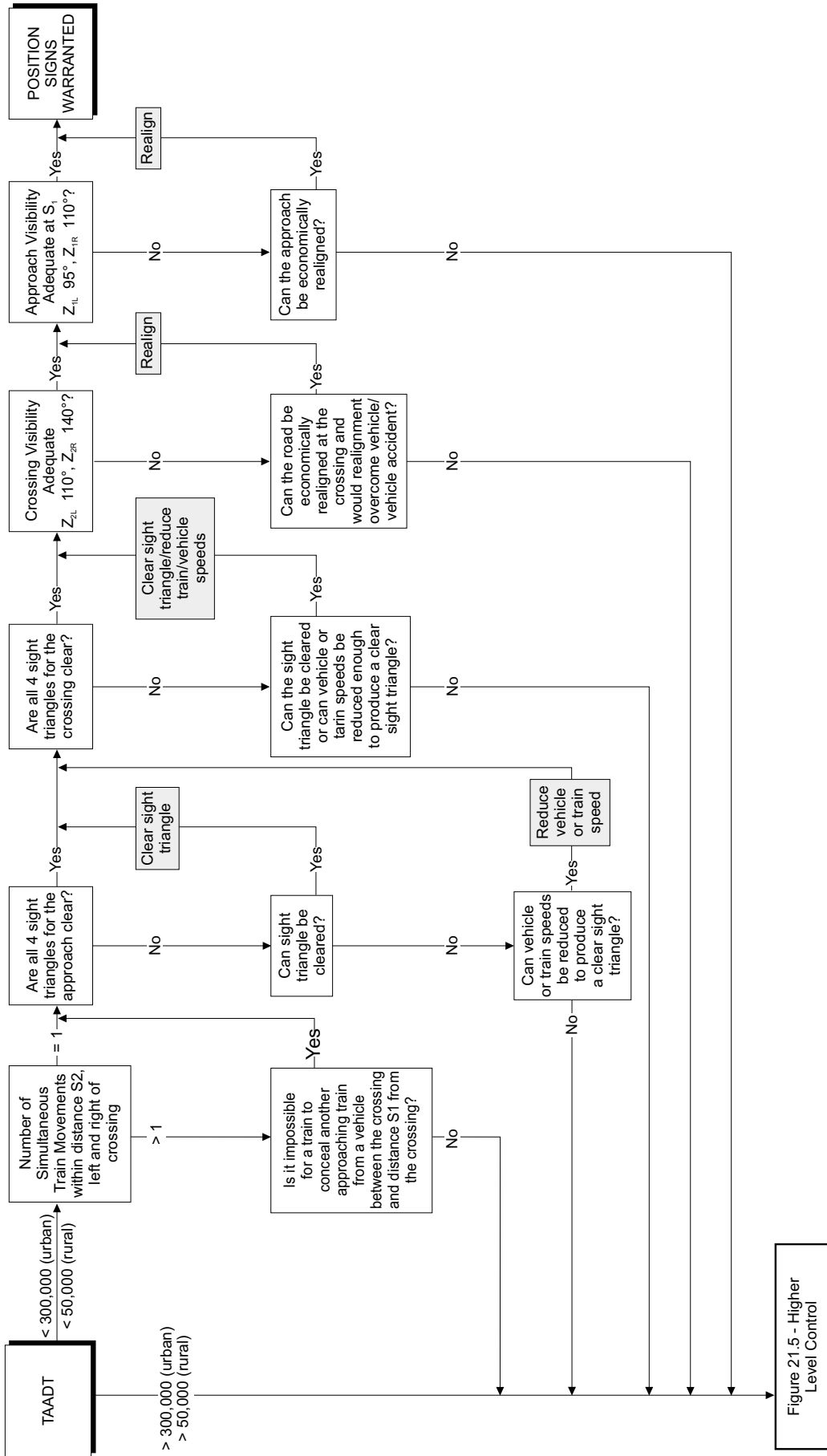


Figure 21.5 Lower Level Control

Figure 21.5 - Higher Level Control

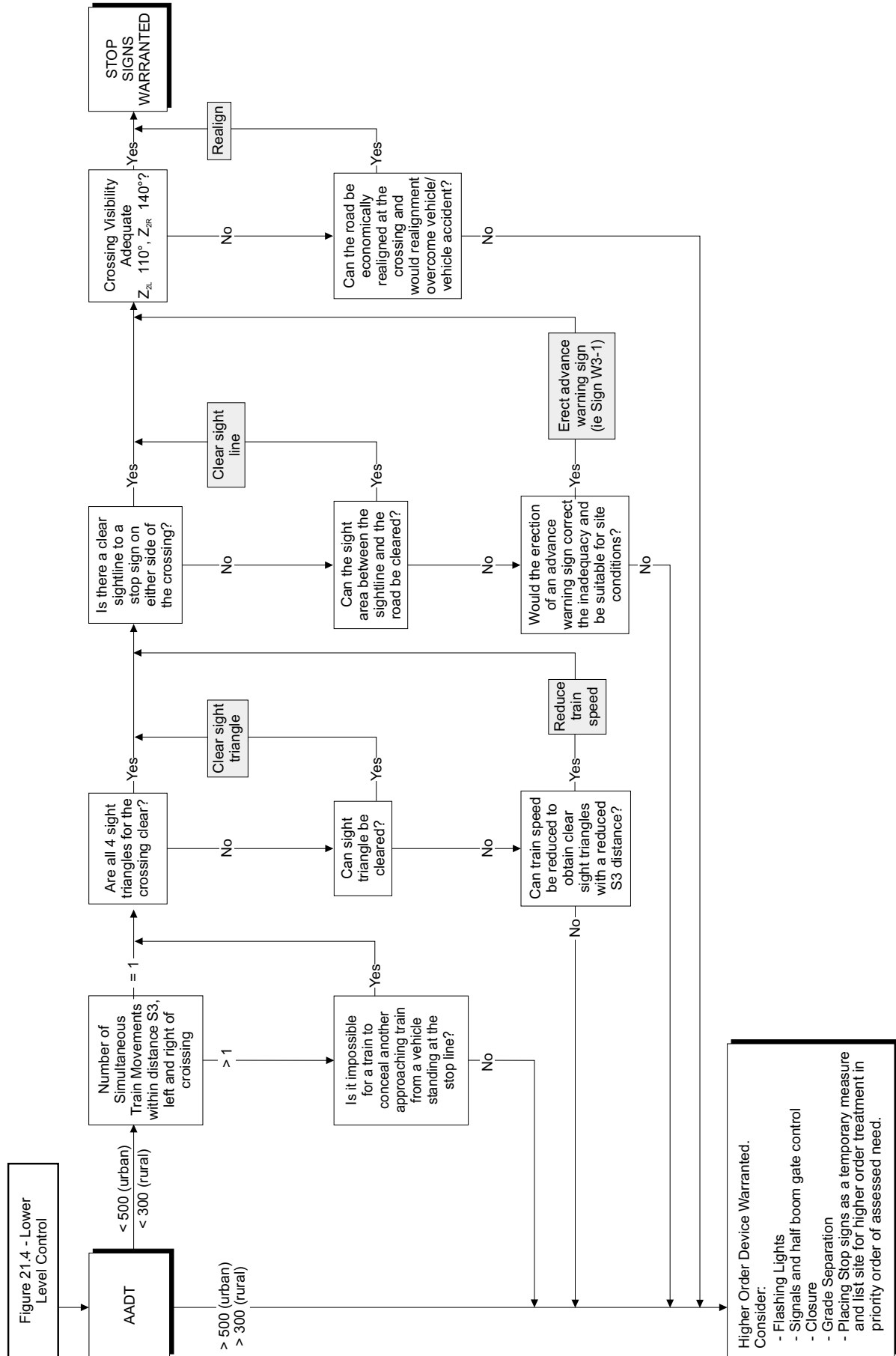


Figure 21.6 Higher Level Control

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Relationship to Other Chapters

- Chapter 9 deals with sight distance parameters;
- Chapters 10, 11 and 12 provide details of alignment requirements;
- Chapter 13 discusses driver visibility principles.

Appendix 21A: The Derivation of Sight Distance Requirements at Open Level Crossings

21A.1 General

Before detailing the procedures used in the derivation of the formulae used in this Guide, it is important that users note that sight distance requirements at open level crossings have historically varied from State to State. The practice outlined in this Appendix more closely aligns Queensland practice with that adopted (or proposed to be adopted) by other Australian States, with the principal exception that conservative additional factors of safety utilised in a number of other states have not been adopted. It was considered that all crossing in Queensland should first be brought up to an initial standard, before adopting conservative increases in safety factors. A more detailed discussion of comparative practices can be obtained from the Traffic Engineering Section, Transport Technology Division.

It is necessary to consider two scenarios in the evaluation of sight distance requirements at railway level crossings. Case 1 addresses the sight distances required for an approaching vehicle considering two critical situations (necessary to establish whether position signing control is adequate); and case 2 addresses the sight distance along the railway for a vehicle stopped at a STOP sign (necessary to establish the adequacy of STOP sign control). The geometry and associated notation for cases 1 and 2 are depicted in Figures 21.2 and 21.3 respectively, in the main part of this Guide.

21A.2 Case 1: Sight Distance Required for Position Sign Control

Case 1 allows a motorist approaching the crossing at distance S_1 to sight a train at distance S_2 from the crossing and either:

- (i) decelerate and safely stop at the stop or holding line; or
- (ii) proceed and clear the crossing with an adequate safety margin.

When motorists reach a crossing and see a train approaching, they must decide whether to decelerate and stop, or proceed and clear the crossing. There is a finite distance required between the vehicle and the rail in order to reach a decision and act in safety. This distance, assuming a level grade crossing site, comprises four components:

- the distance travelled during the perception/reaction time

$$R_T V_V = \frac{R_T V_V}{3.6} \text{ metres}$$

- braking distance

$$\frac{V_V^2}{2a} = \frac{\left(\frac{V_V}{3.6}\right)^2}{2gd} = \frac{V_V^2}{254d} \text{ metres}$$

(g = acceleration due to gravity = 9.81 m/sec²);

- distance of the driver from the front of the vehicle (L_d metres); and
- clearance from the vehicle stop or holding line to the nearest rail (C_V metres).

Thus, to stop on level ground, we require:

$$S_1 \geq \frac{R_T V_V}{3.6} + \frac{V_V^2}{254d} + L_d + C_V \quad (21.1)$$

The influence of slope on the stopping distance component of this equation, can be derived using simple physics (refer Figure 21A.1).

The influence of grade on vehicle deceleration can be derived as follows:

- braking distance

$$\frac{V_V^2}{2a} = \frac{\left(\frac{V_V}{3.6}\right)^2}{2gd} = \frac{V_V^2}{254d} \text{ metres};$$

- component of vehicle mass acting down the slope = $mg \sin \theta$ (g = acceleration due to gravity)

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= 9.81 m/sec²);

- for small angles $\sin\theta = \tan\theta = x/y = G$ (grade is expressed as a ratio, negative for downhill);
- force acting down the slope $\approx mg\sin\theta \approx mg\tan\theta = mgG$;
- effective deceleration = $gd + gG = g(d + G)$; and
- therefore effective deceleration = $g(d + G/100)$ (grade expressed as a percentage)

In order to stop on sloped ground, equation 21.1 subsequently becomes:

$$S_1 \geq \frac{R_T V_V}{3.6} + \frac{V_V^2}{254(d + \frac{G}{100})} + L_d + C_V \quad (21.2)$$

where:-

S_1 = minimum distance of an approaching road vehicle from the nearest rail when the driver of the vehicle can see an approaching train (m);

R_T = perception/reaction time (general case assumption = 2.5 sec);

V_V = the 85th %ile road vehicle speed in the vicinity of the crossing. The road speed limit plus 10% is a reasonable approximation where the 85th %ile speed is

not known (km/h);

d = coefficient of longitudinal deceleration. Refer to Table 1 (AUSTROADS 1990);

L_d = distance from the driver to the front of the vehicle (general case assumption = 1.5m);

C_V = clearance from the vehicle stop or holding line to the nearest rail (general case assumption = 3.5m); and

G = grade, negative for downhill, positive for uphill (%).

Table 21.3 Coefficient of Deceleration for vehicle speeds ranging from 10 - 120 km/h (AUSTROADS 1990)

Vehicle Speed V_V km/h	Coefficient of deceleration (d)	Vehicle Speed V_V km/h	Coefficient of deceleration (d)
10	.68	70	.45
20	.64	80	.43
30	.60	90	.41
40	.56	100	.39
50	.52	110	.37
60	.48	120	.35

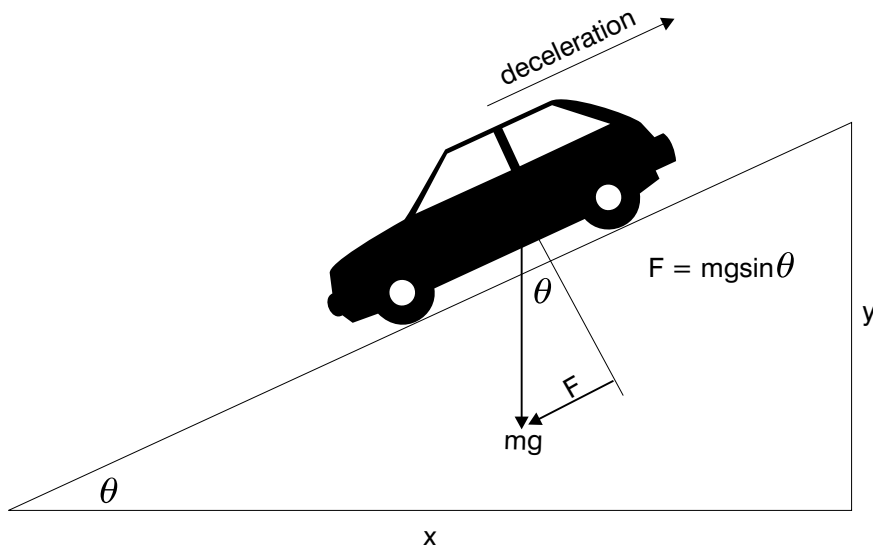


Figure 21A.1 Influence of Slope on Stopping Distance

21A.3 Case 1(i): Decelerate and Safely Stop at the Stop or Holding Line

The time required for a motorist (at a distance S_1 from the nearest rail) to stop at the stop or holding line, comprises:

- perception/reaction time (R_T); and
- braking time

$$\frac{V_V}{a} = \frac{3.6}{gd} = \frac{V_V}{35.3d} \text{ metres}$$

(g = acceleration due to gravity = 9.81 m/sec²).

Therefore, for the motorist to safely stop, the train would have to be sighted at a minimum distance, S_2 from the crossing:

$$S_{2(i)} \geq \frac{V_T}{3.6} (R_T + \frac{V_V}{35.3d}) \quad (21.3)$$

where:-

S_2 = minimum distance of an approaching train from the point of impact with a road vehicle, when the driver of the road vehicle first sees a train approaching in order to safely stop at the stop or holding line (m);

V_T = the speed of the train approaching the crossing (the allowed operating speed of trains, as advised by QR) (km/h);

R_T = perception/reaction time (general case assumption = 2.5 sec);

V_V = the 85th or 15th %ile road vehicle speed in the vicinity of the crossing. The road speed limit plus 10% is a reasonable approximation where the 85th %ile speed is not known, while the 15th %ile speed can be approximated by .75 x 85th %ile speed (Lay 1990:407) (km/h); and

d = coefficient of longitudinal deceleration. Refer to Table 1 (AUSTROADS 1990).

Note that the distance S_2 is measured from alternate datum points which are contingent upon whether a train approaches from the left or right.

For a train approaching from the left, the point of impact is at the road edge line, while for a train approaching from the right, it is at the road centre line. For a field survey, distances S_{2L} and S_{2R} are required to be calculated separately as a common datum point is referenced.

Sight Distance S_{2L} Adjustment

For the case of a train approaching the crossing from the left, the sight distance S_2 is calculated from the left edge line of the road (or the road pavement if there is no edge line). In order to measure distance S_{2L} from the referenced datum point, an adjustment needs to be incorporated into the S_2 equation.

The datum point referenced in the field survey is the intersection of the centre line of the road and the mid point of the rail tracks at the crossing.

$$\text{Adjustment for } S_{2L} \text{ equation} = \frac{0.5W_R}{\sin Z}$$

In the case of a train approaching the crossing from the right, the sight distance, S_{2R} is equal to that adopted for S_2 , as the potential point of impact is at the datum point.

The minimum distances, S_{2L} and S_{2R} , where an approaching train is first sighted in order for a driver of an approaching vehicle to safely stop at the stop or holding line, are calculated from the equations 21.4 and 21.5 respectively.

The minimum distance for a train approaching from the left of the crossing, to enable the driver of a road vehicle to decelerate and safely stop at the stop or holding line is:

$$S_{2L(i)} \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} (R_T + \frac{V_V}{35.3d}) \quad (21.4)$$

The minimum distance for a train approaching from the right of the crossing, to enable the driver of a road vehicle to decelerate and safely stop at the stop or holding line is:

$$S_{2R(i)} \geq \frac{V_T}{3.6} \left(R_T + \frac{V_V}{35.3d} \right) \quad (21.5)$$

The calculated distances S_{2L} and S_{2R} are then compared to the distances obtained in the case of a driver of a road vehicle safely proceeding and clearing the crossing (i.e. Case 1(ii)). The larger value is adopted as the critical case.

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21A.4 Case 1(ii): Proceed and Clear the Crossing with an Adequate Safety Margin

It is also important to consider the case in which a motorist at distance S_1 from the crossing decides to proceed (even though he/she could safely stop) and attempt to clear the crossing prior to the arrival of the train.

Referring to Figure 21.2, the distance a motorist has to travel to clear the crossing is:

$$S_1 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + C_V + C_T + L - L_d$$

Substituting S_1 from equation 21.2, this becomes:

$$\frac{R_T V_V}{3.6} + \frac{V_V^2}{254(d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L$$

Therefore, the distance travelled by the train for the motorist to proceed and clear the crossing:

$$S_{2(ii)} = \frac{V_T}{V_V} \left(\frac{R_T V_V}{3.6} + \frac{V_V^2}{254(d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right) \quad (21.6)$$

where:-

S_2 = minimum distance of an approaching train from the point of impact with a road vehicle, when the driver of the road vehicle can first see the train approaching the crossing in order to proceed and safely clear the

crossing (m);

V_T = the speed of the train approaching the crossing (the allowed operating speed of trains, as advised by QR) (km/h);

V_V = the 85th or 15th %ile road vehicle speed in the vicinity of the crossing. The road speed limit plus 10% is a reasonable approximation where the 85th %ile speed is not known, while the 15th%ile speed can be approximated by .75 x 85th %ile speed¹ (Lay 1990:407) (km/h);

R_T = perception/reaction time (general case assumption = 2.5 sec);

C_V = clearance from the vehicle stop or holding line to the nearest rail (general case assumption = 3.5m);

C_T = clearance or safety margin from stop or holding line on departure side of the crossing (general case assumption = 5m);

d = coefficient of longitudinal deceleration. Refer to Table 1 (AUSTROADS 1990);

L = length of road vehicle, refer to Table 21.4 (m);

W_R = width of the travelled way (portion of the roadway allocated for the movement of the vehicles) at the crossing (m);

W_T = width, outer rail to outer rail, of the rail tracks at the crossing (1.1m for single track, 5.1m for double track); and

Z = angle between the road and the railway at the crossing (degrees).

¹ Investigations by the Main Roads Department (Western Australia – 1991:10) indicate that 15th %ile speed typically ranges from 77% to 84% of the 85th %ile speed.

Table 21.4 Vehicle Lengths

Vehicle Route	Vehicle Type and Length
Roads not on nominated route	Medium car – 4.74m Semi-trailer – 19m
B-double route	B-double – 25m
Road train route – Type 1	Type 1 road train – 33m
Road train route – Type 2	Type 2 road train – 53.5m

Note: AS 2890.1 adopts a 85 %ile length of 4.74m for the average vehicle travelling on roads not on a nominated route.

As discussed in Case 1(i), distance S_2 is measured from alternate datum points to correspond with the potential point of impact for the left and right train approaches. In order to carry out a detailed survey of a crossing, distances S_{2L} and S_{2R} are required to be calculated separately, as a common datum point is utilised.

The minimum distance (S_{2L}) of an approaching train from the intersection of the centre line and the mid point of the rail tracks, when the driver of the road vehicle first sees a train approaching from the left, in order to safely proceed and clear the crossing (considering the sight distance S_{2L} adjustment indicated in Case 1(i)) is:

$$S_{2L(ii)} = \frac{0.5W_R}{\sin Z} + \frac{V_T}{V_V} \left(\frac{R_T V_V}{3.6} + \frac{V_V^2}{254(d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right) \quad (21.7)$$

The minimum distance (S_{2R}) of an approaching train from the intersection of the centre line of the road and the mid point of the rail tracks, when the driver of the road vehicle first sees a train approaching from the right, in order to proceed and clear the crossing is:

$$S_{2R(ii)} = \frac{V_T}{V_V} \left(\frac{R_T V_V}{3.6} + \frac{V_V^2}{254(d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right) \quad (21.8)$$

In order to obtain the critical sight distances, S_{2L}

and S_{2R} , the larger distances from Cases 1(i) and (ii) should be adopted.

21A.5 Case 2: Sight Distance Required for STOP Sign Control

When motorists are stationary at a crossing controlled by a STOP sign, they require adequate sight distance to determine whether or not it is safe to cross the tracks before the train arrives. Refer Figure 21.3 (main part of this Guide). This section presents a method by which the time taken to complete this manoeuvre can be ascertained. The time comprises:

- perception time and time required to depress clutch (J); and
- time to clear the crossing by a ‘safe’ distance

$$2 \left(\frac{\frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L}{a} \right)^{1/2}$$

The distance travelled by the train during this time:

$$S_3 = \frac{V_T}{3.6} (J + \left(\frac{\frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L}{a} \right)^{1/2}) \quad (21.9)$$

Field testing has confirmed that the influence of grade on vehicles accelerating from a stationary position is not accurately modelled by the application of simple physics principles (Lay 1990:571). American literature (AASHTO *Policy on Geometric Design of Highways* quoted in MRD (WA) 1991:16) provides the grade correction factors in Table 21.5.

Equation 21.9 subsequently becomes:

$$S_3 = \frac{V_T}{3.6} \left(J + \frac{\left(\frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)}{a} \right)^{1/2} \quad (21.10)$$

where:-

S_3 = minimum distance of an approaching train from the point of impact with a road vehicle, when the driver of the road vehicle must first see an approaching train in order to safely cross the tracks (m);

V_T = the speed of the train approaching the crossing (the allowed operating speed of trains, as advised by QR) (km/h);

J = sum of the perception time and time required to depress clutch (general case assumption = 2 sec) (Federal Highway Administration 1986);

G_S = grade correction factor, refer to Table 21.5;

L = length of road vehicle, refer to Table 21.4 (m);

C_V = clearance from the vehicle stop or holding line to the nearest rail (general case assumption = 3.5m);

C_T = clearance or safety margin from stop or holding line on departure side of the crossing (general case assumption = 5m);

W_R = width of the travelled way (portion of the roadway allocated for the movement of the vehicles) at the crossing (m);

W_T = width, outer rail to outer rail, of the rail tracks at the crossing (1.1m for single track, 5.1m for double track);

Z = angle between the road and the railway at the crossing (degrees); and

a = average acceleration of vehicle in starting gear (general case assumption = 0.5 m/sec², refer to Table 21.6).

Table 21.5 Grade Correction Factors (AASHTO Policy on Geometric Design of Highways)

Percentage Grade	Grade Correction Factor G_S
- 4	0.8
- 2	0.9
+ 2	1.2
+ 4	1.7

Sight Distance S_{3L} Adjustment

A sight distance adjustment is necessary to calculate S_{3L} for the common datum point used in the field survey. The datum point referenced in the field survey is the intersection of the centre line of the road and the mid point of the railway tracks at the crossing.

Adjustment for S_{3L} equation = $\frac{0.5W_R}{\sin Z}$

Therefore, the minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a road vehicle must first see a train approaching from the left in order to safely cross the track from a stopped position is:

$$S_{3L} = \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} \left(J + \frac{\left(\frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)}{a} \right)^{1/2} \quad (21.11)$$

The minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a road vehicle must first see a train approaching from the left in order to safely cross the track from a stopped position is:

$$S_{3R} = \frac{V_T}{3.6} \left(J + \frac{\left(\frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)}{a} \right)^{1/2} \quad (21.12)$$

Table 21.6 Heavy Vehicle Speed/Acceleration Performance (RTA, 1990 and QT, 1993)

Type of Vehicle	Distance travelled (m)	Time (sec)	Average Speed (m/sec)	Average Acceleration (m/sec ²)
Laden Rigid Truck (RTA 1990)	22.4	9.3	2.4	.50
Laden Semi-Trailer (RTA 1990)	28.9	12.6	2.3	.36
Laden B-double (RTA 1990)	34.4	13.6	2.5	.37
Laden Road Train (RTA 1990)	46.4	21.3	2.2	.29
Laden 19m Semi-Trailer (QT Mt Cotton Facility 1993)	27.5	11.3	2.4	.43
		8.7	3.2	.73
Laden 19m Semi-Trailer (QT Mt Cotton Facility 1993)	34.5	13.8	2.5	.36
		10.8	3.2	.59

In addition to the data provided in Table 21.6, limited data collected by ARRB (Barton 1990:6) suggests the average speed of a heavy vehicle commencing from a stopped position equals 3.3 m/sec over a typical crossing distance. The Main Roads Department (Western Australia) (1991:13) quotes values of acceleration obtained from American literature ranging from “.45 m/sec² for the acceleration of trucks in first gear, to 0.54 m/sec² over a distance of around 12m, then gradually back down to a value of 0.5 m/sec² for a distance of around 50”. For the required crossing visibility at the critical case, they subsequently recommend the adoption of a heavy vehicle acceleration value of 0.5 m/sec² to “be on the conservative side”, and indicate that this value has been shown “to be acceptable by measuring the acceleration rates of a number of fully laden trucks, which resulted in values between 0.55 m/sec² and 0.90 m/sec²”.

Appendix 21B: Field Survey Instructions

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21B1 What is the objective/ purpose of the exercise?

Following the guidelines set out in this document, a survey is necessary at open level crossings to determine the type of passive control devices required (give-way or stop sign control) or whether alternate forms of control are required (flashing lights, boom gates or grade separation).

Higher level devices should be programmed for installation on a priority basis, in consideration of the funding availability for improvements to the safety of the whole of the Queensland Transport road network.

21B2 What must be done to achieve the objective/purpose?

- Measure the sight distance required as a motorist approaches the crossing (for crossing controlled by position signs (stop sign);
- Measure the sight distance required for a motorist to safely clear the crossing (for both crossings controlled by stop signs and giveaway signs); and
- Observe and note all conditions that may affect the safety of the crossing.

21B3 What must be done in the office prior to the survey?

Complete survey forms 1 and 2 as far as is possible. (An example of a practical application showing completed survey forms 1 and 2 is given in Appendix C.)

- Obtain copies of road plans (where available) that indicate the crossings to be surveyed.
- Determine maximum vehicle type permitted to use crossings to be surveyed (refer to road train

and B-Double route maps).

- Note the AADT at the crossing from Queensland Transport records.
- Obtain from Queensland Rail, records of maximum permitted train approach speeds (for both directions) for the crossings to be surveyed and enter on forms.
- Liaise with Queensland Rail to determine train movements expected on the crossings during the survey period (to improve survey staff safety level).
- Read the technical appendix “The Derivation of Sight Distance Requirements at Open Level Crossings”.

21B4 What must be done prior to any work in the rail corridor?

Queensland Rail have certain mandatory requirements which must be satisfied before personnel can work within the rail corridor.

- All survey staff entering the rail corridor must possess current Queensland Rail safety accreditation. Courses are available through the Training Centre, Training and Development Division.
- A Queensland Rail flagman or safety officer must be present each time survey staff enter the corridor. There are courses which enable non QR personnel to gain flagman accreditation. Conditions of entry would need to be negotiated with QR Safety Division.
- Work in the corridor in electrified areas (25,000 volts) requires an additional accreditation in basic Electrification Safety.
- Staff or ranging tools used within electrified areas must be specially insulated. The target height of 2.3 metres above rail, puts the target inside the 2.75 metre exclusion zone of the overhead power. As a consequence, special poles must be used that conform to Maintenance Instruction No. 6 of the Manager Electrical Engineering.

There is a safety procedure to follow each time the pole is used and the poles must be tested every 6 months by either QR or ENERGEX.

- All survey staff must comply with the requirements of the Workplace Health and Safety Act as it applies to work in the rail corridor.

For further information or clarification on any QR requirements contact:

Survey Manager Civil Engineering
Engineering Services
Queensland Rail
Floor 6 Railcentre 2
309 Edward Street Brisbane Qld 4000

21B5 What equipment is needed for the survey?

- Standard survey equipment including safety signs and safety equipment.
- Compass – desirably electronic.
- Two measuring wheels.
- Portable computer with Rail Crossing Mass Action.
- Clinometer (measures in degrees).
- Small step ladder.
- Two-way radios.
- Staff or ranging rod with a target attached with centre line 2.4m from the base (with the rod placed on a sleeper the target represents the train light 2.3m above the track).
- Marker cones and spray paint (road marking).
- Clipboard.
- A calculator.
- This guide with blank forms for stop sign and position sign controlled crossings.

21B6 Procedure to follow at each crossing site

21B6.1 General Conditions (all sites)

- Comply with all mandatory requirements of Queensland Rail.
- Place safety signs on approaches.
- Record the location of the crossing, name of Government Authority; and direction and distance to the nearest town or ARP.
- Note and record the type and condition of the road surface.
- Sketch the approximate relationship of the road and rail for both approaches on Form 1. This is for the purpose of future reference and for unambiguous recording of information.
- On the sketch, indicate the North point and label the approach directions for each approach of the rail and the road (e.g. NW, SE, etc).
- Record and illustrate signed road speed limits on sketch. Note maximum train approach speed obtained prior to site visit.
- Record condition, correct spacing, completeness and correctness of rail crossing warning signs with reference to MUTCD Part 7 (attached as a guide).
- Check and record if signs correspond to new or old standard.
- Measure and record the angle of skewness, Z in degrees, subtended between the driver's line of sight and the railway line at the crossing.

If Stop signs are installed, do not measure approach visibility, commence zoning for crossing visibility.

21B6.2 Approach Visibility

- Adopt a vehicle length L, co-efficient of deceleration d and 85 %ile speed.
- Measure the widths W_R and W_T at the crossing.

- For both road approaches measure the approximate average road grade for the crossing and note this grade on the sketch, as well as the data table showing positive for an uphill grade approaching the crossing and negative for a downhill grade approaching the crossing. The form recommends an appropriate distance from the crossing to measure grade for the respective vehicle speed.
- Calculate S_1 , $S_1(A)$, $S_1(B)$, S_2 , $S_2(A)$ and $S_2(B)$ for both approaches. (Where S_1 and S_2 represent the limits on the road and rail respectively where clear visibility should be available for the road and rail speeds under consideration). Intermediate points $S_1(A)$, $S_1(B)$, $S_2(A)$ and $S_2(B)$ indicate zones of decreasing ability for drivers to stop.
- Two cases are considered for both S_{2L} and S_{2R} for 85th percentile and 15th percentile speeds. The maximum value is adopted for calculated distances S_{2L} and S_{2R} . Where the train speed exceeds the 15th percentile road speed calculate also the values for S_1 , S_2 , etc. using the 15th percentile vehicle speed.
- Assess the sight triangles for compliance with $S_1 - S_2$ distances for each road approach and for each quadrant as follows:
 - Using a measuring wheel on the rail nearest the approach, measure and mark $S_2(A)$, $S_2(B)$ and S_2 to the left of the approach road (i.e. to an approaching driver's left). Commence the measurement from the intersection of the road centre line and the mid point of the rail tracks.
 - Again using a measuring wheel along the road approach measure and mark distances $S_1(A)$, $S_1(B)$ and S_1 . Measure along the edge line, or edge of pavement for safety but the measurement should apply from the road centre line of the nearest rail to the approach.
 - A chainman and observer commence at S_2 for the left hand triangle with the 2.4m high target placed on a sleeper at the S_2 marker. Observe this target from S_1 using an eye height of 1.15m.

Sight Triangle Clear

If the entire left hand sight triangle formed by the crossing, S_1 and S_2 is clear (in practical terms) of visual obstructions then measure and record the angle of driver visibility at S_1 (i.e. the angle between the line of travel at that point and S_2). A compass with bearings marked and a rotatable pointer is of sufficient accuracy.

If the viewing angle between S_1 and S_2 is greater than X_{1L} ($> 95^\circ$), zone D is adopted and recorded on the Score Sheet (Form 2). If the viewing angle is less than or equal to X_{1L} ($\leq 95^\circ$) then the sight triangle $S_1(B)$, $S_2(B)$ is considered. If the actual sight distances and viewing angle do not comply within the calculated requirements, the adjacent sight triangle closer to the crossing is considered until both requirements are met or when zone B does not comply with the requirements, and zone A is adopted.

Repeat the procedure for the right quadrant where the accepted viewing angle is less than or equal to Z_{1R} ($\leq 110^\circ$) and then for both left and right quadrants for the opposite approach.

In the case where the visibility is noticeably insufficient, calculation and measurement of S_2 , $S_2(B)$ are not required. Although, for the purpose of future reference and unambiguous recording of information, sight distance $S_2(A)$ and viewing angles Z_{1L}/Z_{1R} need to be considered to obtain a record of calculated and actual visibility.

Sight Triangle Obstructed

If the sight triangle is obstructed, attempt to measure the angle of driver visibility from S_1 , $S_1(B)$ or $S_1(A)$ and record the angle.

When stating the level of approach visibility use the following determinants:

- (i) The vegetation, signs, buildings, trees, etc., allow reasonable visibility for observing approaching trains, they provide windows of opportunity, **OR**
- (ii) It is assumed that there is no visibility.

Provide a recommendation based on the approach visibility. Continue zoning for the crossibility

visibility to complete the Score Sheet for ranking.

21B6.3 Crossing visibility

- Undertake measurements as required by 21B6.2.
- Measure the grade of the crossing. If the grade varies, take as the critical grade that applies between 3.5 and 10m back from the nearest rail or 10m back from the stop sign (the grade on which a semi-trailer must commence acceleration).
- Measure the widths W_R and W_T at the crossing.
- Calculate the required sight distance S_3 for an eye height corresponding to the vehicle type adopted (eg 1.15m (car) and 2.2m (truck)).
- Using the measuring wheel mark out sight distance S_3 for a particular approach to both the left and the right of the crossing. For both directions, commence the measurement from the intersection of the road centreline and the mid point of the rail tracks. With the 2.4m high marker placed at S_3 check visibility 5m back from the nearest rail. Check from corresponding eye height using a step ladder.

Sight Triangle Clear

If the entire triangle is clear, measure the driver view angle to S_3 for the left quadrant. If the viewing angle is greater than or equal to X_{2L} ($\geq 110^\circ$), zone H is adopted and recorded on the Score Sheet (Form 2). If the viewing angle is less than or equal to X_{2L} ($\leq 110^\circ$) then the sight triangle $S_3(B)$ is considered. If the actual sight distances and viewing angle do not comply within the calculated requirements, the adjacent sight triangle closer to the crossing is considered until both requirements are met or when zone F does not comply with the requirements, and zone E is adopted.

Repeat the procedure for the right quadrant using an acceptable visibility angle of $X_{2R} \leq 140^\circ$ and then for both left and right quadrants for the opposite approach.

In the case where the visibility is insufficient, calculation and measurement of S_3 , $S_3(B)$ are not required. Although, for the purpose of future reference and unambiguous recording of information, sight distance $S_3(A)$ and viewing angles Z_{2L}/Z_{2R} need to be considered to obtain a record of calculated and actual visibility.

Sight Triangle Obstructed

If the sight triangle is obstructed, attempt to measure the angle of driver visibility available and record the angle.

Provide a recommendation based on crossing visibility. Complete the Score Sheet for ranking.

21B6.4 Score Sheet (all sites)

The Score Sheet is required when:

- approach visibility triangle is deficient (eg S_1 , S_2 ; Figure 21.2). or
- approach viewing angle is deficient (eg X_{1L} , X_{1R} ; Figure 21.2). or
- approach visibility triangle is deficient (eg S_1 , S_3 ; Figure 21.3). or
- approach viewing angle is deficient (eg X_{2L} , X_{2R} ; Figure 21.2).
- Allocate the score corresponding to the zone adopted for each quadrant in Form 1 for both approach and crossing visibility. If Stop signs are installed, the approach visibility is not measured. The approach visibility score = 0, since approaching vehicles must stop.
- Calculate exposure ($V_T/1000$) to the nearest whole number.
- From the accident history, record the number of vehicle/train and vehicle/vehicle accidents and apply the scoring system.
- Total scores for each risk type and consider possible treatments.
- Prioritise the surveyed crossings by highest to lowest **total score**.

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2 CHECK CORRECT INSTALLATION OF WARNING SIGNS

	Sign	Maintenance Standard Acceptable?		Required Distance (refer to MUTCD) (m)	Actual Distance (m)
		Yes ✓	No Provide Comments		
Road Approach A	<i>Crossing Assembly</i> Old RLC-L RLC-B New RX-1 D4-3B (L & R)			3.5 m from nearest rail	
	<i>Warning Assembly</i> Old RLC-C New RX-3 W7-7 (L & R)			Distance A	
	<i>Stop Sign Assembly</i> Old RLC-D New RX-2 W3-1			3.5 m from nearest rail Distance A	
	<i>Side Road Sign & Assembly</i> Old RLC-H New RX-4 W7-12 or W7-13			Distance B Distance A	
	<i>Flashing Signals Sign & Assembly</i> Old RLC-E RLC-J RLC-F New RX-5 W7-4 RX-7			Distance A 3.5 m from nearest rail Distance A	
	<i>Gates Sign & Assembly</i> Old RLC-K RLC-G New RX-6 W7-15 RX-8			Distance A 3.5 m from nearest rail Distance A	

	Sign	Maintenance Standard Acceptable?		Required Distance (refer to MUTCD) (m)	Actual Distance (m)
		Yes ✓	No Provide Comments		
Road Approach B	<i>Crossing Assembly</i> Old RLC-L RLC-B New RX-1 D4-3B (L & R)			3.5 m from nearest rail	
	<i>Warning Assembly</i> Old RLC-C New RX-3 W7-7 (L & R)			Distance A	
	<i>Stop Sign Assembly</i> Old RLC-D New RX-2 W3-1			3.5 m from nearest rail Distance A	
	<i>Side Road Sign & Assembly</i> Old RLC-H New RX-4 W7-12 or W7-13			Distance B Distance A	
	<i>Flashing Signals Sign & Assembly</i> Old RLC-E RLC-J RLC-F New RX-5 W7-4 RX-7			Distance A 3.5 m from nearest rail Distance A	
	<i>Gates Sign & Assembly</i> Old RLC-K RLC-G New RX-6 W7-15 RX-8			Distance A 3.5 m from nearest rail Distance A	

3 DATA

Notes:

(a) Use tables below for vehicle length, L and the coefficient of deceleration, d (AUSTROADS 1990).

COEFFICIENT OF DECELERATION

Vehicle Speed (V_V – km/h)	Coefficient of deceleration (d)	Vehicle Speed (V_V – km/h)	Coefficient of deceleration (d)
10	.68	70	.45
20	.64	80	.43
30	.60	90	.41
40	.56	100	.39
50	.52	110	.37
60	.48	120	.35

VEHICLE LENGTH

Vehicle Route	Vehicle Type and Length	
Roads not on nominated route	Medium car	4.74m
	Semi-trailer	19m
B-double route	B-double	25m
Road train route – Type 1	Type 1 road train	33m
Road train route – Type 2	Type 2 road train	50m

- (b) Adopt 10% above the signed speed limit as the 85th %ile speed unless road geometry indicates that a higher or lower speed would apply. In this case, determine an appropriate speed based on judgement after driving over the crossing in both directions.
- (c) Measure the width W_R of the travelled way (portion of the roadway allocated for the movement of the vehicles) at the crossing.
- (d) Measure the width W_T of the rail tracks at the crossing.

DISTANCE FROM CROSSING TO MEASURE GRADE

V_V (km/h)	Distance from Crossing (m)
60	70
70	90
80	115
90	140
100	170
110	205

(e) The grade of the approach, G is the average grade that would affect deceleration and is taken as positive for upgrades and negative for downgrades (e.g. a 2% downgrades would be $G = -2$). The distance from the crossing to correspond with the speed environment is given in the following table representing the stopping sight distance for a 2.5 second reaction time derived from AUSTROADS 1990. Measure the grade at the point where braking is applied at a distance from the crossing indicated in the table unless there is clearly a different grade between this point and the crossing which would have a greater effect on deceleration. In such cases a judgement must be made as to the applicable grade and reasons given.

TABULATED DATA

	Train Speed V_T (km/h)	Signed Road Speed Limit km/h		Coefficient of Deceleration d		Vehicle Length L (m)	Width of Road W_R (m)	Width of Railway Track W_T (m)	Grade G (%)	Angle of Skewness Z°
		Assessed 85th%ile Veh. Speed V_V (km/h)	15th%ile Veh. speed ($0.75 V_V$) (km/h)	85%ile	15%ile					
Road Approach A from										
Road Approach B from										

21

4 CALCULATE SIGHT DISTANCES REQUIRED (for 85th Percentile and 15th Percentile¹ Vehicle Speed)

Notes: General case assumption for L_d and C_V are 1.5m and 3.5m, respectively.

In order to obtain the critical sight distances, S_{2L} and S_{2R} , the greater value from Case 1(i) and (ii) should be adopted for assessment of the sight triangles.

General case assumption for R_T is 2.5 sec, however in case (B) an emergency reaction time of 0.8 sec is assumed. In case (A) and (B) it is assumed that double the coefficient of deceleration is available.

(a) Case 1 – Sight Distance Required for Position Sign Control

		85%ile	15%ile
$S_1 \geq \frac{2.5V_V}{3.6} + \frac{V_V^2}{254(d + \frac{G}{100})} + L_d + C_V$	App A	<input type="text" value="S<sub>1</sub>="/> m	<input type="text" value="S<sub>1</sub>="/> m
	App B	<input type="text" value="S<sub>1</sub>="/> m	<input type="text" value="S<sub>1</sub>="/> m
$S_1(B) \geq \frac{2.5V_V}{3.6} + \frac{V_V^2}{254(2d + \frac{G}{100})} + L_d + C_V$	App A	<input type="text" value="S<sub>1</sub>(B)="/> m	<input type="text" value="S<sub>1</sub>(B)="/> m
	App B	<input type="text" value="S<sub>1</sub>(B)="/> m	<input type="text" value="S<sub>1</sub>(B)="/> m
$S_1(A) \geq \frac{0.8V_V}{3.6} + \frac{V_V^2}{254(2d + \frac{G}{100})} + L_d + C_V$	App A	<input type="text" value="S<sub>1</sub>(A)="/> m	<input type="text" value="S<sub>1</sub>(A)="/> m
	App B	<input type="text" value="S<sub>1</sub>(A)="/> m	<input type="text" value="S<sub>1</sub>(A)="/> m

(b) Case 1(i) – Decelerate and safely stop at the stop or holding line

Left Quadrant

$S_{2L(\theta)} \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} (2.5 + \frac{V_V}{35.3d})$	App A	<input type="text" value="S<sub>2L(θ)</sub>="/> m	<input type="text" value="S<sub>2L(θ)</sub>="/> m
	App B	<input type="text" value="S<sub>2L(θ)</sub>="/> m	<input type="text" value="S<sub>2L(θ)</sub>="/> m
$S_{2L(\theta)}(B) \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} (2.5 + \frac{V_V}{70.6d})$	App A	<input type="text" value="S<sub>2L(θ)</sub>(B)="/> m	<input type="text" value="S<sub>2L(θ)</sub>(B)="/> m
	App B	<input type="text" value="S<sub>2L(θ)</sub>(B)="/> m	<input type="text" value="S<sub>2L(θ)</sub>(B)="/> m
$S_{2L(\theta)}(A) \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} (0.8 + \frac{V_V}{70.6d})$	App A	<input type="text" value="S<sub>2L(θ)</sub>(A)="/> m	<input type="text" value="S<sub>2L(θ)</sub>(A)="/> m
	App B	<input type="text" value="S<sub>2L(θ)</sub>(A)="/> m	<input type="text" value="S<sub>2L(θ)</sub>(A)="/> m

Right Quadrant

$S_{2R(\theta)} \geq \frac{V_T}{3.6} (2.5 + \frac{V_V}{35.3d})$	App A	<input type="text" value="S<sub>2R(θ)</sub>="/> m	<input type="text" value="S<sub>2R(θ)</sub>="/> m
	App B	<input type="text" value="S<sub>2R(θ)</sub>="/> m	<input type="text" value="S<sub>2R(θ)</sub>="/> m
$S_{2R(\theta)}(B) \geq \frac{V_T}{3.6} (2.5 + \frac{V_V}{70.6d})$	App A	<input type="text" value="S<sub>2R(θ)</sub>(B)="/> m	<input type="text" value="S<sub>2R(θ)</sub>(B)="/> m
	App B	<input type="text" value="S<sub>2R(θ)</sub>(B)="/> m	<input type="text" value="S<sub>2R(θ)</sub>(B)="/> m
$S_{2R(\theta)}(A) \geq \frac{V_T}{3.6} (0.8 + \frac{V_V}{70.6d})$	App A	<input type="text" value="S<sub>2R(θ)</sub>(A)="/> m	<input type="text" value="S<sub>2R(θ)</sub>(A)="/> m
	App B	<input type="text" value="S<sub>2R(θ)</sub>(A)="/> m	<input type="text" value="S<sub>2R(θ)</sub>(A)="/> m

Note:

1 Calculate 15th percentile values to check that visibility angles are acceptable for slower drivers (taken as 0.75 x 85th percentile speed).

(c) Case 1 (ii) – Proceed and clear the crossing within an adequate safety margin

Left Quadrant

$$S_{2L(ii)} \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{V_V} \left(\frac{2.5V_V^2}{254(d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

85%ile

15%ile

App A m

m

App B m

m

$$S_{2L(ii)}(B) \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{V_V} \left(\frac{2.5V_V^2}{254(2d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

App A m

m

App B m

m

$$S_{2L(ii)}(A) \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{V_V} \left(\frac{0.8V_V^2}{254(2d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

App A m

m

App B m

m

Right Quadrant

$$S_{2R(ii)} \geq \frac{V_T}{V_V} \left(\frac{2.5V_V^2}{254(d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

App A m

m

App B m

m

$$S_{2R(ii)}(B) \geq \frac{V_T}{V_V} \left(\frac{2.5V_V^2}{254(2d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

App A m

m

App B m

m

$$S_{2R(ii)}(A) \geq \frac{V_T}{V_V} \left(\frac{0.8V_V^2}{254(2d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

App A m

m

App B m

m

5 ASSESS SIGHT TRIANGLES

The detailed survey instructions explain the procedure of assessing sight triangles. The sight triangles can be assessed for both approaches by tabulating information on the following tables.

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APPROACH VISIBILITY - APPROACH A

Z O N E	Case 1		Case 1 (i) - Decelerate and Stop			Case 1 (ii) - Proceed and Clear Crossing				Adopted S ₁₁	Adopted S ₁₂	Adopted S ₁₃	Viewing Angle (degrees)				
	1	2	3	4	5	6	7	8	9	10	11	12	13	Z ₁₁	Z ₁₂	Z ₁₃	
D	S ₁		S _{2,3(i)}			S _{2,3(i)}			S _{2,3(ii)}		Max. value of cols 3,4,7,8		Max. value of cols 5,6,9,10	Z ₁₁	Z ₁₂	Z ₁₃	
	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	Max. value of cols 1, 2	Max. value of cols 3,4,7,8	Max. value of cols 5,6,9,10	Z ₁₁	Z ₁₂	Z ₁₃	
	Calculated																
	Actual																
C	S _{1(B)}		S _{2,3(i)(B)}			S _{2,3(i)(B)}			S _{2,3(ii)(B)}		Adopted S _{11(B)}		Adopted S _{12(B)}	Adopted S _{13(B)}	Z _{11(B)}	Z _{12(B)}	Z _{13(B)}
	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	Max. value of cols 1,2	Max. value of cols 3,4,7,8	Max. value of cols 5,6,9,10	Z _{11(B)}	Z _{12(B)}	Z _{13(B)}	
	Calculated																
	Actual																
B	S _{1(A)}		S _{2,3(i)(A)}			S _{2,3(i)(A)}			S _{2,3(ii)(A)}		Adopted S _{11(A)}		Adopted S _{12(A)}	Adopted S _{13(A)}	Z _{11(A)}	Z _{12(A)}	Z _{13(A)}
	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	Max. value of cols 1,2	Max. value of cols 3,4,7,8	Max. value of cols 5,6,9,10	Z _{11(A)}	Z _{12(A)}	Z _{13(A)}	
	Calculated																
	Actual																
	②																
	③																
	④																

Notes:

- Viewing angle measured for required sight distances and the required viewing angles are ≤ 110° left quadrant and ≤ 140° right quadrant.
- Does the actual distances and viewing angle for the quadrant, comply within the calculated requirements (- Yes, - No).
If — Complete ranking on Score Sheet (Form 2).
- Record the actual viewing angle, and continue to next zone.
- Does the actual distances for the quadrant, comply within the calculated requirements (- Yes, - No).
If — Complete ranking on Score Sheet (Form 2).
- Record the actual viewing angle, and complete ranking on Score Sheet for Zone A.
All distances to be recorded in metres.

APPROACH VISIBILITY - APPROACH B⁵

Z O N E	Case 1		Case 1(i) - Decelerate and Stop			Case 1(ii) - Proceed and Clear Crossing			Adopted S_T	Adopted S_{ZL}	Adopted S_{2R}	Viewing Angle (degrees)	Viewing Angle (degrees)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	Z_{TL} Z_{TR}	
	S_T		$S_{ZL(i)}$		$S_{2R(i)}$		$S_{ZL(ii)}$		$S_{2R(ii)}$		Max. value of cols 1, 2	Max. value of cols 3,4,7,8	Max. value of cols 5,6,9,10		
Calculated	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile					
D	Actual														
C	$S_T(B)$		$S_{ZL(i)}(B)$		$S_{2R(i)}(B)$		$S_{ZL(ii)}(B)$		$S_{2R(ii)}(B)$		Adopted $S_T(B)$ Max cols 1,2	Adopted $S_{ZL}(B)$ Max cols 3,4,7,8	Adopted $S_{2R}(B)$ Max cols 5,6,9,10	$Z_{TL}(B)$	$Z_{TR}(B)$
	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile					
	Calculated	Actual													
B	$S_T(A)$		$S_{ZL(i)}(A)$		$S_{2R(i)}(A)$		$S_{ZL(ii)}(A)$		$S_{2R(ii)}(A)$		Adopted $S_T(A)$ Max cols 1,2	Adopted $S_{ZL}(A)$ Max cols 3,4,7,8	Adopted $S_{2R}(A)$ Max cols 5,6,9,10	$Z_{TL}(A)$	$Z_{TR}(A)$
	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile					
	Calculated	Actual													

Notes:

- 2 Viewing angle measured for required sight distances and the required viewing angles are $\leq 110^\circ$ left quadrant and $\leq 140^\circ$ right quadrant.
- 3 Does the actual distances and viewing angle for the quadrant, comply within the calculated requirements (✓ – Yes, X – No).
If ✓ — Complete ranking on Score Sheet (Form 2).
If X — Record the actual viewing angle, and continue to next zone.
- 4 Does the actual distances for the quadrant, comply within the calculated requirements (✓ – Yes, X – No).
If ✓ — Complete ranking on Score Sheet (Form 2).
If X — Record the actual viewing angle, and complete ranking on Score Sheet for Zone A.

6 RECOMMENDATIONS

SURVEY OF OPEN LEVEL CROSSING SIGHT DISTANCE ASSESSMENT CROSSING VISIBILITY

1 CROSSING GEOMETRY

- (a) On the crossing geometry sketch (Page 1), indicate the road grade that applies between 3.5 and 10m back from the nearest rail.
 (b) Measure S_{3L} and S_{3R} from the intersection of the road centre line and the mid point of the rail tracks at the crossing.

2 DATA

Notes:

- (a) Note the train speed, V_T .
 (b) Using table below, record the vehicle length, L and grade factor, G_S .

VEHICLE LENGTH

Vehicle Route	Vehicle Type and Length	
Roads not on nominated route	Medium car	4.74m
	Semi-trailer	19m
B-double route	B-double	25m
Road train route – Type 1	Type 1 road train	33m
Road train route – Type 2	Type 2 road train	50m

TABLE OF GRADE FACTOR

Percentage Grade (See Note)	Grade Factor G_S
-6	0.7
-4	0.8
-2	0.9
level	1.0
+2	1.2
+4	1.7
+6	2.1

- (c) Grade is negative where road falls towards crossing and positive where road rises to crossing.
 (d) Where approach visibility has not been calculated:
- measure the width W_R of the travelled way (portion of the roadway allocated for the movement of the vehicles) at the crossing;
 - measure the width W_T of the rail tracks at the crossing.

TABULATED DATA

	Train Speed V_T (km/h)	Grade Factor G_S	Vehicle Length L (m)	Width of Road W_R (m)	Width of Railway Track W_T (m)
Road Approach A from					
Road Approach B from					

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3 CALCULATE REQUIRED SIGHT DISTANCES

Note: In the general case $J = 2$ sec, $a_g = 0.5$ m/s².

For case (B) the vehicle is in zone F and $J = 1.5$ sec, $a_g = 0.6$ m/s², $L = 19$ m.

For case (A) the vehicle is in zone E and $J = 0.8$ sec, $a_g = 0.9$ m/s², $L = 5$ m (car).

Left Quadrant

$$S_{3L} = \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} \left[2 + G_S \left[4 \left(L + 12 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A m

App B m

$$S_{3L}(B) = \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} \left[1.5 + G_S \left[3.33 \left(28.5 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A m

App B m

$$S_{3L}(A) = \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} \left[0.8 + G_S \left[2.22 \left(14.5 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A m

App B m

Right Quadrant

$$S_{3R} = \frac{V_T}{3.6} \left[2 + G_S \left[4 \left(L + 12 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A m

App B m

$$S_{3R}(B) = \frac{V_T}{3.6} \left[1.5 + G_S \left[3.33 \left(28.5 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A m

App B m

$$S_{3R}(A) = \frac{V_T}{3.6} \left[0.8 + G_S \left[2.22 \left(14.5 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A m

App B m

4 ASSESS SIGHT TRIANGLES

The detailed survey instructions explain the procedure of assessing sight triangles.

CROSSING VISIBILITY – APPROACH A⁹

ZONE		S_{3L}	Viewing Angle Z_{2L} ⑥	S_{3R}	Viewing Angle Z_{2R} ⑥
H	Calculated				
	Actual				
		⑥			
		$S_{3L(B)}$	Viewing Angle Z_{2L} ⑥	$S_{3R(B)}$	Viewing Angle Z_{2R} ⑥
G	Calculated				
	Actual				
		⑦			
		$S_{3L(A)}$	Viewing Angle Z_{2L} ⑥	$S_{3R(A)}$	Viewing Angle Z_{2R} ⑥
F	Calculated				
	Actual				
		⑧			

CROSSING VISIBILITY – APPROACH B⁹

ZONE		S_{2L}	Viewing Angle Z_{2L} ⑥	S_{2R}	Viewing Angle Z_{2R} ⑥
H	Calculated				
	Actual				
		⑥			
		$S_{2L(B)}$	Viewing Angle Z_{2L} ⑥	$S_{2R(B)}$	Viewing Angle Z_{2R} ⑥
G	Calculated				
	Actual				
		⑦			
		$S_{2L(A)}$	Viewing Angle Z_{2L} ⑥	$S_{2R(A)}$	Viewing Angle Z_{2R} ⑥
F	Calculated				
	Actual				
		⑧			

Notes:

- 6 Viewing angle measured for required sight distances and the required viewing angles are $\leq 110^\circ$ left quadrant and $\leq 140^\circ$ right quadrant.
- 7 Does the actual distances and viewing angle for the quadrant, comply within the calculated requirements (✓ – Yes, ✗ – No).
If ✓ – Complete ranking on Score Sheet (Form 2).
If ✗ – Record the actual viewing angle, and continue to next zone.
- 8 Does the actual distances for the quadrant, comply within the calculated requirements (✓ – Yes, ✗ – No).
If ✓ – Complete ranking on Score Sheet (Form 2).
If ✗ – Record the actual viewing angle, and complete ranking on Score Sheet for Zone E.
- 9 All distances to be recorded in metres.

6 RECOMMENDATION

SCORE SHEET

LOCAL AUTHORITY

ROAD

DISTANCE (km) FROM
(TOWN)

RECORDED BY DATE

21

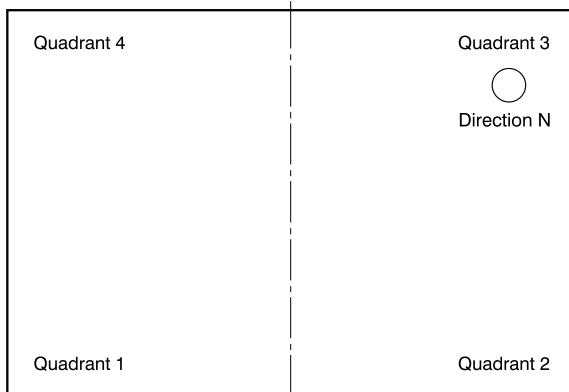


Figure 1 Site Sketch

Approach Visibility	
Zone	Score
A	80
B	40
C	5
D	0
Crossing Visibility	
Zone	Score
E	160
F	80
G	10
H	0

Score by Zone

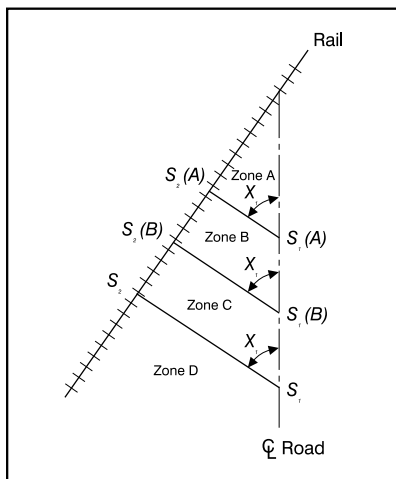


Figure 2 Approach Visibility

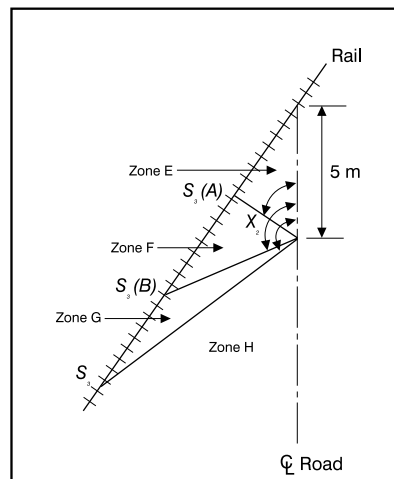


Figure 3 Crossing Visibility

Risk Type	Approach A				Approach B				Score	
	Left		Right		Left		Right			
	Quadrant 1	Quadrant 2	Quadrant 1	Quadrant 2	Quadrant 1	Quadrant 2	Quadrant 1	Quadrant 2	Quadrants 1 → 4	
Approach Visibility	Zone	Score	Zone	Score	Zone	Score	Zone	Score	Quadrants 1 → 4	①
Crossing Visibility	Zone	Score	Zone	Score	Zone	Score	Zone	Score	Quadrants 1 → 4	②
Exposure	[(Trains/wk (2 way) x AADT (2 way))] / 1,000 Nearest Whole Number									③
Safety (5 years)	Vehicle/Train Accidents: 1st accident → Score 20; Subsequent accidents → Score 40									④
	Vehicle/Vehicle Accidents: 1st accident → Score 10; Subsequent accidents → Score 20									⑤
Grand Total ① → ⑤										⑥

SCORE 6

3

Notes:

- 1 Refer Appendix B of Guide for Detailed Survey Instructions.
- 2 If 'Stop' signs are installed, do not measure. Score = 0 since approaching vehicles must stop.
- 3 **Possible Treatments** – Erect 'Stop' signs, clear sight lines of vegetation. Remove signs, buildings, etc., reduce vehicle speed, reduce train speed, remove embankment, change road alignment, change rail alignment, install flashing lights, install boom gates, grade separation.

Appendix C Practical Example

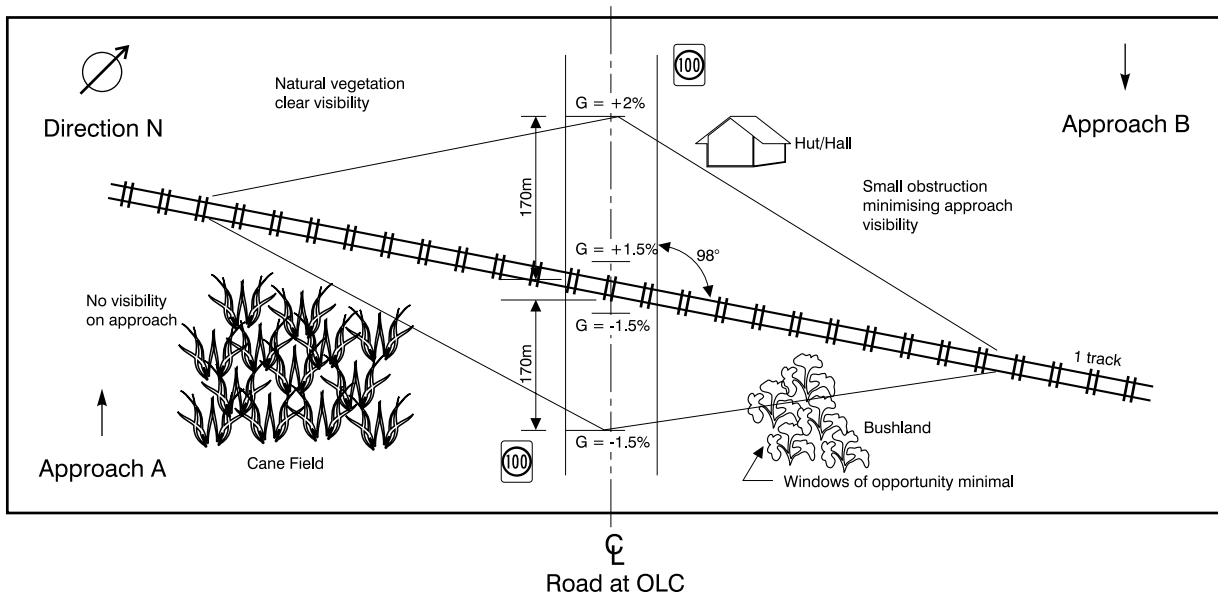
SURVEY OF OPEN LEVEL CROSSING SIGHT DISTANCE ASSESSMENT APPROACH VISIBILITY

LOCAL AUTHORITY *Coastal City Council*
 ROAD *Water Rd*
 DISTANCE (km) *10* FROM *Maveton*
 (TOWN)
 TAADT *150,000* (trains/wk) x (vehicles/day)

ROAD SURFACE AT CROSSING BITUMEN/CONCRETE GRAVEL CONDITION GOOD POOR

21

1 SKETCH CROSSING GEOMETRY



Notes:

- (a) Sketch
 - show bearing of road and rail at crossing and indicate the number of tracks on railway line within distance S_2 , left and right of crossing.
 - indicate any significant obstructions and show or describe how they affect visibility.
 - indicate road grade on approach (refer to 3(e)).
- (b) General Notes
 - measure S_1 from the nearest rail to the driver of the road vehicle.
 - measure S_{2L} and S_{2R} from the intersection of the road centre line and the mid point of the rail tracks at the crossing.
 - measure W_T from outer rail to outer rail perpendicular to the rail tracks.
 - measure W_R between the edge lines of the roadway (or the width of the road pavement if there is no edge line) at the crossing perpendicular to the road centre line.
- (c) Measure and record the angle of skewness, Z , in degrees, subtended between the driver's line of sight and the railway at the crossing.
- (d) Check existing approach signs at crossing. Tabulate type, location and condition of signs in section 2. Check the corresponding sign distance required from the crossing shown in the Table below.

SIGN DISTANCE CROSSING

Velocity V_{85} (km/h)	Distance A (m)	Distance B (m)
< 75	80 – 120	50
75 – 90	120 – 180	60
> 90	180 – 250	70

Road Planning and Design Manual

2 CHECK CORRECT INSTALLATION OF WARNING SIGNS

	Sign	Maintenance Standard Acceptable?		Required Distance (refer to MUTCD) (m)	Actual Distance (m)
		Yes ✓	No Provide Comments		
Road Approach A	<i>Crossing Assembly</i> Old RLC-L RLC-B New RX-1 D4-3B (L & R)	✓		3.5 m from nearest rail	4m
	<i>Warning Assembly</i> Old RLC-C New RX-3 <i>RX-3-3</i> W7-7 (L & R)	✓ ✓		Distance A	201m 270m
	<i>Stop Sign Assembly</i> Old RLC-D New RX-2 W3-1			3.5 m from nearest rail Distance A	
	<i>Side Road Sign & Assembly</i> Old RLC-H New RX-4 W7-12 or W7-13			Distance B Distance A	
	<i>Flashing Signals Sign & Assembly</i> Old RLC-E RLC-J RLC-F New RX-5 W7-4 RX-7			Distance A 3.5 m from nearest rail Distance A	
	<i>Gates Sign & Assembly</i> Old RLC-K RLC-G New RX-6 W7-15 RX-8			Distance A 3.5 m from nearest rail Distance A	

	Sign	Maintenance Standard Acceptable?		Required Distance (refer to MUTCD) (m)	Actual Distance (m)
		Yes ✓	No Provide Comments		
Road Approach B	<i>Crossing Assembly</i> Old RLC-L RLC-B New RX-1 D4-3B (L & R)	✓		3.5 m from nearest rail	3.8m
	<i>Warning Assembly</i> Old RLC-C New RX-3 <i>RX-3-3</i> W7-7 (L & R)	✓ ✓		Distance A	202m 273m
	<i>Stop Sign Assembly</i> Old RLC-D New RX-2 W3-1			3.5 m from nearest rail Distance A	
	<i>Side Road Sign & Assembly</i> Old RLC-H New RX-4 W7-12 or W7-13			Distance B Distance A	
	<i>Flashing Signals Sign & Assembly</i> Old RLC-E RLC-J RLC-F New RX-5 W7-4 RX-7			Distance A 3.5 m from nearest rail Distance A	
	<i>Gates Sign & Assembly</i> Old RLC-K RLC-G New RX-6 W7-15 RX-8			Distance A 3.5 m from nearest rail Distance A	

3 DATA

Notes:

(a) Use tables below for vehicle length, L and the coefficient of deceleration, d (AUSTROADS 1990).

COEFFICIENT OF DECELERATION

Vehicle Speed (V_V – km/h)	Coefficient of deceleration (d)	Vehicle Speed (V_V – km/h)	Coefficient of deceleration (d)
10	.68	70	.45
20	.64	80	.43
30	.60	90	.41
40	.56	100	.39
50	.52	110	.37
60	.48	120	.35

VEHICLE LENGTH

Vehicle Route	Vehicle Type and Length	
Roads not on nominated route	Medium car	4.74m
	Semi-trailer	19m
B-double route	B-double	25m
Road train route – Type 1	Type 1 road train	33m
Road train route – Type 2	Type 2 road train	50m

- (b) Adopt 10% above the signed speed limit as the 85th %ile speed unless road geometry indicates that a higher or lower speed would apply. In this case, determine an appropriate speed based on judgement after driving over the crossing in both directions.
- (c) Measure the width W_R of the travelled way (portion of the roadway allocated for the movement of the vehicles) at the crossing.
- (d) Measure the width W_T of the rail tracks at the crossing.

DISTANCE FROM CROSSING TO MEASURE GRADE

V_V (km/h)	Distance from Crossing (m)
60	70
70	90
80	115
90	140
100	170
110	205

- (e) The grade of the approach, G is the average grade that would affect deceleration and is taken as positive for upgrades and negative for downgrades (e.g. a 2% downgrades would be $G = -2$). The distance from the crossing to correspond with the speed environment is given in the following table representing the stopping sight distance for a 2.5 second reaction time derived from AUSTROADS 1990. Measure the grade at the point where braking is applied at a distance from the crossing indicated in the table unless there is clearly a different grade between this point and the crossing which would have a greater effect on deceleration. In such cases a judgement must be made as to the applicable grade and reasons given.

TABULATED DATA

	Train Speed V_T (km/h)	Signed Road Speed Limit 100 km/h		Coefficient of Deceleration d		Vehicle Length L (m)	Width of Road W_R (m)	Width of Railway Track W_T (m)	Grade G (%)	Angle of Skewness Z°
		Assessed 85th%ile Veh. Speed V_V (km/h)	15th%ile Veh. speed ($0.75 V_V$) (km/h)	85%ile	15%ile					
Road Approach A from <i>Waveton</i>	70	110	83	.37	.42	19	7	1.1	-1.5	98
Road Approach B from <i>Sardberg</i>	70	110	83	.37	.42	19	7	1.1	2	98

4 CALCULATE SIGHT DISTANCES REQUIRED (for 85th Percentile and 15th Percentile¹ Vehicle Speed)

Notes: General case assumption for L_d and C_V are 1.5m and 3.5m, respectively.

In order to obtain the critical sight distances, S_{2L} and S_{2R} , the greater value from Case 1(i) and (ii) should be adopted for assessment of the sight triangles.

General case assumption for R_T is 2.5 sec, however in case (B) an emergency reaction time of 0.8 sec is assumed. In case (A) and (B) it is assumed that double the coefficient of deceleration is available.

(a) Case 1 – Sight Distance Required for Position Sign Control

		85%ile	15%ile
$S_1 \geq \frac{2.5V_V}{3.6} + \frac{V_V^2}{254(d + \frac{G}{100})} + L_d + C_V$	App A	$S_1 = 215.6$ m	$S_1 = 129.6$ m
	App B	$S_1 = 203.5$ m	$S_1 = 124.3$ m
$S_1(B) \geq \frac{2.5V_V}{3.6} + \frac{V_V^2}{254(2d + \frac{G}{100})} + L_d + C_V$	App A	$S_1(B) = 147.1$ m	$S_1(B) = 95.5$ m
	App B	$S_1(B) = 144.1$ m	$S_1(B) = 94.2$ m
$S_1(A) \geq \frac{0.8V_V}{3.6} + \frac{V_V^2}{254(2d + \frac{G}{100})} + L_d + C_V$	App A	$S_1(A) = 95.2$ m	$S_1(A) = 56.3$ m
	App B	$S_1(A) = 92.1$ m	$S_1(A) = 55.0$ m

(b) Case 1(i) – Decelerate and safely stop at the stop or holding line

Left Quadrant

$S_{2L(\theta)} \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} (2.5 + \frac{V_V}{35.3d})$	App A	$S_{2L(\theta)} = 215.9$ m	$S_{2L(\theta)} = 161.0$ m
	App B	$S_{2L(\theta)} = 215.9$ m	$S_{2L(\theta)} = 161.0$ m
$S_{2L(\theta)}(B) \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} (2.5 + \frac{V_V}{70.6d})$	App A	$S_{2L(\theta)}(B) = 134.0$ m	$S_{2L(\theta)}(B) = 106.6$ m
	App B	$S_{2L(\theta)}(B) = 134.0$ m	$S_{2L(\theta)}(B) = 106.6$ m
$S_{2L(\theta)}(A) \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} (0.8 + \frac{V_V}{70.6d})$	App A	$S_{2L(\theta)}(A) = 101.0$ m	$S_{2L(\theta)}(A) = 73.5$ m
	App B	$S_{2L(\theta)}(A) = 101.0$ m	$S_{2L(\theta)}(A) = 73.5$ m

Right Quadrant

$S_{2R(\theta)} \geq \frac{V_T}{3.6} (2.5 + \frac{V_V}{35.3d})$	App A	$S_{2R(\theta)} = 212.4$ m	$S_{2R(\theta)} = 157.5$ m
	App B	$S_{2R(\theta)} = 212.4$ m	$S_{2R(\theta)} = 157.5$ m
$S_{2R(\theta)}(B) \geq \frac{V_T}{3.6} (2.5 + \frac{V_V}{70.6d})$	App A	$S_{2R(\theta)}(B) = 130.5$ m	$S_{2R(\theta)}(B) = 103.0$ m
	App B	$S_{2R(\theta)}(B) = 130.5$ m	$S_{2R(\theta)}(B) = 103.0$ m
$S_{2R(\theta)}(A) \geq \frac{V_T}{3.6} (0.8 + \frac{V_V}{70.6d})$	App A	$S_{2R(\theta)}(A) = 97.4$ m	$S_{2R(\theta)}(A) = 70.0$ m
	App B	$S_{2R(\theta)}(A) = 97.4$ m	$S_{2R(\theta)}(A) = 70.0$ m

Note:

1 Calculate 15th percentile values to check that visibility angles are acceptable for slower drivers (taken as 0.75 x 85th percentile speed).

(c) Case 1(ii) – Proceed and clear the crossing within an adequate safety margin

Left Quadrant

$$S_{2L(ii)} \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{V_V} \left(\frac{2.5V_V^2}{254(d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

85%ile

15%ile

App A $S_{2L(ii)} = 236.8$ m

$S_{2L(ii)} = 171.0$ m

App B $S_{2L(ii)} = 217.7$ m

$S_{2L(ii)} = 159.8$ m

$$S_{2L(ii)}(B) \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{V_V} \left(\frac{2.5V_V^2}{254(2d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

App A $S_{2L(ii)}(B) = 127.9$ m

$S_{2L(ii)}(B) = 99.1$ m

App B $S_{2L(ii)}(B) = 123.1$ m

$S_{2L(ii)}(B) = 96.3$ m

$$S_{2L(ii)}(A) \geq \frac{0.5W_R}{\sin Z} + \frac{V_T}{V_V} \left(\frac{0.8V_V^2}{254(2d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

App A $S_{2L(ii)}(A) = 56.8$ m

$S_{2L(ii)}(A) = 52.0$ m

App B $S_{2L(ii)}(A) = 55.3$ m

$S_{2L(ii)}(A) = 51.1$ m

Right Quadrant

$$S_{2R(ii)} \geq \frac{V_T}{V_V} \left(\frac{2.5V_V^2}{254(d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

App A $S_{2R(ii)} = 233.3$ m

$S_{2R(ii)} = 167.4$ m

App B $S_{2R(ii)} = 214.1$ m

$S_{2R(ii)} = 156.2$ m

$$S_{2R(ii)}(B) \geq \frac{V_T}{V_V} \left(\frac{2.5V_V^2}{254(2d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

App A $S_{2R(ii)}(B) = 124.3$ m

$S_{2R(ii)}(B) = 95.6$ m

App B $S_{2R(ii)}(B) = 119.5$ m

$S_{2R(ii)}(B) = 92.7$ m

$$S_{2R(ii)}(A) \geq \frac{V_T}{V_V} \left(\frac{0.8V_V^2}{254(2d + \frac{G}{100})} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + C_T + L \right)$$

App A $S_{2R(ii)}(A) = 53.3$ m

$S_{2R(ii)}(A) = 48.4$ m

App B $S_{2R(ii)}(A) = 51.7$ m

$S_{2R(ii)}(A) = 47.5$ m

5 ASSESS SIGHT TRIANGLES

The detailed survey instructions explain the procedure of assessing sight triangles. The sight triangles can be assessed for both approaches by tabulating information on the following tables.

Road Planning and Design Manual

APPROACH VISIBILITY - APPROACH A

Z O N E	Case 1		Case 1(i) - Decelerate and Stop		Case 1(ii) - Proceed and Clear Crossing			Adopted S ₁₁		Adopted S ₁₂		Adopted S ₁₃		Viewing Angle (degrees) Z _{r,a}	
	1	2	3	4	5	6	7	8	9	10	11	12	13		
	S ₁ 85%ile 215.6	S ₂ 15%ile 129.6	S ₃ 85%ile 215.9	S ₄ 15%ile 161.0	S ₅ 85%ile 212.4	S ₆ 15%ile 157.5	S ₇ 85%ile 236.8	S ₈ 15%ile 171.0	S ₉ 85%ile 233.3	S ₁₀ 15%ile 167.4	Max. value of cols 1, 2	Max. value of cols 3,4,7,8	Max. value of cols 5,6,9,10		
Calculated											215.6	236.8	233.3	44•	53•
D	Actual														
	2														
	S ₁ (B) 85%ile 147.1	S ₂ (B) 15%ile 134.0	S ₃ (B) 85%ile 106.6	S ₄ (B) 15%ile 103.0	S ₅ (B) 85%ile 130.5	S ₆ (B) 15%ile 103.0	S ₇ (B) 85%ile 127.9	S ₈ (B) 15%ile 99.1	S ₉ (B) 85%ile 124.3	S ₁₀ (B) 15%ile 95.6	Adopted S ₁₁ (B) Max cols 1,2 147.1	Adopted S ₁₂ (B) Max cols 3,4,7,8 134.0	Adopted S ₁₃ (B) Max cols 5,6,9,10 130.5	Z _{r,a} (B) 39•	Z _{r,a} (B) 45•
Calculated														29.5•	
C	Actual														
	3														
	S ₁ (A) 85%ile 95.2	S ₂ (A) 15%ile 56.3	S ₃ (A) 85%ile 101.0	S ₄ (A) 15%ile 73.5	S ₅ (A) 85%ile 97.4	S ₆ (A) 15%ile 70.0	S ₇ (A) 85%ile 56.8	S ₈ (A) 15%ile 52.0	S ₉ (A) 85%ile 53.3	S ₁₀ (A) 15%ile 48.4	Adopted S ₁₁ (A) Max cols 1,2 95.2	Adopted S ₁₂ (A) Max cols 3,4,7,8 101.0	Adopted S ₁₃ (A) Max cols 5,6,9,10 101.0	Z _{r,a} (A) 42•	Z _{r,a} (A)
Calculated															
B	Actual														
	4														

- Notes:
- Viewing angle measured for required sight distances and the required viewing angles are ≤ 110° left quadrant and ≤ 140° right quadrant.
 - Does the actual distances and viewing angle for the quadrant, comply within the calculated requirements (- Yes, - No).
If - Complete ranking on Score Sheet (Form 2).
 - Record the actual viewing angle, and continue to next zone.
Does the actual distances for the quadrant, comply within the calculated requirements (- Yes, - No).
If - Complete ranking on Score Sheet (Form 2).
 - Record the actual viewing angle, and complete ranking on Score Sheet for Zone A.
All distances to be recorded in metres.

APPROACH VISIBILITY - APPROACH B

Z O N E	Case 1		Case 1 (i) - Decelerate and Stop			Case 1 (ii) - Proceed and Clear Crossing					Adopted S ₁₁		Adopted S ₁₂		Adopted S ₁₃		Viewing Angle (degrees) Z ₁₁		
	1	2	3	4	5	6	7	8	9	10	11	12	13	Max. value of cols 3,4,7,8	Max. value of cols 5,6,9,10	Viewing Angle (degrees) Z ₁₂			
	S ₁		S _{2,3,4}			S _{5,6,7,8,9,10}					Max. value of cols 1, 2								
	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	
Calculated	203.5	124.3	215.9	161.0	212.4	157.5	217.7	159.8	214.1	156.2	203.5	221.1	217.6	43	51				
D	Actual																		
	2																		
	S _{1(B)}		S _{2,3,4(B)}			S _{5,6,7,8,9,10(B)}					Adopted S _{11(B)}		Adopted S _{12(B)}		Adopted S _{13(B)}		Viewing Angle (degrees) Z ₁₁		
	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile		85%ile	15%ile
Calculated	144.1	94.2	134.0	106.6	130.5	103.0	123.1	96.3	119.5	92.7	144.1	134.0							
C	Actual																		
	3																		
	S _{1(A)}		S _{2,3,4(A)}			S _{5,6,7,8,9,10(A)}					Adopted S _{11(A)}		Adopted S _{12(A)}		Adopted S _{13(A)}		Viewing Angle (degrees) Z ₁₁		
	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile	85%ile	15%ile		85%ile	15%ile
Calculated																			
B	Actual																		
	4																		

Notes:

- 2 Viewing angle measured for required sight distances and the required viewing angles are ≤ 110° left quadrant and ≤ 140° right quadrant.
- 3 Does the actual distances and viewing angle for the quadrant, comply within the calculated requirements (- Yes, - No).
if — Complete ranking on Score Sheet (Form 2).
- 4 Does the actual viewing angle, and continue to next zone.
if — Record the actual viewing angle, and complete ranking on Score Sheet (Form 2).
- 5 Does the actual distances for the quadrant, comply within the calculated requirements (- Yes, - No).
if — Complete ranking on Score Sheet (Form 2).
if — Record the actual viewing angle, and complete ranking on Score Sheet for Zone A.
All distances to be recorded in metres.

6 RECOMMENDATIONS

SURVEY OF OPEN LEVEL CROSSING SIGHT DISTANCE ASSESSMENT CROSSING VISIBILITY

1 CROSSING GEOMETRY

- (a) On the crossing geometry sketch (Page 1), indicate the road grade that applies between 3.5 and 10m back from the nearest rail.
 (b) Measure S_{3L} and S_{3R} from the intersection of the road centre line and the mid point of the rail tracks at the crossing.

2 DATA

Notes:

- (a) Note the train speed, V_T .
 (b) Using table below, record the vehicle length, L and grade factor, G_S .

VEHICLE LENGTH

Vehicle Route	Vehicle Type and Length
Roads not on nominated route	Medium car 4.74m
	Semi-trailer 19m
B-double route	B-double 25m
Road train route – Type 1	Type 1 road train 33m
Road train route – Type 2	Type 2 road train 50m

TABLE OF GRADE FACTOR

Percentage Grade (See Note)	Grade Factor G_S
-6	0.7
-4	0.8
-2	0.9
level	1.0
+2	1.2
+4	1.7
+6	2.1

- (c) Grade is negative where road falls towards crossing and positive where road rises to crossing.
 (d) Where approach visibility has not been calculated:
- measure the width W_R of the travelled way (portion of the roadway allocated for the movement of the vehicles) at the crossing;
 - measure the width W_T of the rail tracks at the crossing.

TABULATED DATA

	Train Speed V_T (km/h)	Grade Factor G_S	Vehicle Length L (m)	Width of Road W_R (m)	Width of Railway Track W_T (m)
Road Approach A from	70	0.92	19	7	11
Road Approach B from	70	1.15	19	7	11

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3 CALCULATE REQUIRED SIGHT DISTANCES

Note: In the general case $J = 2$ sec, $a_g = 0.5$ m/s².

For case (B) the vehicle is in zone F and $J = 1.5$ sec, $a_g = 0.6$ m/s², $L = 19$ m.

For case (A) the vehicle is in zone E and $J = 0.8$ sec, $a_g = 0.9$ m/s², $L = 5$ m (car).

Left Quadrant

$$S_{3L} = \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} \left[2 + G_S \left[4 \left(L + 12 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A $S_{3L} = 242.0$ m

App B $S_{3L} = 291.9$ m

$$S_{3L}(B) = \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} \left[1.5 + G_S \left[3.33 \left(28.5 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A $S_{3L}(B) = 207.4$ m

App B $S_{3L}(B) = 251.0$ m

$$S_{3L}(A) = \frac{0.5W_R}{\sin Z} + \frac{V_T}{3.6} \left[0.8 + G_S \left[2.22 \left(14.5 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A $S_{3L}(A) = 121.0$ m

App B $S_{3L}(A) = 146.5$ m

Right Quadrant

$$S_{3R} = \frac{V_T}{3.6} \left[2 + G_S \left[4 \left(L + 12 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A $S_{3R} = 238.5$ m

App B $S_{3R} = 288.4$ m

$$S_{3R}(B) = \frac{V_T}{3.6} \left[1.5 + G_S \left[3.33 \left(28.5 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A $S_{3R}(B) = 203.8$ m

App B $S_{3R}(B) = 247.5$ m

$$S_{3R}(A) = \frac{V_T}{3.6} \left[0.8 + G_S \left[2.22 \left(14.5 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} \right) \right]^{1/2} \right]$$

App A $S_{3R}(A) = 117.5$ m

App B $S_{3R}(A) = 143.0$ m



4 ASSESS SIGHT TRIANGLES

The detailed survey instructions explain the procedure of assessing sight triangles.

CROSSING VISIBILITY – APPROACH A⁹

ZONE		S_{ZL}	Viewing Angle Z_{ZL} ⑥	S_{ZR}	Viewing Angle Z_{ZR} ⑥
H	Calculated	242.0	81°	238.5	96°
	Actual				
⑥					
		$S_{ZL}(B)$	Viewing Angle Z_{ZL} ⑥	$S_{ZR}(B)$	Viewing Angle Z_{ZR} ⑥
G	Calculated				
	Actual				
⑦					
		$S_{ZL}(A)$	Viewing Angle Z_{ZL} ⑥	$S_{ZR}(A)$	Viewing Angle Z_{ZR} ⑥
F	Calculated				
	Actual				
⑧					

CROSSING VISIBILITY – APPROACH B⁹

ZONE		S_{ZL}	Viewing Angle Z_{ZL} ⑥	S_{ZR}	Viewing Angle Z_{ZR} ⑥
H	Calculated	291.9	81°	288.4	97°
	Actual				
⑥					
		$S_{ZL}(B)$	Viewing Angle Z_{ZL} ⑥	$S_{ZR}(B)$	Viewing Angle Z_{ZR} ⑥
G	Calculated				
	Actual				
⑦					
		$S_{ZL}(A)$	Viewing Angle Z_{ZL} ⑥	$S_{ZR}(A)$	Viewing Angle Z_{ZR} ⑥
F	Calculated				
	Actual				
⑧					

Notes:

- 6 Viewing angle measured for required sight distances and the required viewing angles are $\leq 110^\circ$ left quadrant and $\leq 140^\circ$ right quadrant.
- 7 Does the actual distances and viewing angle for the quadrant, comply within the calculated requirements (✓ – Yes, ✗ – No).
If ✓ – Complete ranking on Score Sheet (Form 2).
If ✗ – Record the actual viewing angle, and continue to next zone.
- 8 Does the actual distances for the quadrant, comply within the calculated requirements (✓ – Yes, ✗ – No).
If ✓ – Complete ranking on Score Sheet (Form 2).
If ✗ – Record the actual viewing angle, and complete ranking on Score Sheet for Zone E.
- 9 All distances to be recorded in metres.

6 RECOMMENDATION

SCORE SHEET

LOCAL AUTHORITY *Coastal City Council*
 ROAD *Water Rd*
 DISTANCE (km) *10* FROM *Maveton*
 (TOWN)
 RECORDED BY *John Smith* DATE *20/1/95*

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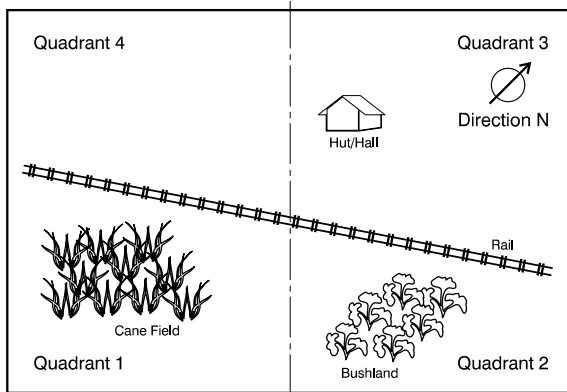


Figure 1 Site Sketch

Approach Visibility	
Zone	Score
A	80
B	40
C	5
D	0
Crossing Visibility	
Zone	Score
E	160
F	80
G	10
H	0

Score by Zone

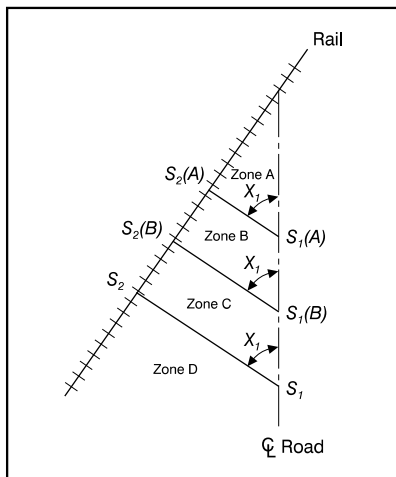


Figure 2 Approach Visibility

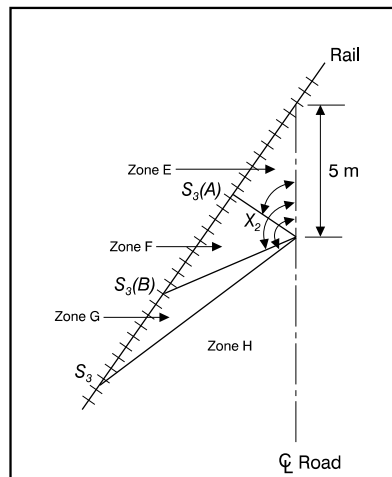


Figure 3 Crossing Visibility

Risk Type	Approach A				Approach B				Score		
	Left		Right		Left		Right				
	Quadrant 1	Quadrant 2	Quadrant 1	Quadrant 2	Quadrant 1	Quadrant 2	Quadrant 1	Quadrant 2	Quadrants 1 → 4		
Approach ² Visibility	Zone B	Score 40	Zone C	Score 5	Zone C	Score 5	Zone D	Score 0	Quadrants 1 → 4	50	①
Crossing Visibility	Zone H	Score 0	Zone H	Score 0	Zone H	Score 0	Zone H	Score 0	Quadrants 1 → 4	0	②
Exposure	[(Trains/wk (2 way) x AADT (2 way))] / 1,000 Nearest Whole Number								150		③
Safety (5 years)	Vehicle/Train Accidents: 1st accident → Score 20; Subsequent accidents → Score 40								20		④
	Vehicle/Vehicle Accidents: 1st accident → Score 10; Subsequent accidents → Score 20								30		⑤
Grand Total ① → ⑤									250		⑥

SCORE 6

250

Notes:

- Refer Appendix B of Guide for Detailed Survey Instructions.
- If 'Stop' signs are installed, do not measure. Score = 0 since approaching vehicles must stop.
- Possible Treatments** – Erect 'Stop' signs, clear sight lines of vegetation. Remove signs, buildings, etc., reduce vehicle speed, reduce train speed, remove embankment, change road alignment, change rail alignment, install flashing lights, install boom gates, grade separation.