RAILWAY CROSSING PROTECTION
IN WESTERN AUSTRALIA

Policy and Guidelines

This document is owned and controlled by the Executive Director Road Network Services. The Manager Traffic and Safety is the delegated custodian. All comments and requests for changes should be submitted to the Manager Traffic and Safety.

Authorisation

I authorise the issue and use of this document - Railway Crossing Protection in Western Australia. Policy and Guidelines.

EXECUTIVE DIRECTOR ROAD NETWORK SERVICES

Date: 6 / 5 / 05

Document No: 9000/01

Controlled Copy: ....

Government of Western Australia

MAIN ROADS Western Australia

ABN: 50 860 676 021

May 2005

Railway Crossing Protection in Western Australia – Policy and Guidelines

Preface:

Main Roads Western Australia and Local Governments directly manage more than 140 000 kilometres of public roads. This road network interfaces with approximately 7 000 kilometres of standard and narrow gauge railway track at some 1 500 public railway crossings throughout Western Australia. There are a similar number of railway crossings on non-public (private or occupational) roads.

This document has been prepared by Main Roads Western Australia and endorsed by the Railway Crossing Protection Committee. Matters concerning policy were reviewed and recommended by the Strategy and Policy Railway Crossing Protection Sub Committee, with the Operational Sub Committee endorsing the technical content.

These policy and guidelines have been prepared to provide direction and guidance on the management, design and operation of railway crossings in Western Australia. This document, along with the roles and activities the two Sub Committees, have no statutory or other legal effect on existing State Acts and/or Regulations, including those pertaining to roads and railways.

Users of this document are encouraged to provide comments on the policy and guidelines. Such comments should be addressed to:

Des Snook
Chairman
Strategy and Policy Railway Crossing Protection Sub-Committee
Main Roads Western Australia
PO Box 6202
EAST PERTH WA 6892

Alternatively, a 'Fax Back' sheet, telephone contact details and an email address are included in the following pages.

REVISION STATUS RECORD

Section No.	Page No.	Latest Revision No.	Revision Description/Reference

Authorised by …………………………………………….………… …../…../…..
Executive Director Road Network Services

Fax Back

Fax No: (08) 9323 4174

Please photocopy or detach this sheet and fax, post or deliver

To: Mr Brian Kidd
Road Safety Manager
Main Roads Western Australia
Waterloo Crescent
EAST PERTH WA 6004 Phone: (08) 9323 4500
Fax: (08) 9323 4547
Email: brian.kidd@mainroads.wa.gov.au

Please provide your comments on suggested changes or modifications to *Railway Crossing Protection in Western Australia – Policy and Guidelines.*

Attach additional sheets if needed

Name: …………………………………………………..

Organisation: ……………………………………………….. Telephone:……………………….

CONTENTS

APPENDICIES

1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to detail the policies and guidelines for railway crossing protection in Western Australia.

1.2 SCOPE

The policy and guidelines are to be applied to all railway crossings on public roads throughout Western Australia, and can be used as a reference for managing and assessing railway crossing protection at railway crossings on non-public roads.

Reference will need to be made to other publications for information on standards and procedures relating to the technical design and emplacement of the various traffic control treatments and devices described in this document

1.3 BACKGROUND

In September 1964 following a spate of serious crashes at railway level crossings, the then Cabinet appointed an inter-departmental committee to review and make recommendations on the safety requirements for all level crossings in Western Australia.

The committee's findings, published in it's 'Report on Railway Crossing Protection in Western Australia' in December 1968 and agreed to by Cabinet, included an outline of the criteria to be used for determining the levels of protection required at railway level crossings and made a number of specific recommendations to ensure that safety requirements were maintained. These included the appointment of a standing committee to undertake further reviews of railway crossing protection requirements. This standing committee, known as the Railway Crossing Protection Committee, continued to review policies and guidelines, publishing a further report on railway crossing protection in December 1980.

Since these times, the level of protection in the network overall has improved and the rate of crashes occurring at railway crossings remains low. However, in 1991 it was recognised that factors such as the progressive increase in the number and size of road freight vehicles and the introduction of high speed passenger rail services in both the metropolitan and rural areas were demanding improved protection requirements at railway crossings if safety was to be maintained. This prompted the Committee to agree to the draft 'Review of the Railway Crossing Protection Criteria' in November 1992, which, together with further consideration to factors effecting railway-crossing safety, forms the basis of this publication.

In January 1996, the Commissioners of Main Roads and Railways agreed to restructure the roles and composition of the Committee to allow for the separation of the strategic and policy areas of railway crossing protection from the operational areas. A ‘Strategy and Policy Sub-Committee’ and an ‘Operational Sub-Committee’ were formed, reporting jointly to the Commissioners.

A revised edition of this document was previously distributed in January 1998.

In December 2000 the Government-owned Westrail freight railway network was privatised, with WestNet Rail Pty Ltd appointed to manage and operate the track and signalling infrastructure under a lease agreement. The Western Australian Government Railways Commission (now known as Public Transport Authority) retained responsibility for the urban passenger railway network infrastructure.

1.4 STRATEGY AND POLICY RAILWAY CROSSING PROTECTION SUB-COMMITTEE

It is important that the various levels of railway crossing protection are applied consistently throughout the State. To achieve this objective it is necessary to determine a strategic programme for the funding of the various major protection activities such as new flashing lights or boom barrier installations, upgrading of existing facilities and development or trials of new techniques. It is necessary to react to changing circumstances and ensure that protection programs are tailored to account for new technology and developments interstate and overseas.

Because of the low rate of crashes, protection of railway level crossings is often perceived as having low safety benefits in direct comparison with other traffic engineering countermeasures. On lightly trafficked roads, only low cost protection can be justified at most crossings. If the benefits of higher levels of protection are to be maximised, it is important that they are installed at crossings where there is the highest risk of a collision. If lower cost protection proves to be viable, and a more proactive approach to protection becomes possible, then it is essential that there is an objective, technically sound method of risk assessment used to determine overall priorities for installation. There are questions to be addressed on the relative importance of protection of road vehicles and rail vehicles, and there is a need to ensure timely and enthusiastic response to innovation and new technology. These and other issues is the province of the Strategy and Policy Railway Crossing Protection Sub-Committee.

The Strategy and Policy Railway Crossing Protection Sub Committee's Terms of Reference are as follows:

a) Objective

To provide a forum for discussion and review of the State's level crossing protection program by representatives of State and Local Government, private railways and road users.

b) Role of the Sub-Committee

Provide advice to the Commissioner of Main Roads and the Chief Executive Officer of the Public Transport Authority of Western Australia (PTA) with regard to:

- Setting and reviewing policy for the protection of all road and rail users at public road and non-public road crossings on all rail systems.
- Long term funding requirements for appropriate rail crossing protection.
- Impacts of road-use policy changes.
- Considering and proposing advances in technology appropriate to the effective reduction of risk in level crossing protection.
- Develop standards for protection systems and signing at railway crossings.
- Determine levels of protection appropriate in any new circumstances.
- Determine funding responsibilities for any new developments.

c) Membership

- Main Roads Western Australia (chairperson)
- Public Transport Authority of Western Australia
- WestNet Rail Pty Ltd
- Private railway infrastructure owners/operators
- Western Australia Police Service
- Local Government
- Transport Forum WA
- Royal Automobile Club
- Office of Rail Safety

Each external organisation will nominate one member. If that member is unable to attend any meeting, that member may nominate a representative. In addition, observers can be invited by the Chairperson to attend meetings.

d) Meetings

Meetings are to be held on a six monthly basis.

e) Support

Main Roads' Manager Traffic and Safety will provide administrative and secretarial support.

f) Agenda and Minutes

- Items for the agenda are to be forwarded to the Manager Traffic and Safety ten working days prior to the meeting.

- The agenda and supporting papers will be distributed five working days prior to the meeting.

- Minutes will be taken and circulated to all members within ten working days of the meeting.

The Agenda will contain the following standing items:

- Minutes of previous meeting
- Action arising
- Program status and issues
- Other issues for discussion

g) Reporting

- Main Roads will prepare progress reports for the meetings. Other members may provide reports, either orally or in writing.
- Sub Committee members are encouraged to report to their own organisations and to others on the outcomes of the meeting, in a manner and to the extent agreed by the meeting.
- An annual report on its activities will be prepared for the information of participating organisations and Government.

1.5 OPERATIONAL RAILWAY CROSSING PROTECTION SUB-COMMITTEE

The day to day operational railway crossing protection activities are the responsibility of the appropriate operational areas responsible for traffic safety and control of the road and railway network, ie Main Roads Western Australia, the Public Transport Authority of Western Australian, WestNet Rail, private railway operators, or local governments as applicable. This allows more focus to be placed upon the strategic operational and technical functions of railway crossing protection.

The Operational Railway Crossing Protection Sub Committee's Terms of Reference are as follows:

a) Objective

To coordinate the day-to-day operational roles for all parties involved in the management of railway crossing protection installations in WA.

b) Role of the Sub-Committee

- To act as a point of coordination between Main Roads Western Australia, railway infrastructure owner and local government on operational matters.
  To monitor incident data, conduct audits and implement improvements. To provide advice to the Strategic and Policy Committee with regard to:

  – Work programs to bring all crossings up to standard in respect of protection levels, warning equipment and devices and level of maintenance.

- Implementation of the Railway Crossing Protection in Western Australia - Policy and Guidelines.
- Standards and Codes of Practice for railway crossing equipment and devices.
- National and international developments in respect of railway protection techniques and equipment.
- Undertake research and/or trials as necessary to develop enhancements to protection levels.

c) Membership

- Main Roads Western Australia (chairperson)
- Public Transport Authority of Western Australia
- Private Railway infrastructure owners/operators
- WestNet Rail Pty Ltd
- Main Roads Project Manager Level Crossing Programs (may be outsourced by MRWA or provided by PTA).
- Other private railway infrastructure owners or local government as required.
- Forest Products Commission.
- Private road owners, e.g. mining companies.

d) Meetings

Meetings are generally to be held on a two monthly basis

e) Support

Main Roads Manager Traffic and Safety will provide administrative and secretarial support.

f) Agenda and Minutes

- Items for the agenda are to be forwarded to the Manager Traffic and Safety ten working days prior to the meeting.
- The agenda and supporting papers will be distributed five working days prior to the meeting.
- Minutes will be taken and circulated to all members within ten working days of the meeting.
- The Agenda will contain the following standing items:
  - Minutes of previous meeting
  - Action arising
  - Program status and issues
  - Incident/crash reports
  - Other issues for discussion

g) Reporting

- Main Roads will prepare work program progress reports for the meetings. Other members may provide reports, either orally or in writing.
- Committee members are encouraged to report to their own organisations and to others on the outcomes of the meeting, in a manner and to the extent agreed by the meeting.

1.6 RESPONSIBILITIES

Funds for railway crossing protection are provided by the Government as road funds and are administered through Main Roads Western Australia.

The Road Traffic Code 2000 Section 297 empowers the Commissioner of Main Roads with responsibility for all traffic signs and traffic control signals on all roads (as defined under the Road Traffic Act) within the State of Western Australia. This empowerment extends to any traffic signing, signalling devices or road markings installed at or on the approaches to railway level crossings on public roads. Where not specified in other technical standards or documentation approved by the Commissioner of Main Roads, all traffic control devices at railway crossings are to be installed in

accordance with Australian Standards *AS 1742.7 Part 7, 1993 - Manual of Uniform Traffic Control Devices for Railway Crossings*.
Traffic control devices on roads that do not qualify as 'roads' under the Road Traffic Act are not the responsibility of the Commissioner of Main Roads. However, it is within the brief of the Railway Crossing Protection Sub-Committees to review policies and operational matters relating to the safety requirements for any railway level crossings on such roads.

Where not otherwise subject to separate agreements and conditions, responsibilities for meeting the costs for railway crossing protection are as follows:

a) At existing railway crossings on public roads, the cost of improving railway-crossing protection, including pedestrian facilities, is to be met by Main Roads Western Australia.

b) Where not otherwise subject to separate agreement, costs associated with maintaining and operating protection devices at railway crossings on public roads are generally to be equally shared between Main Roads and the railway owners.

c) However, costs for installing, improving or modifying railway crossing protection, including pedestrian facilities, required as a result of specific road, rail or land-use improvements or developments, are to be met by the road or rail authority, or by the developer, as appropriate. The costs are to include maintenance requirements extending five years beyond the completion of the development, new construction or upgrading.

d) Where removal of vegetation and/or other visibility obstructions is required to provide adequate sight distances for drivers approaching a public road crossing, the road authority is to meet the costs of removal within the road reserve (and adjacent private property if required), and the rail authority is to meet the cost of removal within the railway reserve.

e) All costs associated with protecting crossings not located on public roads are to be met as agreed between the road and rail infrastructure owners.

Where not otherwise subject to separate agreements, and subject to the approval of the Commissioner of Main Roads as empowered under Regulation 297 of the Road Traffic Code 2000 where appropriate, operational responsibilities for railway crossing protection are as follows:

Road Authority

a) Displaying, installing and maintaining the appropriate regulatory signs, warning signs, road markings and advance flashing warning sign panels on the approaches to crossings on public roads. (This excludes signing affixed to railway hardware, which is the responsibility of the rail authority – see below.)

b) Undertaking and maintaining any vegetation clearing, and/or removal of other physical obstructions, on public roads including adjacent private properties if required (subject to negotiations with property owners), to provide adequate driver visibility on the approaches to railway crossings.

<u>Rail Authority</u>

a) Displaying, installing and maintaining flashing lights and boom barriers, warning bells and pedestrian mazes, gates and paths at crossings (including any signing affixed to these devices) on public roads, providing control devices for advance flashing warning signs, and displaying and maintaining signs at ‘occupational’ and ‘private’ crossings.

b) Undertaking and maintaining any vegetation clearing, and/or removal of other physical obstructions, within the railway reserve to provide adequate driver visibility on the approaches to railway crossings.

c) Maintaining the roadway within 3 metres of the track.

It is essential that all traffic signs, road markings and other devices provided for railway crossing protection be maintained in good order and condition.

Maintenance requirements involving the clearing/removal of vegetation re-growth or other visibility obstructions, to provide adequate driver visibility on the approaches to railway crossings, should be determined through regular inspection programs.

1.7 WORKS IN THE VICINITY OF RAILWAY CROSSINGS

Road and other service related works being undertaken in the vicinity of railway level crossings could have adverse impacts on the level of safety at the crossings.
Widening of the carriageway without providing for additional clearances to railway crossing protection equipment and other railway infrastructure, road realignments or modifications requiring adjustment to the focal alignment or repositioning of flashlight signals, visibility obstructions due to the placement of road side furniture, bus shelters etc, are some examples where there is a potential for a reduction in safety at nearby railway crossings, both while works are in progress and as a consequence of the completed works.

Road authorities are responsible for contacting the appropriate rail authority to advise of any planned work within the road reserve, either of a temporary or permanent nature, in the vicinity of railway crossings or the rail reserve. The need for such notification will depend on the type of work to be undertaken and the proximity of the work to their crossing. As a general guide, the table 1 shows the minimum distances from the railway, within which any work should not proceed without prior notification having been given to the railway authority.

Speed Limit Km/h	Distance from railway m
<70	150
70 to 90	200
>90	300

TABLE 1

Notification should preferably be in writing and accompanied by design plans, and forwarded Two (2) weeks prior to the commencement of works to the applicable railway authority.

1.8 Traffic Management for Road Works at Railway Crossings

Where a section of road under the control of Traffic Controller for road works is within the distances in Table 1, an accredited Flag Person shall also be stationed at the crossing in the vicinity of the traffic stop line at least 3m from the nearest rail. This also applies where a road under traffic control is on one side of a railway crossing only. The Flag Person shall have two-way communication with Traffic Controllers and Railway Train Control, diligently keep watch for trains and advise Traffic Controllers when to stop traffic to enable safe passage of trains through the crossing. The Flag Person shall be accredited under the relevant railway authority safe working requirements and possess a current MRWA Traffic Controller certificate of qualification.

The Flag Person shall notify Railway Train Control on each day prior to the commencement of works requiring traffic control. Railway Control shall advise the Flag Person of approaching trains estimated time of arrival thought the period of works and also advise train drivers of the works in the vicinity of the crossing.

Traffic controllers shall ensure that stopped vehicles do not queue back over a railway crossing under any circumstances. All persons working within 10m of any railway crossing shall wear high visibility day/night safety vests that comply with AS/NZ1906 and AS/NZ 46023

2 LEVELS OF PROTECTION

There are a total of five different levels of protection used in normal circumstances at railway crossings in this State. In ascending order, they are:

Give Way Signs
Stop Signs
Flashing Lights
Boom Barriers
Grade Separation

The funds available in Main Roads Western Australia's budget for railway crossing protection generally do not allow for the construction of bridges or tunnels however, the Railway Crossing Protection Sub-Committees can make recommendations for their construction if considered warranted. (See Section 7.)

The remaining four levels of 'at-grade' protection fall into two groups, Give Way Signs and Stop Signs being considered as passive devices whilst Flashing Lights and Boom Barriers are considered as active devices. In making an assessment as to an appropriate level of protection for any particular railway crossing, the basic philosophy is to provide an adequate level of safety with the minimum amount of disruption to road traffic and at the lowest cost. Often these requirements conflict as evidenced by the fact that Flashing Lights provide less disruption to road traffic than Stop Signs, but obviously at a much greater cost.

The Sub-Committees then have to make decisions taking these conflicting requirements into account. Examples of each type of protection are shown in Australian Standard 1742.7 Part 7, 1993. This document also details the layout of the standard signs and road markings associated with each type of protection.

The process of determining the appropriate level of protection for any railway crossing entails systematically checking the adequacy of each level of protection, starting from Give Way Sign control and working upwards until an adequate level is determined. This is done in accordance with the criteria set out in Sections 3 to 8.

This document includes a selection of appendices, which provide detailed reference information, tables, graphs, flow charts and diagrams to assist in determining levels of protection and other requirements. Appendix A defines the notations and terms used throughout the document. It should be noted that many of the tables and graphs do not provide for the full range of variables and conditions that may apply at a railway crossing. They are only intended to provide an initial guide as to which form of treatment is likely to be appropriate. The full range of variables should be used in the detailed assessment process, which will often require calculations to be performed in conjunction with an on-site investigation of the crossing.

The Sub-Committee's terms of reference are only with road crossings involving vehicular movements. Pedestrian crossings and other access ways, which are remote from road crossings, are not within the ambit of the Sub-Committees, although pedestrian facilities at road crossings are within the brief of the Sub-Committees.

It is important that records be kept of the protection installed at each railway crossing. Main Roads Western Australia maintains a computerised record of the type of protection installed at all crossings on all railway lines in Western Australia.

3 GIVE WAY SIGNS

3.1 GENERAL

A railway crossing protected by Give Way Signs works on the principle that sufficient visibility is provided to the driver of a road vehicle approaching the crossing to enable him or her to make a decision whether to cross the rail in front of an approaching train or to stop at the crossing and let the train pass. This level of protection generally applies to crossings where train and/or vehicle volumes are relatively light.

There are six conditions to be satisfied before Give Way Sign control may be considered to be an adequate level of protection:

a) Due to the difficulties a motorist can face in being able to view and perceive the rate of approach of a high-speed train over long distances, Give Way Signs are not appropriate where the train speed is in excess of 80 km/h. However, it is not expected that this condition would apply to non-public crossings where drivers would generally be familiar with the conditions and exercise a greater level of caution when approaching these crossings.

b) The extent of clear visibility either actually available, or that could be made available, on the road approaches to the crossing must be at least equal to the minimum level necessary as determined from consideration of train and vehicle speeds over the crossing and the geometry of the crossing. Section 3.2 refers.

c) The clear visibility required by b) above must be available without requiring the driver of a vehicle approaching the crossing to rotate his or her head through a range of angles considered beyond either the human body's or the vehicle's capacity. Section 3.4 refers.

d) The extent of clear visibility either actually available, or that could be made available, to a motorist at the stopped position at the crossing must be at least equal to the minimum level necessary as determined from consideration of train speeds over the crossing and the geometry of the crossing. Section 4.2 refers.

e) The clear visibility required by d) above must be available without requiring the driver of a vehicle approaching the crossing to rotate his or her head through a range of angles considered beyond either the human body's or the vehicle's capacity. Section 4.3 refers.

f) The level of train and vehicle activity should be below that warranting active protection to be installed. Sections 5.1 and 6.1 refer.

3.2 SIGHT DISTANCE REQUIREMENTS FOR GIVE WAY SIGNS

The driver of a vehicle approaching a railway crossing protected by Give Way Signs needs to be able to see any approaching train that represents a potential hazard. Furthermore, the driver needs to be able to see the train from a sufficient distance down the road that would allow time to stop the vehicle if required. This distance, S_{vg}, is measured from the hold line at the crossing, (in the absence of a hold line assume its position to be 3.5m from the nearest rail), to the position indicated as A on Figure 1 and is made up of the following three components.

a) The distance travelled during the reaction time, Rtg, which is required by the driver to see the train, appreciate the need to stop and apply the brakes.

b) The required braking distance (for the predominant type of vehicle using the road).

c) The distance between the driver's position and the hold line when the vehicle is stopped at the hold line. (Can be taken as 3m.)

The reaction time used for calculating stopping sight distances for vehicles approaching an intersection is 2.5 seconds for an un-alerted, high-speed rural situation. Although a motorist can be alerted to the presence of the railway crossing by the installation of signs, the driver needs to look both left and right through an angle of up to 202^{o} in order to search for any approaching trains and then, if a train is seen, appreciate the need to stop.

As such it is considered appropriate to use a minimum reaction time of 3.0 seconds. An additional 0.5 seconds of reaction time is added for each of the following conditions if they apply on the approach to the crossing:

a) Driver's do not expect to encounter a train due to low train volumes, i.e. less than 2 trains per day (or train movements are subject to significant seasonal variation).

b) The conditions of the road on the approach to the crossing result in the motorist concentrating more on physically driving the vehicle than looking for trains, e.g. sharp bends, narrow pavements, poor road surfaces, etc.

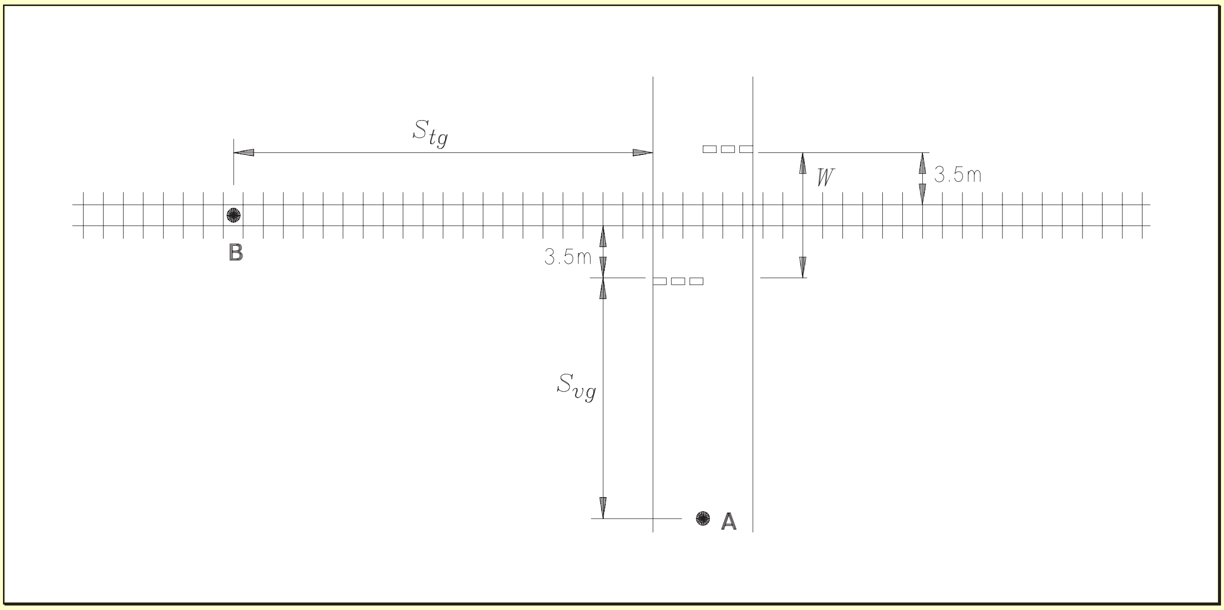
The braking distance varies depending on the 85th percentile approach speed of the vehicles, V_v, the deceleration rate, d, and the grade of the road, G_g. Deceleration rates d for sealed and unsealed roads is given in Table1. The grade of the road is taken as positive for upgrades and negative for downgrades, (e.g. a 2% downgrade would have a G_g value of -0.02). The distance

S_{vg} can therefore be derived as follows:

$$S_{vg} = \frac{R_{tg} \bullet V_v}{3.6} + \frac{V_v^2}{254[d + G_g]} + 3$$

***Note:* V_v in km/h**

Figure 1 - Sight Distance Requirements for Give Way Signs



Approach Speed (Km/h)	Deceleration Rate *d*	
	Sealed Road	Unsealed Road
10	0.73	0.55
20	0.66	0.50
30	0.60	0.45
40	0.56	0.42
50	0.52	0.39
60	0.48	0.36
70	0.45	0.34
80	0.43	0.32
90	0.41	0.31
100	0.39	0.29
110	0.37	0.28

Table 2 – Assumed values for the coefficient of Deceleration, d

Note Value of d taken from Austroads Guide to Traffic Engineering Practice number 5, Intersections at grade. For speeds less than 40 km/h the values have been interpolated.

A motorist at the position indicated as A on Figure 1, who cannot see any trains should be able to proceed without changing speed, and clear the crossing in advance of any approaching train that may have been just out of view. To incorporate a comfortable safety margin the vehicle needs to be clear of the crossing at least 5 seconds prior to the arrival of the train. The distance down the track, S_{tg}, at which a motorist at position A needs to be able to see an approaching train is measured from the edge of the road carriageway to the point indicated as B on Figure 1 and is made up of the following three components.

a) The distance travelled by the train, at the maximum train speed Vt, in the time taken for a vehicle to travel the distance from point A to a point where it is clear of the crossing. This distance is made up of Svg, plus the longest length of the vehicle permitted upon the road, L, plus the width of the crossing, W. The width of the crossing allows for a 3.5m clearance distance from the tracks on each side of the crossing.

b) The distance travelled by the train in the 5-second safety margin.

c) A 5-metre safety margin. (This value is useful on very low speed lines and is insignificant on higher speed lines.)

The distance S_{tg} can therefore be derived as follows:

$$S_{tg} = V_t \bullet \left[\frac{S_{vg} + W + L}{V_v} + 1.39 \right] + 5$$

Note: Vt and Vv in km/h

Adequate visibility is defined as being a driver's ability to view at least two thirds of the frontage area, including any warning or head-light/s, of the approaching locomotive from an eye height of 1.15 metres above the road surface level.

It is not necessary to completely remove all obstacles within the sight triangles. Isolated obstructions such as trees can be retained so long as any blanketing effect upon visibility is removed and drivers are able to readily detect the presence of an approaching train within the distance S_{tg} from the crossing.

It would normally be expected that the road authority would be responsible for arranging or co-ordinating any clearing activities.

3.3 ANGLE REQUIREMENTS FOR GIVE WAY SIGNS

In addition to having clear visibility between the vehicle at point A and the train at point B, drivers cannot be expected to turn their heads through too great an angle in order to see the train.

For a moving vehicle the accepted maximum angles are $\underline{94}^{o}$ to the left and $\underline{108}^{o}$ to the right. For slow moving vehicles these angles can substantially reduce a driver's ability to check for approaching trains. In the same way that the 85^{th} percentile speed disregards the top 15% of vehicle speeds in determining the operating speed, the bottom 15% is also disregarded in selecting the speed of the slower moving vehicles.

Observation shows that on average the 15th percentile speed falls between approximately 77% and 84% that of the 85th percentile speed. Accordingly, when determining whether or not the accepted maximum angles can be met, a speed value of 77% that of V_v is used to calculate the values of S_{vg} and S_{tg}, which for angle measurements are expressed as S_{vga} and S_{tga}.

The various forms in which these angle requirements are to be met are shown in Figure 2, and are measured between points C and D. For crossings having both straight road and rail approaches over the full distances of S_{vga} and S_{tga}, the angle requirements can also be assessed from the measured angle between the right hand side of the road and the rail, $\angle_g$.

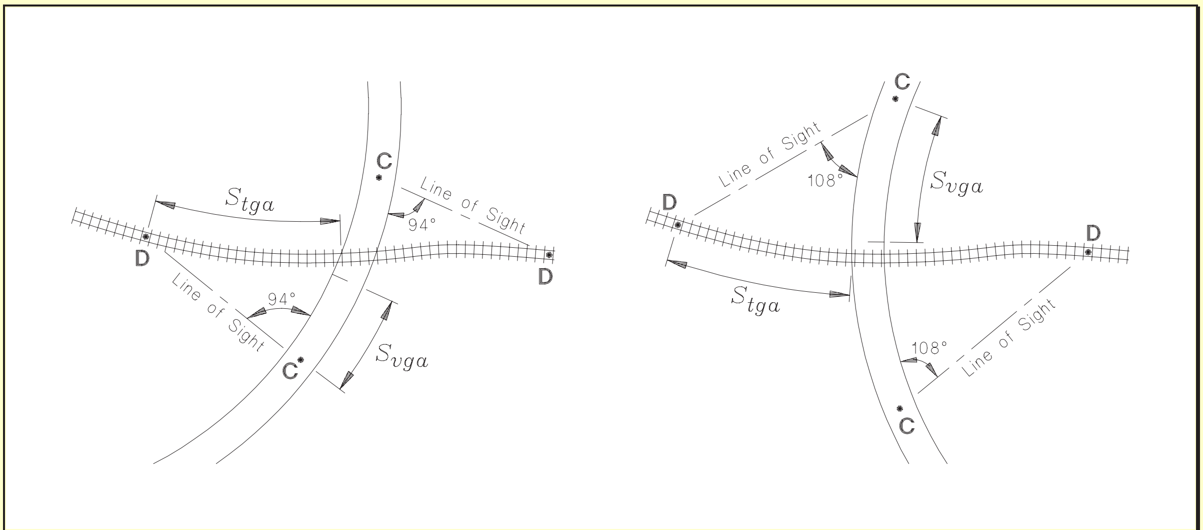
The range of crossing angles can be calculated from the following:

$$94 + \arcsin\left[\frac{S_{vga} + 3.5}{S_{tga}} \bullet \sin 94\right] > \angle_g$$

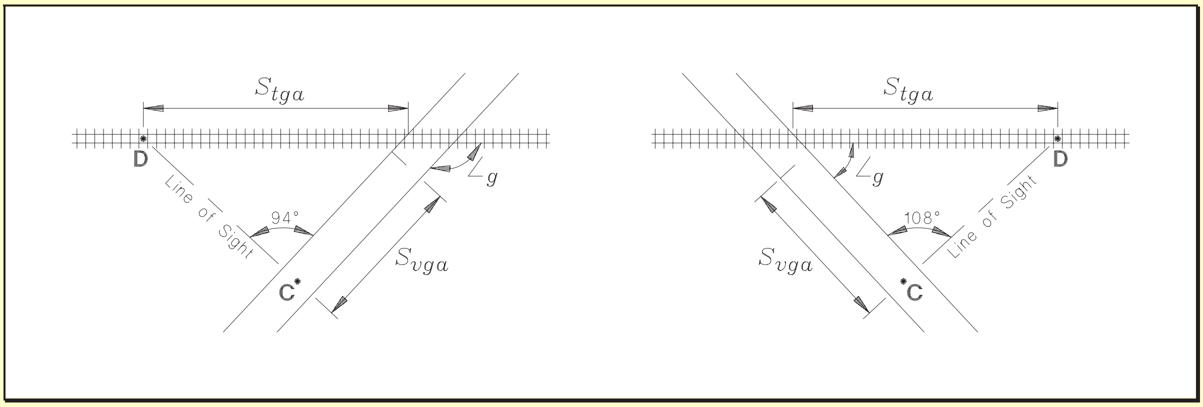
$$> 180 - 108 - \arcsin\left[\frac{S_{vga} + 3.5}{S_{tga}} \bullet \sin 108\right]$$

for; $S_{vga} + 3.5 < S_{tga}$

Figure 2 - Angle Requirements for Give Way Signs



General maximum angle requirements



Angle $\angle_g$ applies to crossings having both horizontally straight road and rail approaches only and is always applied to the right edge of the road.

3.4 ASSESSMENT FOR GIVE WAY SIGNS ON SIDE ROAD CROSSINGS

Many railway lines throughout the State have roads running close by and parallel. While travelling along such roads motorists may be unaware of a train travelling just behind the vehicle in the same direction. The speed of a vehicle turning from a parallel road into a side road is often variable with the driver's concentration being primarily directed to the turning manoeuvre and other possible conflicting traffic. It is not until such time as this manoeuvre has been completed that a driver is in a position to safely check for approaching trains.

For this situation, S_{vg} and S_{vga} are always based upon the value of V_v as measured at the tangent point of the corner curve as shown in Figure 3. (This as based upon there being no increase in vehicle speeds after drivers reach this point.)

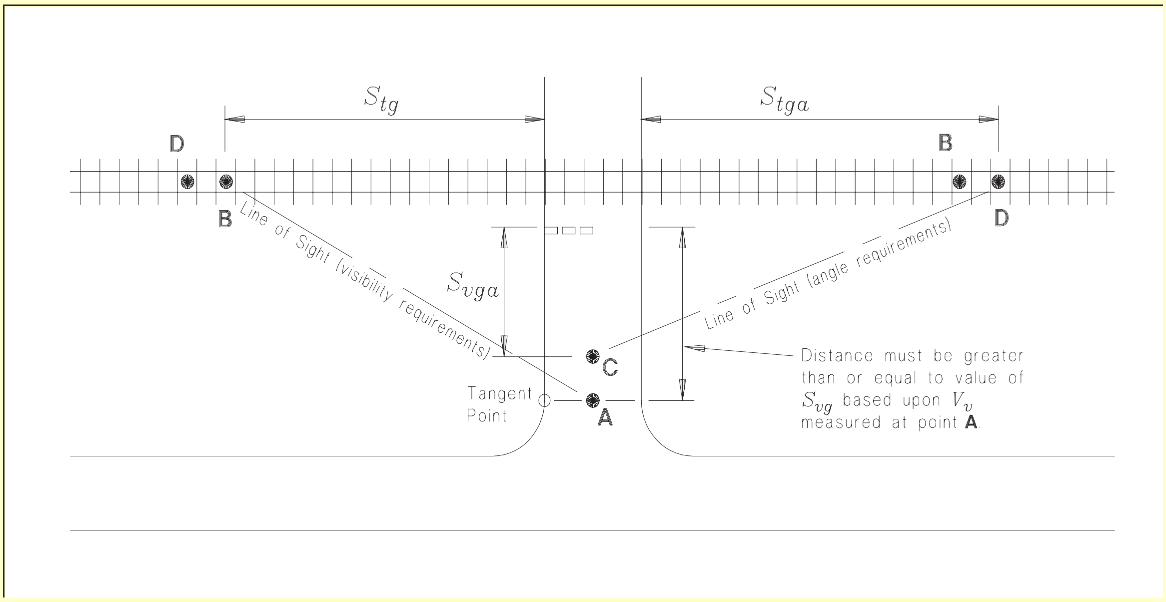
Also, as it is likely that drivers would become aware of the existence of the crossing before or during the turning manoeuvre, and would be conscious of the need to stop the vehicle if required, a reduced driver reaction time of 2.0 seconds is appropriate for this situation.

Thus S_{vg} and S_{vga} are always based upon the value of R_{tg} being 2.0 seconds.

3.5 SIGHT DISTANCE AND ANGLE REQUIREMENTS FOR STOPPED VEHICLES

Where there is the likelihood of drivers having to stop at or near a crossing controlled by Give Way Signs on a regular basis, such as due to frequent train activity or because of nearby connecting roads or development, it is necessary that the differing sight distance and angle limitations for stopped vehicles, as opposed to moving vehicles, are taken into account. This situation would also apply to drivers carrying hazardous goods who are legally required to stop at all passive railway crossings and also at any multi track crossing where a driver, after having stopped for a train travelling in one direction, is required to assess the presence of a train approaching from the other direction. For these cases it is necessary that all of the visibility and geometric requirements for Stop Signs, as described in Section 4, is also met.

Figure 3 - Sight Distance and Angle Requirements for GIVE WAY Signs on Side Road Crossings



3.6 OTHER SAFETY REQUIREMENTS

Adjacent intersections and their controls should take into account the need to accommodate any vehicle queuing which may occur without impediment to traffic movement over the railway crossing. Also, the layout of the intersection should allow for the longest length of vehicle permitted to use the crossing to stop at the intersection control, if required, without impinging upon the railway crossing safety clearance area.

a) The installation of suitable street lighting can reduce the problem of trains already on the crossing not being visible to approaching drivers at night. This particularly applies where nigh time shunting activities occur. It is desirable that the lighting include illumination on both sides of the railway a short distance either side of the crossing.

b) To provide for safe pedestrian access over a railway crossing a suitable fencing, maze and signing treatment should be installed at crossings where regular pedestrian activity occurs and/or in conjunction with any abutting footpath, dual-use-path or cycleway associated with the road.

c) Where there is the likelihood of pedestrian movements or other extraneous activity at or near a railway crossing, warning should be provided by the long sounding of the approaching train's siren or horn at a distance from the crossing appropriate to the speed of travel, but not less than a distance equivalent to Stg from the crossing. The initial warning is to be repeated at regular intervals until the crossing is reached.

d) The headlight/s of locomotives and railcars should be maintained on high beam when approaching the railway crossing during the day or night.

I. See Appendix A for definition of terms and notation.

II. Reference graphs for determining the various sight distance and angle requirements for Give Way signs are at Appendices C and D

III. A flow chart of the steps required for assessing Give Way signs is at Appendix E.

4 STOP SIGNS

4.1 GENERAL

A railway crossing protected by Stop Signs works on the principle that visibility restrictions on the road approaches to the crossing, either by virtue of the crossing geometry or adjacent development/vegetation, are such that a motorist is not able to make an appropriate decision on proceeding over the crossing without first stopping on the approach side to assess the conditions. However, there is sufficient visibility from the stopped position to an oncoming train to enable the motorist to decide whether to cross before the train reaches the crossing or wait until the train has passed. Similar to Give Way sign control, this level of protection generally applies at locations where train and/or vehicle volumes are relatively light.

There are four conditions to be satisfied before Stop Sign control may be considered to be an adequate level of protection;

a) Due to the difficulties a motorist can face in being able to view and perceive the rate of approach of a high-speed train over long distances, Stop Signs are not appropriate where the train speed is in excess of 100 km/h. However, It is not expected that this condition would apply to non-public crossings where drivers would generally be familiar with the conditions and exercise a greater level of caution when negotiating these crossings.

b) The extent of clear visibility either actually available, or that could be made available by clearing works, to a motorist at the stopped position at the crossing must be at least equal to the minimum level necessary as determined from consideration of train speeds over the crossing and the geometry of the crossing. Section 4.2 refers.

c) The clear visibility required by b) above must be available without requiring the driver of a vehicle stopped at the crossing to rotate his or her head through a range of angles considered beyond either the human body's or the vehicle's capacity. Section 4.3 refers.

d) The level of train and vehicle activity should be below that warranting active protection to be installed. Sections 5.1 and 6.1 refer.

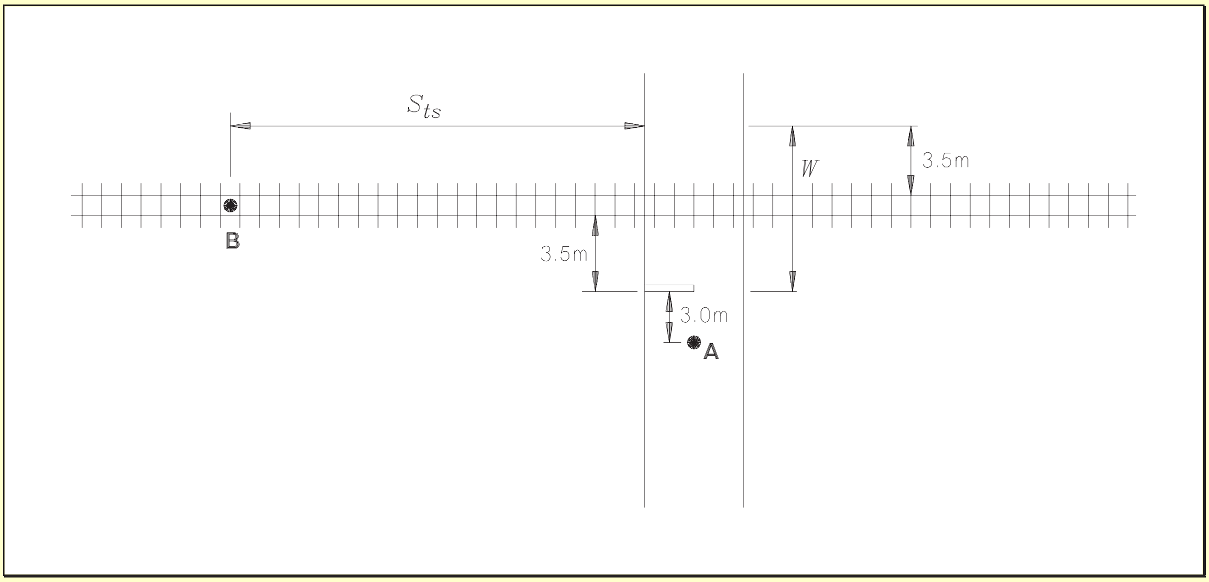
4.2 SIGHT DISTANCE REQUIREMENTS FOR STOP SIGNS

For Stop Sign protected crossings, motorists need to be able to see any approaching train that represents a potential conflict, while stopped at the hold line. (In the absence of a hold line assume the front of the vehicle to be 3.5m from the nearest rail.) The position of the driver's eye can be taken as being 3m back from the hold line.
The sight distance required by the driver, S_{ts}, can then be calculated as the product of the maximum train speed, V_t, and the time required for the vehicle to clear the crossing plus a 5 second safety margin. The time taken for the vehicle to clear the crossing is derived from the following variables:

a) The reaction time, Rts, taken by the motorist to begin accelerating after looking in both directions for approaching trains. (Taken as 2 seconds.)

b) The acceleration rate, a, for the longest vehicle permitted to use the road. (see table 3).

Figure 4 - Sight Distance Requirements for Stop Signs



Nominal Vehicle Type	Acceleration Rate (m/s²) *a*
Light Vehicle	0.50
Semi Trailer	0.26
B-Double	0.22
Double Road Train	0.18
Triple Road Train	0.15
Quadruple Road Train	0.14

TABLE 3

c) The distance the vehicle is required to travel in order to clear the crossing. This distance is the sum of the width of the crossing, W, and the length of the vehicle, L, (which is taken as the longest type of vehicle permitted to use the road).

d) A grade correction factor, Gs. (Table 4)

Grade	Correction Factor G_s
-4%	0.8
-2%	0.9
0%	1.0
+2%	1.3
+4%	1.7

TABLE 4

The distance, S_{ts}, can therefore be calculated as follows (for V_t in km/h):

$$S_{ts} = \frac{V_t}{3.6} \bullet \left[5 + R_{ts} + G_s \bullet \left[\frac{2[W+L]}{a} \right]^{1/2} \right]$$

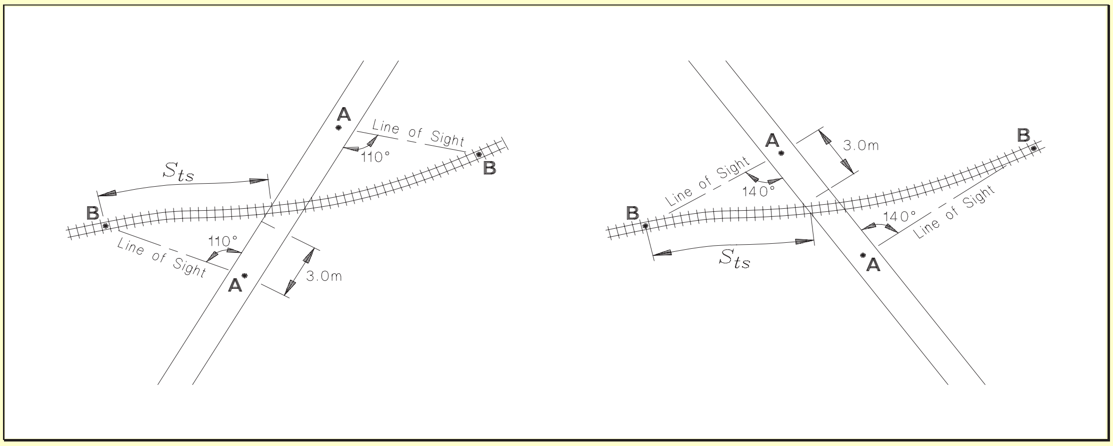
Adequate visibility is defined as being a driver's ability to view at least two thirds of the frontage area, inclusive of any warning or headlight/s, of the approaching locomotive from an eye height of 1.15 metres above the road surface level.

The sight triangles should be clear of any obstructions so as to ensure that drivers are able to readily detect the presence of an approaching train within the distance S_{ts} from the crossing. (See Figure 4.)

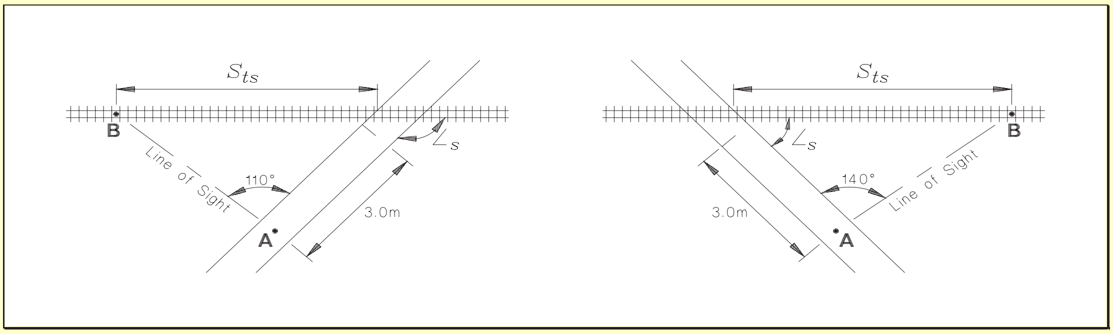
4.3 ANGLE REQUIREMENTS FOR STOP SIGNS

In addition to needing clear visibility of trains at a distance of S_{ts}, drivers cannot be expected to turn their heads through too great an angle in order to see the train. For a stopped vehicle the accepted maximum angles are <u>110</u>^{o} to the left and <u>140</u>^{o} to the right. The various forms in which these angle requirements are to be met are shown in Figure 5.

Figure 5 - Angle Requirements for Stop Signs



General maximum angle requirements



Angle $\angle_s$ applies to crossings having both horizontally straight road and rail approaches only and is always applied to the right edge of the road.

For crossings having straight rail approaches, the angle requirements can also be assessed from the measured angle between the right hand side of the road and the rail, $\angle_{s.}$ the range of crossing angles can be calculated from the following:

$$110 + \arcsin\left[\frac{[3+3.5]}{S_{ts}} \bullet \sin 110\right] > \angle_s$$

$$> 180 - 140 - \arcsin\left[\frac{[3+3.5]}{S_{ts}} \bullet \sin 140\right]$$

4.4 OTHER SAFETY REQUIREMENTS

a) Adjacent intersections and their controls should vehicle queuing which may occur take into account the need to accommodate any without impediment to traffic movement over the railway

Also, the layout of the intersection should allow for the longest length of vehicle permitted to use the crossing to stop at the intersection control, if required, without impinging upon the railway crossing safety clearance area.

To provide for safe pedestrian access over a railway crossing a suitable fencing, maze and signing treatment should be installed at crossings where regular pedestrian activity occurs and/or in conjunction with any abutting footpath, dual-use-path or cycleway associated with the road

c) Where there is the likelihood of pedestrian movements or other extraneous activity at or near a railway crossing, warning should be provided by the long sounding of the approaching train's siren or horn at a distance from the crossing appropriate to the speed of travel, but not less than a distance equivalent to Sts from the crossing. The initial warning is to be repeated at regular intervals until the crossing is reached.

d) The headlight/s of locomotives and railcars should be maintained on high beam when approaching the railway crossing during the day or night.

e) As an interim safety measure at crossings where the sight distance requirements cannot be met, drivers can be advised to 'Listen for Trains' in lieu of normal signing advising motorists to 'Look for Trains'. Such signing is always to be complemented with audible warning by the sounding of the approaching train's siren or horn.

I. See Appendix A for definition of terms and notation.

II. Reference graphs for determining the sight distance requirements for Stop Signs are at Appendix F.

A flow chart of the steps required for assessing Stop Signs is at Appendix G.

5 FLASHING LIGHTS

5.1 GENERAL

Flashing Lights are an active form of control at a railway crossing and obviate the need for drivers to check for approaching trains. If any of the following four conditions apply at a railway crossing, consideration should be given to the installation of Flashing Lights:

a) The geometric requirements for passive control cannot be met and no more than one through train can approach the railway crossing at the same time.

b) The volumes and speeds of trains and vehicles create a potential hazard at a level that justifies the installation of Flashing Lights.

c) The replacement of Stop Signs with Flashing Lights may be shown to have a cost benefit.

d) The road is of a classification, which drivers would generally expect to have priority of travel on the route, i.e. a declared Highway or Main Road.

Meeting any of the above conditions does not automatically lead to the installation of Flashing Lights. For example, it may be more cost effective to provide for passive control by realigning the road or by reducing train or vehicle speeds.

5.2 INSTALLATION OF FLASHING LIGHTS DUE TO LEVEL OF POTENTIAL HAZARD

The potential hazard at a railway crossing is influenced by the level of conflict between trains and vehicles. The conflict is normally expressed as the product of the number of trains and vehicles using the crossing, i.e. trains x vehicles. Given that potential hazards can also be influenced by the speed at which trains and vehicles approach a crossing, it is appropriate to assume that crossings having the same level of conflict but different train and vehicle speeds, also have different levels of potential hazard. To account for these differences, it is necessary to apply weighting factors to the level of conflict based on the speed of trains and vehicles to establish the <u>weighted conflict</u> at a crossing in order to assess its level of potential hazard.

The weighted conflict is calculated from the average number of trains per week, N_t, multiplied by the number of vehicles per day, *AADT,* based upon a standard speed of 60 km/h for both the train and the vehicles. The weighting factor therefore does not change the vehicle x train conflict if the train and vehicle speeds are 60 Km/h. (For existing crossings protected by Stop Signs, the value of V_v is always taken as 60 km/h.)

When assessing the installation of flashing lights the weighted conflict, C_{wf}, is derived as follows:

$$C_{wf} = \frac{V_t}{60} \bullet N_t \bullet \frac{V_v}{60} \bullet AADT$$

If C_{wf} is greater than 14 000, consideration should be given to the installation of Flashing Lights.

5.3 INSTALLATION OF FLASHING LIGHTS BASED UPON BENEFIT TO COST RATIO

The compulsory stopping of vehicles by the installation of Stop Signs represents a cost to the community by increased vehicle operating costs and increasing travel times. Although the cost is justified by the increased level of safety, there comes a point when, because of the vehicle volumes, the installation of Flashing Lights may be justified.

The benefit cost ratio, *BCR*, (i.e. the ratio of benefits to costs) can be calculated from the annual stopping costs, A_{sc}, associated with vehicles stopping at a crossing, compared with the installation costs, I, and the maintenance costs, M, of a set of Flashing Lights. In order to relate future benefits and costs to present values it is necessary to determine the service life, *SL*, of the installation and the economic discount rate, *EDR*, based on the general interest rate applicable at the time of study.

The *BCR* can then be calculated as follows:

$$BCR = \frac{\sum \frac{A_{sc}}{[1+EDR]^{SL}}}{I + \sum \frac{M}{[1+EDR]^{SL}}}$$

For a *BCR* value greater than 2, consideration should be given to the installation of Flashing Lights. It should be noted that the *BCR* calculation assumes that no vehicles will be required to stop once Flashing Lights have been installed. Although not strictly correct, the number of vehicles required to stop, in situations were this criterion is likely to apply, would be negligible, i.e. crossings with high vehicle volumes and low train volumes. Crossings that also have high train volumes, and hence the operation of Flashing Lights could be expected to stop a significant number of vehicles, would be likely to qualify for Flashing Lights on a weighted conflict basis.

5.4 VISIBILITY REQUIREMENTS FOR FLASHING LIGHTS

The operating flashing light signals should be clearly visible to approaching motorists from a distance of at least equal to the stopping sight distance applicable for the section of road.

Since the crossing may also generate a queue of vehicles, it is important that an approaching motorist can also see the end of the queue from a distance of at least equal to the stopping sight distance, wherever the end of the queue may be. (Refer to Figure 6.)

The required driver visibility distance to the flashing light signals, S_{vf}, is therefore made up of the following components:

a) The distance travelled during the reaction time, Rtf, which is required by the driver to see the lights flashing, appreciate the need to stop and apply the brakes. (Taken as 2.5 seconds.)

b) The required braking distance (for the predominant type of vehicle using the road).

The average maximum length of any queue of vehicles, Lq, that may have formed from the stop line following commencement of the lights flashing. The braking distance varies depending on the 85th percentile approach speed of the vehicles, V_V, the deceleration rate, *d*, and the grade of the road, G_f. The appropriate deceleration rates are shown in section 4 Table 3.

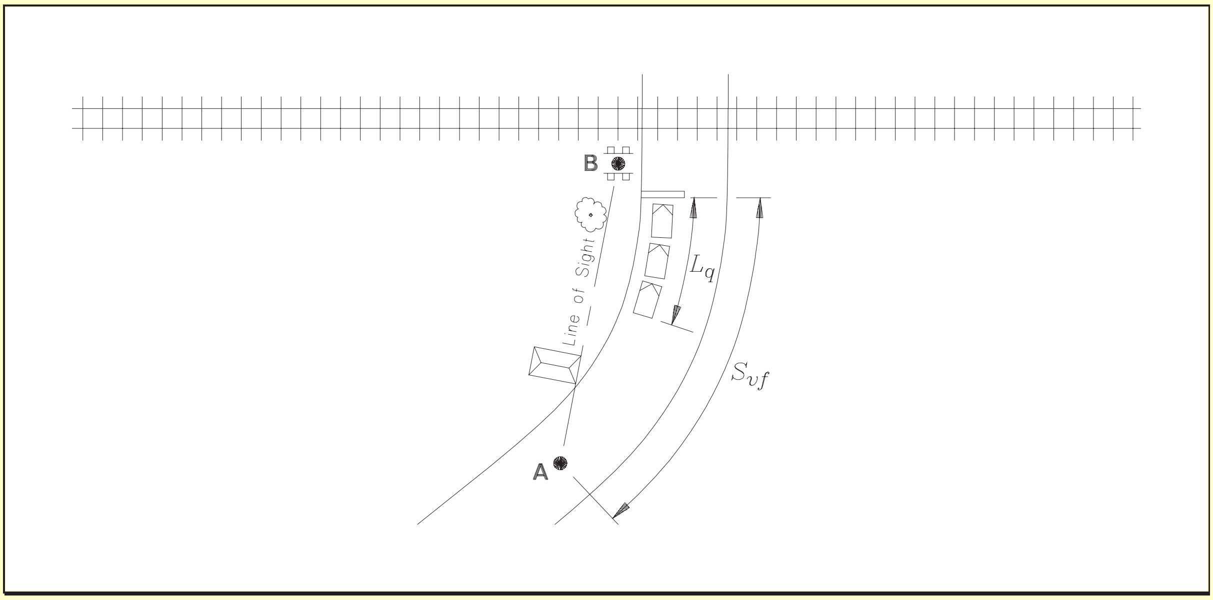
The value, G_f, is positive for upgrades and negative for downgrades (e.g. a 2% downgrade would have a value of -0.02). The distance S_{vf} can therefore be derived as follows:

$$S_{vf} = \frac{R_{tf} \bullet V_v}{3.6} + \frac{[Vv]^2}{254[d + G_f]} + L_q$$

The length of vehicle queues that can form at a crossing is influenced by a number of factors including arrival rates, the type of traffic flow (i.e. random, bunched or platooned), number of lanes, vehicle types, crossing closure times etc. In the absence of measured data or observations to determine the average maximum vehicle queue length, Appendix H can be used as a guide for estimating values for L_q.

These values are based upon random arrivals on a single lane approach to a typical crossing.

Figure 6 - Visibility Requirements for Flashing Lights



(A 7% heavy vehicle composition has been assumed.)

Should the required visibility distance, S_{vf}, not be available, one or a combination of the following measures should be considered:

a) Geometric modifications to the road alignment.

b) Removal of obstructions such as vegetation, embankments, structures, etc.

c) Modifications to the flashing light signal displays, i.e. additional, taller or offset masts, etc.

d) Advance flashing warning signs. (Refer to Section 8).

5.5 OTHER SAFETY REQUIREMENTS

Apart from the possibility of visibility to the flashing lights being reduced by the road geometry and other physical obstructions, visibility can also be adversely effected by various traffic and environmental conditions, such as:

- Traffic congestion on multi-lane roads, where slow moving or queued vehicles in one lane can obstruct visibility for drivers in an adjacent lane.
- Large vehicles regularly stopping at nearby side roads or driveways and blocking sight lines.
- Distractions in the form of other signal displays and illuminated signs and devices.
- Sight lines regularly obstructed by kerbside or verge parking.

Consideration should be given to installing overhead or cantilevered flashing light displays to address visibility obstructions caused by any of these conditions.

a) To provide for safe pedestrian access over a railway crossing, a suitable fencing, maze and signing treatment should be installed, including warning bells, at all Flashing Light protected crossings where regular pedestrian activity occurs and/or in conjunction with any abutting footpath, dual-use-path or cycleway associated with the road.

b) On unsealed roads there is the possibility of dust obscuring the signals. Therefore, the installation of Flashing Lights on unsealed road crossings should be accompanied by the sealing of the approaches for a distance of at least 50 metres either side of the railway.

c) On routes approved for use by 'oversize' vehicles, e.g. road trains, investigations should be undertaken to determine any particular safety requirements that need to be incorporated into the operation of the Flashing Lights, e.g. longer pre-warning times and sight distances to the signals, allowance for greater safe stopping distances by installing advance flashing warning signs (refer to Section 8) etc.

d) Adjacent intersections and their controls should take into account the need to accommodate any vehicle queuing which may occur without impediment to traffic movement over the railway crossing. Also, the layout of the intersection should allow for the longest length of vehicle permitted to use the crossing to stop at the intersection control, if required, without impinging upon the railway crossing safety clearance area.

e) Where there is the likelihood of pedestrian movements or other extraneous activity at or near a railway crossing, warning should be provided by the long sounding of the approaching train's siren or horn at a distance from the crossing appropriate to the speed of travel, but not less than a distance from the crossing equivalent to the value of S_{ts} as determined from Section 4. The initial warning is to be repeated at regular intervals until the crossing is reached.

f) The headlight/s of locomotives and railcars should be maintained on high beam when approaching the railway crossing during the day or night.

I. See Appendix A for definition of terms and notation.

II. Reference graphs for determining sight distance requirements to Flashing Light signals are at Appendix H

6 BOOM BARRIERS

6.1 GENERAL

Boom Barriers are installed to supplement the level of protection provided by Flashing Lights. They are an active control device, providing a visual barrier between the movement of vehicles and trains. The effectiveness of this barrier in improving safety is particularly realised at busy urban crossings subject to heavy and often congested vehicle flows.

If any of the following conditions apply at a railway crossing then consideration should be given to the installation of Boom Barriers.

a) The volumes and speeds of trains and vehicles create a potential hazard at a level that justifies the installation of Boom Barriers.

b) The crossing is located on a railway with multiple through tracks and it is possible for more than one train to approach the crossing at the same time.

Apart from the above conditions, the methodology and requirements for crossings supplemented with Boom Barriers are identical to those for Flashing Lights alone. (Refer to Section 5.).

6.2 INSTALLATION OF BOOM BARRIERS DUE TO LEVEL OF POTENTIAL HAZARD

The method for determining the weighted conflict, and hence the level of potential hazard at a rossing protected by Boom Barriers, C_{wb}, utilises the same formula for determining warrants for Flashing Lights, as follows:

$$C_{wb} = \frac{V_t \bullet N_t \bullet V_v \bullet AADT}{3600}$$

If C_{wb} is greater than 700,000, consideration should be given to the installation of Boom Barriers. (If Stop Signs exist at the crossing, the vehicle speed needs to be estimated as if Flashing Lights were installed.)

6.3 OTHER SAFETY REQUIREMENTS

In conjunction with the installation of Boom Barriers in urban areas, particularly at multiple track crossings, it is desirable that suitably designed traffic islands be installed to provide a barrier between opposing carriageway approaches. The islands assist in preventing motorists from driving around the ends of the boom arms to bypass delays which can be caused by the approach of a second train, and also serve to highlight the location of the crossing.

See Appendix A for definition of terms and notation.

7 GRADE SEPARATION

This Section Under Development

8 ADVANCE FLASHING WARNING SIGNS

8.1 GENERAL

Advance Flashing Warning Signs are installed to supplement the level of protection provided by Flashing Lights and Boom Barriers. They are an active warning device incorporating the message 'Prepare to Stop', and provide visual advance warning to motorists that there is a requirement to stop for the flashing light signals at the railway crossing ahead.

The effectiveness of this advance warning in improving safety is particularly realised on high speed road approaches where the required visibility to the flashing lights cannot be attained by normal measures. Heavy vehicles, particularly road trains derive significant benefit from the advance warning signals.

The decision to install advance flashing warning signs should be based upon sound traffic engineering judgement which includes consideration to factors such as traffic speeds, traffic volumes, heavy vehicle composition, road geometry, visibility and vehicle crash history.

To ensure some uniformity in vehicle operating speeds the road should conform to the requirements for speed zoning. It would generally be expected that the section of road would have a posted speed limit of 80 km/h or higher and that at least one of the following minimum conditions would be met:

a) The road is a designated heavy vehicle route or a specified road train route.

b) The railway crossing has a known history of vehicle crashes of the type, which cannot reasonably be alleviated by other warning signs or devices.

c) Available driver sight distance to the primary flashing lights at the railway crossing is below that specified in Section 5.4 and the available sight distance cannot be reasonably increased by other measures.

d) Driver visibility of the operating railway crossing flashing lights can at times be severely reduced by sun-glare, either as a consequence of the sun shining directly upon the signal lenses or due to the sun shining directly into the driver's line of vision.

8.2 LOCATION AND OPERATIONAL TIMING

The warning signs should be located sufficiently in advance of the railway crossing to enable drivers travelling at the 85th percentile speed for the particular road, to safely and comfortably stop at the stop line after viewing the signals commence operation. The distance the warning signs are located in advance of the stop line, $S_{vw)}$, allows for the following: (Refer to Figure 7)

a) The distance travelled during the reaction time, R_{tw}, which is required by the driver to perceive the sign flashing. Applied as follows:

- On urban roads 1.5 -2.0 seconds
  On rural roads 2.0 - 2.5 seconds

b) The required braking distance.

The braking distance varies depending on the vehicle speed, V_{vh}, the deceleration rate, d, and the grade of the road, G_w. The value, G_w, is positive for upgrades and negative for downgrades (e.g. a 3% downgrade would have a value of -0.03).

It is commonly accepted that a driver needs to be a distance of at least 22 metres in advance of the warning signs to be able to physically view the operating flashing signals. This constant distance is therefore subtracted from the calculated stopping distance when determining the locations of the signs.
The distance S_{vw} in metres can therefore be derived by the following formula:

$$S_{vw} = \frac{R_{tw} \bullet V_{vh}}{3.6} + \frac{[V_{vh}]^2}{254[d + G_w]} - 22$$

Where:
R_{tw} = reaction time
V_{vh} = vehicle speed
d = deceleration rate
G_w = approach gradient of the road

Values of S_{vw} for various approach grades can be determined from Appendix L.

The length of time in seconds, T, that the advance signals flash before the railway crossing flashing lights begin to operate is determined by the following formula:

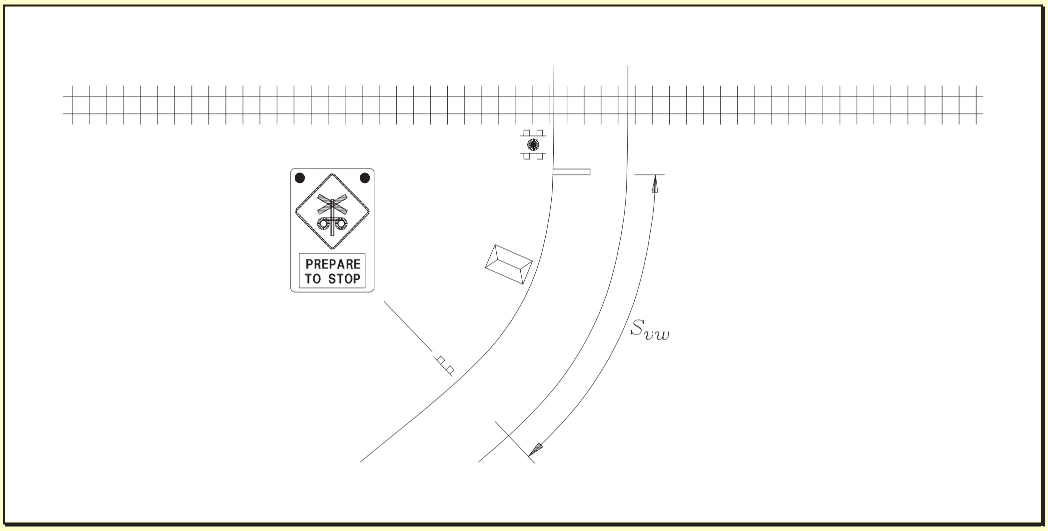
$$T = \frac{3.6[S_{vw} + 22]}{V_{vh}}$$

Where:
S_{vw} = sign distance in metres
V_{vh} = vehicle speed

Values of T for various approach grades can be determined from Appendix L.

To allow for major obstacles and other physical features, which may effect the on-site location of the warning signs, a 5% tolerance can be applied to the values of S_{vw} in Appendix L, without the need to recalculate the length of time, T. For sign installation outside of this 5% tolerance, a new value for T, must be determined and applied.

Figure 7 - Location of Advance Yellow Flashing Warning Signs



8.3 HEAVY VEHICLES ON DOWNGRADES

For particularly heavy vehicles descending long and steep grades, the deceleration rate is significantly reduced due to the affect of gravity. Under some situations acceleration due to gravity can exceed the deceleration rate, requiring the driver to descend in low gear to avoid the vehicle gaining excessive speed. In these situations, appropriate signs (Trucks Use Low Gear) should be installed in advance of the flashing warning signs.

When determining the location and timing of advance flashing warning signs, vehicles that are required to approach the crossing at slower than normal operating speed are ignored when applying the value of V_{vh}. (Appendix L identifies the grade of approach in which this situation is likely to apply.)

SIGN SIZE SELECTION

Advance Flashing Yellow Warning Signs comprise of a standard a standard diamond shaped railway level crossing flashing light ahead sign on a yellow rectangular background. Sign size selection is related to the posted speed limit of the road and applied as follows:

(a) On declared highways and main road where the posted speed limit is 80km/h or higher Type 4 Signs are to be used.

(b) Where the posted speed limit is 80km/h or higher and there is restricted area for sign installation, Type3 signs may be considered.

(c) Sign Types 1 and 2 may be considered where there is restricted area available for sign installation.

SIGN TYPE	SIGN WIDTH	SIGN SIZE	DIAMOND SIZE	TEXT HEIGHT
1	900	1300	600X600	100 DM
2	1100	1600	750 X 750	120DM
3	1350	1950	900 X 900	160 DM
4	1800	2600	1200 X 1200	200 DM

TABLE 5 – AFYWS Standard Sign Sizes

8.4 OPERATIONAL RESPONSIBILITIES

Design, installation and maintenance of advance flashing yellow warning signs are the responsibility of MRWA. Where not otherwise subject to separate agreements, operational responsibilities (including funding) for advance flashing warning signs are as follows:

Main Roads Western Australia

- Design, supply and installation of sign panel and posts, signal aspects, sign location distances and operational parameters.
- Maintenance of the sign panel and posts.

<u>Rail Authority</u>

- Design, supply, installation, testing and commissioning (in conjunction with Main Roads WA) of electrical railway control and switching for the activation of the flashing signals.
- Maintenance (at Main Roads WA cost) of the railway control and switching equipment, underground cabling and signal aspects.

It is essential that the warning signs be maintained in good order and condition and that visibility to the signs is not obstructed by vegetation growth and other signs or obstructions.

I. Refer to MRWA Drawing 9531-1112 for standard design layout of advance flashing warning sign.

II. Refer to MRWA Drawing 9631-3525-1 for electrical equipment details.

III. Refer to Australian Standard as1742.2, Section 3.9 for reference information regarding steep grades

IV. *Reference can be made to MRWA draft document 'Regulatory Signs, Warning Signs, and Advance Directional Signing Policy' for further details and information on advance warning sign systems.*

9 PRIORITIES FOR ACTIVE PROTECTION

9.1 GENERAL

Whilst there are a number of crash prediction models available to determine relative hazard and hence priorities for upgrading protection levels, these are largely based upon or compared to some historical measure of crash occurrences. Railway crossing crashes in Western Australia are low in numbers and widely dispersed. Given the diversity of the road and railway network and the continuing changes occurring in the transportation area, the ranking or prioritising of protection requirements based upon previous or predicted crash levels is not considered the most effective method of identifying or forecasting hazards at railway crossings in this State. Nevertheless a crossing having a continuing history of train-vehicle crashes obviously demands attention. There are other factors including social and economic considerations, which can also influence the priority given to the upgrading of protection.

9.2 METHODOLOGY

After having established from Sections 5 and 6 that upgrading of protection from passive control to active control or from Flashing Lights to Boom Barriers is warranted, it is often a requirement that the installation be incorporated into a funding program. In many cases there are more installations identified as meeting the warrants at any one time that budget allocations will allow to proceed.

In these circumstances it is necessary to establish priorities for the works to determine which installations should be programmed ahead of others.

An appropriate method of prioritising warranted Flashing Light and Boom Barriers installations is to consider the degree to which the warrants are exceeded or the geometric requirements are deficient, as well as any other peripheral safety hazards associated with a crossing. These additional hazards can arise from the particular geometric layout of the crossing and its approaches, operational and physical aspects of the site, as well as any environmental factors, which should be taken into account.

At Appendix M is a list of these factors together with a range of point scores for the degree or level at which they occur. Using the total of these point scores, direct comparisons can be made between the relative level of potential hazard at each location. The following should be noted in respect to this point scoring method:

a) It should not be used to determine the need for upgrading of protection levels.

b) Crossings should only be compared with the same proposed level of protection, i.e. a crossing to be provided with Flashing Lights should not be scored against a crossing that is proposed to be upgraded to Boom Barriers.

Use proforma at Appendix M for prioritising active protection installations.

10 GENERAL PROTECTION REQUIREMENTS

10.1 GENERAL

As well as looking specifically at the appropriate levels of protection, it is necessary to take into account any other factors that may influence safety at a railway crossing.

10.2 PHYSICAL AND GEOMETRIC CONSIDERATIONS

Preferably, adjacent intersections, pedestrian crossings, bus stops, or other traffic devices and treatments should not be located or installed in the vicinity of railway crossings.

This also applies to advertising signs or hoardings, which may distract a driver's attention away from the driving task.

10.3 CESSATION OF RAILWAY OPERATIONS

As a general rule, railway crossing protection devices should only be installed in situations where they are required; otherwise motorists become complacent about railway crossing signing and begin to ignore them. A problem then arises if they subconsciously ignore the same signs in locations where they are required.

From time to time train movements on a particular line cease either permanently, or temporarily as a part of seasonal operations. On closed or unused sections of lines where the recommencement of services is not a realistic possibility, all signs and signalling devices should be removed. Where necessary, appropriate warning signs, e.g. 'hump', 'dip', 'rough surface' etc. should be erected at the time of removal of the railway crossing signs.

On closed or unused lines where the recommencement of services is a realistic possibility, then only Stop Sign plates and associated stop sign ahead warning signs should be removed, where they are installed. On public roads the temporary removal of these signs requires approval from the Commissioner of Main Roads.

10.4 PRIVATE RAILWAY CROSSINGS

The protection requirements for crossings located on non-public roads where access is not available to the public, e.g. those established in farm properties to allow access between paddocks, can be varied to suit the particular situation as agreed between the property owner and the railway network owner.

10.5 PERMISSION TO ENTER THE RAILWAY RESERVE

Investigation of railway crossing protection in many cases requires investigation personnel to enter the railway reserve in the vicinity of the crossing.

Any person entering land under the control of any railway networks owner must be fully aware of any entry requirements or conditions that may be imposed by the rail network owner.

10.6 RAILWAY CROSSING BOARDS (RX-9 ASSEMBLIES)

While the general requirements for Railway Crossing boards (RX-9 Assemblies) are described in Australian Standard 1742 Part 7, 1993, this section provides greater clarity on their use within Western Australia.

Railway crossing boards along with the associated width markers provide additional warning to drivers of the approaching railway crossing, and also highlight the position of the crossing. The width markers provide vertical delineation of the width of crossing, and thus offer safe guidance past potential roadside hazards associated with railway crossings such as flashing light masts, boom arm equipment and exposed rails, sleepers, etc. Railway crossing boards should generally be installed if any of the following circumstances prevail:

a) The road has an 85th percentile speed over the crossing of 80 km/h or greater.

b) The railway crossing has active protection and the road approaches are not kerbed.

c) Railway crossing signal equipment and exposed rails, sleepers etc are located within the nominal width of the outer edge of the road shoulders.

In all cases, Railway Crossing boards should not obstruct visibility from nearby intersecting roads or driveways.

NOTE: The Road Traffic Regulations permit agricultural implements up to 9.5m in width to be moved between farm properties in day light hours. When using railway crossing width marker boards (RX9 Assembly) at level crossings adjacent to or in the vicinity of rural properties, additional width for farm implements up to 9.5m wide should be considered.

11 SHORT STACKING AND QUEUING HAZARDS

11.1 GENERAL

Some railway crossings are prone to vehicles stopping on the railway tracks due to factors involving short storage or stacking distances between the crossing and a nearby intersection, and/or traffic congestion which results in vehicle queues extending back over the crossing. Also, the crossing itself may contribute to queues extending back into nearby intersections.

There are obvious hazards associated with these situations and it is necessary to identify and implement suitable treatments to eliminate or reduce these hazards, or at least to provide information to drivers warning of these conditions. The more dangerous situation occurs at crossings with short departure stacking where the stopped vehicle is at risk of being hit by a train.

11.2 SHORT DEPARTURE STACKING

As indicated above, short departure stacking occurs when part of a vehicle, which is legally permitted to use the road, remains on the crossing while stopped to give way to traffic on the priority road of an intersection located beyond the crossing. These conditions typically arise at crossings on side roads where the priority road is a main route running parallel and close to the rail track. Another short departure stacking situation is where a vehicle remains on the crossing while attempting to turn right into a side road and is blocked by opposing vehicles. This situation is of less concern than being stopped by through traffic because the driver has the option of continuing on if a train approaches the crossing.

The normal vehicle stopping position at a priority road intersection is generally indicated by a stop or holding line. In the absence of a marked line, the stopping position can either be assessed on site or conservatively taken as 2 metres from the edge of the through road.

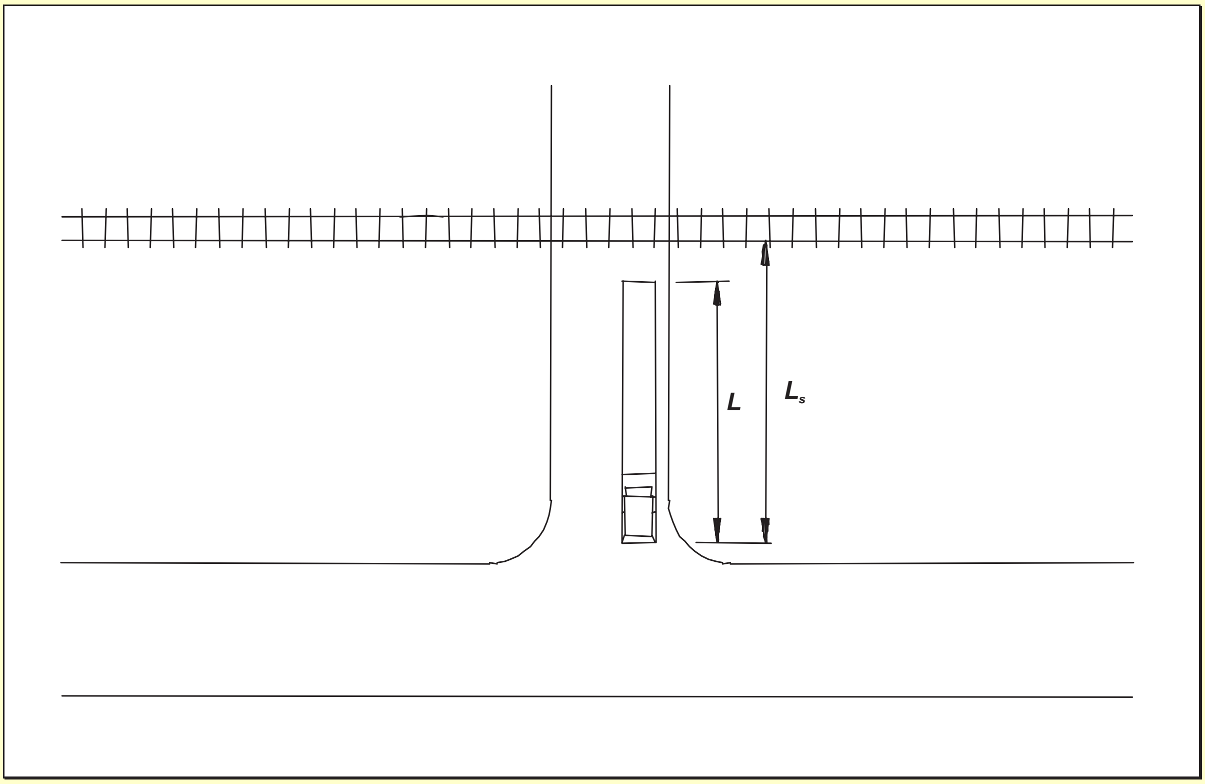
The longest 'as-of-right' vehicle legally allowed to use the road, *L*, can be taken as 19 metres, which provides for a semi-trailer. Generally on major routes and in many rural areas, vehicles exceeding this length are permitted. The length of these vehicles is commonly 27.5 metres for a B-double or Long Vehicle, and 36.5 metres for a double road train. However, as oversize vehicle routes and permitted oversize vehicle lengths are subject to change, Main Roads Western Australia's Road Transport Operations Section should be consulted for up-to-date information on the maximum vehicle length that applies to a particular crossing.

A 3-metre safety zone between a vehicle and the nearest rail is required. This has been derived from the minimum railway structure clearance plus a 1-metre safety factor. The minimum structure clearance varies according to the gauge and radius of the track and the type of rolling stock, but is generally within 2 metres from the nearest rail.

Therefore, the length of stacking distance available, L_S, measured from the nearest rail to the normal vehicle stopping position, is considered to be insufficient if the following applies. (Refer to Figure 8.)

$$L_s(m) < L(m) + 3$$

Figure 8 - Short Stacking Measurements



11.3 SHORT APPROACH STACKING

Short approach stacking occurs when a vehicle, which is legally permitted to use the road, is unable to fully clear a priority road of an intersection when stopping at an adjacent railway crossing.

Short approach stacking is also evident when the length of queued vehicles forming at a railway crossing regularly extends back into an adjacent priority road.

As well as obstructing traffic flows; these situations pose potential hazards for vehicles at the intersection.

On the approach to the crossing, the stopping position is normally indicated by a stop or holding line, or in the absence of a line, assumed to be 3.5 metres back from the nearest rail.

11.4 POSSIBLE TREATMENTS FOR SHORT STACKING

A range of possible treatments for short stacking at railway crossings is shown in Appendix N.
It is intended that Appendix N be used as a checklist to try and identify possible treatments to a particular crossing with a short stacking problem. These treatments should not be considered exhaustive and there may be other solutions that are not shown here. In many situations, a combination of treatments may be applicable.

The preferred treatment cannot always be implemented straight away due to timing, financial and other constraints. In these cases, an interim treatment should be considered as a first stage to reduce the risk of a collision occurring at the crossing.

11.5 QUEUING HAZARDS

Railway Crossings which are regularly subject to traffic congestion are locations where there is potential for vehicles to stand on the tracks.

Although Road Traffic Code regulations make it an offence to enter a railway crossing if the vehicle cannot be driven immediately clear of the crossing, observations show that in many instances it is not a deliberate flouting of the law when vehicles stop on the tracks during traffic congestion but rather, it is caused by the driver's inability to anticipate the forming of a queue behind vehicles performing a manoeuvre downstream of the crossing. In some cases, vehicles, which have stopped in a queue on the approach to a crossing, move off in a platoon formation only to find that one of the vehicles in the front of the formation stops (usually to turn right). Following vehicles inadvertently continue onto the crossing, not perceiving the hold up which is occurring ahead of them.

Particularly at multi-track or skew angle crossings, this problem is compounded by drivers being unable to accurately perceive the extent or limits of the crossing zone beyond the tracks.

To alleviate these conditions, appropriate delineation of the crossing zone in which vehicles should not enter unless they can proceed immediately to the other side of the crossing, is required. This delineation is achieved by the installation of yellow cross hatch markings within the area of the crossing zone, supplemented with 'KEEP CLEAR' signs installed on the approach and departure limits of the zone. Appendix O shows the general layout of the yellow cross-hatching and signing. Reference should be also be made to MRWA Drawings 9731-1096-1 and 9731-2493 for the standard signing and road marking design details.

It is clear that the markings and signs alone will not eliminate the problem and that continuing education and enforcement programs will be required to ensure the effectiveness of these measures.

I. See Appendix N for possible short stacking solutions

II. Appendix O shows the general standard layout of 'KEEP CLEAR' signs and yellow cross hatch markings.

III. Refer also to MRWA Drawings 9731-1096-1 and 9731-2493 for signing and road marking details for 'KEEP CLEAR' signs and yellow cross hatch markings.

12 PEDESTRIAN RAIL CROSSING PROTECTION

This Section Under Development

13 SAFETY AUDITS AND INSPECTIONS

13.1 SAFETY AUDITS GENERAL

The principles of road safety audits can be readily applied to railway crossings. These principles are documented in Austroads' Road Safety Audit Guidelines (Second Edition), which explain many of the general philosophies and processes associated with formal safety audits. The design and construction of new railway crossings are subject to the following stages:

- Stage 1 - Feasibility
- Stage 2 - Preliminary Design
- Stage 3 - Detailed Design
- Stage 4 - Pre-opening

For existing railway crossings, the road safety audit process can be applied in the form of a 'road safety review' of the existing physical, operational and environmental features of the crossing. This section covers only the 'road safety review' of existing railway crossings, with applicable safety audit checklists provided at Appendix P.

The safety audit process is designed to assess the potential for future crashes at a railway crossing, and thus is not suitable for investigation of past crashes, although it is recommended that crash investigations include a safety audit of the crossing.

13.2 REQUIREMENTS OF ROAD SAFETY AUDIT PERSONNEL

As well as knowledge of general road safety and traffic engineering principles, standards and guidelines, railway crossing safety audit personnel should be familiar with the various Government Acts and Regulations that relate to safety at railway crossings, (e.g. Road Traffic Act 1974, Road Traffic Code 2000, various Government and Private Railways Acts, etc).

13.3 ADVICE TO SAFETY AUDIT AND INSPECTION PERSONNEL

It is essential that personnel conducting a safety audit or inspection have previously acquired knowledge of a range of conditions and operational requirements associated with the railway crossing to be audited or inspected. These conditions and requirements include the following:

a) Knowledge of the speed, frequency and of type of train services, vehicle and non-motorised activity that exists at the crossing throughout the year. Seasonal train service variations may need to be taken into account.

b) Awareness of any special operating or safe-working conditions that the railway infrastructure owner may have applied under agreement with the train operator. These conditions may include special train speed reductions, shunting operations, sounding of train whistles, use of flag persons, etc.

c) Knowledge of any special timings that apply to the operation of flashlight signals, boom barriers, warning bells and, where appropriate, interface to adjacent road traffic control signals.

d) Awareness of any entry requirements or permits that may need to be obtained from the rail authority prior to entering the railway reserve, (e.g. a Track Access Permit see 12.4) .

The crossing should be examined from a vehicle driver's perspective under a range of ambient light conditions, including dawn and dusk,

particularly for east west aligned crossings. Also, the on-site inspection should give consideration to any potential hazards from a train operator's perspective. It is necessary to determine whether
Traffic control devices conflict visually with any train control devices.

13.3 OTHER REQUIREMENTS OF PERSONS CARRYING OUT AUDITS OR INSPECTIONS

When working on or about or otherwise occupying the railway all persons including contractors, sub contractors, employees of contractors or sub contractors or self employed shall:

a) Wear a high visibility orange day/night safety vest that complies with AS/NZS 1906.4 and AS/NZS 4602. Safety footwear must also be warn.

b) Arrange appropriate rail track access permits or accreditation when working at or closer than 3.0m from the nearest rail.

c) Arrange prior authorisation to enter the railway reserve from the railway infrastructure owner. Where possible, the railway infrastructure owner should be advised 14 days prior to the required access.

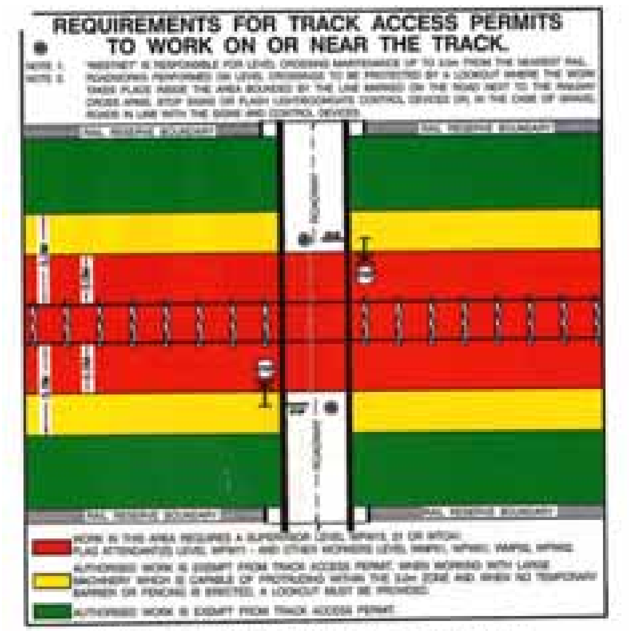
13.4 TRACK ACCESS PERMIT REQUIREMENTS

Track access accreditation is required by all persons requiring to work on or about the railway network at or closer than 3.0m from the nearest rail for any purpose.

Written exception from accreditation may be granted by the Chief Executive Officer of the Public Transport Authority Western Australia or the General Manager WestNet Rail whichever is applicable.

Accreditation to levels WMP 01, WMP 02 (non electrified territory) and WPW 01, WPW 02 (electrified territory) do not authorise the holder to work or otherwise be on or about the railway without the supervision of a qualified with level WPW 15 or higher.

Persons holding category WMP 05 and WPW 05 are authorised to enter within 3.0m unaccompanied for inspections or minor works except track infrastructure.



REQUIREMENTS FOR WORKING IN THE ELECTRIFIED AREA

Use checklists at Appendix P for railway crossing safety audits.

Appendix A - *Definition of Notation and Terms*

V_v The 85th percentile speed of vehicles approaching a railway crossing.

V_t The maximum train speed.

R_{tg} The reaction time required by a motorist to see an approaching train, appreciate the need to stop and apply the brakes, while approaching a Give Way Sign controlled crossing.

d The coefficient of longitudinal deceleration.

G_g The approach grade of the road at Give Way Sign controlled crossings, (derived from the average grade over the distance S_{vg}).

g Acceleration due to gravity (9.8 m/s^2).

S_{vg} The minimum distance from the crossing, measured along the road, at which a motorist needs to be able to see an approaching train, which is at a given distance along the rail, for Give Way Sign control.

L The length of the longest vehicle allowed to use the crossing. (Information on permitted vehicle lengths can be obtained from Main Roads Western Australia's Road Transport Section on telephone (08) 9470 0777.)

W The width of the crossing (includes 3.5m clearance distance from the tracks on both sides of the crossing).

S_{tg} The minimum distance from the crossing, measured along rail, at which a motorist needs to be able to see an approaching train, from a given distance along the road, for Give Way Sign control.

S_{vga} A reduced value of S_{vg} obtained for calculating the range of permissible angles at Give Way Sign controlled crossings. The calculation uses a value of $0.77V_v$ in order to approximate the 15th percentile vehicle approach speed.

S_{tga} A reduced value of S_{tg} obtained for calculating the range of permissible angles at Give Way Sign controlled crossings. The calculation uses a value of $0.77V_v$ in order to approximate the 15th percentile vehicle approach speed.

$\angle_g$ The crossing angle at Give Way Sign controlled crossings with straight road and rail approaches, measured between the rail and the right hand edge of the road.

R_{ts} The reaction time taken by the motorist to begin accelerating, after looking in both directions for approach ing trains, at Stop Sign controlled crossings.

a The acceleration rate for vehicles at Stop Sign controlled crossings.

G_s A grade correction factor for vehicles at Stop Sign controlled crossings, (derived from the average grade over a distance of 6.5 m back from the nearest rail).

S_{ts} The minimum distance from the crossing, measured along the rail, at which a motorist needs to be able to see an ap proaching train, from a distance of 6.5m back from the nearest rail, for Stop Sign controlled crossings.

$\angle_s$ The crossing angle at Stop Sign controlled crossings, measured between the rail and the right hand edge of the road.

N_t The average number of trains per week.

$AADT$ The annual average daily vehicle traffic.

C_{wf} A weighted conflict value used for consideration of Flashing Lights, i.e. the average number of trains per week multiplied by the number of vehicles per day adjusted by the speeds of the vehicles and trains.

BCR The benefit cost ratio of the installation of a set of Flashing Lights due to the savings in vehicle stopping costs.

A_{sc} The annual stopping costs associated with Stop Sign controlled crossings.

I Installation costs for a set of Flashing Lights.

M The average annual maintenance costs for a set of Flashing Lights.

SL Service life of a set of Flashing Lights.

EDR Economic discount rate of a set of Flashing Lights.

R_{tf} The reaction time required by a motorist to see an activated set of Flashing Lights, appreciate the need to stop, and apply the brakes.

G_f The approach grade of the road at Flashing Light controlled crossings (derived from the average grade over the distance S_{vf}).

L_q The length of vehicle queue formed on the approach to an activated set of Flashing Lights.

S_{vf} The minimum distance from the crossing, measured along the road, at which a motorist needs to be able to see an activated set of Flashing Lights.

C_{wb} A weighted conflict value used for consideration of Boom Barriers, i.e. the average number of trains per week multiplied by the number of vehicles per day adjusted by the speeds of the vehicles and trains.

R_{tw} The reaction time taken by the motorist to observe the activation of an advance flashing warning sign.

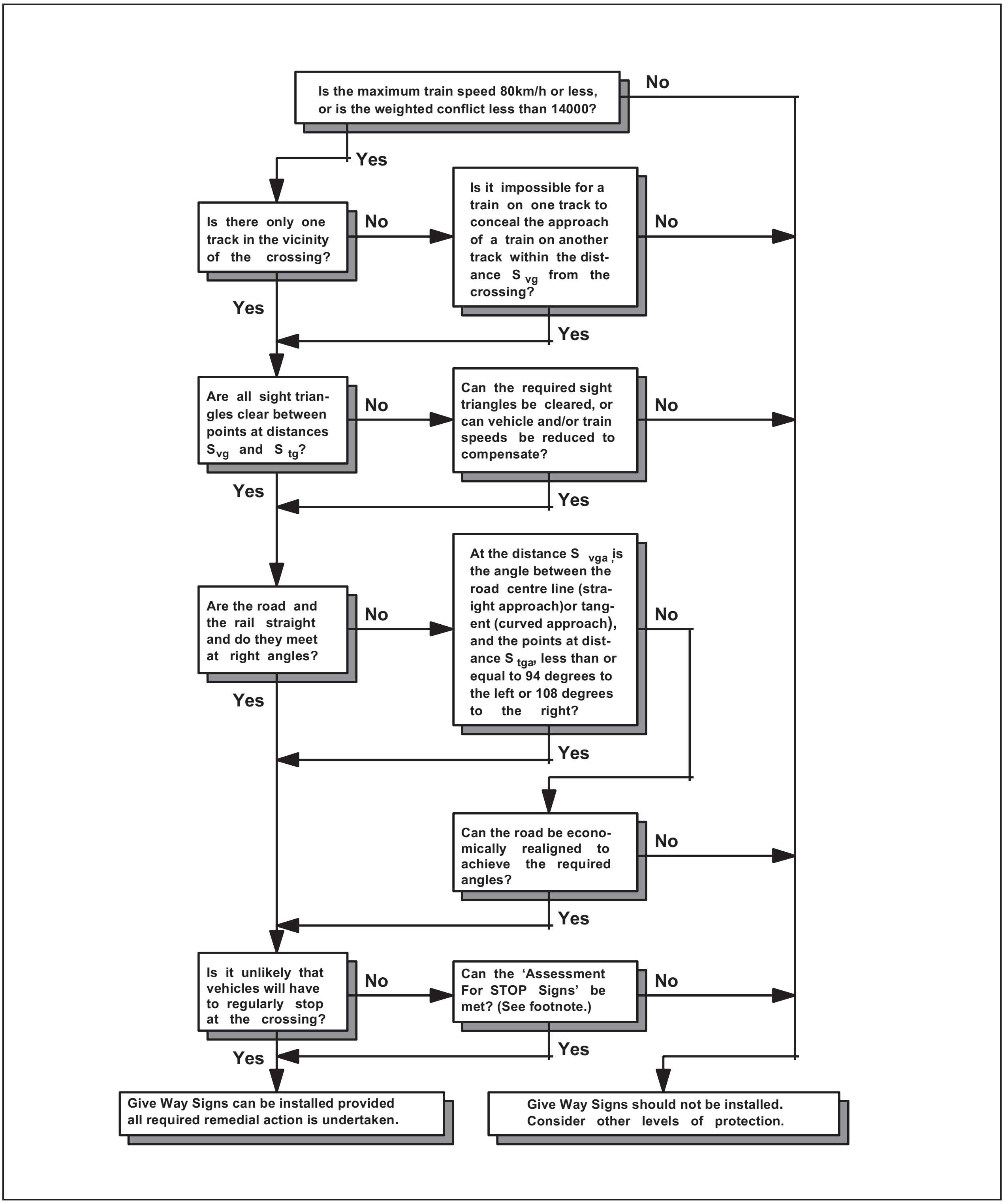
G_w The approach grade of the road at Flashing Light controlled crossings (derived from the average grade over the distance S_{VW}).

V_{vh} The 85th percentile speed of the heaviest class of vehicle approaching the railway crossing.

S_{vw} The distance, measured along the road, an advance flashing warning sign is installed in advance of a railway crossing stop line.

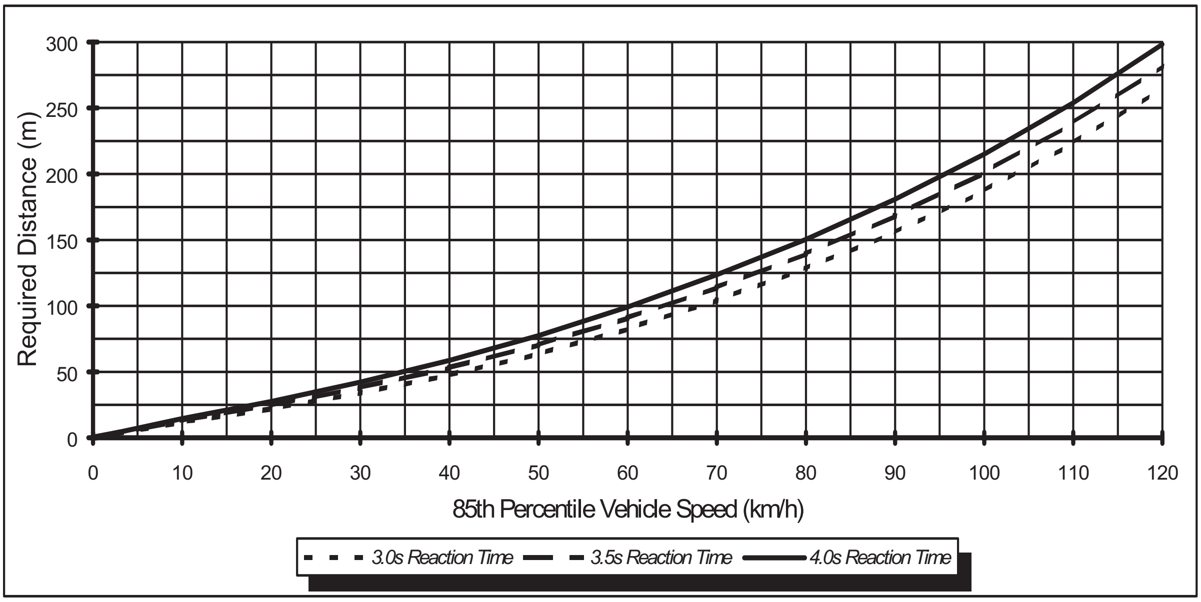
L_s The length of vehicle stacking distance between the rail and an adjacent priority road.

Appendix B - *Assessment for Give Way Signs*

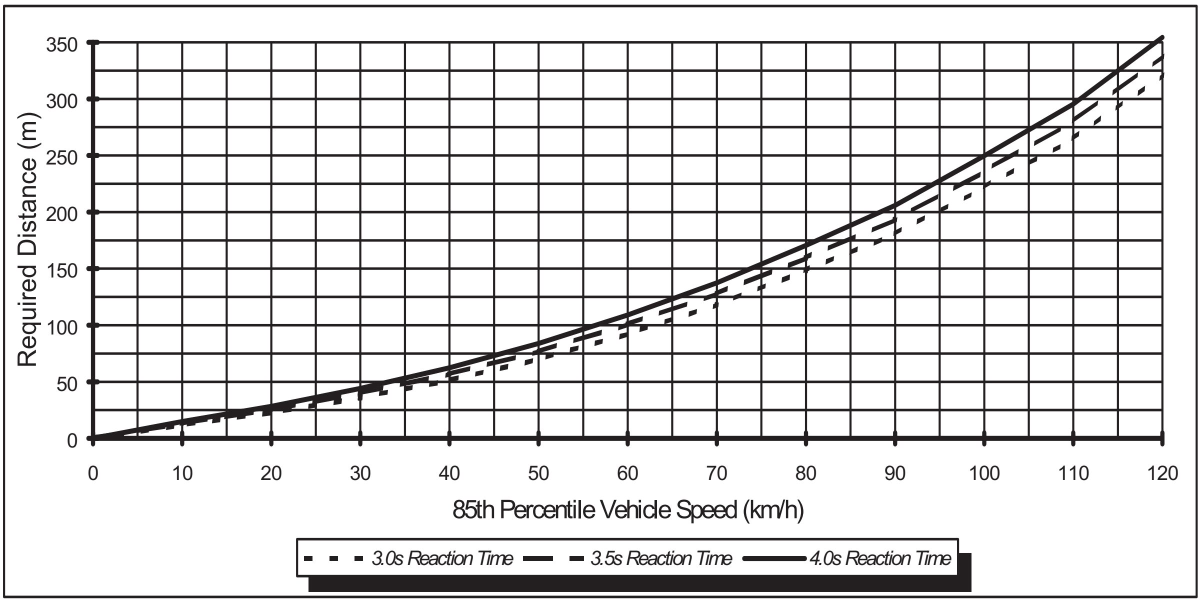


Appendix C - *Sight Distances for GIVE WAY Signs, S_{vg}*

Road Surface: *Sealed*
Approach Grade: *Level*

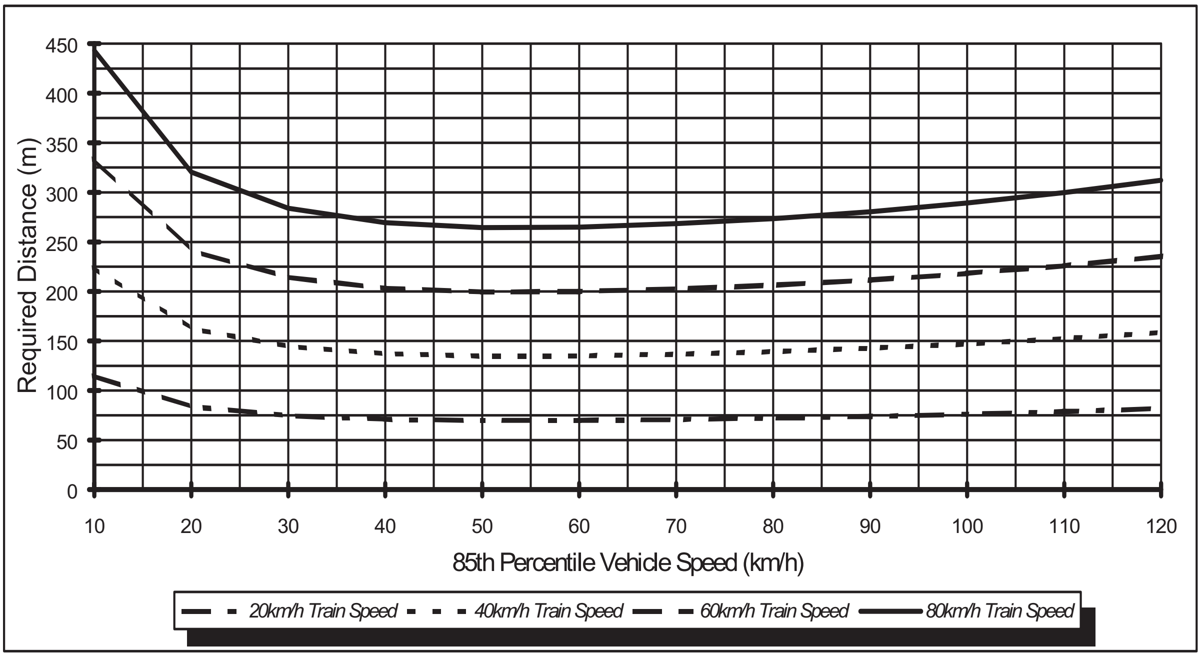


Road Surface: *Un-Sealed*
Approach Grade: *Level*

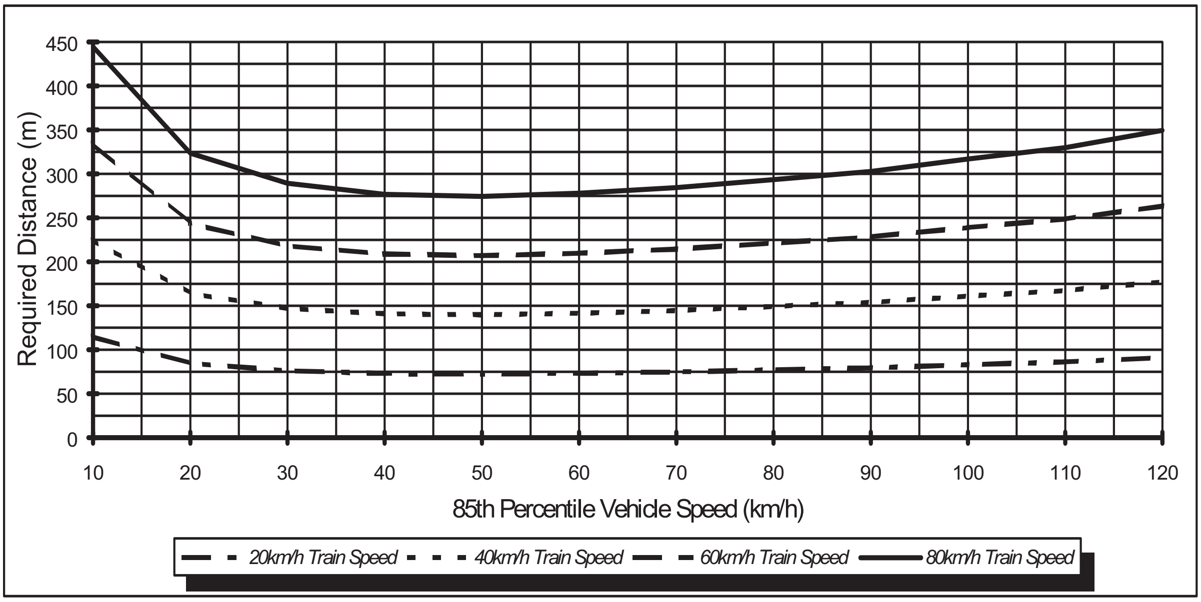


Appendix D - *Sight Distances for GIVE WAY Signs, S_{tg}*

Road Surface: *Sealed*
Approach Grade: *Level*
Reaction Time: *3.0 s*
Crossing Width: *10 m*
Maximum Vehicle Length: *19 m*

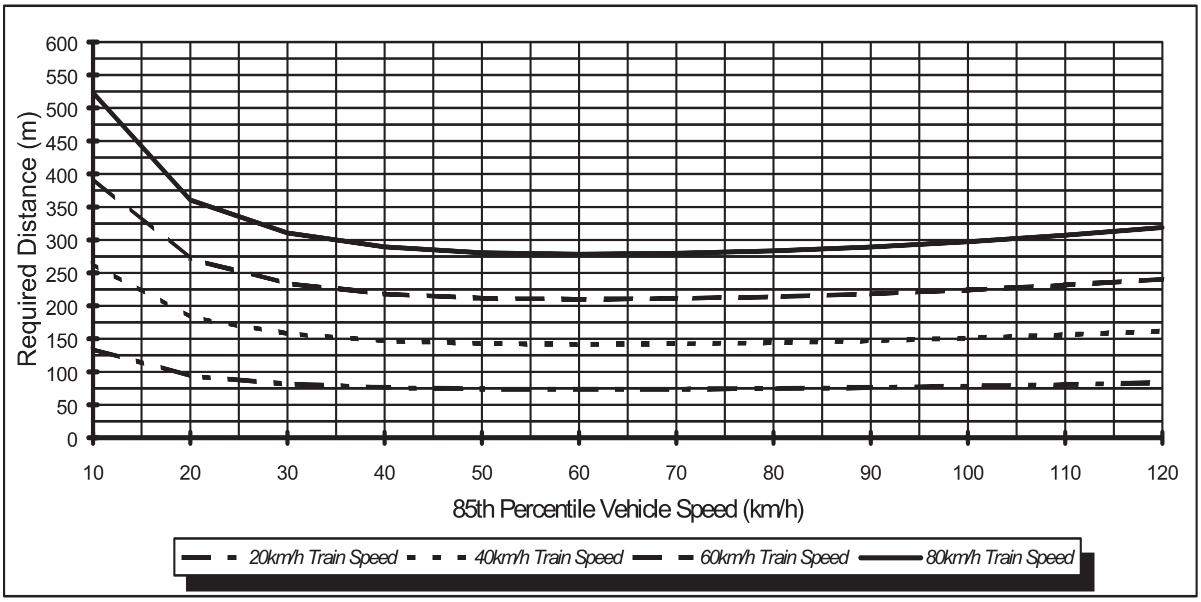


Road Surface: *Un-Sealed*
Approach Grade: *Level*
Reaction Time: *3.0 s*
Crossing Width: *10 m*
Maximum Vehicle Length: *19 m*

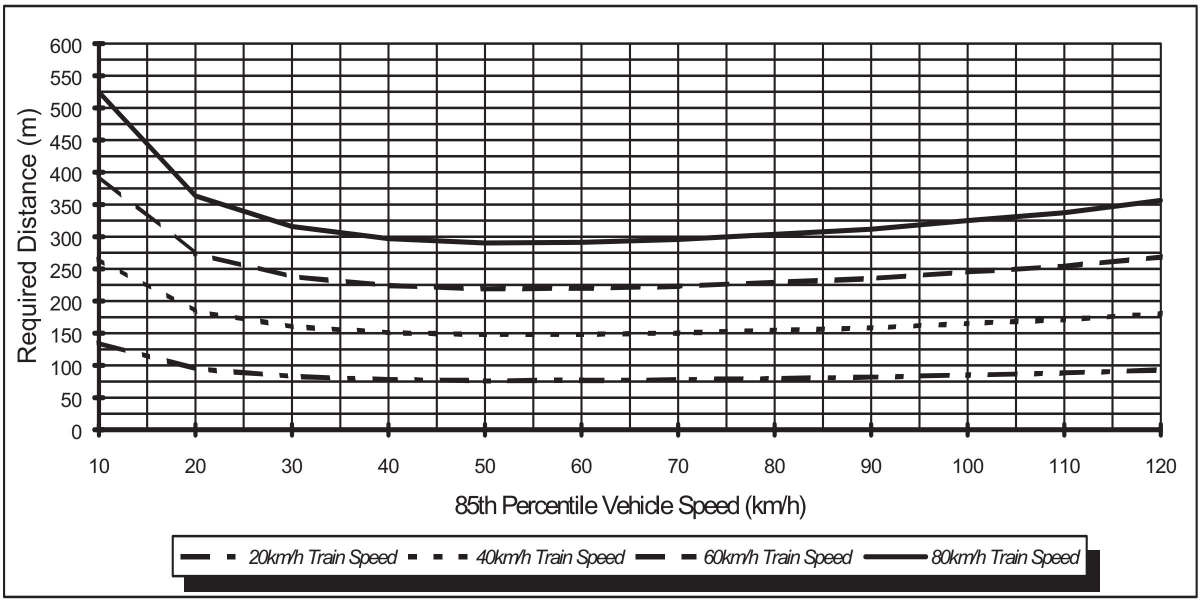


Sight Distances for GIVE WAY Signs, S_{tg}

Road Surface: *Sealed*
Approach Grade: *Level*
Reaction Time: *3.0 s*
Crossing Width: *20 m*
Maximum Vehicle Length: *19 m*

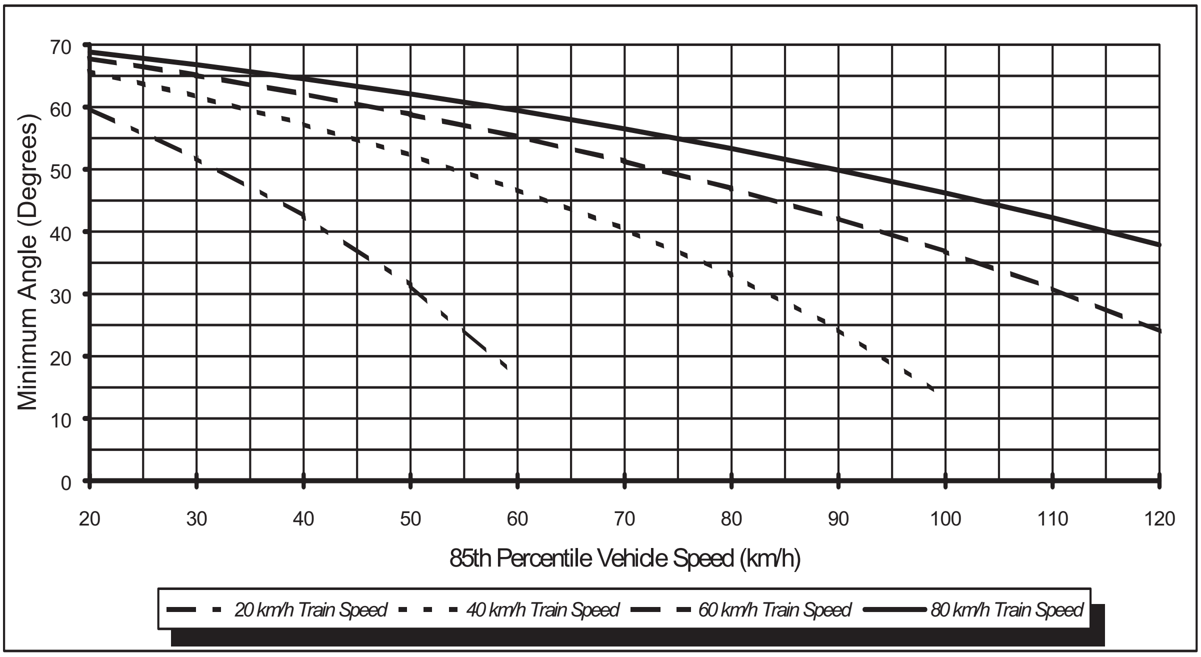


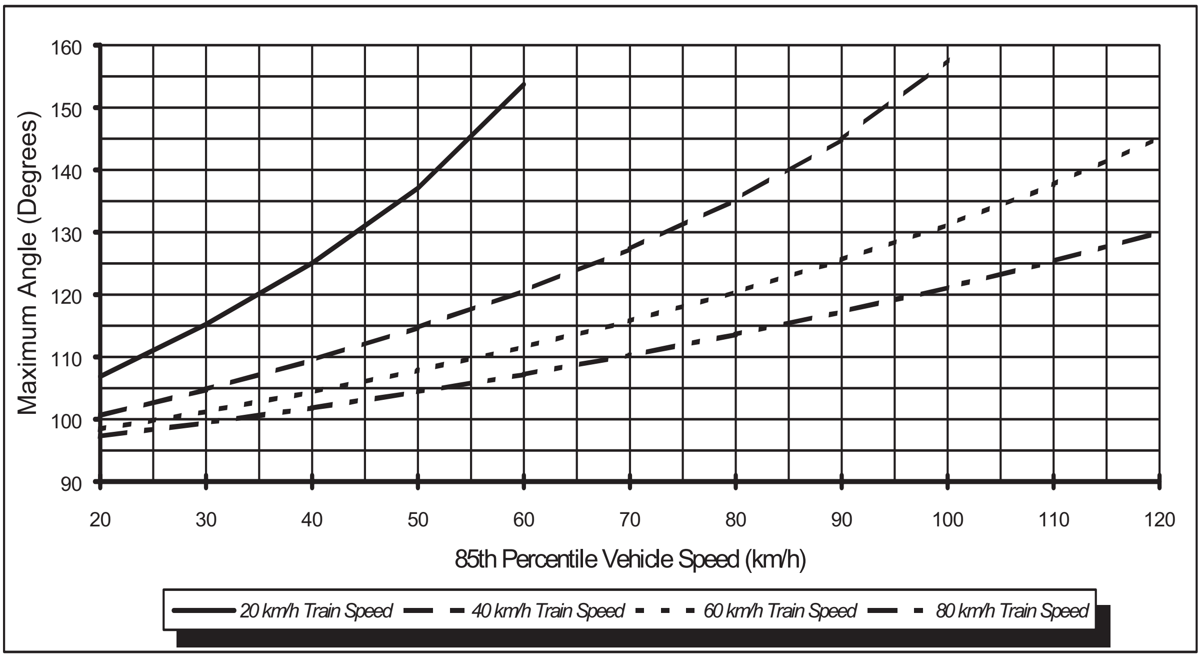
Road Surface: *Un-Sealed*
Approach Grade: *Level*
Reaction Time: *3.0 s*
Crossing Width: *20 m*
Maximum Vehicle Length: *19 m*



Appendix E - *Maximum and Minimum Angles for GIVE WAY Signs, $\angle_g$*

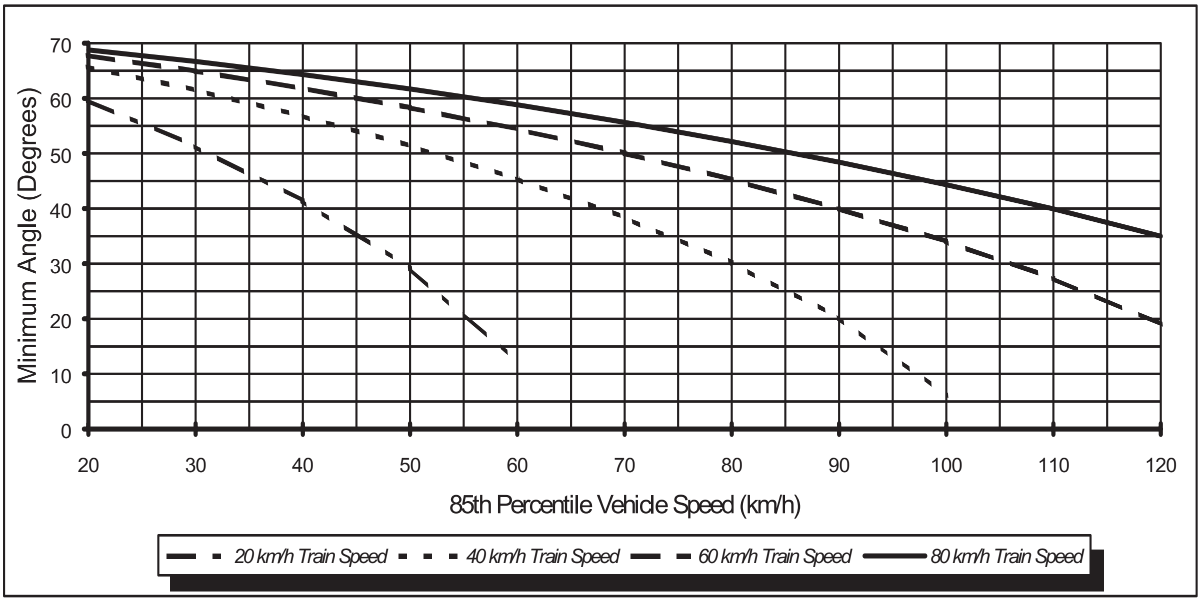
Road Surface:	*Sealed*
Approach Grade:	*Level*
Reaction Time:	*3.0 s*
Crossing Width:	*10 m*
Maximum Vehicle Length:	*19 m*

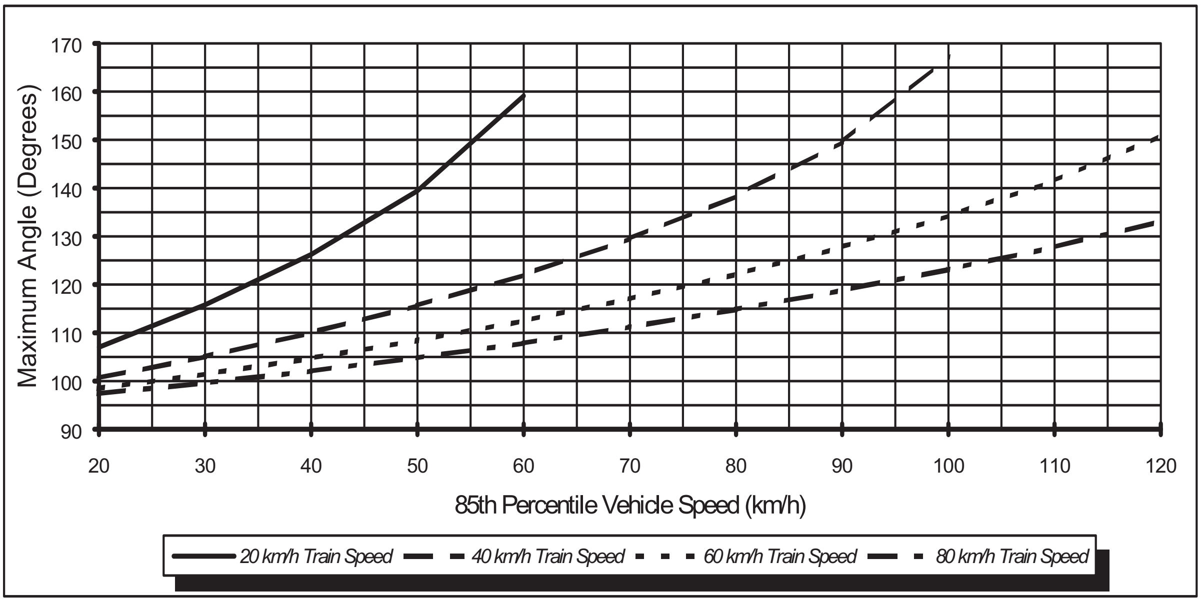




Maximum and Minimum Angles for GIVE WAY Signs, $\angle_g$

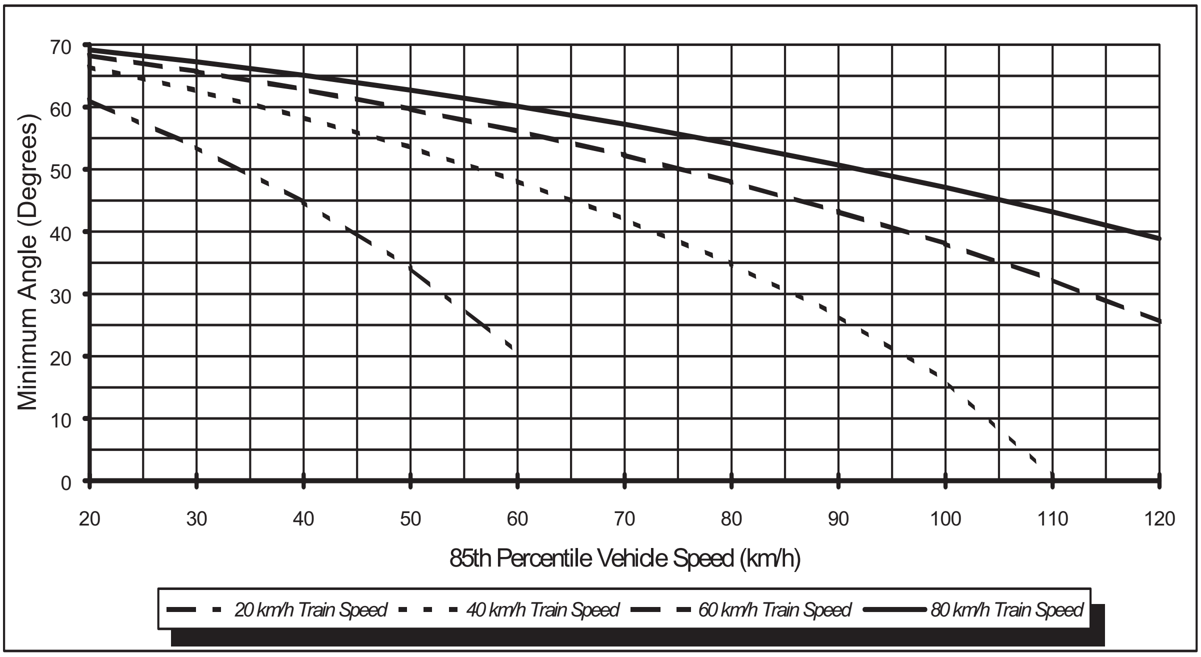
Road Surface:	*Un-Sealed*
Approach Grade:	*Level*
Reaction Time:	*3.0 s*
Crossing Width:	*10 m*
Maximum Vehicle Length:	*19 m*

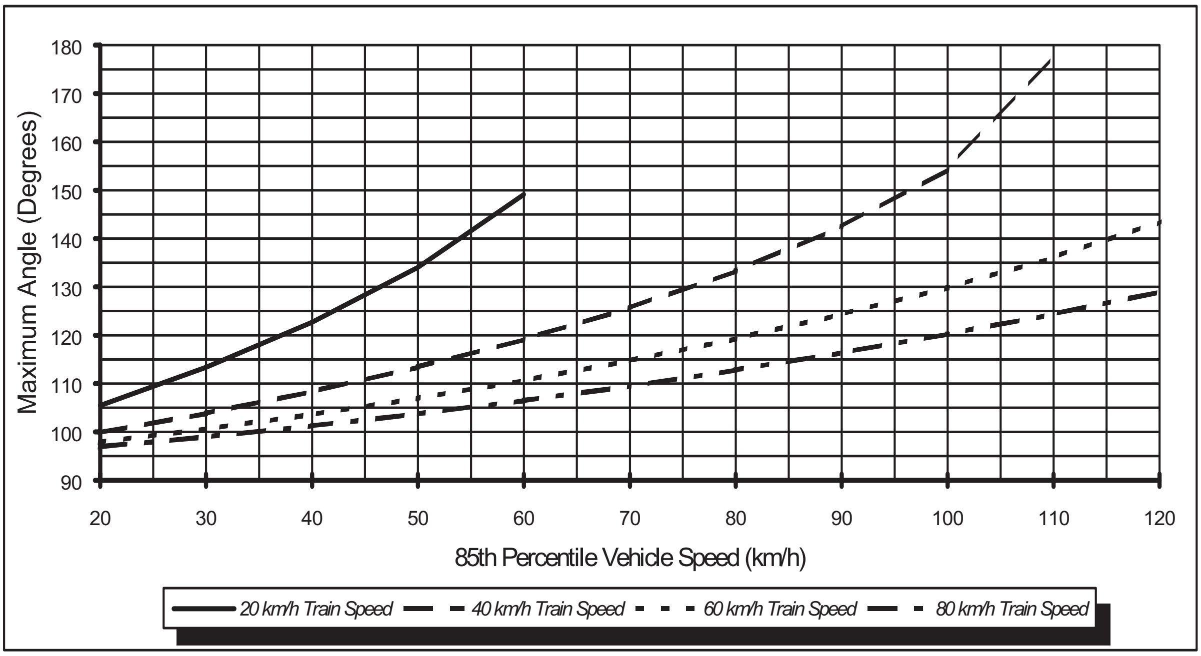




Maximum and Minimum Angles for GIVE WAY Signs, $\angle_g$

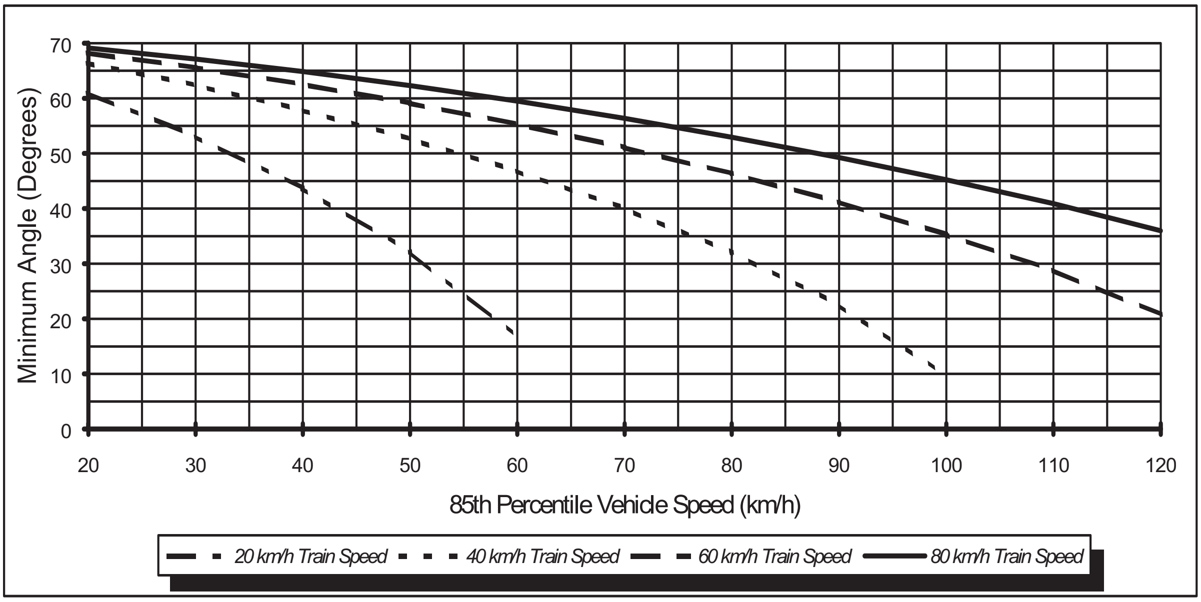
Road Surface:	*Sealed*
Approach Grade:	*Level*
Reaction Time:	*3.0 s*
Crossing Width:	*20 m*
Maximum Vehicle Length:	*19 m*

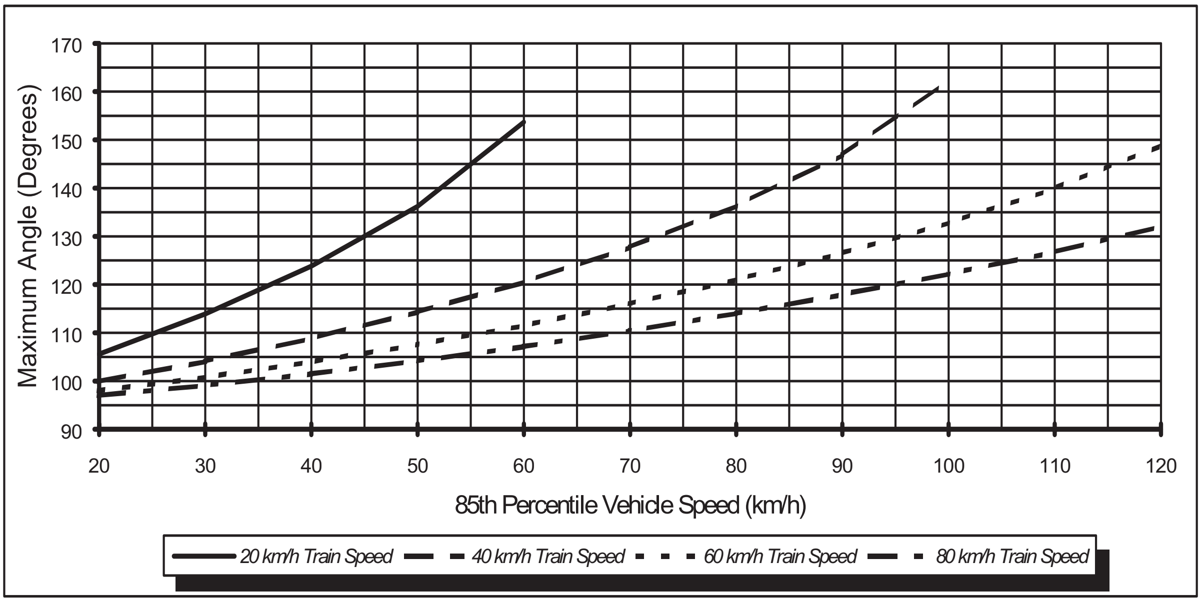




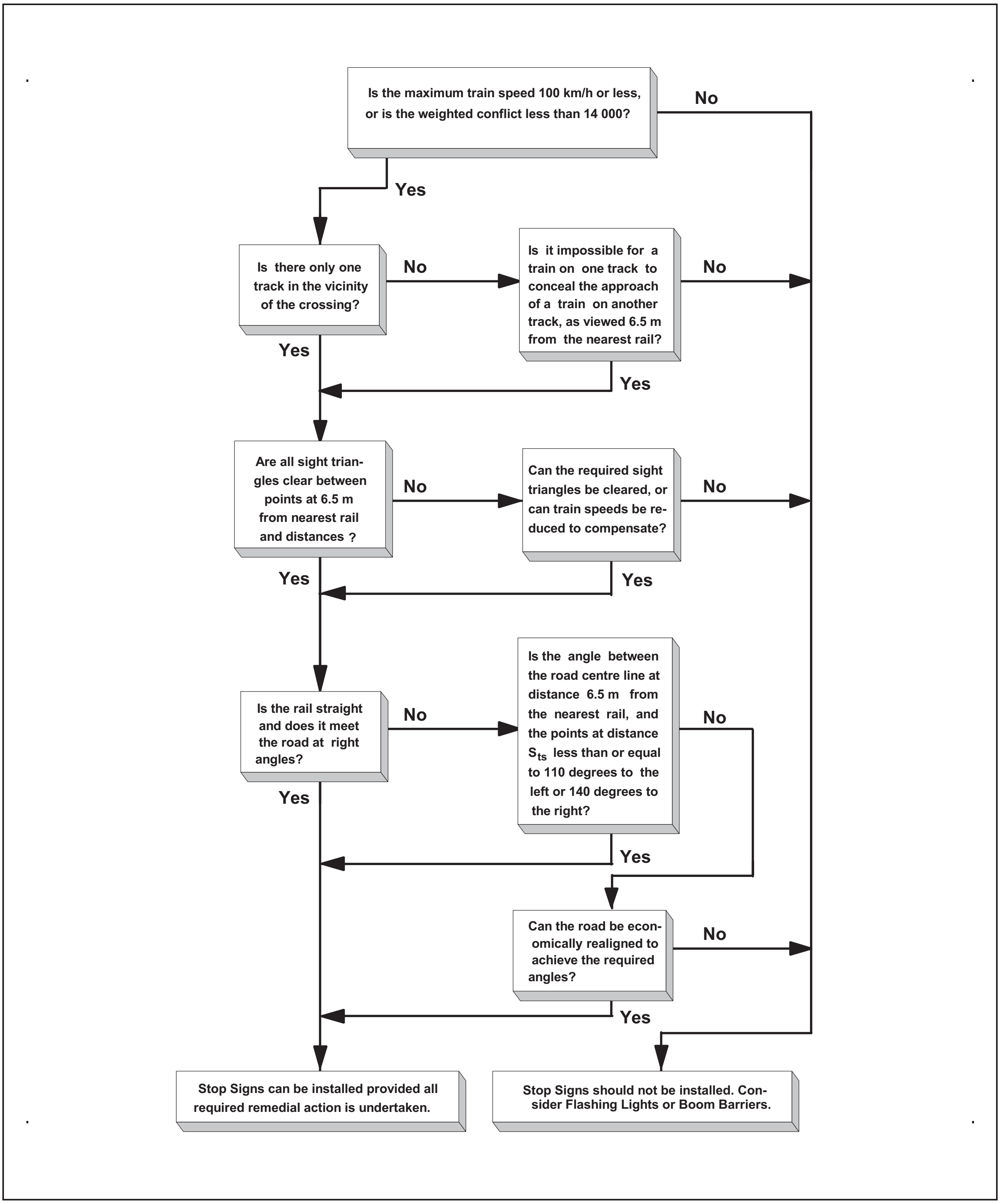
Maximum and Minimum Angles for GIVE WAY Signs, $\angle_g$

Road Surface:	*Un-Sealed*
Approach Grade:	*Level*
Reaction Time:	*3.0 s*
Crossing Width:	*20 m*
Maximum Vehicle Length:	*19 m*



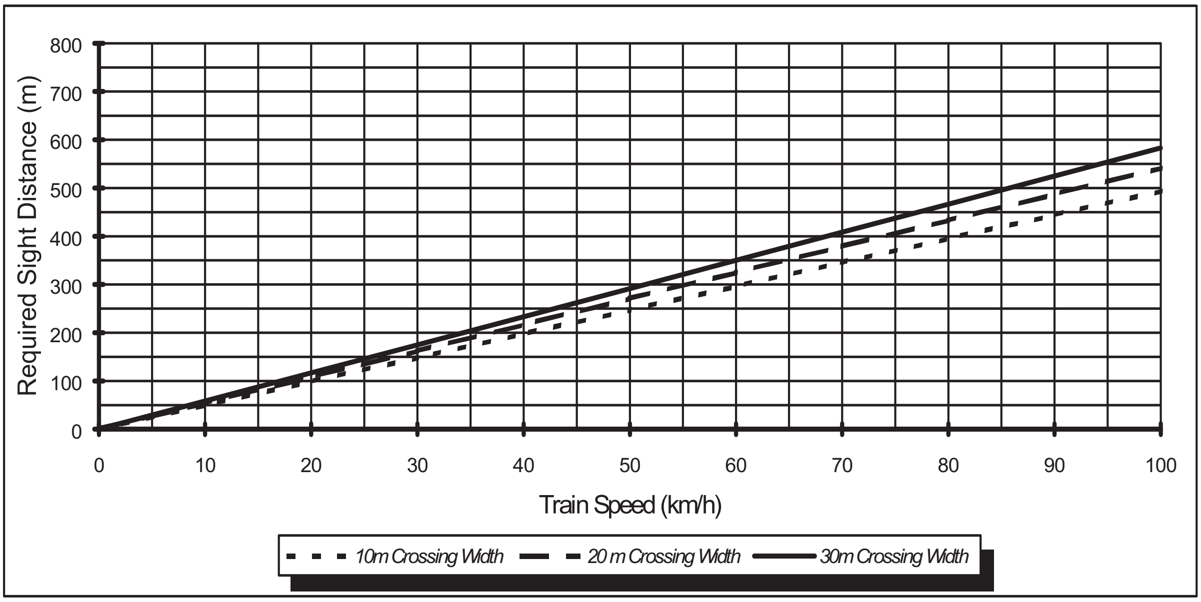


Appendix F – *Assessment for Stop Signs*

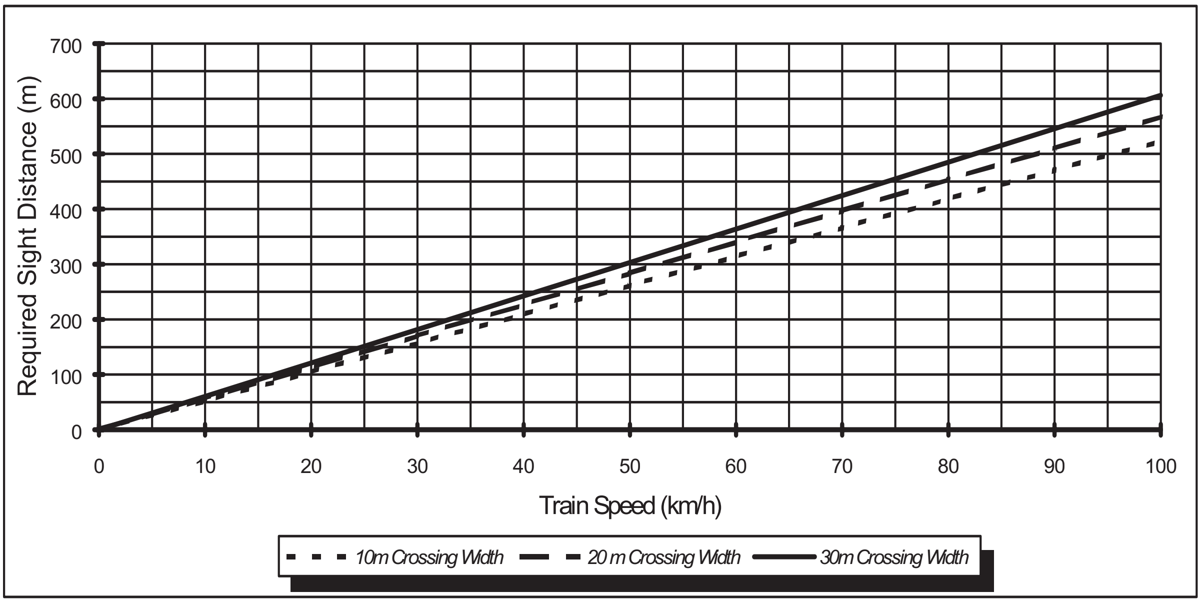


Appendix G - *Sight Distances for STOP Signs, S_{ts}*

Maximum Vehicle Length: *19 m*
Approach Grade: *Level*
Reaction Time: *2.0 s*
Acceleration Rate: *0.5 m/s²*

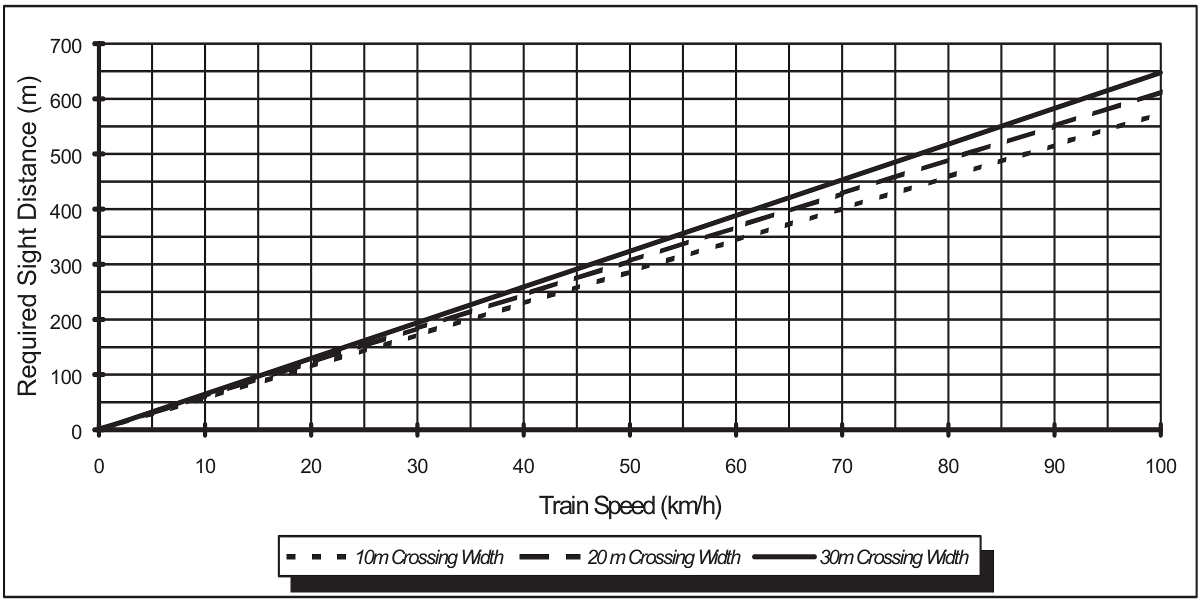


Maximum Vehicle Length: *25 m*
Approach Grade: *Level*
Reaction Time: *2.0 s*
Acceleration Rate: *0.5 m/s²*

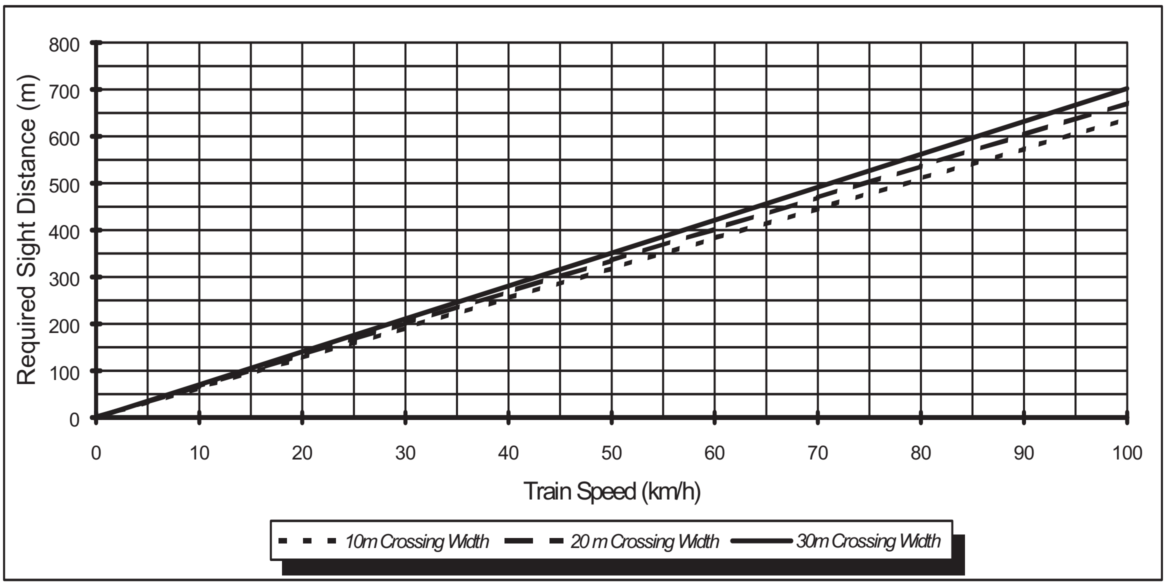


Sight Distances for STOP Signs, S_{ts}

Maximum Vehicle Length: 36.5 m
Approach Grade: Level
Reaction Time: 2.0 s
Acceleration Rate: 0.5 m/s²



Maximum Vehicle Length: 53.5 m
Approach Grade: Level
Reaction Time: 2.0 s
Acceleration Rate: 0.5 m/s²



Appendix H – *Estimation of Vehicle Queue Lengths at Railway Crossings*

Annual Average Daily Traffic (AADT)	Crossing Closure Times (Minutes)									
	0.5	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**
0 – 2 000	7	14	21	28	35	42	49	56	63	70
2 001 – 4 000	14	28	42	56	70	84	98	113	127	141
4 001 – 6 000	21	42	63	84	106	127	148	169	190	211
6 001 – 8 000	28	56	84	113	141	169	197	225	253	281
8 001 – 10 000	35	70	106	141	176	211	246	281		
10 001 – 12 000	42	84	127	169	211	253	295			
12 001 – 14 000	49	98	148	197	246	295				
14 001 – 16 000	56	113	169	225	281					
16 001 – 18 000	63	127	190	253						
18 001 – 20 000	70	141	211	281						

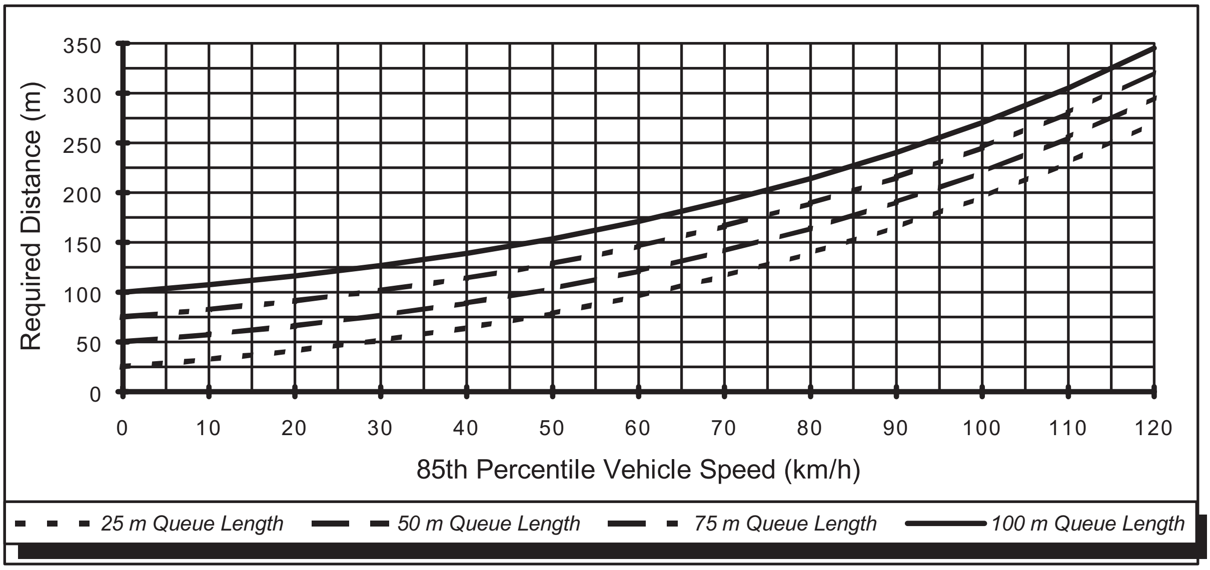
Vehicle Queue Lengths (m)

To Note:

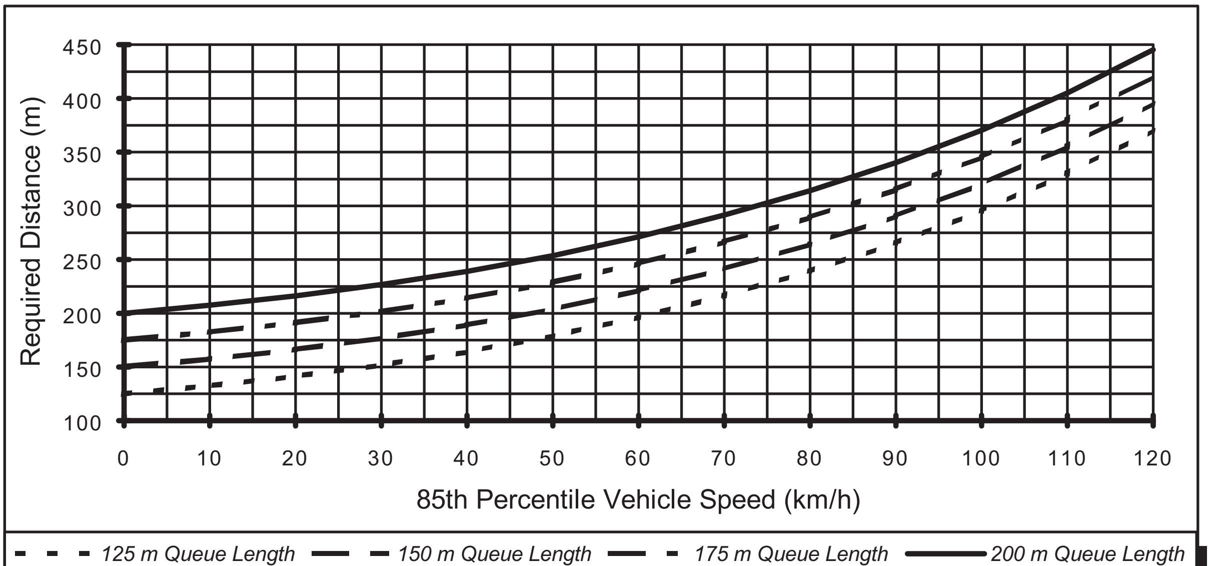
Values based upon random arrivals on a single lane approach to a typical crossing.
A 7% heavy vehicle composition has been assumed.

Appendix I - *Sight Distances for FLASHING LIGHTS, S_{vf}*

Road Surface: *Sealed*
Approach Grade: *Level*
Reaction Time: *2.5 s*
Vehicle Queue Range: *25 m to 100 m*



Road Surface: *Sealed*
Approach Grade: *Level*
Reaction Time: *2.5 s*
Vehicle Queue Range: *125 m to 200 m*



Appendix J - Standard *Layout for Pedestrian Treatments at Railway Crossings*

This Section Under Development

Appendix K - *Assessment for Grade Separation*

This Section Under Development

Appendix L – *Location and Timing of Advance Flashing Warning Signs*

STANDARD DESIGN VEHICLE

VEHICLE SPEED (km/h)	VALUES OF d (for wet sealed road surface)
70	0.313
80	0.300
90	0.294
100	0.290
110	0.280

TABLE 1- Assumed values for coefficient of deceleration (wet road surfaces)

CALCULATION

$Rtw =$	2.5
$Vvp =$	110
$D =$	0.28
$Gw =$	0

$S_{vw} =$	246.5 m

$S_{vw} = =$	247 m
$V_{vh} =$	110km/h

$T =$	8.8 s

FORMULA

$$S_{vw} = \frac{R_{tw} \bullet V_{vh}}{3.6} + \frac{[V_{vh}]^2}{254[d + G_w]} - 22$$

$$T = \frac{3.6[S_{vw} + 22]}{V_{vh}}$$

EXAMPLE 1 – Calculating Sign location and Timing

85th Percentile Speed V_{vh} (km/h)	Value	Grade, G_W								
		-0.12 *	**-0.09 ***	**-0.06 ***	**-0.03**	**Level**	**0.03**	**0.06**	**0.09**	**0.12**
70	S_{vw}	149	135	125	117	110	105	100	96	93
	T	6.2	5.7	5.3	5.0	6.8	4.7	4.4	4.2	4.1
80	S_{vw}	196	176	161	149	140	132	126	120	116
	T	7.8	7.1	6.6	6.2	7.3	5.5	5.3	5.1	5.0
90	S_{vw}	246	219	199	183	171	161	153	146	140
	T	9.6	8.7	8.0	7.4	7.7	6.6	6.3	6.0	5.8
100	S_{vw}	301	266	241	221	205	192	182	173	165
	T	11.6	10.4	9.5	8.7	8.2	7.7	7.3	7.0	6.7
110	S_{vw}	374	327	292	267	247	230	217	205	195
	T	13.0	11.4	10.3	9.5	8.8	8.2	7.8	7.4	7.1

TABLE 2 - Location and Operational Timing of Advance Flashing Yellow Warning Signs

Note:

1. *Values based upon corrected deceleration rate 'd' for standard design vehicle on wet sealed road surface refer table 1.*
2. * Designates that grade and length of approach may necessitate heavy vehicles descending at reduced speed in low gear

Appendix M - *Prioritising Warranted Active Protection Installations*

Location of Crossing:	*LG:*
Railway Line:	*Km:*

1	**GEOMETRIC & OTHER FACTORS**		*Points*	*Score*
a)	What percentage of the required sight distance along the rail, (S_{tg} or S_{ts}), is unavailable to drivers? <u>Use worst case</u>	None, or flashing lights installed 1% - 25% 26% - 50% 51% - 75% 76% - 100%	0 4 6 8 10	
b)	By what percentage is the driver-viewing angle exceeded? (Allowable maxima are 202° for **Give Way Signs** and 250° for **Stop Signs.**) <u>Use worst case</u>	None, or flashing lights installed 1% - 25% 26% - 50% 51% - 75% 76% - 100%	0 4 6 8 10	
c)	By what percentage is the weighted conflict warrant, (C_{wf} or C_{wb}), exceeded?	Not exceeded 1% - 25% 26% - 50% 51% - 75% 76% - 100%	0 4 6 8 10	
d)	How many road approaches are curved?	None, or flashing lights installed 1 2	0 1 2	
e)	How many rail approaches are curved?	None, or flashing lights installed 1 2	0 1 2	
f)	How many main line tracks are at the crossing?	1 1 plus siding track/s 2 2 plus siding track/s More than 2	0 2 4 8 10	
g)	How many traffic lanes approach the crossing?	2 4 More than 4	0 2 4	
h)	How many train vs vehicle crashes have occurred at the crossing in the last 5 years?	None 1 2 More than 2	0 5 8 10	
			Sub Total	

PHYSICAL/OPERATIONAL CHARACTERISTICS		*Points*	*Score*
Is the crossing illuminated by street lighting at night?	Yes No	0 2	
Is the crossing regularly used by oversize vehicles (road trains)?	No Yes	0 2	
Is the crossing regularly used by pedestrians and/or cyclists?	No Yes	0 2	
Is the crossing used by regular passenger transport services?	No By rail By road (including school buses)	0 2 4	
Is the crossing used for the transportation of hazardous/dangerous goods?	No By rail By road	0 2 4	
Is the road unsealed and therefore subject to dust sometimes reducing driver visibility?	No Yes	0 2	
		Sub Total	

ENVIRONMENTAL FACTORS		*Points*	*Score*
Do the road approaches generally face east west and are therefore prone to sun glare problems at times of rising and setting sun?	No Yes	0 4	
Can visibility be sometimes reduced due to fog, mist, heat haze etc.?	No Yes	0 4	
Is the crossing located in a townsite?	No Yes	0 4	
		Sub Total	

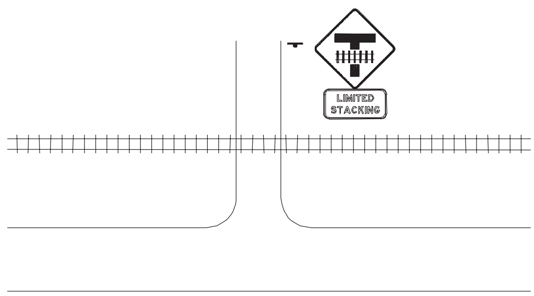
Total Point Score	

Appendix N – *Short Stacking Solutions*

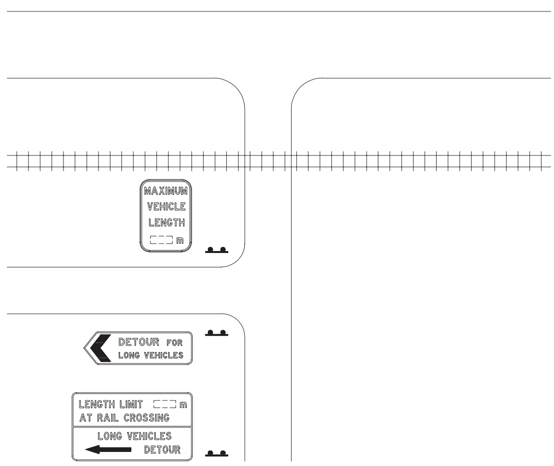
SHORT DEPARTURES

1. Signs and Road Markings

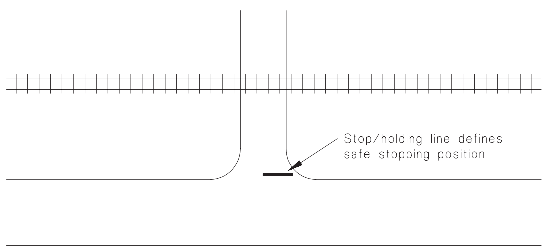
1.1 Advisory Signs

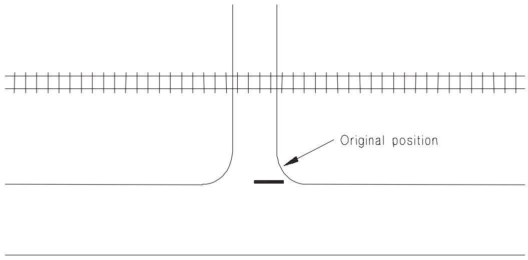
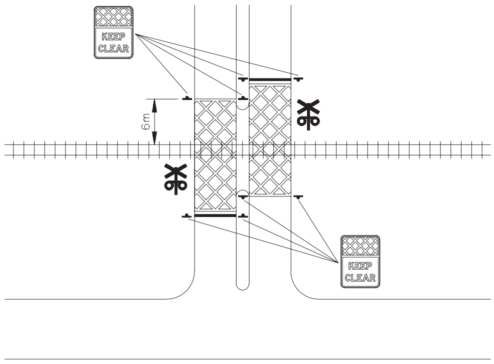


1.2 Regulatory Signs



1.3 Add Stop/Holding Line

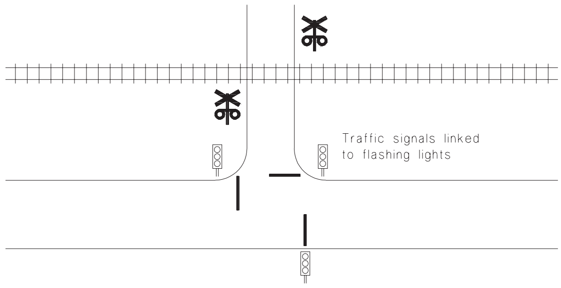


1.4 Move Stop/Holding Line Forward	
1.5 KEEP CLEAR Signs and Yellow Cross Hatching	

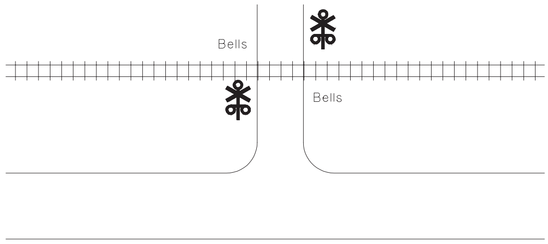
2. Signals

2.1 Traffic Signals

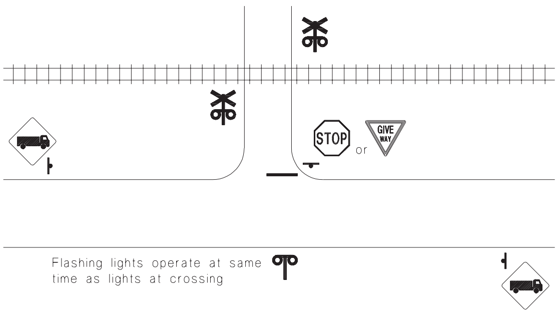
Note: For very short stacking distances, the stop line and signal display on the departure side of the crossing may be relocated to the approach side of the crossing.



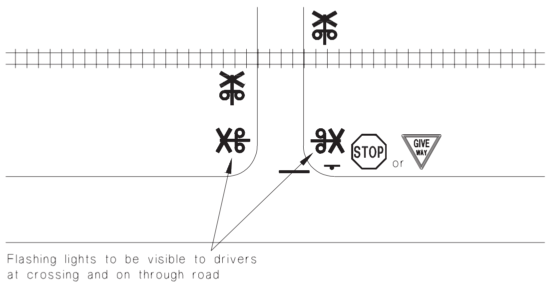
2.2 Add Bells to Flashing Lights



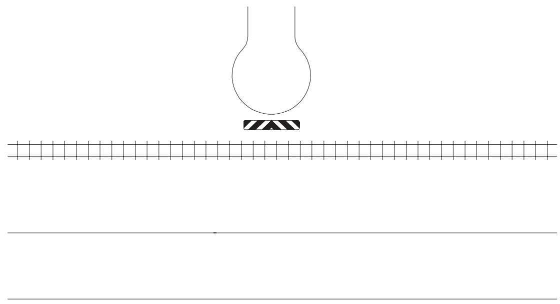
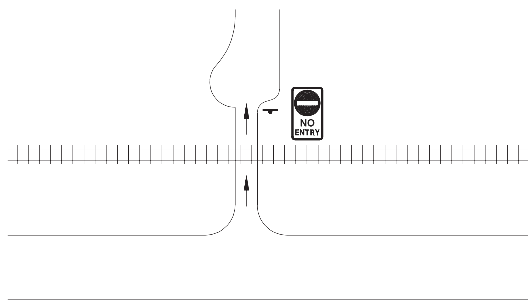
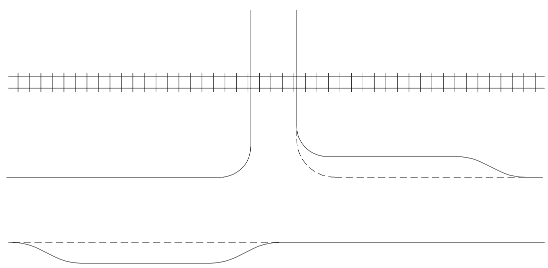
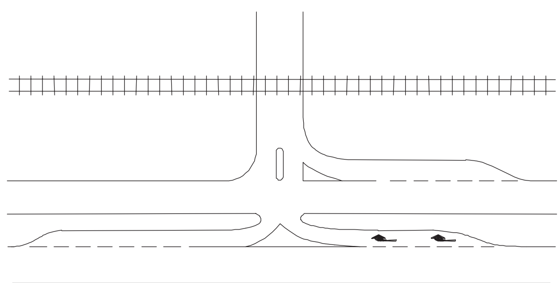
2.3 Signal facing Driver Entering Intersection

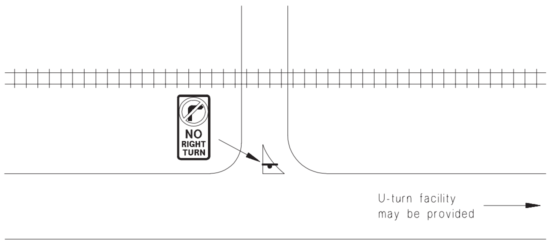
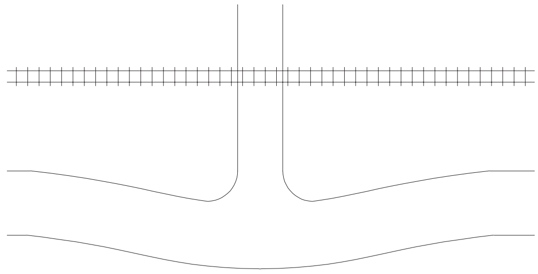
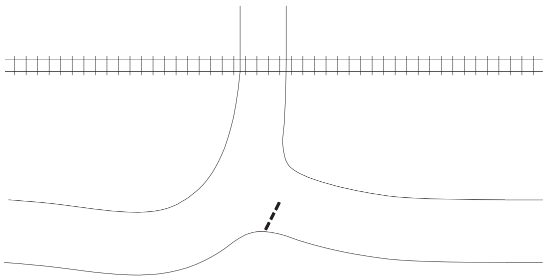
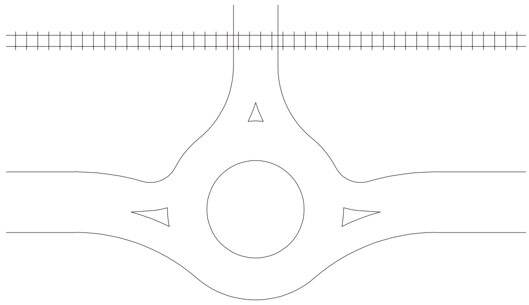


2.4 Flashing Lights Beside Through Road

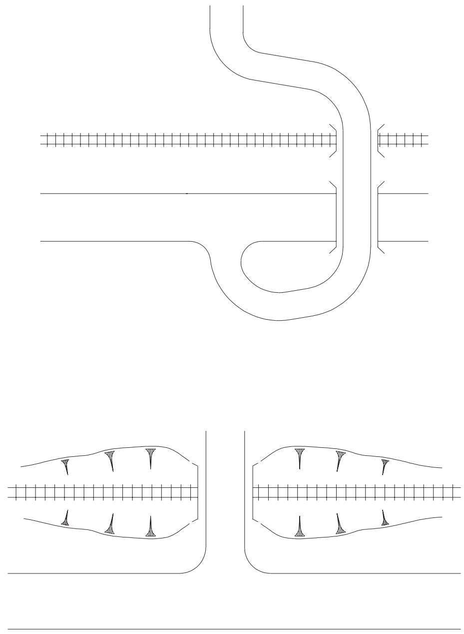


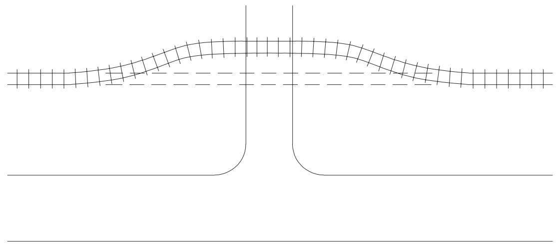
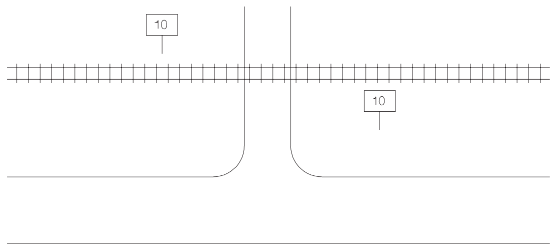
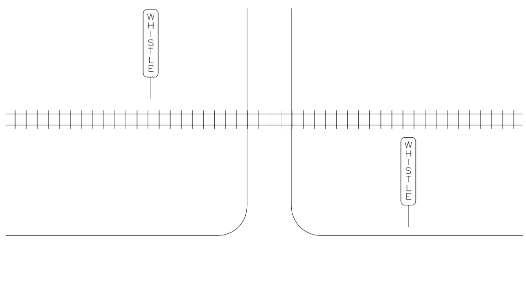
3 Road Construction

3.1 Full Closure	
3.2 Partial Closure	
3.3 Escape Facilities	
3.4 Acceleration Lanes	

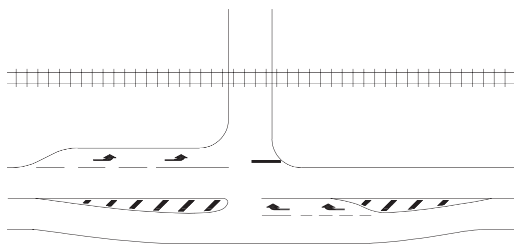
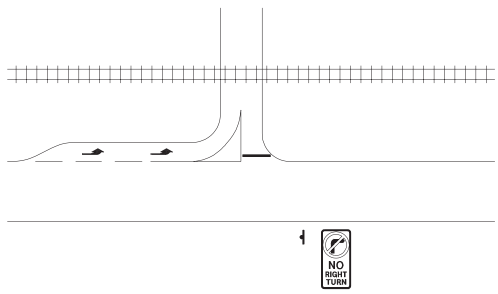
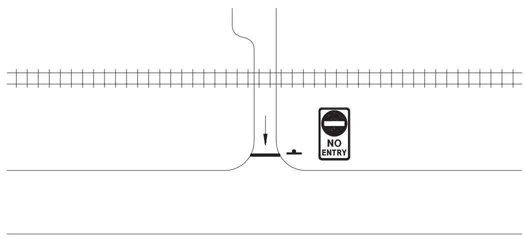
3.5 Right Turn Prohibition	
3.6 Realign Road away from Railway	
3.7 Change Road Priority	
3.8 Roundabout Beside Railway Note: There is a need to ensure that separation between railway and roundabout is sufficient to accommodate queuing on approach to roundabout.	

3.9 Grade Separation

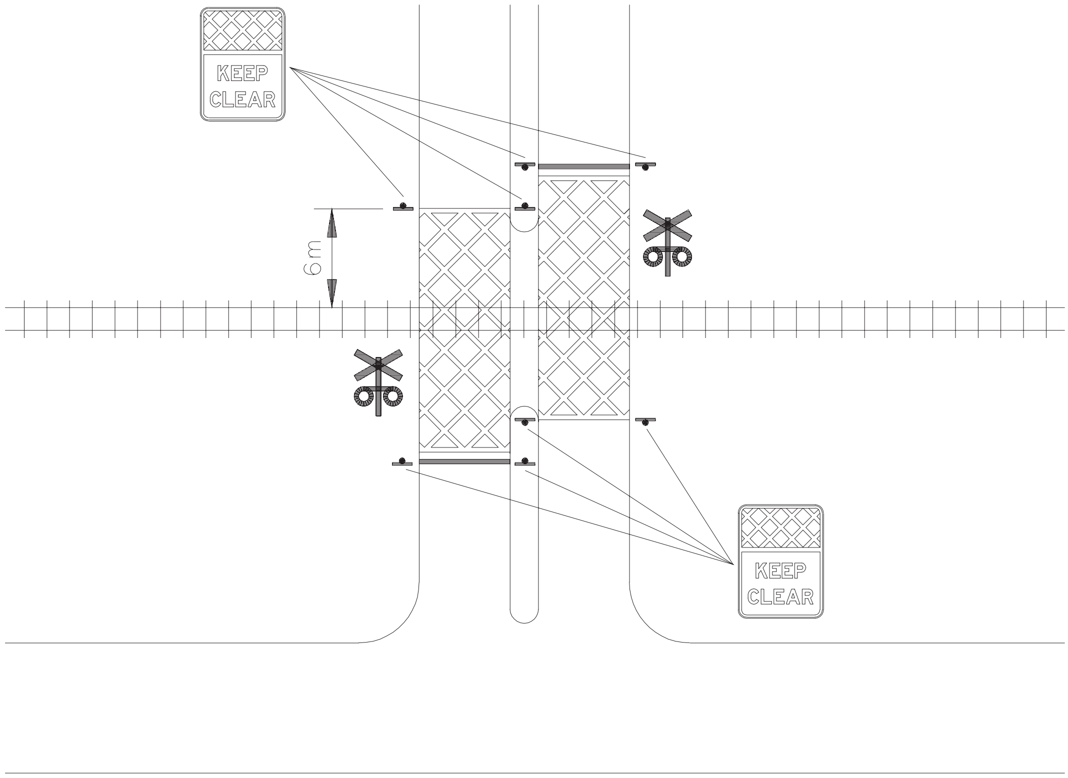


4. Railway Construction and Operation	
4.1 Realign Railway Away From Road	
5.1 Reduce Train Speed to Allow Train to Stop if Required Note: Only appropriate for some light rail operations, eg tourist trams.	
5.2 Sound Horn	

1. SHORT APPROACHES

1 Left and Right Turn Lanes Note: Unsuitable for crossings under passive control because train may approach from behind driver.	
2 Right Turn Prohibition Note: Unsuitable for crossings under passive control because train may approach from behind driver.	
3 Partial Closure	

Appendix O - *Standard Layout of Yellow Cross-Hatch Marking and Signing at Railway Crossings*



RAILWAY CROSSING SAFETY AUDIT

Road Safety Review of Existing Railway Crossing

Location: ___________________________________ **Crossing No.** __________

Date of On-Site Inspection: (Day) / / (Night) / / Weather: ____________

CHECKLIST 5.1 - GENERAL TOPICS

ITEM	*ISSUES TO BE CONSIDERED*	*COMMENTS*
1 ***Level of protection***	Is the level of protection (eg Give Way Signs, Stop Signs, Flashing Lights, Boom Barriers) in accordance with guidelines?	
2 ***Sight distances***	Are required sight distances likely to be restricted by future vegetation growth? Is it possible for sight distances to be obstructed by temporary events such as parked wagons and vehicles, stockpiles, etc?	
3 ***Variations in Train Activity***	Has the railway operator been contacted to check for any changes or seasonal variation in train activity? Is the railway still in use?	
4 ***Railway Operations***	Has the railway operator/s been contacted to determine whether any special operational conditions apply to the train (e.g. sound horn, display headlights, reduce speed, flag person control, etc.)?	
5 ***Emergency Access***	Is there adequate provision for emergency vehicle access to the crossing?	
6 ***Temporary Works***	Are all locations free of construction or maintenance equipment, and any signing or temporary traffic control devices that are no longer required?	

CHECKLIST 5.2 - ALIGNMENT AND CROSS SECTION

ITEM	*ISSUES TO BE CONSIDERED*	*COMMENTS*
1 ***Visibility, Sight Distances***	Is sight distance to other vehicles adequate for the speed of traffic approaching the crossing? Is adequate sight distance provided for intersections, driveways, pedestrian crossings etc?	
2 ***Design Speed***	Is the horizontal and vertical geometry (including the longitudinal profile of the road over the rails) suitable for the (85th %ile) traffic speed? Does the road superelevation conflict with the rail profile, or vice versa?	
3 ***Readability by Drivers***	Are there any sections of roadway or railway which may cause confusion, eg: (a) Have disused pavement or rail tracks been removed? (b) Have disused signs, pavement markings or signalling equipment been removed properly? (c) Do streetlight and tree lines conform with the road and/or rail alignment? (d) Are all railway tracks in use clearly obvious?	
4 ***Widths***	Are all traffic lane and carriageway widths, adequate? Are shoulder or verge widths appropriate (eg for broken down or emergency vehicles)?	
5 ***Drainage Structures***	Are drainage structures in the vicinity of the crossing safe for run off vehicles to traverse?	

CHECKLIST 5.3 - LAYOUT AND CONTROLS

ITEM	ISSUES TO BE CONSIDERED	COMMENTS
1 ***Location***	Is the crossing located safely with respect to horizontal and vertical alignment?	
2 ***Warning***	Where the crossing is located near the end of high-speed road sections (eg on the terminating approach to a T-junction), are there traffic control devices to alert drivers?	
3 ***Controls***	Do signs and/or pavement markings conform with actual vehicle movements at the crossing satisfactorily?	
4 ***Layout***	Is the alignment of kerbs, traffic islands and medians satisfactory? Is the crossing layout obvious to all users? Are turning radii and tapers at nearby intersections and driveways appropriate? Are adequate approach and departure stacking distances available for long vehicles? Can queuing over the rails suddenly occur due to unexpected downstream events (eg right turn vehicle giving way to opposing traffic, pedestrian crosswalk, guard crossing, etc)? Do pedestrian mazes, fences or other structures restrict visibility from side roads or driveways?	
5 ***Access Tracks***	If provided, can vehicles safely enter and leave nearby railway maintenance track/s?	

CHECKLIST 5.4 NON-MOTORISED TRAFFIC

ITEM	ISSUES TO BE CONSIDERED	COMMENTS
1 ***Paths***	Are there appropriate travel paths and crossing points for pedestrians, cyclists and the disabled (wheel chairs/'gophers')?	
2 ***Barriers and Fencing***	Where necessary, are pedestrian maze treatments and/or gates installed for pedestrians and cyclists? Is the pedestrian maze in accordance with AS1772-7, 1993? are associated signing and/or warning lights and audible warning devices installed? Is fencing installed to guide pedestrian movements and is fencing of appropriate design (eg avoids solid horizontal rails)? Where necessary, is crash barrier installed to protect pedestrian and cyclist flows?	
3 ***Surface***	Are rail tracks flush with the road and/or path surface to avoid tripping by pedestrians and dislodgement of cyclists?	
4 ***Elderly and Disabled***	Are there adequate provisions for the elderly, the disabled, children, wheelchairs and baby carriages (eg holding rails, kerb and median crossings, ramps)? Where necessary, are handrails provided and are they adequate?	
5 ***Cyclists***	Is the pavement width adequate for the number of cyclists using the crossing? Where designated dual-use-paths adjoin pedestrian mazes, are 'END' DUP signs installed? Are bicycle safe grates provided at drainage pits where necessary?	

CHECKLIST 5.5 SIGNS AND LIGHTING

ITEM	ISSUES TO BE CONSIDERED	COMMENTS
1 ***Street Lighting***	Is appropriate lighting installed? Is all lighting operating satisfactorily? Are the appropriate types of poles used for all locations and correctly installed (eg slip-base at correct height, rigid poles protected if within clear zone)?	
2 ***Conflicting Signals***	Are all locations free of any lighting or other signalling which may conflict visually with railway crossing signals or railway train signals?	
3 ***Signs***	Are all necessary signs in place? Are they conspicuous and in accordance with AS1742-7, 1993? Are there any redundant signs? Are traffic signs in their correct locations, and properly positioned with respect to lateral clearance and height? Are signs placed so as not to restrict sight distance, particularly for turning vehicles? Are all signs effective for all likely conditions (eg day, night, rain, fog, rising or setting sun, oncoming headlights, poor lighting)? Do sign supports conform to guidelines? Where applicable, are overhead electric warning signs installed? Where appropriate, are the numbers of tracks signed?	

CHECKLIST 5.6 PAVEMENT MARKING AND DELINEATION

ITEM	ISSUES TO BE CONSIDERED	COMMENTS
1 ***Pavement Marking***	Is all necessary pavement marking installed? Are pavement markings (centre lines, edge lines, transverse lines, cross hatching) clearly visible and effective for all likely conditions (eg day, night, rain, fog, rising or setting sun, oncoming headlights, light coloured pavement surface, poor lighting)? Particularly at skewed crossings, does longitudinal pavement marking provide adequate guidance through the crossing? Are stop or holding lines positioned correctly?	
2 ***Delineation***	Have delineation devices (eg width markers, RAILWAY CROSSING boards, guide posts, chevron alignment markers, etc) been installed where required? Are they correctly placed? Is delineation effective for all likely conditions (eg day, night, rain, fog, rising or setting sun, oncoming headlights)? Can dust from unsealed surfaces adversely effect delineation? On truck routes, are reflective devices appropriate to driver's eye height?	
3 ***Raised Pavement Markers***	Where coloured raised pavement markers are used, have they been installed correctly? On light coloured pavement surfaces (eg concrete) are RPMs used to simulate traffic lanes? Are RPMs in good order?	

CHECKLIST 5.7 - SIGNALS AND BOOM BARRIERS

ITEM	ISSUES TO BE CONSIDERED	COMMENTS
1 ***Operation***	Are signals, boom barriers and bells operating correctly? Are pre-warning times and sequences prior to the arrival of the train in accordance with appropriate codes of practice? Is the number and location of signal displays appropriate? Where appropriate, are the railway crossing signals co-ordinated with nearby traffic control signals? Are the delays to vehicles due to train activity excessive, (ie > 50% of cycle time)? Where appropriate, are the railway crossing signals co-ordinated with the train signalling system?	
2 ***Visibility***	Are signals clearly visible to approaching motorists, (as per guidelines)? Have correct focal alignments (for both cars and trucks) been used? Can visibility to signals be obscured by temporary events such as high vehicles stopped in side roads? Is the end of likely vehicle queues visible to motorists so that they may stop safely? Have any visibility problems caused by the rising or setting sun been addressed (eg target boards)? Are signal displays focused and aligned so that they can be seen only by the motorists for whom they are intended? Where signal displays are not visible from an adequate distance, are supplementary signals or advance flashing warning signs installed? Is appropriate warning provided to vehicles entering from side roads and driveways? Is there possible driver distraction from roadside advertising signs and hoardings?	

CHECKLIST 5.8 - PAVEMENT

ITEM	ISSUES TO BE CONSIDERED	COMMENTS
1 ***Pavement Defects***	Is the pavement free of defects (eg excessive roughness or rutting, corrugations, potholes etc), which could result in safety problems (eg loss of steering control)?	
2 ***Skid Resistance***	Does the pavement appear to have adequate skid resistance? Has skid resistance testing been carried out where necessary? Are the rail tracks located on vehicle turning paths and when wet, pose potential skidding hazards to turning vehicles, particularly motorcycles?	
3 ***Ponding***	Is the pavement free of areas where ponding or sheet flow of water may occur, with resultant safety problems?	
4 ***Loose Screenings***	Is the pavement free of loose screenings?	