RAILWAY CROSSING CONTROL
IN WESTERN AUSTRALIA

Policy and Guidelines

This document is owned and controlled by the Executive Director Metropolitan and Southern Regions. The Level Crossing Safety and Policy Coordinator is the delegated custodian. All comments and requests for changes should be submitted to the Level Crossing Safety and Policy Coordinator.

Authorisation

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

[Signature]

Executive Director Road Network Services

Date: 30/6/15

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Preface:

Main Roads WA and Local Governments directly manage more than 140,000 kilometres of public roads as at April 2015. This road network interfaces with approximately 8,100 kilometres of standard and narrow gauge railway track at some 1,400 public railway crossings throughout Western Australia. There are a similar number of non-public (private or occupational) rail crossings.

These Policy and Guidelines are authorised by the Executive Director Metropolitan and Southern Regions Main Roads WA and have been prepared by Main Roads WA and endorsed by the Strategy and Policy Railway Crossing Protection Sub-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 of 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:

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(Attention: Level Crossing Safety and Policy Coordinator)
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Executive Director Metropolitan and Southern Regions
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1. INTRODUCTION

1.1 PURPOSE

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

1.2 SCOPE

This 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 control at railway crossings on non-public roads.

As per the Road Traffic Act 1974 a road is defined as any highway, road or street open to, or used by, the public and includes every carriageway, footway, reservation, median strip and other traffic island thereon.

The use of the term ‘public road’ within this document is defined as a road that is owned by a local or state road authority. Most public roads have a road number and have an allocated road reserve. All crossings which do not fall into the definition of a public road are the responsibility of the road and rail owners to assess risk and implement appropriate controls. Similarly pedestrian facilities within public level crossings are within the brief of this document. However, pedestrian crossings and other access ways which are remote from level crossings are not covered within this document.

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 e.g. Australian Standard Manual of Uniform Traffic Control Devices Part 7: Railway Crossings. In the event there is a conflict between this document and Australian Standard 1742 Part 7 - Manual of Uniform Traffic Control Devices for Railway Crossings (AS 1742.7), this document shall take precedence.

1.3 DEFINITIONS

For the purpose of this document, the definitions below apply.

Level Crossing is a crossing of a railway at grade, provided for vehicle traffic.

Operational Responsibilities is a party’s responsibilities for undertaking physical works (whether on behalf of another party or not) and is the authority responsible for that relative asset. Note: operational responsibility is not associated with cost liability.

Public Road is owned by a Local or State road authority. As described in section 1.2.

Rail Infrastructure Manager an organisation responsible for managing the safe operation of a railway. This is often separate to the Rail Owner.

Road Manager is an organisation responsible for managing and maintaining a roadway. This is usually Main Roads WA or a Local Government Authority.

Safety Management Plan is a risk assessment document required for works which may impact on the safe operation of the railway.
1.4 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 its ‘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 control 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 control 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 control 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 regional areas were demanding improved control 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 (revised edition in 1998), 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 WA 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 control from the operational areas. A ‘Strategy and Policy Sub-Committee’ and an ‘Operational Sub-Committee’ were formed, reporting jointly to the Commissioners.

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. In 2011 WestNet Rail Pty Ltd was taken over by Brookfield Rail Pty Ltd. The Western Australian Government Railways Commission (now known as Public Transport Authority) retained responsibility for managing the urban passenger railway network infrastructure. Although the majority of public rail crossings are owned by PTA or managed by Brookfield Rail, there are a number of other rail infrastructure owner / managers. These include but are not limited to; Pilbara Rail, BHP Billiton, Roy Hill, FMG, Hotham Valley Railway and Pemberton Tram Company.

In May 2010 the State Government integrated WA’s three key transport agencies to form a central head of the Transport portfolio, consisting of the Department of Transport, Main Roads WA and the Public Transport Authority. This position has the three titles of the Director General of the Department of Transport, Commissioner for Main Roads WA and Chief Executive Officer of the Public Transport Authority. There is now a Managing Director at Main Roads WA and a Managing Director at the Public Transport Authority.

In February 2011, the “Rail Safety Act 2010” was promulgated by the Western Australian Parliament. The Act addresses many issues and clearly defines responsibilities of the Road Manager and the Rail Infrastructure Manager. In 2015 the Rail Safety National Law (WA) was passed by the Legislative Assembly and is currently referred to a Legislative Council Committee.
1.5 TERMS OF REFERENCE

STRATEGY AND POLICY RAILWAY CROSSING PROTECTION SUB-COMMITTEE

It is important that the various levels of railway crossing control 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 control 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 control programs are tailored to account for new technology and developments interstate and overseas.

Because of the low rate of crashes, control of railway level crossings is often perceived as having low safety benefits in direct comparison with other traffic engineering countermeasures. On low traffic volume roads, only low cost control can be justified at most crossings. If the benefits of higher levels of control are to be maximised, it is important they are installed at crossings where there is the highest risk of a collision. If lower cost control proves to be viable, and a more proactive approach to control becomes possible, then it is essential that there is an objective, sound method of risk assessment used to determine overall priorities for installation. There are questions to be addressed on the relative importance of control of road vehicles and rail vehicles, and there is a need to ensure timely and informed response to innovation and new technology. These and other issues are 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 control by representatives of State and Local Government, private railways and road users.

b) Role of the Sub-Committee
Provide advice to the Managing Director of Main Roads WA and the Chief Executive Officer of the Public Transport Authority of Western Australia (PTA) with regard to:

- Setting and reviewing policy for the control of road and rail users at public road and non-public road crossings on all rail systems.
- Long term funding requirements for appropriate rail crossing control.
- Impacts of road-use policy changes.
- Considering and proposing new or emerging risk reduction treatments at level crossings.
- Discuss and review standards for level crossing controls.
- Discuss national and international developments in respect of railway control techniques and equipment.
- Discuss other contentious issues.

c) Membership
Chair
- Executive Director Metropolitan and Southern Regions, Main Roads WA

Sub-Committee Representatives
- Main Roads WA
- Public Transport Authority of Western Australia
- Brookfield Rail Pty Ltd
Industry Sector Representatives
- Private railway infrastructure owners/operators including:
  - Heavy Haul Freight, and
  - Tourist and Heritage
- Occupational Crossing (Pastoral Grassers Association of WA)

Each organisation will nominate one member to represent their views and interests. Industry Sector representatives will be nominated by the sub-committee to provide an industry perspective. If a member is unable to attend any meeting, that member may nominate a proxy representative.

d) Meetings
Meetings are to be held as required (generally two per year).

e) Support / Secretariat
Level Crossing Safety and Policy Coordinator, Main Roads WA will provide administrative support.

f) Agenda and Minutes
- All discussion topics and items are to be forwarded to the Level Crossing Safety and Policy Coordinator, Main Roads WA ten working days prior to the meeting for consideration as agenda items.
- 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.

g) Reporting
- Main Roads WA will draft proposed changes to the Railway Crossing Control in Western Australia Policy & Guidelines.
- Sub-Committee members are encouraged to report on the meeting outcomes to their organisations.

OPERATIONAL RAILWAY CROSSING PROTECTION SUB-COMMITTEE

It is important that ongoing operational railway crossing control activities are discussed and resolved by those accountable for the safety and control of the road and rail networks. Where operational activities cannot be resolved between relevant parties; the Operational Railway Crossing Protection Sub-Committee provides a forum where the strategic operational and technical functions of railway crossing control can be addressed.

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

a) Objective

To provide guidance on the day-to-day operational roles for all parties involved in the management of railway crossing control in WA.
b) Role of the Sub-Committee

To act as a point of coordination between Main Roads WA, railway infrastructure managers, owners, operators, road managers and local government on operational matters. To monitor incident data, conduct audits and implement improvements. To provide advice to the Strategy and Policy Railway Crossing Protection Sub-Committee with regard to:

- Particular level crossing sites that require a coordinated resolution.
- Knowledge and lessons learnt from level crossings treatments.
- Implementation of the Railway Crossing Control in Western Australia Policy and Guidelines.
- Recommendations for changes to the Railway Crossing Control in Western Australia Policy and Guidelines.
- Undertake research and/or trials as necessary to develop enhancements to control levels.

c) Membership

Chair
- Level Crossing Safety and Policy Coordinator, Main Roads WA

Sub-Committee Representatives
- Main Roads WA
- Public Transport Authority of Western Australia
- Brookfield Rail Pty Ltd
- Local Government

Industry Sector Representatives
- Private railway infrastructure owners/operators including:
  - Heavy Haul Freight,
  - Tourist and Heritage, and
  - Mining industry

Each organisation will nominate one member to represent their views and interests. Industry Sector representatives will be nominated by the sub-committee to provide an industry perspective. If a member is unable to attend any meeting, that member may nominate a proxy representative.

h) Meetings

Meetings are to be held as required (generally three per year).

i) Support / Secretariat

Level Crossing Safety and Policy Coordinator, Main Roads WA will provide administrative support.

j) Agenda and Minutes

- All discussion topics and items are to be forwarded to the Level Crossing Safety & Policy Coordinator, Main Roads WA ten working days prior to the meeting for consideration as agenda items.
- 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.

k) Reporting

- Sub-committee members are encouraged to report on the meeting outcomes to their organisations.
2. ROAD AND RAIL WORKS

Funds for public railway crossing control are provided by the State Government as road funds and are administered through Main Roads WA.

Section 297 of the Road Traffic Code 2000 empowers the Commissioner of Main Roads WA with the responsibility for all traffic signs and traffic control signals on all roads (as defined under the Road Traffic Act 1974) 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 WA, all traffic control devices at railway crossings are to be installed in accordance with 1742.7. Traffic control devices on roads that do not qualify as 'roads' under the Road Traffic Act 1974 are not the responsibility of the Commissioner of Main Roads WA. However, it is within the brief of the Strategy and Policy Railway Crossing Protection Sub-Committee and Operational Railway Crossing Protection Sub-Committee to review policies and operational matters relating to the safety requirements for any railway level crossings on such roads.

2.1 INTERFACE AGREEMENTS

The Rail Safety Act 2010 identifies the Rail Infrastructure Manager and the Road Managers responsibility to manage risk on their network. The Rail Safety Act 2010 requires all parties involved with all public or private (if required) rail crossings in Western Australia to seek to enter into Interface Agreements from January 2014. Refer to individual Interface Agreements for specific asset managers responsibilities.

2.2 COSTS

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

a) At existing railway crossings on public roads, the cost of improving railway crossing control, including pedestrian facilities at public road level crossings, is to be met by Main Roads WA.

b) Where not otherwise subject to separate agreement, costs associated with maintaining and operating control devices on public roads at PTA and Brookfield Rail managed railway crossings are generally to be equally shared between Main Roads WA and the railway manager. Generally on privately owned rail lines, costs associated with this function are met by the private rail manager.

c) The costs for installing, improving or modifying railway crossing control, including pedestrian facilities, required as a result of specific road, rail or land-use improvements or developments, are to be met by the Road Manager or Rail Infrastructure Manager 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 (negotiating with adjacent private property if required), and the rail owner is to meet the cost of removal within the railway reserve.
e) All costs associated with controlling crossings not located on public roads are to be met as agreed between the road and rail infrastructure managers.

2.3 ACTIVITIES

Where not otherwise subject to separate agreements and subject to the approval of the Commissioner of Main Roads WA where appropriate, operational responsibilities for railway crossings are as follows:

Main Roads WA

a) Install and maintain the appropriate regulatory signs, warning signs, road markings and Advance Flashing Warning Assembly panels on public road approaches to level crossings - excludes signage affixed to railway hardware.

Road Manager

a) Maintain the public road approaches up to three metres (3m) either side from the outside running rail.
b) Arrange, undertake and maintain any vegetation clearing and/or removal of other physical obstructions on Roads to provide requisite driver visibility sightlines on the approaches to level crossings (including any approach made to, or negotiation required with private property owners).
c) Where on a public road, report to Main Roads WA any damaged and unserviceable line marking and signage associated with a level crossing identified during inspection in accordance with normal maintenance regimes.

Rail Infrastructure Manager

a) Arrange and coordinate application designs for the installation of flashing lights, boom barriers, warning bells and Advance Flashing Warning Assembly control devices.
b) Maintain and install flashing lights, boom barriers, warning bells and Advance Flashing Warning Assembly control devices.
c) Undertake and maintain any vegetation clearing and/or removal of other physical obstructions within the rail reserve to provide adequate visibility on the approaches to level crossings.
d) Maintain the roadway within three metres (3m) of the outside running rails.
e) At pedestrian crossings, install and maintain flashing lights, warning bells, pedestrian mazes, gates and crossing paths (excludes approach paths) as applicable, including any signage affixed to these devices.

Reciprocal Action for All Parties

a) Notify each other party of changes to usage of an Interface of which a party is aware, such as changes to traffic volumes.
b) 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.

2.4 ROAD 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 control equipment and other railway infrastructure; road realignments or modifications requiring adjustment to the focal alignment or repositioning of flashlight signals, and visibility obstructions due to the placement of road side furniture, bus shelters, etc., are some examples of potential reduction in safety at railway crossings, both while works are in progress and/or as a consequence of the completed works.

Road managers are responsible for advising the appropriate Rail Infrastructure Manager 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 level of risk of the work to be undertaken and the proximity of the work activity to the Interface. As a general guide, Table 1 shows the minimum distances from the railway, within which any road or other works shall not proceed without prior notification to the Rail Infrastructure Manager.

<table>
<thead>
<tr>
<th>Speed Limit</th>
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<tr>
<td>&lt;70 km/h</td>
<td>150 m</td>
</tr>
<tr>
<td>70 to 90 km/h</td>
<td>200 m</td>
</tr>
<tr>
<td>&gt;90 km/h</td>
<td>300 m</td>
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**TABLE 1**

Refer to Main Roads WA: *Traffic Management for Works on Roads Code of Practice*

If notification for planned works is determined to be required, it is preferably to be in writing to the applicable Rail Infrastructure Manager, and accompanied by traffic management plans, design plans, and forwarded a minimum four (4) weeks prior to the commencement of works.

The rail infrastructure manager may determine a Safety Management Plan (SMP) is required for road works which impact on the safe operation of the railway. A SMP shall be prepared by the Road Manager and submitted to the Rail Infrastructure Manager for approval. The Rail Infrastructure Manager will liaise with the Road Manager to assist in developing the SMP; which should be in place a minimum of two (2) weeks prior to implementation of the works.

A worker in the rail reserve may require protection by a qualified flag person to lookout for approaching trains.

**Track Access Permit Requirements**

Track access permits (TAP) are required when working within the railway reserve. TAP accreditation is undertaken to ensure those working within the rail reserve are aware of hazards and safe working procedures specific to the rail environment. Accreditation is gained by passing the relevant mandatory health assessment applicable to the level of accreditation that is sought and successfully completing applicable training module(s). Successful candidate are issued with the relevant level of TAP.

TAPs are intended for people who work in the rail industry not for one off visitors or workers doing specialist activities. For brief works, specialists or one off visitors, written exemptions to the requirement for TAPs can be sought from the Rail Infrastructure Manager provided that alternate safe working procedures or supervision by appropriately accredited rail safety workers are put in place as per the relevant Rail Infrastructure Manager rules. For specific TAP requirements refer to the relevant Rail Infrastructure Manager.

**2.5 RAIL WORKS IN THE VICINITY OF ROAD CROSSINGS**

Any party undertaking rail work which may impact on the safety of road users shall prepare a Traffic Management Plan (TMP). This TMP shall provide a means of planning and implementing how road users will be safely and efficiently guided through, past or around the affected site; provide for the safety of workers; and ensure the network performance is not unduly impacted, for the duration of the works. These TMPs must be prepared in accordance with Main Roads WA: *Traffic Management for Works on Roads Code of Practice*. TMPs are prepared by appropriately accredited people in advance of the works being conducted and must be approved for implementation by the road authority.
Figure 1 – Example Interface Demarcation
3. LEVELS OF CONTROL

3.1 GENERAL

There are five levels of control used in normal circumstances at level crossings in this State. In ascending order, they are:

- Give Way Signs
- Stop Signs
- Flashing Lights
- Boom Barriers
- Grade Separation

The funds available to Main Roads WA for railway crossing control generally do not allow for grade separation i.e. the construction of bridges or tunnels however, the Railway Crossing Protection Sub-Committees can make recommendations for their construction if considered warranted (See Section 9).

The remaining four levels of ‘at-grade’ control fall into two groups; Give Way Signs and Stop Signs are considered as passive devices while Flashing Lights and Boom Barriers are considered as active devices. In making an assessment as to an appropriate level of control for any particular railway crossing, the basic philosophy is to provide an adequate level of safety with the minimum amount of disruption to road or rail 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, however at a much greater cost.

Additional treatment may be required to prompt drivers of the potential hazards ahead, such as:

- Reduced Speed Zones
- Passive Advanced Warning Signs
- Active Advanced Flashing Warning Assemblies

The Sub-Committees make decisions taking these conflicting requirements into account. Examples of each type of control are shown in AS 1742.7, which also details the layout of the standard signs and road markings associated with each type of control.

The process of determining the appropriate level of control for any railway crossing entails systematically checking the adequacy of each level of control, starting with Give Way Sign control and working upwards until an adequate level is determined. This is done in accordance with AS 1742.7, along with the criteria set out in Sections 4 to 9 of this document, considering the flags and risk highlighted by the Australian Level Crossing Assessment Model (ALCAM) and using appropriate safety consideration. This document details requirements additional to AS 1742.7 and therefore takes precedence where discrepancies occur.

This document includes a selection of appendices, which provide detailed reference information, tables, graphs, flow charts and diagrams to assist in determining levels of control 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.
It is important that records be kept of the control installed at each railway crossing. Main Roads WA
maintains a record of the type of control installed at all crossings on all railway lines in Western
Australia using the ALCAM and its associated database. Those organisations upgrading the levels of
control are responsible for advising Main Roads WA when the works are completed.

3.2 SIGHT DISTANCE REQUIREMENTS

Sighting requirements must be measured using AS 1742.7 supplemented by this document.

3.3 MAXIMUM ROAD SPEED LIMIT AT LEVEL CROSSINGS

Road users and train occupants are exposed to risk at level crossings due to the possibility of a
collision. Road users are required to stop or give way to trains at level crossings. The most significant
variable in the distance required for a road vehicle to stop is its velocity (or speed). Therefore reducing
road speeds to a maximum of 80km/h at level crossings decreases the likelihood of vehicles being
unable to stop at level crossings. Studies have shown that road user compliance with a reduction in
speed at level crossings is good. There is an additional benefit of reducing road speeds given level
crossings are typically rougher than the road surface either side of the level crossing.

A maximum speed limit of 80km/h is applied to level crossings in Western Australia to decrease the
risks.

Speed zoning the road at 80km/h is not applicable to level crossings:
- within 300 metres of a road terminating; or
- where the crossing is under stop control.
In both of the above scenarios drivers are required to stop; therefore posting a speed limit of 80km/h
would encourage higher speeds and decrease the safety of the crossing.

To be able to speed zone a section of road there are a number of road design factors to be satisfied
such as the design speed, seal width (greater than 5.5 metres) and length of seal.

At all crossings speed zoned at 80 km/h, ‘X RAIL’ line marking shall be installed as per AS 1742.7. It
should be noted the ‘X RAIL’ uses the letter height of 3 m for ‘X’ and 2.5 m for ‘RAIL’, with the ‘X’ being
installed prior to the ‘RAIL’ linemarking.

Further detail can be found in the “Policy and Application Guidelines for Speed Zoning” on the Main
Roads WA website: https://www.mainroads.wa.gov.au

3.4 OTHER SAFETY CONSIDERATIONS

Some additional considerations for improving safety at level crossings are outlined below:

a) Where there is the likelihood of pedestrian movements or other extraneous activity at or near a
railway crossing that does not have audible warning bells associated with the road crossing, warning
can be provided by the sounding of the approaching train's siren or horn at a distance determined by
the relevant Rail Infrastructure Manager.

b) 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 night 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.

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

d) While not normally appropriate for public roads, alternate safety measures may be considered at private crossings where sight distance requirements cannot be met. For example, drivers can be advised to ‘Call Train Control’ in lieu of normal signing advising motorists to ‘Look for Trains’. All interim treatments to manage sight distance at public level crossings must be approved by Main Roads WA.

e) ‘Railway Crossing’ boards along with the associated width markers (RX-9 Assembly) 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, exposed rails, sleepers, etc. In all cases, Railway Crossing boards should not obstruct visibility from nearby intersecting roads or driveways.

f) Rumble strips can be effective at warning drivers of a hazard. Rumble strips in advance of railway crossings can be used in areas prone to driver fatigue or where a rail crossing is not expected.

g) On gravel roads, sealing the approaches to the level crossing will reduce dust and improve visibility of the crossing. This also will improve the maintenance life of level crossing assets. Refer to Main Roads WA design guides for minimum length of seal.

h) At locations prone to vandalism or noncompliance with the Road Traffic Code, Closed Circuit Television (CCTV) can be installed to assist law enforcement. Prior arrangement with the Western Australian Police is required where prosecution will be sort, to ensure the image quality and other specific requirements are met.
4. **GIVE WAY SIGNS (RX-1)**

4.1 **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 see an approaching train in time to stop if necessary before reaching the crossing and allow the train to pass. This level of control 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 control:

a) Give Way Signs are not appropriate where the train speed is in excess of 80 km/h due to the difficulties faced by a motorist to view and perceive the rate of approach of a high-speed train over long distances.

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 distance necessary for a driver to see an approaching train and be able to stop safely prior to reaching the crossing as determined from consideration of train and vehicle speeds over the crossing, vehicle types, approach road surface and grades, and geometry of the crossing. Refer to \( S_1 \) and \( S_2 \) calculation given in AS 1742.7.

c) The clear visibility required by b) above must be available through a range of angles that does not require excessive rotation of the driver's head or that may be obscured by parts of the vehicle. The maximum angles are:
   - To the left \( X_{1L} \) 95 degrees; and
   - To the right \( X_{1R} \) 110 degrees.
   Refer \( X_{1R} \) and \( X_{1L} \) given in AS 1742.7.

d) Vehicles giving way to a passing train must stop at the Give Way hold line, therefore the minimum clear visibility either actually available or that could be made available at the stopped position at the crossing must be at least equal to the minimum distance necessary that applies to stop sign control crossings. Refer to \( S_3 \) calculation given in AS 1742.7 and section 5.2 of this document for additional considerations.

e) The clear visibility required by d) above must be available through a range of angles that does not require excessive rotation of the driver's head or that may be obscured by parts of the vehicle. The maximum angles are:
   - To the left \( X_{2L} \) 110 degrees; and
   - To the right \( X_{2R} \) 140 degrees.
   Refer \( X_{2R} \) and \( X_{2L} \) given in AS 1742.7 and section 5.2 of this document for additional considerations.

f) The level of train and vehicle activity should be below that warranting active control to be installed (see Section 6.2 and 7.2).

Western Australian practice is to have no Give Way control on multi-track level crossings or on level crossings adjacent to sidings.
4.2 SIGHT DISTANCE REQUIREMENTS FOR GIVE WAY SIGNS

Sight distance requirements for give way signs can be determined from AS 1742.7 or entering relevant data into ALCAM. When using either method consideration of the following sections should be taken into account:

4.3 $S_1$ CALCULATION

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. The sight distance required, $S_1$, is measured from the nearest rail.

In locations where there are a high number of vehicles moving significantly below the 85th percentile speed of the road, there may be a need to calculate equivalent $S_1$ and $S_2$, and the subsequent angle requirements. These assessments will be based on the 15th percentile and 85th percentile speed.

$S_1$, calculation including factors and coefficients can be found in AS 1742.7.

Key Considerations When Using the $S_1$ Calculation

Total Perception Reaction Time $R_t$

$R_t$ used for calculating stopping sight distances for vehicles approaching an intersection is generally taken as 2.5 seconds. Although a motorist can be alerted to the presence of the railway crossing by the installation of signs, $R_t$ is principally comprised of the time a driver needs to look both left and right through an angle of up to 205° (see figure 2) in order to search for any approaching trains and then, if a train is seen, appreciate the need to stop. 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) Drivers 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) High-speed road in a rural environment.

c) 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.

85th Percentile Vehicle Speed

Is the speed in kilometres/hour at which 85th percent of vehicles are travelling at or below. Where speed data information is not available the road speed limit plus 10% may be used.

Curved Approaches

Vehicles traversing curves have a reduced braking ability, compared to vehicles traveling in a straight line due to the available friction supplied by the tyres. The $S_1$ distance must follow the curvature in the road, as it represents the distance travelled by the approaching road vehicle.

4.4 $S_2$ CALCULATION

A motorist reaching the $S_1$ position 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, $S_2$, at which a motorist at $S_1$ needs to be able to see an approaching train is measured from the centre of the road carriageway along the track. $S_2$, calculation including factors and coefficients can be found in AS 1742.7.
Key Considerations When Using The S2 Calculation

Adequate visibility is defined as being a driver's ability to view at least two thirds of the frontage area, including any warning or headlight/s, of the approaching locomotive from an eye height of 1.1 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 \( S_2 \) from the crossing.

4.5 ANGLE REQUIREMENTS FOR GIVE WAY SIGNS

In addition to having clear visibility between the vehicle at \( S_1 \) and the train at \( S_2 \), drivers cannot be expected to turn their heads through too great an angle in order to see the train. Maximum angles are set out in Figure 2.

Due to the maximum viewing angles as a vehicle approaches a crossing, the driver's ability to check for an approaching train reduces. The \( S_1 \) sighting distance uses the 85th percentile road vehicle speed; however, for slow moving vehicles and fast moving trains the equivalent \( S_1 \) and \( S_2 \) may result in viewing angles outside of the maximum range. Where a road speed is considered variable, equivalent \( S_1 \) and \( S_2 \) calculations and angle requirements should be checked for the 15th percentile road vehicle speed.

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.

![Figure 2 – Maximum Angle Requirements for Give Way Signs](image)

4.6 ASSESSMENT FOR GIVE WAY SIGNS ON SIDE ROAD CROSSINGS

Many railway lines throughout the State have roads running close by and parallel to the tracks. 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. For this situation the equivalent \( S_1 \) and \( S_2 \) are always based upon the 85th percentile vehicle speed as measured at the tangent point as shown at Point A in Figure 3. (This is based upon there being no increase in vehicle speeds after drivers reach this point.)
While the driver may be aware of the existence of the crossing before turning into the side road, the driver's concentration is primarily directed to the turning manoeuvre and other possible conflicting traffic, therefore 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. Point C shows the position of the driver 2.5 seconds after completing the turning manoeuvre.

**Figure 3 - Requirements for Give Way Signs on Side Road Crossings**

4.7 **SIGHT DISTANCE AND ANGLE REQUIREMENTS FOR STOPPED VEHICLES**

Given drivers will at times be required to stop at Give Way controlled level crossings there is a requirement to measure sight distance and angle requirements at the hold line. The visibility and geometric requirements at the hold line shall be met, as described for Stop Signs, in Section 5.

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* I. A flow chart of the steps required for assessing Give Way signs is at Appendix B.

* II. Austroads Guide to Road Safety recommends using a driver eye height of 1.10 metres.
5. **STOP SIGNS (RX-2)**

5.1 **GENERAL**

A railway crossing controlled 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 approaching train to enable the driver to decide whether the distance to the train is such that it will not be a collision threat and it is safe to cross or if they must wait until the train has passed. Similar to Give Way sign control, this level of control 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 control:

a) Stop Signs are not appropriate where the train speed is in excess of 100 km/h due to the difficulties faced by a motorist to view and perceive the rate of approach of a high-speed train over long distances. 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, vehicle length and acceleration, grade and surface of the road, and geometry of the crossing. Refer to \( S_3 \) calculation given in AS 1742.7.

c) The clear visibility required by b) above must be available through a range of angles that does not require excessive rotation of the drivers head when stopped at the crossing or that may be obscured by parts of the vehicle. Refer \( X_{2R} \) and \( X_{2L} \) given in AS 1742.7 and section 4.1.

d) The level of train and vehicle activity should be below that warranting active control to be installed (see Section 6.2 and 7.2).

5.2 **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 the sight distance shall be measured as the control sign (generally 3.5 m from the outside edge of the rail).

The minimum distance down the track, \( S_3 \), at which a motorist stopped at the hold line, needs to be able to see an approaching train is measured from the centre of the crossing.

The \( S_3 \) calculation including factors and coefficients can be found in AS 1742.7.
5.3 KEY CONSIDERATIONS FOR S3 CALCULATIONS

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 1.1 metres above the road surface level.

The sight triangles should be clear of any obstructions to ensure drivers are able to readily detect the presence of an approaching train within the distance $S_3$ from the crossing.

5.4 ANGLE REQUIREMENTS FOR STOP SIGNS

In addition to needing clear visibility of trains at a distance of $S_3$, drivers cannot be expected to turn their heads through too great an angle in order to see the train. Maximum angles are set out in AS 1742.7.

The various forms in which these angle requirements are to be met are shown in Figure 4.

Figure 4 - Maximum Angle Requirements for Stop Signs

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I. A flow chart of the steps required for assessing Stop Signs is at Appendix C.
6. FLASHING LIGHTS (RX-5)

6.1 GENERAL

Flashing Lights are an active form of control at a railway crossing that alert the vehicle driver of an approaching train and their need to stop. If any of the following 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.

b) The volumes and speeds of trains and vehicles create a potential conflict 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 that drivers would generally expect to have priority travel on, i.e. a declared highway or main road.

Meeting any of the above conditions does not automatically lead to the installation of Flashing Lights. Additionally on major roads, within regional townsites, provision of active control devices is encouraged and should be considered.

6.2 INSTALLATION OF FLASHING LIGHTS DUE TO LEVEL OF POTENTIAL CONFLICT

The potential conflict 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 conflicts 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 conflict. 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 weighted conflict at a crossing in order to assess its level of potential conflict.

When assessing the installation of flashing lights the weighted conflict, \( C_w \) is derived as follows:

\[
C_w = \frac{V_t}{60} \times N_t \times \frac{V_v}{60} \times AADT
\]

The weighted conflict (\( C_w \)) is the product of the average annual daily traffic (AADT), and the average number of train movements per week (\( N_t \)), with weighting factors applied for 85th percentile vehicle approach speeds (\( V_v \)), and maximum train speeds (\( V_t \)), that vary from a base speed of 60km/h. For existing crossings controlled by Stop Signs, the value of \( V_v \) is always taken as 60 km/h.

If \( C_w \) is greater than 14 000, consideration should be given to the installation of Flashing Lights.
6.3 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 increased level of safety justifies the cost, at some point vehicle volumes may warrant the installation of Flashing Lights.

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:

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

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 where 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.

6.4 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 (SSD) applicable for the section of road for the largest vehicle type.

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 from wherever the end of the queue may be.

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

a) \( S_1 \) can be calculated from AS 1742.7; and

b) The average maximum length of any queue of vehicles, \( L_q \), which may have formed from the stop line following commencement of the lights flashing.

\( S_{vf} \) can then be calculated as follows:

\[
S_{vf} = S_1 + L_q
\]
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. Appendix D can be used as a guide for estimating values for $L_q$ in the absence of measured data or observations to determine the average maximum vehicle queue length. Should the required visibility distance, $S_{vi}$, not be available, one or a combination of the following measures should be considered:

a) Geometric modifications to the road alignment.

b) Reduce speed of approaching road vehicles

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

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

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

6.5 OTHER SAFETY CONSIDERATIONS

The ability of a driver to view flashing lights can be adversely effected by various traffic and environmental conditions, such as:

a) Traffic congestion on multi-lane roads, where slow moving or queued vehicles in one lane can obstruct visibility for drivers in an adjacent lane.

b) Large vehicles regularly stopping at nearby side roads or driveways and blocking sight lines.

c) Distractions in the form of other signal displays and illuminated signs and devices.

d) Sight lines regularly obstructed by kerbside or verge parking.

Consideration should be given to installing rectangular back boards or overhead cantilever flashing light displays to address visibility obstructions caused by any of the conditions above.

e) 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. Where a speed limit of 80 km/h is required, 400 metres of seal either side of the crossing will need to be provided.

f) On routes approved for use by ‘oversize’ vehicles e.g. road trains, investigations should be undertaken to determine if any particular safety requirements 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).

6.6 DESIGN AND OPERATION OF ACTIVE FLASHING LIGHT SIGNALS

Design and operational requirements for flashing light protection are outlined in AS 7618 and PTA document 8190-600-009 “Design Principles for Active Level Crossing Warning Systems”.

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1. See Appendix A for definition of terms and notation.
7. **BOOM BARRIERS (RX-5)**

**7.1 GENERAL**

Boom Barriers are installed to supplement the level of control provided by Flashing Lights. They are an active control device providing a visual barrier between the movement of vehicles and trains, typically comprising of a boom spanning from the left hand kerb to:

- Right hand kerb or edge of one way roadway
- Edge of physical median island or centre of island depicted only by road marking
- Dividing line or centre of roadway

The boom includes red and white bands as well as three red lamps as per AS 1742.7.

The effectiveness of this barrier in improving safety is particularly realised at 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 conflict 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. This is to prevent drivers falsely anticipating the crossing is safe after the passage of one train and proceeding to cross by anticipating a light change.

Meeting any of the above conditions does not automatically lead to the installation of Boom Barriers. Additionally on major roads, within regional townsites, provision of active control devices is encouraged and should be considered.

**7.2 INSTALLATION OF BOOM BARRIERS DUE TO LEVEL OF POTENTIAL CONFLICT**

The method for determining the weighted conflict, \( C_{wb} \), and hence the level of potential conflict at a crossing controlled by Boom Barriers utilises the formula as follows:

The level of exposure at a railway level crossing, \( C_{wb} \), is based on two factors:

- Weighted conflict (\( C_{wb} \)) - The product of the average annual daily traffic (AADT), and the average number of train movements per week (\( N_t \)), with weighting factors applied for 85th percentile vehicle approach speeds (\( V_v \)) in km/h, and maximum train speeds (\( V_t \)) in km/h;

- Heavy vehicle factor (\( H_v \)) - Is based on the percentage of heavy vehicles (\( P_v \)), as a whole number, (Note: 5% as the default value) This is multiplied by a road grade factor (\( Gr \)), as a whole number. \( P_v \) must be adjusted where there are road trains (Austroads class 10 and above). The class 10-12 vehicles are multiplied by a factor of 1.5. Take for example a crossing has a total of 30% heavy vehicles with 10% of all vehicles being class 10 and above. The adjusted \( P_v \) is \((20 + 10 \times 1.5) = 40\). \( Gr \)is the steepest incline within 400 metres of the crossing (averaged over 100m).

The exposure level is derived from the following formula:
\[ C_{wb} = C_W \cdot H_v \]

Where:
\[ C_w = \frac{V_i \cdot N_i \cdot V_v \cdot \text{AADT}}{60} \]

And:
\[ H_v = \left[ 1 + \left( \frac{P_v}{S} \right) \right] \left[ 1 + \frac{Gr}{10} \right] \]

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.)

### 7.3 OTHER SAFETY CONSIDERATIONS

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.

Interconnection between active control devices (such as boom barriers) and road traffic signals is required where a car may be trapped within a level crossing due to traffic lights and a lowered boom barrier.

### 7.4 OPERATIONAL SEQUENCES AND TIMING

Recommended operational sequence and timing for active control containing boom barriers are contained within AS 7658. PTA document 8190-600-009 “Design Principles for Active Level Crossing Warning Systems” and Brookfield Rail document W190-600-011 “Code of Practice for the Design of Active Level Crossing Warning Systems” may also be used.

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1. See Appendix A for definition of terms and notation.
8. **ACTIVE ADVANCE WARNING ASSEMBLIES (RX-11)**

### 8.1 GENERAL

Active Advance Warning Assemblies (AAWA) are installed to supplement the level of control 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 AAWA.

The decision to install AAWA 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. 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, 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 8.2 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 on the signal lenses or due to the sun shining directly into the driver’s line of vision.

### 8.2 LOCATION AND OPERATIONAL TIMING

The AAWA 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 AAWA commence operation. For vehicles up to the size of a B-Double, refer to Appendix E of AS 1742.7.

For the minimum distance of triple and quad road trains, refer to the table below.
### Longitudinal Location, of AAWA Triple Road Train and AAB Quad

<table>
<thead>
<tr>
<th>Speed (km/h)</th>
<th>Average Approach Grade (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-14</td>
</tr>
<tr>
<td>70</td>
<td>196</td>
</tr>
<tr>
<td>80</td>
<td>247</td>
</tr>
<tr>
<td>90</td>
<td>305</td>
</tr>
<tr>
<td>100</td>
<td>386</td>
</tr>
<tr>
<td>110</td>
<td>514</td>
</tr>
<tr>
<td>120</td>
<td>602</td>
</tr>
</tbody>
</table>

Note: the distance a vehicle needs to comfortably stop has previously been calculated as $S_1$ and it is commonly accepted that a driver needs to be a distance of at least 22 metres in advance of the AAWA signs to be able to physically view their operation. This constant distance has therefore been subtracted from the calculated stopping distance to determine the location $S$, of AAWA signs above.

Note: If advanced warning is being installed due to insufficient approach visibility to the crossing, $L_a$ will need to be added to $S$. Values of $S$ for various approach grades can be determined from AS 1742.7.

The length of time in seconds, $T$, which the advance signals flash before the railway crossing flashing lights begin to operate, is shown in Appendix E of AS 1742.7. To allow for major obstacles and other physical features, which may affect the on-site location of the AAWA, a 5% tolerance can be applied to the values of $S$ without the need to recalculate the length of time, $T$. For AAWA sign installation outside of this 5% tolerance, a new value for $T$, must be determined and applied. Vehicles traveling at slower speeds may pass the AAWA signs prior to them activating and still be able to sight the control or queue in time to stop.

### 8.3 SIGN SIZE SELECTION

AAWA comprise of 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) Type C sign shall be used on roads where the posted speed limit is 80km/h.

b) Type B sign shall be used on roads where the posted speed limit is below 80 km/h, OR where it is impractical to provide sufficient space for a Type C.

<table>
<thead>
<tr>
<th>SIGN TYPE</th>
<th>SIGN WIDTH</th>
<th>SIGN HEIGHT</th>
<th>DIAMOND SIZE</th>
<th>TEXT SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>1100</td>
<td>1600</td>
<td>750 x 750</td>
<td>120 DM</td>
</tr>
<tr>
<td>C</td>
<td>1350</td>
<td>1950</td>
<td>900 x 900</td>
<td>160 DM</td>
</tr>
</tbody>
</table>

1. Refer to Main Roads WA Drawing 9531-1112 for standard design layout of advance flashing warning sign.
2. Refer to Main Roads WA Drawing 9631-3525-1 for electrical equipment details.
3. Refer to AS 1742.2, for reference information regarding steep grades.
4. Reference can be made to Main Roads WA draft document ‘Regulatory Signs, Warning Signs, and Advance Directional Signing Policy’ for further details and information on advance warning sign systems.
9. GRADE SEPARATION

9.1 GENERAL

Grade separation using a bridge or an underpass offers the safest but most expensive treatment at a rail crossing. Justification of the high expenditure involved with grade separation is required before replacing an existing level crossing or constructing a new grade separated crossing.

9.2 WARRANTS FOR GRADE SEPARATION

Grade separation shall be pursued in the following scenarios:
- Where the current or anticipated exposure level is greater than 5 million for rail and road interfaces.
- Railway crossings on all freeways and controlled access highways.
- Where new crossings are proposed within the current or proposed Perth urban passenger rail network which results in an increase in the total number of level crossings.
- Where the Road Manager determines that a proposed crossing location presents an intolerable risk to road users and / or network efficiency (this will generally be due to factors such as road and rail geometry and alignment which are not fully encapsulated by the exposure level formula).
- Where there is a dual track crossing proposed on a highway or high volume road of strategic importance to the State.

Note: Where the crossing is an existing public rail and public road interface that exceeds the 5 million exposure level, further investigation into project cost, traffic impacts, pedestrian activity, safety risks, ALCAM scores, recorded crashes, incidents, and project feasibility should be used to adjust grade separation priorities prior to seeking government funding.

There may be certain scenarios where the 5 million exposure level is reached, however grade separation may not be an appropriate treatment (section 9.4).

9.3 DETERMINATION OF EXPOSURE LEVEL

The level of exposure at a railway level crossing, $C_{wgr}$ is based on three factors:
- Weighted conflict ($C_w$) - The product of the average annual daily traffic (AADT), and the average number of train movements per week ($N_t$), with weighting factors applied for 85th percentile vehicle approach speeds ($V_v$) in km/h, and maximum train speeds ($V_t$) in km/h;
- Heavy vehicle factor ($H_v$) - Is based on the percentage of heavy vehicles ($P_v$), as a whole number, (Note: 5% as the default value) This is multiplied by a road grade factor ($Gr$), as a whole number. $P_v$ must be adjusted where there are road trains (Austroads class 10 and above). The class 10-12 vehicles are multiplied by a factor of 1.5. Take for example a crossing has a total of 30% heavy vehicles with 10% of all vehicles being class 10 and above. The adjusted $P_v$ is $(20 + 10 \times 1.5) = 40$. $Gr$ is the steepest incline within 400 metres of the crossing (averaged over 100m).
- Vehicle delay factor ($D_v$) - Determined from the length of the longest train ($L_{di}$) in metres, and the maximum speed of the longest train ($V_{di}$) in km/h that travels over the crossing.
The exposure level is derived from the following formula:

\[ C_{wgr} = C_w \times H_v \times D_v \]

Where:

\[ C_w = \frac{V_i}{60} \times N_i \times \frac{V_v}{60} \times AADT \]

And:

\[ H_v = \left[ 1 + \left( \frac{P_v}{5} \right) \right] \times \left[ 1 + \frac{Gr}{10} \right] \]

Note: percentages are expressed as whole numbers for the purpose of the equation.

And:

\[ D_v = \frac{1 + \left( 21 + \frac{3.6L_{00}/0.9V_{vl}}{25} \right)}{2} \]

Note: Unless subject to shunting operations, 0.9V_{vl} can be assumed to be representative of the slowest train speed through a crossing.

9.4 INVESTIGATION

In certain scenarios where the exposure level is exceeded, grade separation may be deemed inappropriate. These particular locations will only be considered where the below criteria are met for level crossings:

- Where the warrant for grade separation will only be exceeded for a relatively short period of time in relation to the design life of a bridge or underpass; and
- The vast majority of road users are not ordinary members of the public (i.e. from one company) and therefore the exposure can be managed by other means.

These particular scenarios will generally only occur on Local Government or private roads as a result of activities such as mining projects with limited mine life. Additional controls will need to be put in place to ensure safety and efficiency is not compromised. These controls may include:

- additional overtaking lanes;
- additional seal lengths;
- inductions for road drivers from the mining company using the road;
- staggered departure times for controlled vehicles including GPS tracking;
- CCTV at the crossing;
- radio messaging to heavy vehicles through the two way radio; or
- recourse for drivers that disobey the induction.

These level crossings will be subject to reassessment for grade separation if the additional controls fail to mitigate the risk.
These level crossings must have the highest level of active control and advanced warning installed.

Where there are existing level crossings on the public rail network and the exposure level is exceeded, grade separation may be cost prohibitive in the short to medium term. In some instances grade separations will not be able to be contained within existing reservations and may impact on landowners and businesses or require significant cost implications to mitigate impacts. In such cases, investigations into other measures to reduce traffic impacts and improve safety should be investigated and implemented where appropriate.

9.5 FUNDING

For Private Railways, existing private rail/public road crossings grade separation must be funded by the rail owner. The costs are to include maintenance requirements extending five years beyond the completion of the development, new construction or upgrading.

For public railway crossings, any grade separation which is required as a result of specific road, rail or land-use improvements or development, must be funded by the Road Manager or Rail Infrastructure Manager, or by the developer, as appropriate.

9.6 ADDITIONAL SAFETY CONSIDERATIONS

Consideration of the following grade separation safety issues is required:

- Protection of people and property from objects or material falling, suspended or thrown from one level to another;
- Protection of traffic on either the upper or lower facility from any consequences of incidents such as road crashes or train derailments on the other facility;
- Provision of safe clearances or low clearance warning for road traffic under railway structures gantries on approaches to be installed;
- Provision of safe clearances for railway traffic under railway, road or other facility structures; and
- Protection from contact with live electrical equipment.
- Refer to AS 5100.1 and Main Roads WA Structures Engineering Design Manual for bridge design specification and general principles.

1. See Appendix A for definition of terms and notation.
10. PRIORITISING LEVEL CROSSING PROJECTS

10.1 GENERAL

Whilst there are a number of crash prediction models available to determine relative hazard and hence priorities for upgrading control levels, these are largely based upon or compared to some historical measure of crash occurrences.

Crashes at railway crossings in Western Australia are 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 control requirements based upon previous or predicted crash levels is not considered an effective method of identifying or forecasting hazards at railway crossings in this State. Nevertheless a crossing having a continuing history of train-vehicle crashes or near misses obviously demands attention. There are other factors including social and economic considerations, which can also influence the priority given to the upgrading of control.

After having established from previous sections that upgrading of control 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 can fund. In these circumstances it is necessary to establish priorities for the works to determine which installations should be programmed ahead of others.

10.2 METHODOLOGY

The accepted 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.

The following should be noted in respect to the prioritising crossing upgrades:
- ALCAM risk score.
- Flags generated by the ALCAM or failings in the crossings layout/control in relation to AS 1742.7.
- The exposure level of the crossings in question.
- Crossings should only be compared with the same proposed level of control 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.
11. CLOSURE OF LEVEL CROSSINGS

11.1 GENERAL

Level crossings can be closed and removed subject to agreement between the Rail Infrastructure Manager and the Road Manager, typically Main Roads WA or the Local Government.

The authority to approve the removal of level crossings controls on the public road network remains the responsibility of the Executive Director Metropolitan and Southern Regions, Main Roads WA as the regulatory authority for all public crossings.

11.2 CESSATION OF RAILWAY OPERATIONS

From time to time train movements on a particular rail line cease either permanently, or temporarily. To ensure railway crossing control devices are effective they should only be installed in situations where they are required; otherwise motorists can become complacent and may ignore them. On lines which will have no rail movement for the foreseeable future, consideration should be given to removing the regulatory level crossing signage and disabling active controls, and replacing them with “Railway Crossing Not In Use” (G9-74) signage. Where necessary, additional appropriate warning signs (e.g. 'hump', 'dip', 'rough surface', etc.) should be erected at the time of removing the railway crossing signs. Speed limits on the approaching road shall not be increased and any vehicle restriction must remain in place (i.e. restriction on vehicle lengths/weights, restrictions for stacking).

On rail lines where train movements are seasonal or temporarily suspended, consideration of alternate method to combat complacency should be considered i.e. media campaigns alerting local people to changes in rail movements.

It should be noted that Rail Infrastructure Managers may have different definitions for the status of lines on their network i.e. operational, non-operational, disused, seasonal, not-in-use, closed, etc. Permanent closure of a rail line in Western Australia requires an act of State Parliament before it can be removed from the network.
12. NEW LEVEL CROSSINGS

12.1 GENERAL

Approval of additional level crossings on the public road network is by agreement between the Road Manager and Rail Infrastructure Manager. The level of control remains the responsibility of the Executive Director Metropolitan and Southern Regions, Main Roads WA as the regulatory authority.

The introduction of new road level crossings for the purpose of residential development is not supported by State Government. The Public Transport Authority does not permit an increase in the net number of level crossings on the public rail network. Other options must be considered prior to applying for new level crossings, these may include: Grade Separation, realignment or relocation of existing rail level crossings.

Where a new road level crossing is required on a public road and all alternate options have been considered, the crossing will need to be proven to have significant benefits to the State e.g. town bypass for a new heavy vehicle route, The project will be investigated by Main Roads WA and the relevant Rail Infrastructure Managers.

It is the responsibility of the Applicant (usually a project manager from the Local Government or new rail manager applying for a new level crossing) to manage communications between all stakeholders, obtain the required approvals and arrange for ALCAM and Rail Safety Reports to be undertaken.

For the introduction of new level crossings as a result of a new rail project, the applicant (usually a project manager from the rail manager), as part of the Change Advice process, must apply to the Office of Rail Safety. There are many other agencies which must be involved and the Office of Rail Safety can provide further information on the process.

When the level crossing is first ALCAM assessed, it will be issued an ALCAM Crossing Number by Main Roads WA for a universal identifier. The ALCAM Crossing Number is usually different to an organisations asset tracking number.
13. SHORT STACKING AND QUEUING HAZARDS

13.1 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 hazards associated with these situations and it is necessary to identify and implement suitable treatments to eliminate or reduce this hazard.

13.2 SHORT DEPARTURE STACKING

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. The normal vehicle stopping position at a priority road intersection is generally indicated by a holding line. In the absence of a hold line, the stopping position can be assessed on site from the edge of the through road. The available stacking distance is measured 3 m from the nearest rail to where a vehicle is expected to stop. This is taken as either 2 m from the edge of the through road or 1 m from the hold line, whichever results in the shortest stacking distance (see figure 6).

The longest ‘as-of-right’ vehicle legally allowed to use the road, L, is 19 metres, which provides for a semi-trailer. Generally on major routes and in many rural areas, vehicles exceeding this length are permitted.

Main Roads WA’s Heavy Vehicle Services should be consulted for up-to-date information on the maximum vehicle length that applies to a particular crossing.

Visit the Heavy Vehicle Services web page for more information.
13.3 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 intersection. 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 holding line or in the absence of a line, assumed to be 3.5 metres back from the nearest rail.

13.4 POSSIBLE TREATMENTS FOR SHORT STACKING

A range of possible treatments for short stacking at railway crossings is shown in Appendix E. It is intended that Appendix E be used as a checklist to 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.
13.5 QUEUING HAZARDS

Railway crossings which are regularly subject to traffic congestion have the potential for vehicles to be stationary on the tracks.

The *Road Traffic Code 2000* makes it an offence to enter a railway crossing if the vehicle cannot be immediately driven clear of the crossing. Observations show that in many instances vehicles stopping on the track during traffic congestion may not be occurring deliberately but rather is caused by the driver's inability to anticipate the forming of a queue ahead.

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, an appropriate minimum 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. Reference should be also be made to Main Roads WA 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 E for possible short stacking solutions.

II. Refer also to Main Roads WA Drawings 9731-1096-1 and 9731-2493 for signing and road marking details for 'KEEP CLEAR' signs and yellow cross hatch markings.
14. PEDESTRIAN CONTROL AT LEVEL CROSSINGS

14.1 GENERAL

At level crossings where facilities are to be provided for pedestrians to cross the tracks, an appropriate treatment selected from the hierarchy of controls set out below is required. The treatment shall provide for all pedestrians including; people on bicycles, people with disabilities, including ambulant, vision and hearing impairment. There are six levels of control used in normal circumstances for pedestrians at railway crossings in this State. In ascending order, they are:

- Passively Signed Crossing
- Pedestrian Maze Crossing
- Adjacent Active Control
- Actively Signed Crossing (with or without maze)
- Gated Maze Crossing
- Grade Separation (Underpass or Overpass)

In making an assessment as to an appropriate level of control for any particular railway crossing, the basic philosophy is to provide an adequate level of safety with the minimum amount of disruption to pedestrian movements and at the lowest cost.

Note: Warrants for the installation and level of control for pedestrian crossings that are remote to level crossings (i.e. at a midblock pedestrian crossing) are determined by the rail and adjacent land owners. It is recommended that devices should be installed in accordance with AS 1742.7 as a minimum and this section can be taken as a guide.

14.2 SIGHT DISTANCE

At pedestrian railway crossings the required minimum sight distance (SD) in metres for a person to see an oncoming train shall be calculated as follows:

\[ SD = \frac{V_t}{3.6} \times \left( \frac{d}{V_p} + MS \right) \]

- \( V_t \) is the maximum speed of trains in km/h.
- \( d \) is the pedestrian crossing distance in metres measured between pedestrian holding lines/locations if they exist, or 1.5 m from the outside edge of rail on each side. At crossings with train speeds greater than 80 km/h the total distance shall be extended by 1 m
- \( V_p \) is the pedestrian walking speed, usually taken to be 1.0 m/s. On crossings where there is likely to be significant use by high risk pedestrians (people with ambulant disabilities, using perambulators, school aged children or the elderly) the walking speed shall be reduced to 0.8 m/s.
- \( MS \) is a margin of safety of 2, as a minimum. It is required to increase the margin of safety, where the pedestrian crossing is narrow, uneven, on a grade or where ‘platoons’ of pedestrians are present.
14.3 WARRANTS

Safety requirements of pedestrian movements will have to be assessed at each site individually. There are many design and geographical issues with retrofitting new pedestrian crossings at existing level crossings. While pedestrian control requirements are listed below, they are not all inclusive, as other factors may affect the appropriate level of control required. Typical arrangements are included in AS 1742.7.

Level 1 – Passively Signed Crossings

Is a formalised pathway with signs as per AS 1742.7 it is generally the simplest and cheapest option, passively signed crossings are considered to provide the lowest level of protection. Level 1 is only recommended where the location meets sight distance requirements, is a single track line and all of the following conditions apply:

- Low pedestrian volumes (less than 50 pedestrians per day)
- Low train volumes (less than 30 trains per week)
- Low train speeds (less than 80km/h)

At Level 1 pedestrian crossings adjacent to vehicular crossings the general arrangement is to provide additional width on the roadway to include a path within the shoulder, with a clear width of 1200 mm, defined by tactile ground surface indicators (TGSi) and pedestrian holding markings, and install “Look For Train” signs (W7-14-5).

Level 2 – Pedestrian Maze Crossing

Is a formalised pathway which includes pedestrian mazes on both approaches to the crossing. The general arrangement requires a defined footway with an enclosed maze which shall be designed so that pedestrians are forced to make at least one 180 degree turn when walking through the maze and results in the pedestrian looking alternatively in the up and down direction of the railway line increasing likelihood of sighting oncoming trains that may approach the level crossing from either direction. Pedestrian maze crossings are recommended where the location meets sight distance requirements, is a single track line and any of the following conditions apply:

- Moderate pedestrian volumes (between 50 and 100 pedestrians per day)
- Moderate train volumes (between 30 and 50 trains per week)
- High train speeds (greater than 80km/h)

See AS 1742.7 for general maze layouts and dimensions. The width shall be sufficient to allow wheel chairs and prams sufficient room to negotiate the pathway through the maze. The treatment also includes the provision of “Look For Train” signs (W7-14-5).

Level 3 – Adjacent Active Control

Where the site distance requirements are not met, passively protected crossings with or without mazes (as detailed above) which are adjacent to vehicular roads which have active controls are considered to have a higher level of protection in the following circumstances:

- Where audible warning from the adjacent crossing sounds continuously during the approach of an oncoming train and until such time as the train has pasted and is no longer a collision threat; and
Where the flashing lights from the vehicle crossing are visible to approaching pedestrians and can provide warning of the need to wait until the train has cleared before commencing crossing.

Signage requirement for Pedestrian crossing (with or without mazes) with active control for vehicular traffic only are outlined in AS 1742.7

**Level 4 – Actively Signed Crossing**

Actively signed crossings provide additional control to crossings with poor sight distance. Actively signed crossings are recommended where the following condition applies;

- Insufficient sight distance (refer to section 14.2)
- Two or more operational tracks
- Moderate to high pedestrian volumes (50 or more pedestrians per day)
- Moderate to high train volumes (30 or more trains per week)

The general arrangement requires a defined footway with a clear width of 1800 mm. A control point including a hold line, TGSI, a red symbolic standing pedestrian signal assembly (RX-12), associated alarms or bells and “Do Not Cross While Lights Are Displaying or Alarm Sounding” signs (W7-14-6). Refer to AS 1742.7 for general arrangements.

**Level 5 – Gated Maze Crossing**

Gated maze crossings are considered the highest level of at-grade protection and as such typically cost the most (excluding grade separation). Gated maze crossings are recommended where any of the following conditions apply:

- High pedestrian volumes (100 or more pedestrians per day)
- High train volumes (50 or more trains per week)
- Volume factor greater than 500 ($N_p \times N_t > 500$)

Note: where $N_p$ is the number of people per day and $N_t$ is the number of trains per day.

The general arrangement requires a defined footway with an enclosed maze as required in Level 2. In addition, the installation of a pedestrian gate that is remotely controlled and lockable (activated by the presence of an approaching train). The treatment also includes the provision of red symbolic standing pedestrian signal assembly (RX-12), associated alarms or bells, and “Do Not Cross While Lights Are Displaying or Alarm Sounding” signs (W7-14-6).

**Level 6 – Grade Separation**

Grade separation is considered the ultimate pedestrian treatment. If appropriately designed it removes all conflict between pedestrians and trains. Additionally pedestrian delays as a result of train movements are eliminated. Therefore the following should be included in assessment for grade separation;

- Total closure times for a pedestrian level crossing; and
- How motivated pedestrians are to disobey level crossing control (e.g. proximity to train station).

While all grade separation treatments must be individually designed and assessed, the following should be considered for pedestrian grade separation:
• Protection of people and property from objects or material falling, suspended or thrown from one level to another;
• Protection from contact with live electrical equipment;
• Perceived safety of pedestrians (due to crime) using the crossing (particularly for underpasses); and
• Additional lighting requirements.

14.4 OTHER SAFETY CONSIDERATIONS

In addition to the levels of pedestrian control, some safety items should be considered:
• Location may meet sight distance requirements as a single track line; however a siding or additional track may be located within the required length of sighting distance, where this occurs active control should be considered. This is to acknowledge that a train on one line may mask another train approaching on the other line.
• Rationalisation of pedestrian crossings should be carried out where multiple crossings are located in close succession.
• A guard fence along the edge of the approach footways or along the rail reserve, guiding pedestrians to the designated pedestrian crossing shall be provided where it is likely for pedestrians to short-cut the crossing.
• Any pedestrian crossing provided at a location where pedestrians would not have time to cross the tracks safely before the arrival of a previously unseen train shall be provided with one or more active warning devices.
• A sign should be installed to indicate an alternate crossing option when the crossing has a history of being temporarily blocked by shunting operations.
• In areas subject to large amounts of visual and audible distraction, this may include pedestrians using mobile devices, a physical barrier may be required to direct the attention away from the distraction and promote observation of the rail tracks.

I. Pedestrian and train volumes shall be calculated based on yearly averages and should be seasonally adjusted.
**Appendix A – Definition of Notation and Terms**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_{sc}$</td>
<td>Annual stopping costs associated with Stop Sign controlled crossings.</td>
</tr>
<tr>
<td>$AADT$</td>
<td>Annual average daily vehicle traffic</td>
</tr>
<tr>
<td>$AAWA$</td>
<td>Active Advance Warning Assembly</td>
</tr>
<tr>
<td>$ALCAM$</td>
<td>Australian Level Crossing Assessment Model</td>
</tr>
<tr>
<td>$BCR$</td>
<td>Benefit cost ratio</td>
</tr>
<tr>
<td>$C_w$</td>
<td>Weighted conflict</td>
</tr>
<tr>
<td>$C_{wgr}$</td>
<td>Weighted conflict for Grade Separations</td>
</tr>
<tr>
<td>$CCTV$</td>
<td>Closed Circuit Television</td>
</tr>
<tr>
<td>$D$</td>
<td>Deceleration rate</td>
</tr>
<tr>
<td>$d$</td>
<td>Pedestrian crossing distance in metres</td>
</tr>
<tr>
<td>$D_v$</td>
<td>Vehicle delay factor</td>
</tr>
<tr>
<td>$EDR$</td>
<td>Economic discount rate of a set of Flashing Lights</td>
</tr>
<tr>
<td>$G$</td>
<td>The approach grade of the road to a level crossing</td>
</tr>
<tr>
<td>$H_v$</td>
<td>Heavy vehicle factor</td>
</tr>
<tr>
<td>$I$</td>
<td>Installation cost for a set of Flashing Lights</td>
</tr>
<tr>
<td>$L$</td>
<td>Length of the longest vehicle, legally allowed to use the road</td>
</tr>
<tr>
<td>$L_{ll}$</td>
<td>Length of the longest train</td>
</tr>
<tr>
<td>$L_q$</td>
<td>Length of vehicle queue formed on the approach to a level crossing</td>
</tr>
<tr>
<td>$L_s$</td>
<td>The length of vehicle stacking distance between the rail and an adjacent priority road.</td>
</tr>
<tr>
<td>$M$</td>
<td>The average annual maintenance cost</td>
</tr>
<tr>
<td>$MS$</td>
<td>Margin of Safety</td>
</tr>
<tr>
<td>$N_p$</td>
<td>The average number of pedestrians a day</td>
</tr>
<tr>
<td>$N_t$</td>
<td>The average number of trains per week</td>
</tr>
<tr>
<td>$P_v$</td>
<td>Percentage of heavy vehicles</td>
</tr>
<tr>
<td>$PTA$</td>
<td>Public Transport Authority of Western Australia</td>
</tr>
<tr>
<td>$R_t$</td>
<td>Reaction time of a driver</td>
</tr>
</tbody>
</table>
The distance from the crossing the warning signs are located in advance of the holding line

\( S \)

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

\( S_1 \)

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

\( S_2 \)

The minimum distance from the crossing, measured along the rail, at which a motorist needs to be able to see an approaching train from a distance of 6.5 m back from the nearest rail

\( S_{\text{vf}} \)

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.

\( SD \)

Sight Distance

\( SL \)

Service life

\( SMP \)

Safety Management Plan

\( SSD \)

Stopping Sight Distance

\( T \)

Length of time in seconds

\( TGSI \)

Tactile Ground Surface Indicators

\( TMP \)

Traffic Management Plan

\( V_p \)

The average walking speed of a pedestrian

\( V_t \)

The maximum train speed

\( V_{tt} \)

The maximum speed of the longest train

\( V_v \)

The 85\(^{\text{th}}\) percentile speed of vehicles approaching a railway crossing
Appendix B – Assessment for Give Way Signs

Is the maximum train speed less than or equal to 80km/h, or is the weighted conflict less than 14,000?

Yes

Is there only one track in the vicinity of the crossing?

Yes

Are all sight triangles clear between points at distances \( S_1 \) and \( S_2 \)?

Yes

Can the required sight triangles be cleared? or can train speeds be reduced (without affecting operations) to compensate?

Yes

Can the rail straight and does it meet the road at right angles?

Yes

At the distance \( S_1 \), is the angle between the road centre line and the minimum \( S_2 \) sighting distances required fall between points ≤95 degrees to the left and ≤110 degrees to the right?

Yes

Can the road be economically realigned to achieve the required angles and sighting distances?

Yes

Can the ‘Assessment For STOP Signs’ be met?

Yes

Give Way Signs can be installed provided all required remedial action is undertaken.

No

Give Way Signs should not be installed. Consider other levels of control.

No

Is it impossible for a train on one track to conceal the approach of a train on another track within the \( S_1 \) distance from the crossing?

No

Are all sight triangles clear between points at distances \( S_1 \) and \( S_2 \)?

Yes

Can the road be economically realigned to achieve the required angles and sighting distances?

Yes

Can the ‘Assessment For STOP Signs’ be met?

Yes

Give Way Signs can be installed provided all required remedial action is undertaken.

No

Give Way Signs should not be installed. Consider other levels of control.
Appendix C – Assessment for Stop Signs

Is the maximum train speed less than or equal to 100km/h, or is the weighted conflict less than 14,000?

- Yes
- No

Is there only one track in the vicinity of the crossing?

- Yes
- No

Is it impossible for a train on one track to conceal the approach of a train on another track, as viewed 5m from the nearest rail line?

- Yes
- No

Are all sight triangles clear between points at 5m from the nearest rail and the minimum required Sشرق sighting distances attainable?

- Yes
- No

Can the required sight triangles be cleared? or can train speeds be reduced (without effecting operations) to compensate?

- Yes
- No

Is the angle between the road centre line and the minimum Sشرق sighting distance, taken at a distance of 1.5m from the stop line ≤110 degrees to the left and ≤140 degrees to the right?

- Yes
- No

Can the road be economically realigned to achieve the required angles and Sشرق sighting distances?

- Yes
- No

Stop Signs should not be installed. Consider Flashing Lights or Boom Barriers.

Stop Signs can be installed provided all required remedial action is undertaken.
### Appendix D – Estimation of Vehicle Queue Lengths at Railway Crossings

<table>
<thead>
<tr>
<th>Annual Average Daily Traffic (AADT)</th>
<th>Crossing Closure Times (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>0 – 2 000</td>
<td>7</td>
</tr>
<tr>
<td>2 001 – 4 000</td>
<td>14</td>
</tr>
<tr>
<td>4 001 – 6 000</td>
<td>21</td>
</tr>
<tr>
<td>6 001 – 8 000</td>
<td>28</td>
</tr>
<tr>
<td>8 001 – 10 000</td>
<td>35</td>
</tr>
<tr>
<td>10 001 – 12 000</td>
<td>42</td>
</tr>
<tr>
<td>12 001 – 14 000</td>
<td>49</td>
</tr>
<tr>
<td>14 001 – 16 000</td>
<td>56</td>
</tr>
<tr>
<td>16 001 – 18 000</td>
<td>63</td>
</tr>
<tr>
<td>18 001 – 20 000</td>
<td>70</td>
</tr>
</tbody>
</table>

**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.
1. Short Term Solutions

1.1 Advisory Signs

1.2 Regulatory Signs

1.3 KEEP CLEAR Signs and Yellow Cross Hatching

Refer to Main Roads WA standard drawing 9731-2493
### 2. Medium Term Solutions

#### 2.1 Change Road Priority

#### 2.2 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.

#### 2.3 Signal Facing Driver Entering Intersection

#### 2.4 Flashing Lights Beside Through Road
2.5 Partial Closure

2.6 Escape Facilities

2.7 Acceleration Lanes

2.8 Right Turn Prohibition
### 3. **Long Term Solutions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3.1</strong></td>
<td>Realign Road away from Railway</td>
</tr>
</tbody>
</table>
|   | ![Diagram](image1)
|   | ![Diagram](image2)
| **3.2** | Grade Separation |
|   | ![Diagram](image3)
| **3.3** | Realign Railway Away From Road |
|   | ![Diagram](image4)

Note: This is not intended to be an all-inclusive list of solutions and individual locations will require further assessment before installation.