Design Guidance for Pedestrian & Cycle Rail Crossings

Final Guide for Industry Use (version I), 7 July 2017

Developed for the NZ Transport Agency and KiwiRail by ViaStrada Ltd and Stantec Ltd

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Cover Photo: Automated gate crossing, Tawa, Wellington (photo: Glen Koorey)

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Executive summary

About this guide

This guide provides urban designers and planners, and traffic and rail engineers, with principles, design considerations and standard designs for level crossings located on footpaths, shared paths or cycle paths. Many of the principles discussed should also be applied when considering providing for cyclists using on-road cycle lanes. It asks users to consider ***all*** types of rail crossing options, including grade separation and the potential to remove a rail level crossing completely; however, the design guidance only covers treatments at rail level crossings.

This guide focuses on **crossings** of the rail corridor; it does not consider the planning and design of pedestrian/cycle pathways running ***along*** rail corridors. Guidance and requirements for public pathways or cycleways in the rail corridor can be found in *Applications for New Rail Crossings: Guide for Applicants* (KiwiRail, 2015).

This guide will enable the road and rail sectors to put more emphasis on safety of pedestrians and cyclists at level crossings in light of the upwards trend in incidents for cyclists and pedestrians with rail. This document has been developed based on an initial interim guide, related workshops, and subsequent industry feedback.

This guide is endorsed by KiwiRail, the NZ Transport Agency and the Road Controlling Authorities' Forum and is consistent with the mandatory requirements of the NZTA *Traffic control devices manual* part 9. It has been developed in conjunction with another study undertaken for KiwiRail that developed a new risk assessment process for assessing the safety impacts of changes to all level crossings and how these might be mitigated. The resulting *Level Crossing Risk Assessment Guidance* (KiwiRail, 2017) is hereafter referred to as the "*Risk Assessment Guide*" and relates to all rail crossings, not just those for pedestrians and cyclists. The *Risk Assessment Guide* outlines the Level Crossing Safety Impact Assessment process (also summarised in section 3 of this guidance) that must be undertaken by qualified assessors and, in particular, is required for all upgrades to or new level crossings that are along or adjacent to a new cycleway or shared path. Designers and assessors should both understand the principles presented in this guide where rail crossings involving pedestrians and / or cyclists are involved.

The guide does **not** address legal or property matters. Councils wishing to upgrade level crossings or using level crossings or other parts of the rail corridor for cycleways or shared paths need to contact KiwiRail to find out about the application process (cycleways@kiwirail.co.nz).

Best practice in the field of designing level crossings for pedestrians and cyclists is still being refined and further work is needed to expand and amend the guidance currently provided in this document. Users of the guide and road controlling authority staff are invited to provide feedback to KiwiRail regarding the application and content of this guide. In particular, feedback should be directed to:

- Leah Murphy - Project Manager, Urban Cycleway Projects (Leah.Murphy@kiwirail.co.nz)
- Eddie Cook - Project Engineer, Level Crossings (Eddie.Cook@kiwirail.co.nz)

Pedestrian/cycle crossing design principles and factors

Rail crossings in New Zealand should be constructed and managed using the same "safe system" approach that is applied to other transport infrastructure. Namely, it is important to remember that humans make mistakes (but shouldn't be disproportionately punished for them), they are vulnerable to injury (requiring a focus on harm minimisation), and a shared responsibility is required to address safety (incl. rail operators, road controlling authorities, system users, etc).

This guide proposes the following main design principles to apply:

- Minimise the **need** for at-grade crossings (through good planning of walking/cycling routes)

- Seek **awareness** (by users) of crossings and trains, particularly in complex situations
- Seek **compliance** when crossing, to encourage users to stop and wait when necessary
- Provide for safe, accessible and practical use by **all** user types (including those who have physical, sensory or cognitive impairments)
- Provide **appropriate and consistent** treatments for the actual level of risk
- Crossing treatments should be **maintainable** (for both KiwiRail and the adjacent landowner)

The design aspects of rail crossings for pedestrians and cyclists can be divided into three general categories of factors:

- ***The crossing users (i.e. people walking and cycling):*** A basic understanding of human behaviour is required to improve awareness and compliance at many crossings sites. KiwiRail now require user counts be undertaken, and extrapolated to represent future scenarios. Designers also need to consider the different types of users and their relevant attributes such as age, impairments, speed, manoeuvrability, distractions (e.g. from headphones or mobile devices, one of the key causes of recent incidents), and familiarity. On-site observation of usage and behaviour is critical for optimal design.
- ***The nature of the site itself:*** Sites have a number of attributes that can help or hinder their safe and efficient operation, and some may influence people's behaviour near the crossing. Designers may need to consider visibility and sight distances, approach gradients and angles, parallel paths and roads, number of tracks, design of the flange gaps (a problem for users of wheeled devices), and proximity to intersections, stations and other distractions.
- ***The train movements at the crossing:*** It is important to understand the various attributes of trains using a crossing site, including speeds, lengths, and frequencies, to determine whether other site or user factors should be considered.

The guide describes the various attributes under these three categories that influence crossing design. Each site has unique aspects related to these attributes, and thus it is important that each site design is customised to suit its location, rather than just copying a standard design layout.

General design features and treatment options

The guide discusses the following design features that may need to be considered at all pedestrian/cycle rail crossings for inclusion:

- Rail corridor clearances (including emergency escape areas)
- Passive warning control options (including signs, markings, rumble strips, tactile ground surface indicators, bollards/rails, and kerb extensions)
- Active warning control options (including flashing lights and bells, in-ground lights, traffic signals, audible messages, dynamic warning signs and lights, and barriers/gates)
- Security issues (including personal security and injury prevention, site lighting, fencing and vegetation, and vandalism)
- Path surface treatments (including crossing surface materials and flange gap treatments)
- Non-infrastructure treatments (including education/promotion campaigns, enforcement, and crossing marshals)

The main crossing treatment options available for pedestrian/cycle rail crossings presented include:

- **Grade separation** – either via an overbridge or underpass
- **Automatic barriers** – active protection either via swing gates or raised boom barriers
- **Audible and visual warning** – active protection using flashing lights and bells or similar
- **Physical calming** – passive protection using chicane or maze layouts on approaches

- **Simple passive control** – passively protected crossing using signs and markings only
- **Removing (closing) or relocating** the crossing

In each case a basic description is provided of the treatment, examples of their application are given, and their respective merits (or otherwise) are discussed. Typical layout details for standard crossing treatments are also provided in the guide, although they should only be a starting point from which the additional guidance in this document and professional engineering judgment should be applied to modify them to suit.

New innovative approaches to slowing people down at level crossings and encouraging them to look towards approaching trains are included in the guide, using physical calming devices such as chicanes with hoops, and "Z" approaches. These are considered especially useful for cyclists and those using wheelchairs and other wheeled devices. KiwiRail will be seeking Council participation in further trials of such treatments in the New Zealand context.

Glossary of terms used in this guide

AADT: Annual Average Daily Traffic; a determination of the overall average numbers of users per day throughout the year, which allows for typical differences in observed numbers due to seasonal and temporal variations (e.g. day of the week, time of the year, public holidays). Although commonly used for motor traffic, similar AADT values can also be estimated for pedestrian and cycle numbers.

Active controls (or active warning devices): traffic control devices that are actuated when a train is approaching the crossing point to warn road/path users not to enter the rail crossing. They are generally fixed in place at the crossing point (e.g. bells, lights and barriers).

Active users: people who travel by a mode of transport that requires some human power input and provides some form of physical exercise. This includes people who walk (including those with a pushchair, wheelchair, walking stick or walking frame), cycle (including electric bikes) or ride devices such as skateboards, scooters or roller skates. The term is extended to include those who use mobility scooters or other low-powered mobility devices as these users have similar characteristics and use the same facilities. The nature of these modes means 'active users' are sometimes termed 'vulnerable users' although, in the case of trains, all crossing users are vulnerable to serious injury.

ALCAM: Australasian Level Crossing Assessment Model – a safety assessment tool used to help prioritise treatment of level crossings according to their comparative safety risk.

CAS: Crash Analysis System; NZTA's national database for reported road crashes.

Cognitive impairment: any condition of the brain that results in difficulties comprehending and assessing the rail crossing environment and the way information there is presented to users. This could include congenital or degenerative conditions, the results of serious head injuries, and limitations attributable to childhood development or temporary modifiers such as drugs and alcohol.

Cycle path: A facility, separated from the roadway, intended for the sole use of cyclists.

Cycleway: A generic term to describe any network route that provides for cycling, on-road or off-road. Some cycleways may be shared with either pedestrians or motor vehicles. A cycleway may not necessarily have specific cycle facilities, e.g. neighbourhood greenways.

Flange(way) gap: the gap between the rail and the adjacent crossing surface, to allow the train wheels to pass, which can be a hazard for crossing users, especially those with ***wheeled devices***, or where the flange has widened over time.

FLBs: Flashing lights and bells; a form of ***active control*** at railway crossings. Refer to section 5.4.1 for more details.

Footpath: a facility provided solely for pedestrians, with cyclists and motor vehicles being excluded.

Grade separation: when two transport modes are accommodated separately at different vertical levels, thus spatially disassociated. In the context of this guide, grade separation referred to involves separating active users from trains; this can be done either by underpasses or overbridges.

HABs: Half-arm barriers; a form of crossing treatment that physically stops users from crossing a railway line.

IRIS: Incident Recording Information System; KiwiRail's national database for recording train collisions and near-misses.

LCSIA: Level Crossing Safety Impact Assessment – a process developed in parallel with this guidance to assess the level of crash risk of existing and new/upgraded level crossings (for road and/or path users).

LCSS: Level Crossing Safety Score – the risk of crashes occurring at a level crossing used in the LCSIA.

Level crossing: a location where a road and/or path crosses a railway line at-grade (i.e. on the same level, without any grade separation). Sometimes referred to overseas as a “grade crossing”.

Mobility impairment: any condition that hampers a person’s ability to walk with the speed and agility that most able-bodied people can achieve. Some people may use a mobility device to assist them, e.g. wheelchair, walking frame, mobility scooter.

NZTA: New Zealand Transport Agency

Path(way): a facility provided for active users but specifically not for motor vehicles (i.e. distinct from the roadway). Different subsets of path are footpath, shared path and cycle path.

Passive controls (or passive warning devices): traffic control devices that are static, constant and present all the time, i.e. regardless of whether a train is present/approaching or no trains are present (compare with active warning controls, which do distinguish between these two situations). For example, warning signs, path markings and rumble strips. See section 5.3.

RCA: Road controlling authority; typically, a City or District Council (for local roads) or NZTA (for state highways). It may also include organisations that control other roads, such as Government departments (e.g. Department of Conservation) or private landowners.

Roadside crossing: a ***level crossing*** for ***active users*** located adjacent to a roadway level crossing (see Figure 1).

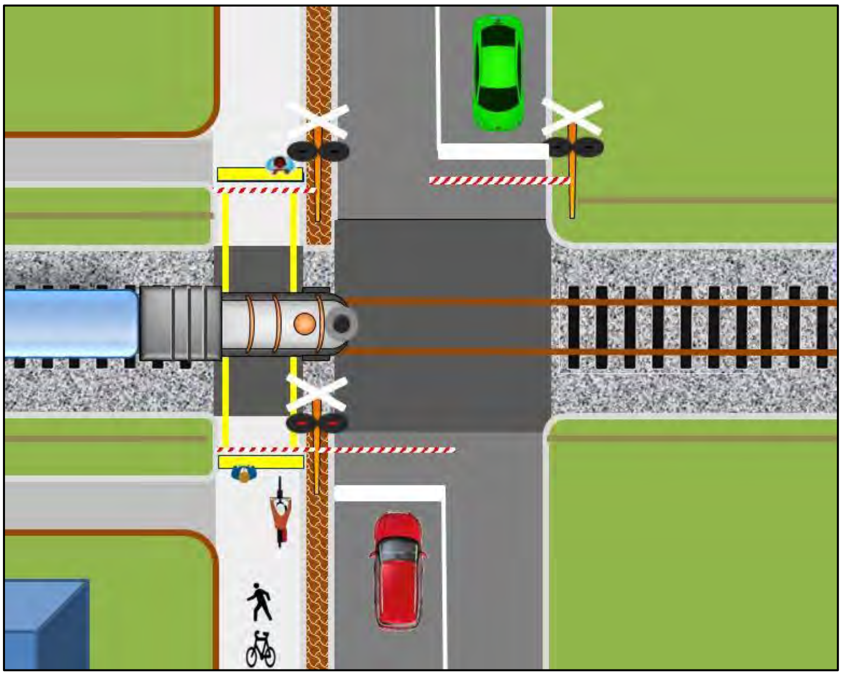


Figure 1: Single road-side crossing

Sensory impairment: a partial or total loss of one of the main human senses; usually either vision or hearing. This limits the ability of visual or audible devices to provide adequate warning to crossing users with such impairments.

Shared path: a facility, separated from the roadway, that is shared by pedestrians and cyclists.

Stand-alone crossing: a ***level crossing*** for ***active users*** where there is no adjacent road (see Figure 2).

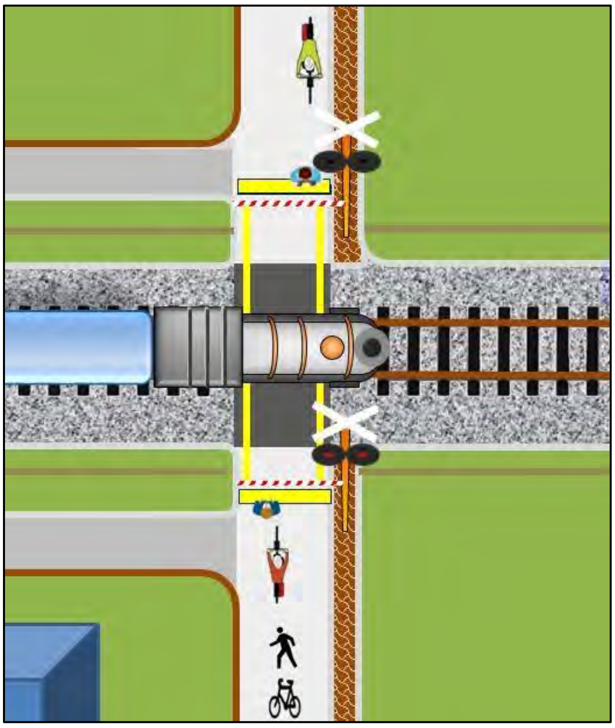


Figure 2: standalone crossing

Traffic: The users of a particular transport facility. This could be motor vehicles on a road, ***active users*** on a path or trains on a railway.

TCDM Part 9: The relevant section of the NZTA *Traffic control devices manual* (Part 9) that deals with ***level crossings*** (NZTA 2012).

TGSI: Tactile Ground Surface Indicators; i.e. textured pavement devices intended to provide guidance for vision-impaired users (see section 5.3.4)

Warning devices: any combination of ***active or passive controls*** used to make approaching users aware of the rail crossing and the presence of trains.

Wheeled device: a device for ***active transport*** that has one or more wheels. Including bicycles, wheeled recreational devices (skateboards, roller skates, kick-scooters etc), wheelchairs (manual and electric), segways, and mobility scooters.

1. Introduction

1.1. Background context

1.1.1. Existing policy and guidance

There is a currently lack of cohesive policy, information and guidance for pedestrians and cyclists at rail crossings in New Zealand, particularly level crossings. In general, information and guidance is better developed for roadway level crossings than for pathway level crossings.

Part 9 of NZ Transport Agency's (thereafter referred to as the 'Transport Agency', or 'NZTA' in relation to references) *Traffic control devices manual* ('TCDM Part 9') covers pedestrians briefly but is light on cycling facilities. NZTA's *Cycling Network Guidance* also has a gap for rail crossings.

As a result, while individual parties have no doubt endeavoured to design the best provision, the combined approach to choosing treatments has been *ad hoc*, and there is limited evidence that they've been based on a consistent or objective understanding of risk. In addition, there is an upwards trend in incidents with cyclists and pedestrians versus rail, whereas there is a downwards trend for incidents with road traffic versus rail.

The Urban Cycleways Fund and NZ Cycle Trail programme have accelerated a number of cycleways throughout the country that are in the process of being designed and constructed. Without clear guidance nationally, there is a risk of inconsistent provision for treatments at rail crossings along these routes, with the possibility that safety is compromised.

This background has led to the development of this design guide for pedestrian and cycle facilities at rail crossings, both alongside roadways and stand-alone.

This work is linked with another study undertaken for KiwiRail that developed a new risk assessment process for assessing the safety impacts of changes to all level crossings and how these might be mitigated. The resulting *Level Crossing Risk Assessment Guidance* (KiwiRail, 2017) is hereafter referred to as the "*Risk Assessment Guide*". It relates to all level crossings, not just those for pedestrians and cyclists.

The *Risk Assessment Guide* outlines the Level Crossing Safety Impact Assessment (LCSIA) process (also summarised in section 3 of this guide) that must be undertaken by qualified assessors and, in particular, is required for all upgrades to or new level crossings that are along or adjacent to a new cycleway or shared path. Designers and assessors should both understand the principles presented in this guide for rail crossings involving pedestrians and / or cyclists. LCSIA reviews are expected to highlight any significant problems or unacceptable risks with existing crossings or proposed crossing concepts and recommend suitable treatment solutions. However, they are still no substitute for good detailed design and subsequent safety auditing.

1.1.2. Pedestrian/cycle rail injuries and near misses in NZ

Figure 3 shows the number of pedestrians and cyclists who have been killed or injured at rail level crossings or locations on a railway line not near a crossing point *(note, this latter category constitutes trespassing, and can include self-harm cases)*. While there are relatively small numbers of pedestrian/cycle level crossing deaths and injuries from year to year, unlike motor vehicle crossing statistics they show no signs of reducing over time.

For the period of 2000 to 2015, over 60% of all recorded pedestrian and cycle collisions at rail level crossings resulted in a fatality. This proportion is much higher than for road crashes - data from the Ministry of Transport factsheets show that only 3% of pedestrian and cycle crashes on the road network result in fatality. This is also consistent with international patterns of rail crashes resulting in much higher severities than road crashes, especially for pedestrians and cyclists who are more vulnerable without protection systems. In practice, very few pedestrian/cycle collisions with trains are ever minor or non-injury.

Note that the data displayed come from IRIS (Incident Recording Information System) which is used by KiwiRail. An investigation of the CAS database would show few crashes of this nature, as no motor vehicles are generally involved.

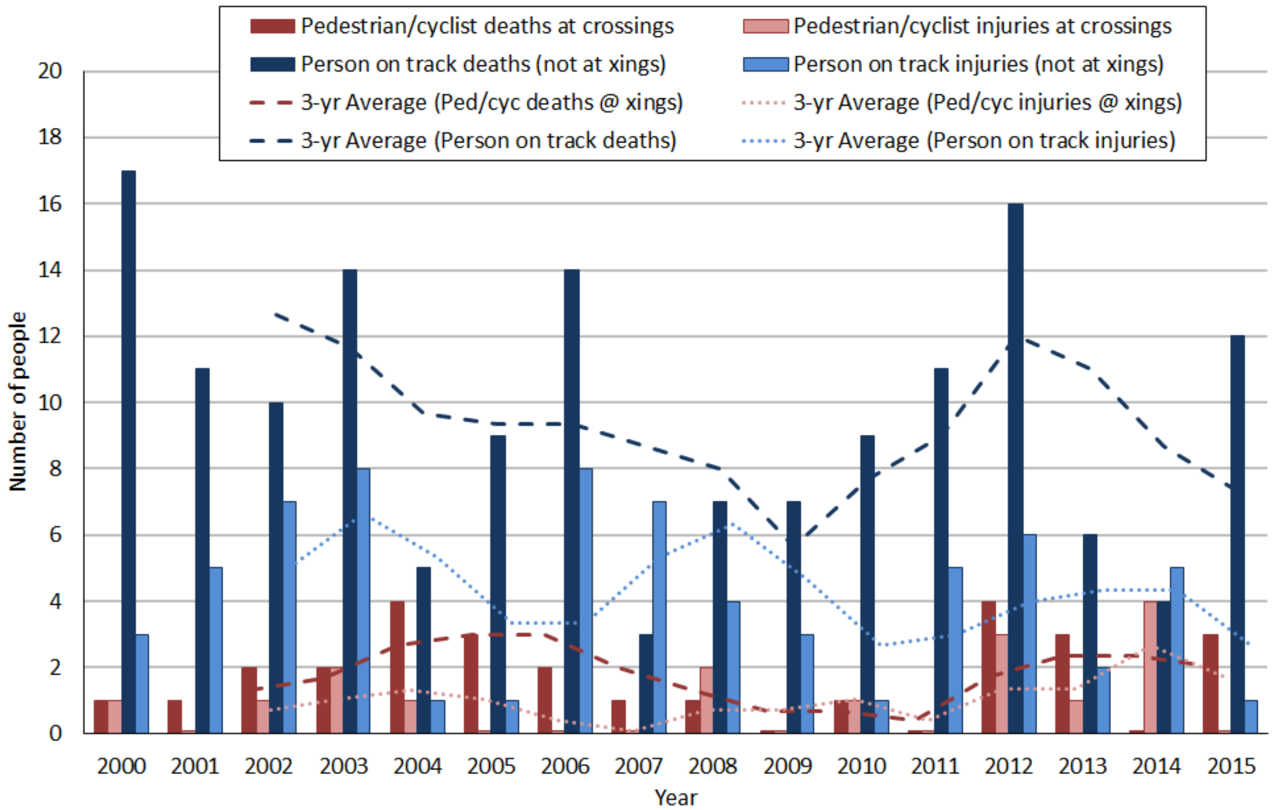


Figure 3: Pedestrian and cyclist rail crossing deaths and injuries in New Zealand, 2000–2015

IRIS also contains information on near-collisions, as shown in Figure 4:

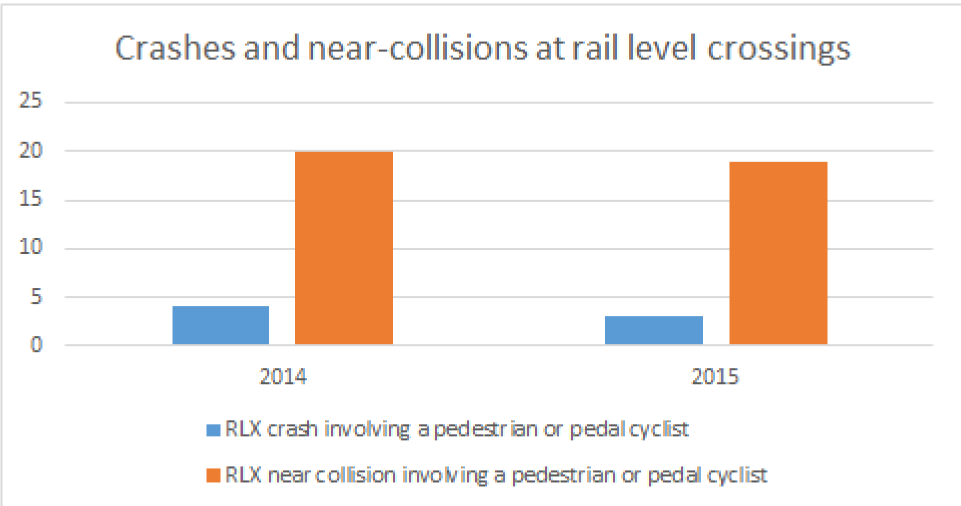


Figure 4: pedestrian and cyclist crashes and near-collisions at rail level crossings, 2014–2015

As indicated in Figure 4, in the period 2014 to 2015, there were about five and half times as many near-collisions reported as actual crashes.

KiwiRail (2016b) identifies that 52% of crashes involving active road users (pedestrians or cyclists) at rail level crossings occur at sites with half arm barriers and adjacent pedestrian crossings, whereas 30% occur at sites with lights and bells only. A number of contributing factors were identified: distractions, for example from using headphones or mobile devices; confusion from other trains; flange gaps; poor signage; user complacency; and (in)effectiveness of maze configurations. In particular, a growing number of pedestrian and cycle crashes feature users who are distracted and not paying attention to their surrounding environment.

1.2. Document scope

Figure 5 summarises the structure of this guide and the relationships between its various sections.

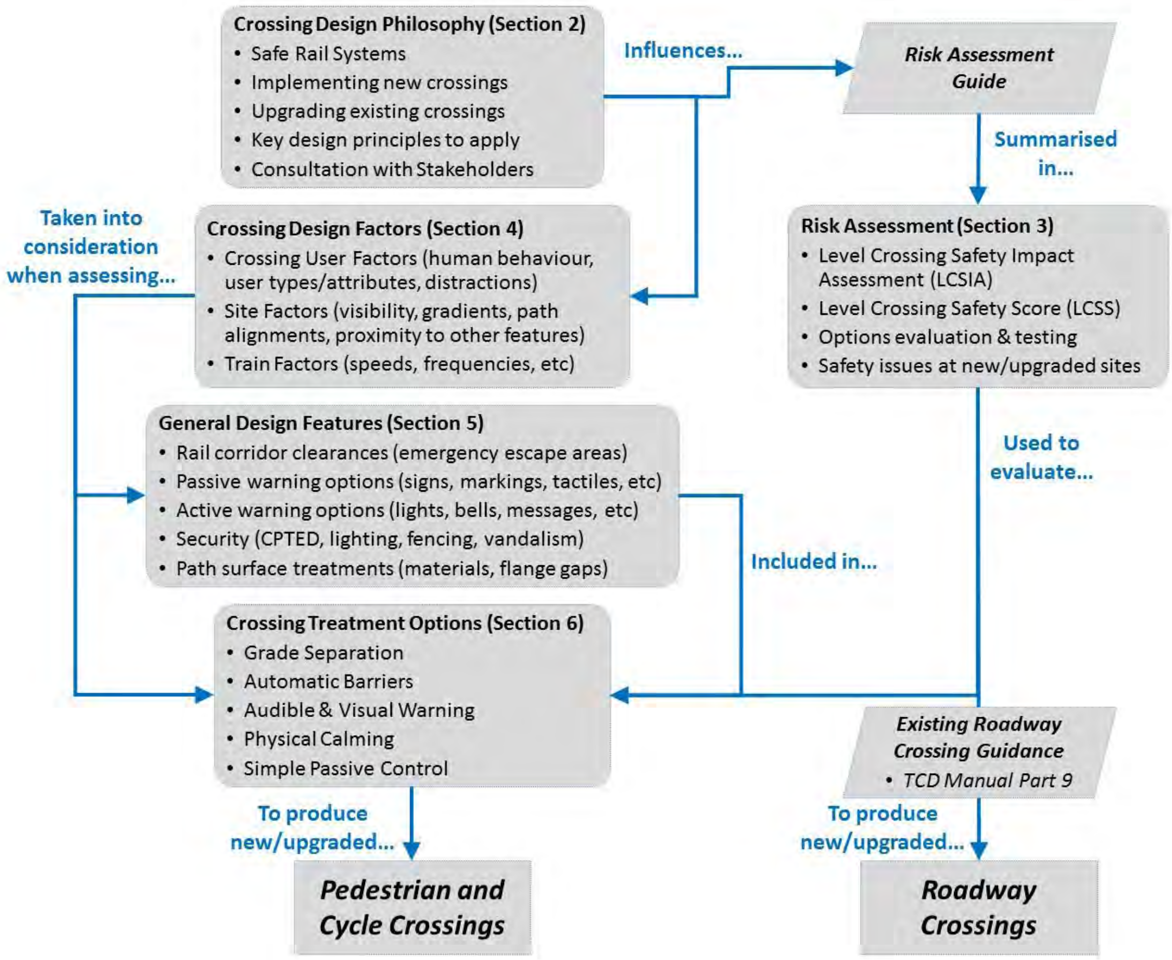


Figure 5: Structure of this guide

The design guidance is mostly limited to separate pedestrian/cycle crossings; the design of roadway level crossings is already covered elsewhere, e.g. *TCDM Part 9* (NZTA 2012).

The guide covers stand-alone pedestrian/cycle crossings (i.e. away from the road) and roadside pedestrian/cycle crossings (i.e. where the path is adjacent to the road). To some extent, on-road crossing provision for cycling is also covered, as the principles are the same, but designers should also refer to *TCDM Part 9* when providing on-road cycle lanes at level crossings. This guide asks users to consider ***all*** types of rail crossing options, including grade-separation and the potential to remove a crossing completely. However, most of this guide provides details about with treatments at level crossings.

As a general principle, design information in this guide tries to not repeat information that is common to **all** rail crossings, focusing instead on aspects that are **specific to pedestrian/cycle crossings**. Where necessary, reference is made to relevant documents elsewhere that contain further information.

This guide focuses on the design of **crossings** of the rail corridor; in general, it does not consider the planning and design of pedestrian/cycle pathways running ***along*** rail corridors. Any organisation that wishes to cross or use rail land for a cycleway or other shared path needs to obtain an appropriate agreement with KiwiRail. Please see KiwiRail's website for more information.

The *Guide for Applicants of Pathways in the operational rail corridor* (KiwiRail 2015) outlines the full process.

1.3. Other relevant information

Throughout this guide, a number of other documents will be referenced, where they produce more detail on specific matters, or background evidence regarding treatments and design features discussed. A list of all these references can be found in Section 8.

1.3.1. Relevant NZ legislation

The Railways Act 2005 ("the Act") defines the main obligations of rail operators and other participants in the rail corridor. Its main purpose is to promote the safety of rail operations and to clarify the law relating to management of the railway corridor. Following recent updates, it now also incorporates aspects of the Health and Safety at Work Act 2015.

When considering the safety of rail operations in the Act, a key concept is that of **"reasonably practicable"**, which is defined as:

In this Act, unless the context otherwise requires, reasonably practicable, in relation to a duty to ensure health and safety or to protect property, means that which is, or was, at a particular time, reasonably able to be done in relation to ensuring health and safety or the protection of property, taking into account and weighing up all relevant matters, including—

(a) the likelihood of the hazard or the risk concerned occurring; and

(b) the degree of harm or damage that might result from the hazard or risk; and

(c) what the person concerned knows, or ought reasonably to know, about—

(i) the hazard or risk; and

(ii) ways of eliminating or minimising the risk; and

(d) the availability and suitability of ways to eliminate or minimise the risk; and

(e) after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

The Act also defines "level crossings" to include both where *"a railway line crosses a road on the same level"* or where *"the public is permitted to cross a railway line on the same level"*. The latter can therefore include crossings that are only accessible by people walking or cycling.

Behaviour around level crossings by users is prescribed in Part 9 of the Land Transport (Road User) Rule 2004. The general requirements are that:

- A person approaching or crossing a level crossing must keep a vigilant lookout for any approaching rail vehicle using the railway line.
- A driver *[including a cyclist]* must give way to a rail vehicle using the railway line that is approaching and within 800 m of the level crossing.
- A person must not walk or attempt to walk across a level crossing when there is a risk of that person being involved in a collision with a rail vehicle using the railway line.
- A person must not ride, drive, or attempt to ride or drive a vehicle or animal on or across a level crossing when there is a risk of that vehicle or animal being involved in a collision with a rail vehicle using the railway line.

1.3.2. Discussions with KiwiRail

When planning to install or upgrade an existing rail crossing, it is important to make contact with KiwiRail early and often. A Level Crossing Safety Impact Assessment, Grant of Right and Permit to Enter are ***required*** before any works can take place. KiwiRail will liaise with you about:

- Technical feedback on proposed design treatments (designs must be reviewed and approved at 50%, 85% and 100% stages)
- Required rail corridor clearances (horizontal and vertical)
- Location of any assets or services within the rail corridor (e.g. fibre-optic cables)
- Previous site incidents or concerns identified by KiwiRail personnel
- Future rail corridor developments that need to be considered (e.g. double-tracking)
- Processes required to obtain the necessary approvals
- Opportunities for undertaking trials of new crossing treatments

The work to develop this new guidance has identified a number of new treatment options requiring further investigation and trialling. These include new chicane layouts, active warning signs and markings, and safer crossing surfaces. Road controlling authorities are encouraged to trial the new crossing designs, signs and markings that are presented in this guide but not currently in extensive use in New Zealand. KiwiRail and the NZ Transport Agency are supportive of these trials, and should be contacted to determine what designs or signs should be trialled, the requirements for formal trials, and any additional assistance they may be able to provide.

It is acknowledged that best practice in the field of designing level crossings for pedestrians and cyclists is still being refined and further work is needed to expand and amend the guidance currently provided in this document. Designers and road controlling authority staff are welcome to provide feedback to KiwiRail regarding the application and content of this guide. In particular, feedback should be directed to:

- Leah Murphy - Project Manager, Urban Cycleway Projects (cycleways@kiwirail.co.nz or Leah.Murphy@kiwirail.co.nz)
- Eddie Cook - Project Engineer, Level Crossings (Eddie.Cook@kiwirail.co.nz)

2. Crossing design philosophy

2.1. Safe rail systems

Rail crossings in New Zealand should be constructed and managed using the same "safe system" approach that is applied to other transport infrastructure. Namely, it is important to remember that:

- **Humans make mistakes** (but shouldn't be disproportionately punished for them)
- **Humans are vulnerable** to injury (leading to a focus on harm minimisation)
- **A shared responsibility is required** to address safety (incl. rail operators, road controlling authorities, system users, etc)

Applying this thinking to rail crossings involves considering the behavioural aspect of human interactions with crossings and applying appropriate infrastructure (e.g. engineering, vehicle technology) or non-infrastructure (e.g. education, enforcement) treatments to each site. A risk management process can be used to inform this; refer to the *Risk Assessment Guide* for more detail.

2.2. New and existing crossings

Development of rail crossings in New Zealand requires differing philosophies, depending on whether they are existing or new crossings, as discussed below. New risk assessment processes, described in the *Risk Assessment Guide*, will help to inform the choice of different treatment options.

2.2.1. New crossings

As per *TCDM Part 9* (NZTA, 2012), the provision of new level crossings is ***strongly discouraged***. Any new crossing ***must*** be designed with a **low or medium-low risk** from the outset (refer to the *Risk Assessment Guide* for details of the risk rating system) – this may require grade separation. KiwiRail has an application guide and process for new level crossings (KiwiRail 2016c); the final decision about whether new level crossings will be allowed rests with KiwiRail.

KiwiRail's policy is that, generally, a new level crossing cannot be installed across the rail corridor unless a level crossing of equivalent (or worse) risk is closed elsewhere. Adding completely new level crossings can only be done under exceptional circumstances, due to the potential for increased crossing risk and maintenance costs. This is consistent with the general principle to reduce the overall risk of level crossings across the rail network.

2.2.2. Existing crossings

The general principle for modifying existing crossings (or where they are across or adjacent to upgraded routes are connecting to them) is that the currently calculated risk ***must*** be reduced to a **low or medium-low risk** where possible or, at a minimum, not made any higher. This is currently KiwiRail policy; refer to the *Risk Assessment Guide* for further discussion.

For existing crossings that already have a high risk (refer to the categorisations in Figure 7), every effort should be made to reduce the crossing risk at the time of any modifications. Ultimately this may require grade separation or crossing closure to mitigate the risk.

In practice, due to their higher train frequencies and pedestrian/cycle numbers, most level crossings in the Auckland and Wellington metropolitan service areas would fall into this category.

2.3. Key design principles to apply

The following are some high-level principles to bear in mind when developing rail crossing options for people walking and cycling. The subsequent sections of the guide then provide some detail as to how these principles might be achieved.

2.3.1. Minimise the need for at-grade crossings

Good planning for walking and cycling routes includes asking whether the facility needs to cross the railway line at all, particularly on level crossings. For example, if a potential route requires crossing the railway corridor and then further on crossing back again, it might be worth exploring an alternative route option that stays on the same side of the rail corridor.

The first question that should be asked is whether grade separation is possible (in terms of practicality and cost proportionate to the risk).

2.3.2. Seek awareness (by users) of crossings and trains

People crossing the rail corridor at-grade should be made aware firstly that there is a rail crossing and secondly if any trains are approaching. This is particularly important when any of the following conditions are applicable:

- Crossing users are distracted by personal devices or other things, and not concentrating on the crossing task (increasingly common)
- The crossing is obscured on approach by obstructions such as vegetation, fencing, or buildings
- Approaching trains are obscured by physical obstructions or nearby distractions such as traffic noise
- Multiple trains approach a crossing at about the same time
- Crossing users approach the crossing at speed, requiring time to react and stop

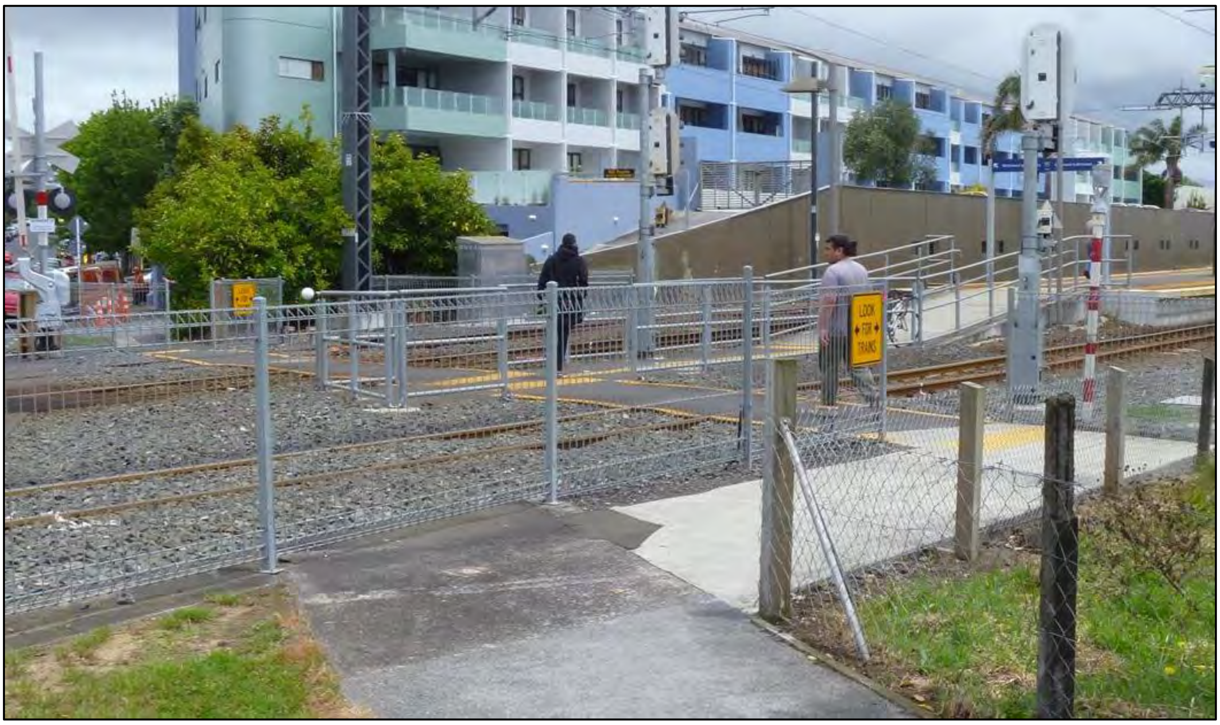


Figure 6: Crossing users need to be aware of any oncoming trains

2.3.3. Seek compliance by users when crossing

Having been made aware of the presence of approaching trains, the design of the crossing should encourage users to comply with the requirement to stop and wait until the danger has passed. A number of studies show that this is not an easy task, as different users have different levels of risk-acceptance and seek information from different sources (including past experience).

The type of path involved at the crossing (e.g. footpath, shared path or cycle path) influences the types of users and their characteristics. The choice of treatment should consider how best to encourage compliance by the predominant user type(s) expected.

2.3.4. Provide for safe, accessible and practical use by all user types

Many rail crossings will be used by a wide variety of people using different travel modes and with varying ages and abilities. It is important that crossings allow for this variety in their design, including consideration of the physical, cognitive and sensory abilities (or otherwise) of different users, and the vehicles or devices they may be using to assist them. If a particular crossing is not safely or conveniently useable by a particular group, then a suitable alternate crossing should be reasonably nearby, and clearly identified. Planning and design should also consider the numbers and dominant types of crossing users (including at peak times).

2.3.5. Provide appropriate and consistent treatments for the actual level of risk

National and local government policies are encouraging greater use of active modes and it is important to consider ease of use alongside safety at crossing treatments. Otherwise, unreasonable impositions on users may inadvertently discourage active travel. For crossings with similar attributes and a similar level of calculated risk, it is preferable for the same type of crossing treatment to be used throughout the country. This promotes better legibility by users and fairness across the different local authorities. Determining crossing risk levels in an objective, consistent, quantifiable manner should also minimise the use of overly conservative or overly incautious treatment options, as may have previously been developed due to historical practice, practitioner bias, or previous incidents.

2.3.6. Crossing treatments should be maintainable

The operational costs and practicalities of any proposed treatments (for both KiwiRail and the adjacent landowner or local authority) should be manageable. This includes taking into consideration the potential for vandalism or equipment deterioration.

2.4. Consultation with stakeholders

Throughout the planning and design process, rail crossing designers ***must*** ensure that they receive feedback from a wide range of stakeholders. This should result in a higher quality solution, which addresses the needs and issues of the different users.

Consultation can occur at the network planning stage (i.e. when identifying high-priority sites of concern), the conceptual design stage (i.e. when different treatment options are being considered) and at the detailed design stage (i.e. when specific features and layouts are being finalised). Parties to consult could include:

- Local walking advocates (e.g. Living Streets Aotearoa)
- Local cycling advocates (e.g. Cycling Action Network and their local groups)
- Mobility advocates (e.g. Blind Foundation, CCS Disability Action, Deaf Aotearoa, Blind Citizens NZ)
- Local institutions, services and facilities (e.g. schools, rest-care homes, community centres, recreational facilities)
- Local residents and businesses
- Where relevant, motoring organisations (e.g. Automobile Association, Road Transport Association)
- Road Controlling Authority staff
- KiwiRail staff (refer to section 1.3.2)

Planning and design reports should summarise what consultation has been undertaken, the feedback received, and how it has been responded to.

3. Risk assessment

3.1. Introduction to risk assessment

In conjunction with this guide, a new KiwiRail Level Crossing Safety Impact Assessment (LCSIA) developed to better understand the crash risk at level crossings and the issues that need to be addressed to make the crossing safer for all road users. This is detailed fully in the separate *Risk Assessment Guide* and summarised here in this section.

3.2. Level Crossing Safety Impact Assessment

The Level Crossing Safety Impact Assessment (LCSIA) process has been developed to assess the level of crash risk of existing and new/upgraded level crossings designs. Introduction to the LCSIA process is being provided through industry training and assessor certification workshops. KiwiRail accredited assessors are required to be involved in all safety reviews of new and existing crossings.

The LCSIA score involves five risk bands ranging from low (0-10 points) to high (50-60 points), as outlined in Figure 7:

Figure 7: Level crossing safety score risk bands

3.3. Level Crossing Safety Score

A key component of the LCSIA is the Level Crossing Safety Score (LCSS) which builds on the traditional **ALCAM** model (developed in Australia), adding historical crash and incident data, safety observations made by locomotive engineers and RCA engineers, and a more detailed site assessment of the impact of the surrounding transport network and land-use.

LCSS has a maximum value of 60, which denotes a very unsafe crossing. This score consists of the following risk rating elements:

- ALCAM Score (30 points);
- Crash and incident history – from IRIS, CAS and KiwiRAP (10 points);
- A site-specific safety score (factors not covered adequately in ALCAM) (10 points); and
- Locomotive engineers' and RCA engineers' observed assessment of risk (10 points).

The assessment is undertaken for vehicle and pedestrian/cycle crossings separately. For new crossings and modified level crossings the LCSS ***must*** involve a site visit.

The overall LCSS ranking of the ***existing*** crossing (where applicable) is calculated by adding together all four risk rating elements. The process is then repeated to provide an LCSS of any ***proposed*** conceptual design of a new crossing to see if it scores 'Low' or 'Medium-Low'. Should the assessor recommend other necessary treatments/modifications or changes that should be made, another LCSS should be conducted on the ***modified*** design to see if the LCSS reduces further. An LCSIA also considers what the ***future*** LCSS will be, taking into account predicted growth. The assessor will then conclude their report by stating the necessary form of control required in order to keep the safety risk at acceptable levels. KiwiRail will then use this assessment to the applicant what level of control they require.

3.4. Options evaluation

There are two major reasons that motivate safety improvement works at level crossings: where a crossing has a 'High' or 'Medium-High' level of risk and KiwiRail has prioritised the site for upgrade; or where there is a significant change expected at a level crossing that will impact on safety.

In many cases, the upgrade option will also include other changes not directly associated with improving the safety of the level crossing, e.g. a major upgrade to the adjoining intersection, or the provision of a new shared pedestrian/cycle path across the railway line. These changes may impact on the safety of the level crossing and need to be evaluated alongside the safety changes to the level crossing itself (e.g. installation of barrier arms). Overall, the intention should still be to reduce the risk of the roadway crossing to 'Low' or 'Medium-Low'.

3.5. General safety issues identified

As for a safety audit, the LCSIA safety assessors are to identify any safety issues at the current crossing. At this stage, the safety review won't be considered a formal safety audit. But in the future, it may be adapted to meet all the requirements of a safety audit.

Any suggested changes to the proposed design should be rated in the same manner as in a safety audit, along with a decision-tracking process whereby the designer, safety engineer, the RCA and KiwiRail can agree on whether or not the change should be made.

3.6. Recommendation on approving crossings or not

A recommendation will be provided based on the criteria specified for the LCSS. To satisfy Criterion 1, the level crossing safety score must be 'Low' or 'Medium-Low'. Additional treatments will be considered in the analysis to determine if these criteria can be met.

Where Criterion 1 cannot be satisfied, then an assessment would be made on whether the crossing upgrade meets Criterion 2 (this criterion does not apply to new crossings). The first element of Criterion 2 is that the ALCAM score and LCSS of the upgraded crossing is ***not worse*** than the existing crossing. The second element requires evidence that the upgrade needed to meet Criterion 1 (e.g. grade separation) involves a very high cost to construct a "Low" or "Medium-Low" facility, or the physical space available to provide such a facility is limited (e.g. considerable land purchase).

In any event, ***all*** serious and significant safety issues identified by the assessors during the site visit need to be addressed (i.e. either removed or reduced to a lower risk level). Should the KiwiRail Level Crossing Safety Manager agree to do otherwise, such exceptions ***must*** be clearly documented with adequate justification and reasoning. Any unaddressed 'moderate' safety issues and the reasons these cannot be addressed also need to be discussed with KiwiRail and the relevant RCA.

4. Pedestrian/cycle crossing design factors

The design aspects of rail crossings for pedestrians and cyclists fall under three general categories:

- The crossing users (i.e. people walking and cycling)
- The nature of the site itself
- The train movements at the crossing

The following sections describe the various attributes under these three categories that influence crossing design. Each site has unique aspects related to these attributes, and thus it is important that crossing designs are site-specific, rather than just copying standard layout designs.

4.1. Crossing user factors

Understanding the nature of people crossing the railway corridor is an essential part of producing a crossing design that works in both a safe and efficient manner. Some of these aspects are common to people at all sites, while others are specific to certain locations. Observation of actual site behaviour is important to understand issues to be resolved.

4.1.1. Human behaviour: awareness and compliance

The key design principles (section 2.3) indicate two key behavioural challenges in crossing design:

- **Awareness** by users of both the crossing itself (and how to negotiate it) and approaching trains
- **Compliance** by users with indicators requiring them to stop and wait until a train has passed

The first point is largely in the psychological realm of cognition and perception, although it is also influenced by issues such as **distraction** (an increasing problem – see section 4.1.8).

The second point deals with human volition (i.e. choice of action) and may be influenced by demographic and physical attributes of the users, as well as past experiences at crossings.

Humans are prone to inadvertent mistakes or errors of judgment, but can also choose to make deliberate violations of legal or expected behaviour. Both types of behaviour are often observed at rail crossings, although one or the other may be more prevalent at a particular site. Deliberate user actions may be influenced by time pressures, copying others, desire for risk-taking, or other motivations.

Different people have different **perceptions of risk** regarding the same hazard; this is partly physiological and partly based on people's prior experiences. Younger people, for example, often have much lower perceptions of the relative risk of a situation (especially if they have never had a dangerous crossing encounter) and are likely to act accordingly. However, various studies (e.g. Searle *et al* 2012, Mulvihill *et al* 2016)) have concluded that most level crossing users inadvertently engage in risky behaviour. Sometimes engineering countermeasures intended to improve decision making (e.g. flashing lights), may have the ***opposite*** effect for some people because the additional information provides a high level of flexibility for circumventing the desired behaviour.

Social interactions can affect a user's decisions to comply; for example, a pedestrian may feel pressured to walk through the emergency escape gate to access the tracks because another pedestrian has held it open for them. People will often use cues other than the "official" warning devices at a crossing site to decide their behaviour, such as simply tailing the movements of other people in front of them or following well-worn routes to informal crossing points.

It is therefore important to observe human behaviours at rail crossings to identify informal desire lines that may contradict "official" walking and cycling paths. Figure 8 illustrates the type of behaviour to consider. A cyclist coming out of the side road and wishing to access the cycleway to the north may elect to use the north-side footpath as a short-cut to getting to their destination, despite it being technically illegal to do so. Crossing design may need to consider whether sufficient warning is also provided for higher speed cyclists coming from this "contra-flow" position.

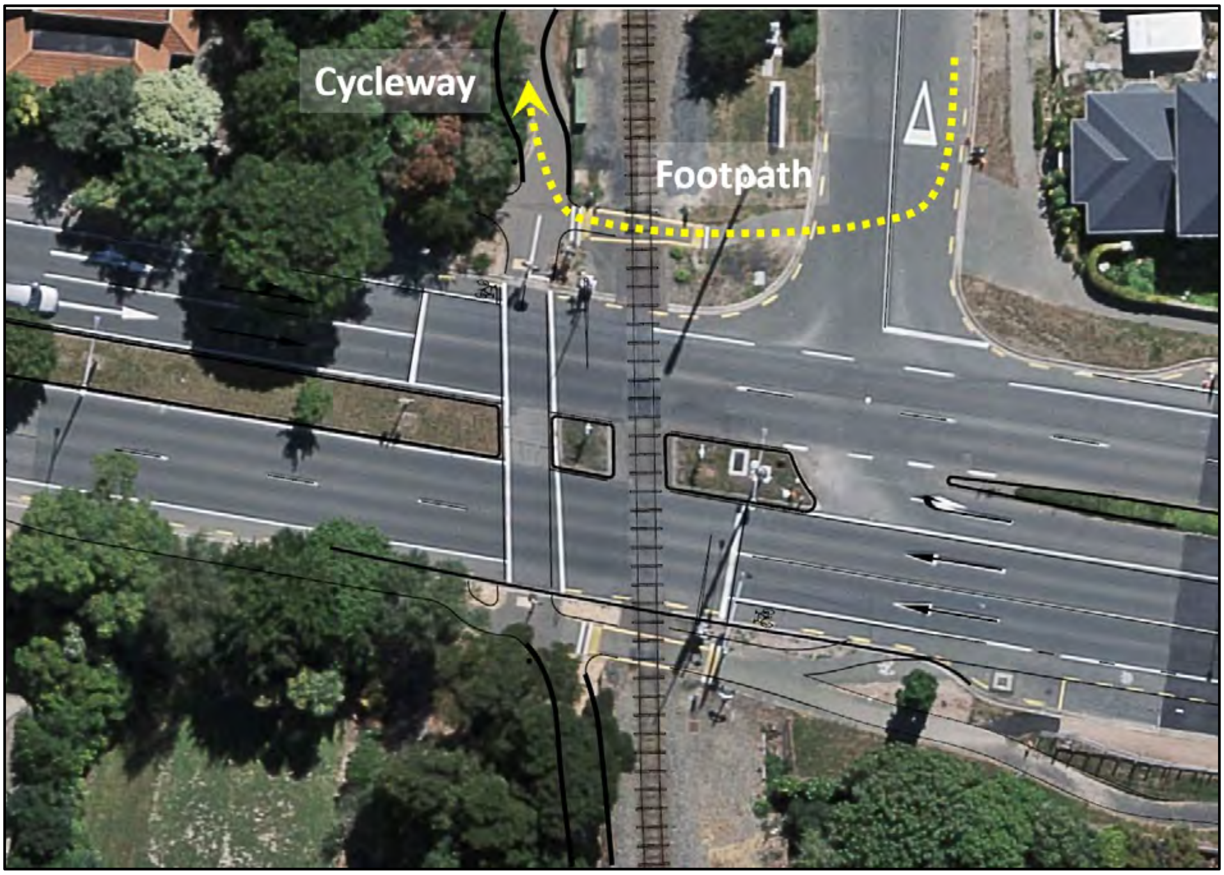


Figure 8: Example of an informal desire line

4.1.2. Frequency of users

To assess the likely risk at a crossing site it is critical to get good estimates of the numbers and types of people walking and cycling there, both now and in the future. If a crossing is being created or upgraded as part of an adjacent route improvement (e.g. new pathway), efforts need to be made to estimate the likely numbers immediately following the improvement and for the foreseeable future (e.g. 5–10 years). Otherwise a site may require further upgrading or suffer from poor levels of service soon after it is commissioned. Post-implementation counts at least 6 months after installation should be undertaken to confirm estimated changes (see the *Risk Assessment Guide*).

There are a number of ways to estimate the likely numbers of existing users:

- A video camera could be mounted above the site for a period of time and the resulting footage then viewed to determine counts *(video also has the advantage of being able to identify different user behaviours and actions, e.g. non-compliant movements)*.
- Automated count equipment could be installed and monitored, e.g. rubber tubes, inductive detector loops, infrared beam counters *(note that different technologies may be required to accurately capture both pedestrian and cycle numbers, and further note that video technology is also in use for automated counting)*.
- Surveyors could manually observe and record crossing movements during the peak periods.

Different methods can be more suited to different types of users. If counts of multiple user types are required, it may be necessary to employ a combination of counting methods (e.g. infrared beam counters plus inductive loops to distinguish cyclists form pedestrians).

Care needs to be taken with monitoring equipment left unattended to ensure that vandalism and theft of the equipment is discouraged (e.g. by placing it in obscure or inaccessible locations). Advice on best-practice methods for collecting pedestrian and cycle data can be found in Ryus *et al* (2014) and Figliozzi *et al* (2014).

Automated continuous counts observed over a period of at least a week are desirable, to account for variations by time of the day and day of the week. Even then, it is important to account for seasonal variations due to weather/temperature, school/tertiary holidays, etc. However, short-term surveys undertaken at peak times (including school finish time if applicable) are useful in their own right (and are practically necessary for manual surveys) to help understand maximum typical crossing flows, which has implications for crossing capacity, delays and available storage/queuing space. When shorter survey periods are used, some form of scaling factor will be needed to produce good estimates of daily demand. NZTA has a cycle count scaling spreadsheet to assist with estimating cycle counts; refer to *Technical Note TN003* (NZTA 2016). Further guidance is also provided in the *Risk Assessment Guide*.

If sites have both roadway and path components, it is useful to understand the typical split of users using each facility. Bear in mind that, even if not legal, there may be cyclists using some footpaths.

It is useful to identify whether peak flows are tidal (i.e. mostly in one direction) or more evenly distributed. This will help to determine whether narrow crossing treatments such as mazes may create additional delays and congestion, due to users having to wait their turn to cross.

Estimating the types and volumes of future users is a much more difficult task, often requiring specialist advice in demand estimation (e.g. Kuzmyak *et al* 2014, FHWA 1999). If in doubt, it may be prudent to *over-estimate* likely growth, so that any potential crossing improvement works are suitably foreshadowed in time. Sensitivity testing of expected numbers can also help identify whether a different treatment might be warranted. Alternatively, regular ongoing count monitoring may be necessary to discern actual trends in numbers.

If there are temporary increases in numbers (e.g. for a one-off event or a temporary diversion), consider whether temporary traffic control is needed to manage the increased crossing risk.

4.1.3. User age and type

Different crossing locations may experience a predominance of different groups of users, and this should be accounted for in the crossing design. Nearby land uses and connected walking/cycling routes may inform this, or data may be collected from site observation.

It may also help to understand the predominant types of crossing users when designing the site, e.g.

- Sites near to schools, tertiary institutions, or other places where younger people are more likely to congregate may need to consider greater likelihood of distraction, risk-taking, or non-compliance. There may also be a higher proportion of small-wheeled devices such as skateboards and scooters used. Children may have limited height to see over barriers or to notice warning devices located up high. They may also have limited strength to operate a manual barrier.
- Sites near elderly care centres or facilities for people who have impairments (e.g. Blind Foundation) may need to consider additional sensory warning treatments and adequate provision for mobility devices.
- Sites located on major urban cycle routes may need to account for greater numbers of riders trying to get through at peak periods and to consider issues of storage space (while trains pass) and manoeuvrability.

Note that it is not necessary to design crossings for all unintended users. For example, rail crossings at footpaths (which are not intended to be used by cyclists in general) do not have to be designed to accommodate cyclists in general (apart from those legally allowed to ride on the footpath, under the Road User Rule). Roadway level crossings, however, should be designed with on-road cyclists in mind, even if the road does not include marked cycle facilities. A design statement that specifies the "target users" or dominant users of the site is useful to ensure that all parties involved in crossing design development and review understand the reasons for the design choices made.

4.1.4. Trip purpose

Compliance with rail crossing treatments may be influenced by trip purposes. Users who have a utility purpose for their trip (e.g. commuting to work, accessing a nearby train station) may be less inclined to comply with train crossing warnings if they are going to be delayed, unless there are stronger physical cues. Conversely, users undertaking recreational trips (e.g. cycle tourists, recreational walkers) may be content to wait when active train crossing warnings are implemented. However, such generalisations shouldn't be expected to apply to all users, and it is usually important to observe existing behaviour where possible to identify site-specific issues.

4.1.5. Physical/sensory/cognitive impairments

Approximately 15-20% of pedestrian users, and a lesser proportion of cycle users, may have some form of impairment. They can typically fall into three general categories:

- People with **physical impairments** (including temporary and short-term) have difficulty moving unassisted and may require an aid such as a walking stick or walking frame, or a device such as a wheelchair or mobility scooter. These people are likely to move slowly across the crossing. Some normally physically mobile adults may also be physically hampered either by a temporary impairment (e.g. broken leg) or short-term constraints (e.g. carrying children or groceries, pulling wheeled cases).
- People with **sensory impairments** have partial or total loss of hearing and/or sight. They may therefore be unable to react to the conventional rail warning lights and bells. Note that it is reasonably common that when people have vision impairment that they also have a hearing impairment.
- People with **cognitive impairments** have some reduction in the normal ability to think and process the tasks required to safely negotiate a crossing. Some may be adults with an intellectual disability; children can also fall under this category when their perception and decision-making capabilities have not yet been fully developed. Normally able-bodied adults can also act in a cognitively impaired manner when under the influence of alcohol or drugs; this may be pertinent when a crossing is located near public entertainment and hospitality venues.

Any surveying of a crossing site should attempt to identify proportions of impaired users (and whether this differs from expected numbers via other national/local surveys); this is particularly important where there are land uses nearby that may attract greater than average proportions.

Not all crossing users may be fluent English speakers. Where possible, signs and markings should not rely solely on written words, and make use of pictures or symbols to illustrate the warning message or intended behaviour.

4.1.6. Speed of different users

There is quite a range of variation in typical travel speeds for pedestrians and cyclists; while some of the former group may struggle to walk at 2 km/h, some of the latter group can travel in excess of 40 km/h. These speeds may also be increased or decreased by approach gradients.

Speed affects the distance available to react and respond to the presence of a rail crossing and any trains. Crossing approaches with poor sight distance may need faster users to slow down, in case they need to come to a sudden halt, and should be designed accordingly. Advance warning signs and markings may also be warranted to alert higher-speed users as they approach.

Typical design speeds to consider are:

- Mobility impaired pedestrian: 3–4 km/h (0.8–1.1 m/s)
- Normal able-bodied pedestrian: 4–6 km/h (1.1–1.7 m/s)
- Mobility scooter user: 6–16 km/h (1.7–4.4 m/s)
- Skateboard/scooter user: 10–15 km/h (2.8–4.2 m/s) *{NB: electric devices may be faster}*
- Novice/child cyclist: 12–18 km/h (3.3–5.0 m/s)

- Adult commuter cyclist: 20–25 km/h (5.6–6.9 m/s)
- Fit road cyclist (or electric bike user): 30–35 km/h (8.3–9.7 m/s)

Designers should consider the context of the site and the users present when selecting the appropriate design speeds to use (e.g. proximity to a school or rest-home). If unsure, it may be appropriate to observe and time the existing users.

4.1.7. Cycle and mobility device constraints/limitations

Many wheeled devices are much longer or wider than a typical standing human; this has issues when considering manoeuvring through maze, barrier or chicane treatments or when providing adequate storage space. There may also be congestion/delay problems if there are a large number of these users during peak periods (e.g. a major cycleway route).

Mobility users who rely on using their hands to control their devices may also struggle to operate some barriers such as swing gates; some users may also have very limited strength or reach to operate a manual barrier. The location of any push-buttons or latches for barriers also needs to be done with consideration of the height and reach of mobility device users and suitable identification by vision-impaired users.

Some typical device dimensions (incl. clearances) are:

- Tandem/twin stroller/pram: 1.4m L x 0.8m W
- Standard bicycle: 2.0m L x 1.0m W
- Tandem, recumbent, cargo bike or bike with trailer: 2.4m L x 1.1m W
- Manual wheelchair: 1.3m L x 0.9m W
- Powered wheelchair: 1.6m L x 0.9m W
- Mobility scooter: 1.7m L x 1.1m W

Larger wheeled devices may also have large turning radii, making it difficult to negotiate tight treatments like mazes. This could cause people to fall off or have to dismount. It might also lead them having to concentrate on navigating a maze that is too tight, distracting them from what should be their primary task – observing oncoming trains.

Small or narrow wheeled devices are prone to getting caught in the rail flange gaps if these are not properly protected; refer to section 5.7.2 for further details. All users may also be vulnerable to slipping on the smooth surface of the rail tracks (especially in the wet).

Unless stated, the design plans provided in this guide generally provide adequate room for manoeuvring by all of the above devices (although there may not be room for two-way travel). If there is concern about a constrained design layout, consider testing it first by mocking up the layout on an open space using temporary barriers and getting different devices to try using it.

4.1.8. User distractions

Increasingly, many crossing users are engaged in using interactive devices such as mobile phones, handheld games, and music players while travelling. Users may also be using earphones or headphones (sometimes with noise-cancelling technology) to listen to their devices. These devices have great potential to divert attention from the rail crossing and to mask the presence of trains. The use of distracting devices like this have been cited in a growing number of fatal and serious train incidents in New Zealand involving pedestrians and cyclists, e.g. use of earphones and mobile phone was considered a likely factor in the 2015 pedestrian fatality at the Morningside Drive railway crossing (Transport Accident Investigation Commission, 2015).

Users focused on their hand-held devices have a tendency to look down, only occasionally glancing up at their surrounds. Therefore, it may be sensible to consider additional warnings at ground level (e.g. painted markings or in-ground LEDs) to catch their attention. Approach treatments involving barriers or a deviating path may also force people to look up to assess their forward progress.

4.1.9. User familiarity and complacency

User behaviour near rail crossings is often influenced by their previous experiences at such sites. This is particularly the case at sites with extremes of train frequencies:

- Locations with frequent regularly scheduled trains may create problems if some users expect a train to arrive at a consistent time and it turns out to be earlier or later than that.
- Locations with multiple trains commonly passing close in time to each other may require extra warnings to alert users who, having waited for the first train, are not expecting a second train.
- Locations with very few train movements (e.g. sites with monthly private excursion trains only) may result in users not expecting to see any trains based on their usual absence.

In either case, it is important that crossing designers provide active warnings or strong messaging to get people to check for trains before crossing. For example, a "TRAINS RUNNING" warning sign (see Figure 9) could be employed when an infrequent service is operating.

Figure 9: T235 sign

4.2. Site factors

Rail crossing sites have a number of attributes that can help or hinder their safe and efficient operation. Some of these attributes may influence people's behaviour near the crossing and should be accounted for in designing the crossing treatment.

The crossing site can be subdivided into five specific sections:

1. ***Approach*** – where the path user can first see the railway line and crossing
2. ***Transition*** – where the path converts from the midblock layout to the storage, often involving some sort of speed reduction or warning measures to alert users.
3. ***Storage*** – where path users can wait and look for approaching trains before crossing.
4. ***Traverse*** – where the path user physically crosses the railway line.
5. ***Departure*** – the path after the railway line crossing, connecting to the next midblock section.

Each section needs to be adequately catered for in the planning and design of a crossing. KiwiRail's *Track Standard for Level Crossings* (KiwiRail 2016a) provides some guidance on what to check for.

4.2.1. Roadside versus stand-alone crossings

Crossings for people walking and cycling to cross the railway corridor may be either:

- In conjunction **with a roadway** crossing – i.e. involves one or more footpaths, shared paths or cycle paths situated immediately next to the roadside (or, for cyclists, a cycle lane included on the road itself - covered under *TCDM part 9*).
- A **standalone** crossing –solely for active transport users, away from the road corridor.

Equity of adjacent crossing treatments is an important principle. If a roadside pedestrian/cycle crossing is made prohibitively difficult to negotiate for many users, it will not be surprising if some elect to cross via the less-constrained roadway instead, which could introduce additional traffic safety risks. Conversely, busy road crossings often have barrier arms across the traffic lanes but none across the adjacent path, which could encourage active users to cross even when a train is approaching. Where there is an inequity in adjacent crossing treatments, designers should consider making the 'easy' alternative less attractive.

Roadside crossings typically have warning equipment on each side focused on alerting the drivers coming from the normal two-way road direction, i.e. drivers approaching a crossing typically see warning devices facing them on the left-hand side of the road. If the adjacent pathway allows two-way walking/cycling (or it is reasonable to expect that contra-flow users may access the pathway), it is critical that these users also receive the same messages in both directions.

Stand-alone crossings are often away from the natural surveillance of roads and other land uses. Therefore, more effort may be required to ensure that they are considered safe to use by most people, and to remove the opportunity for vandalism. These factors may even play in role in determining the exact siting of a new crossing.

4.2.2. Public versus private crossings

While about half of New Zealand's rail crossings are along road or public reserve corridors under the control of local authorities or Government departments, there are also many crossings that provide a link over private land (e.g. road access to a farm). These could also include walking/cycle trail crossings for routes that traverse private land.

Generally, the same design principles apply to private crossings as for public crossings. Although their usage may be less (both in terms of users and possibly trains), risks still exist and need to be accounted for.

4.2.3. Visibility of crossings and trains

Many crossing sites may suffer from a variety of environmental conditions that limit approaching people's awareness of the site itself or the presence of trains. Such features include:

- Glare from the sun when low in the sky or in full and direct sunlight may blind users either to the presence of the crossing or trains in one direction
- Masking of the crossing or approaching trains by topography, vegetation, fencing, buildings, poles, signage, etc
- Shading of the crossing point in bright sunshine due to nearby trees
- Poor visibility in fog/rain/snow
- Poor night-time visibility of the crossing point

Some of these issues can be mitigated by design and maintenance; for example:

- Additional warning devices (signs, lights, etc) on approach
- Orienting approach paths to allow viewing the crossing from multiple angles
- Trimming back or removing trees and vegetation, hills, fences, etc
- Relocating buildings, poles and other structures
- Additional lighting (possibly on during the day) to highlight the crossing point

Because of the transient nature of some of these issues, identifying them may require on-site inspections at different times of the day and in different lighting conditions.

4.2.4. Sight distances

{Refer also to Appendix B in TCDM Part 9 (NZTA 2012)}

Level crossing sites require sufficient sight distance along the tracks to enable:

(1) a person approaching to identify the crossing point in time to ***slow down and stop*** at the limit line; and

(2) a person already stopped at a crossing to be able to ***restart moving*** and safely cross before a train arrives.

These two scenarios are discussed below.

Scenario (1) – Safe stopping on approach

While approaching the crossing at speed, the minimum user **stopping distance *S*** (metres) to the crossing limit line (or location of any physical barrier) depends on:

- the maximum likely speed (km/h) of an approaching user, V_A *(see section 4.1.6 for more discussion on this)*
- the minimum likely deceleration (proportion of *g*) of an approaching user, ***d*** *(typically normal safe deceleration for bicycles in wet conditions is about 0.25 g)*
- the gradient (metres gained per metre) of the path approaching the crossing, ***G*** *(positive values are climbing towards the crossing)*
- the maximum assumed reaction time (sec) for people to assess that it is not safe to cross, R_T *(normally 2 s, unless the site has additional complexity)*

The minimum stopping distance ***S*** is:

$$S = \frac{R_T . V_A}{3.6} + \frac{V_A^2}{254(d+G)}$$

This is the distance for which it is necessary that the crossing point is visible to the approaching user. If it is not possible to provide this distance, a treatment that requires users to slow down on the approach could be employed. If there is a physical control prior to the crossing (e.g. a maze) potentially requiring users to significantly slow down, then there also needs to be sufficient sight distance to see this and take appropriate action. Figure 10 illustrates two examples of this scenario, where the approaching user has adequate or inadequate sight distance to see the rail crossing in time to stop safely, from a distance ***S*** away from the crossing.

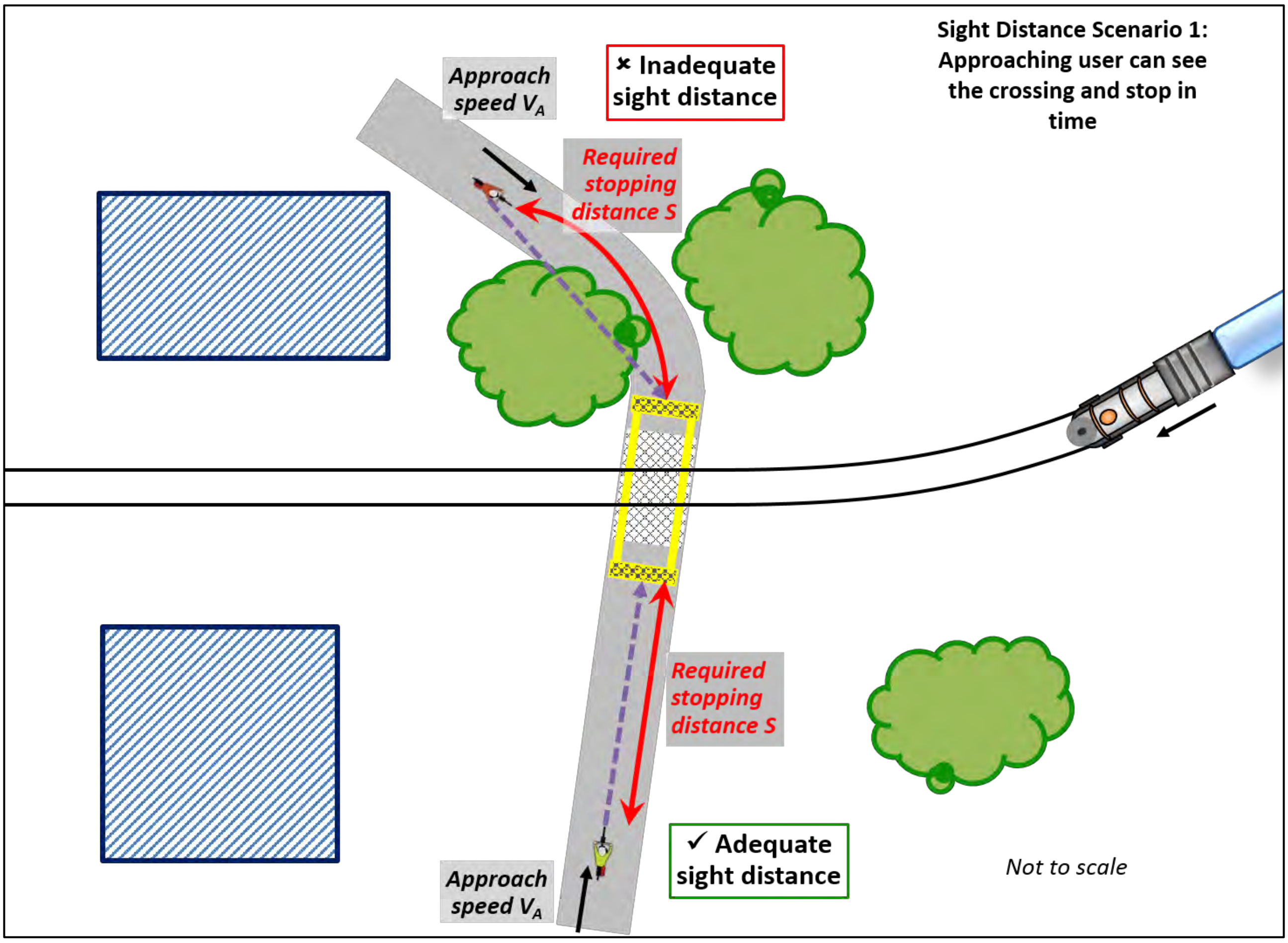


Figure 10: Examples of adequate and inadequate stopping sight distance

Typically, a **fast cyclist** (e.g. 30 km/h) is the design user that should be considered for pedestrian/cycle crossings. If it is certain that only pedestrians will use a crossing facility then a fast scooter or skateboard user is the design user; however, with a slower speed than a bicycle but less deceleration, the calculated stopping distance is likely to be only slightly less. Refer to section 4.1.6 for further discussion on this. Note also that a horizontal curve may slightly reduce the travel speed of a cyclist, but this is not accounted for in the equation for ***S***. Table 1 summarises the estimated stopping distances for a cyclist approaching at design speeds of 15 km/h and 30 km/h with a reaction time of 2 s and a deceleration rate of 0.25*g*.

Table 1: Stopping distances for a typical cyclist approaching at 15 km/h and 30 km/h

Approach gradient G	**-0.09**	**-0.06**	**-0.03**	**0**	**0.03**	**0.06**	**0.09**
Stopping distance **S** - 15 km/h	13.9 m	13.0 m	12.4 m	11.9 m	11.5 m	11.2 m	10.9 m
Stopping distance **S** - 30 km/h	38.8 m	35.3 m	32.8 m	30.8 m	29.3 m	28.1 m	27.1 m

Scenario (2) – Safe restart at crossing

Once at the crossing, the **sight distance *T* to safely start and cross** (assuming a near-stationary starting position) depends on:

- the <u>maximum</u> speed (km/h) of a train, $\boldsymbol{V_T}$ *(refer to KiwiRail for highest authorised speeds on a track section)*
- the <u>minimum</u> likely speed (km/h) of a crossing user, $\boldsymbol{V_C}$ *(see Section 4.1.6 for more discussion on this)*
- the distance (m) across the crossing (to beyond the minimum track envelope clearances), ***D***
- the assumed reaction time (sec) for people to assess whether it is safe to cross, $\boldsymbol{R_T}$ *(normally 2 s, unless the site has additional complexity)*
- a safety margin of time to be clear of the tracks before a train arrives *(assume 2 sec)*

The minimum required sight distance ***T*** in each direction of track is:

$$\boldsymbol{T = \frac{V_T}{3.6}\left[\frac{3.6\,D}{V_C} + R_T + 2\right]}$$

Note: technically, the initial acceleration rate of the user would also need to be considered; for simplicity, it is assumed that ultimate speed is instantaneous. This is largely true for a pedestrian; for a bicycle, the initial acceleration lag is compensated by a higher maximum speed.

Figure 11 illustrates two examples of this scenario, where the waiting user has adequate or inadequate sight distance to get across the crossing safely before an approaching train arrives.

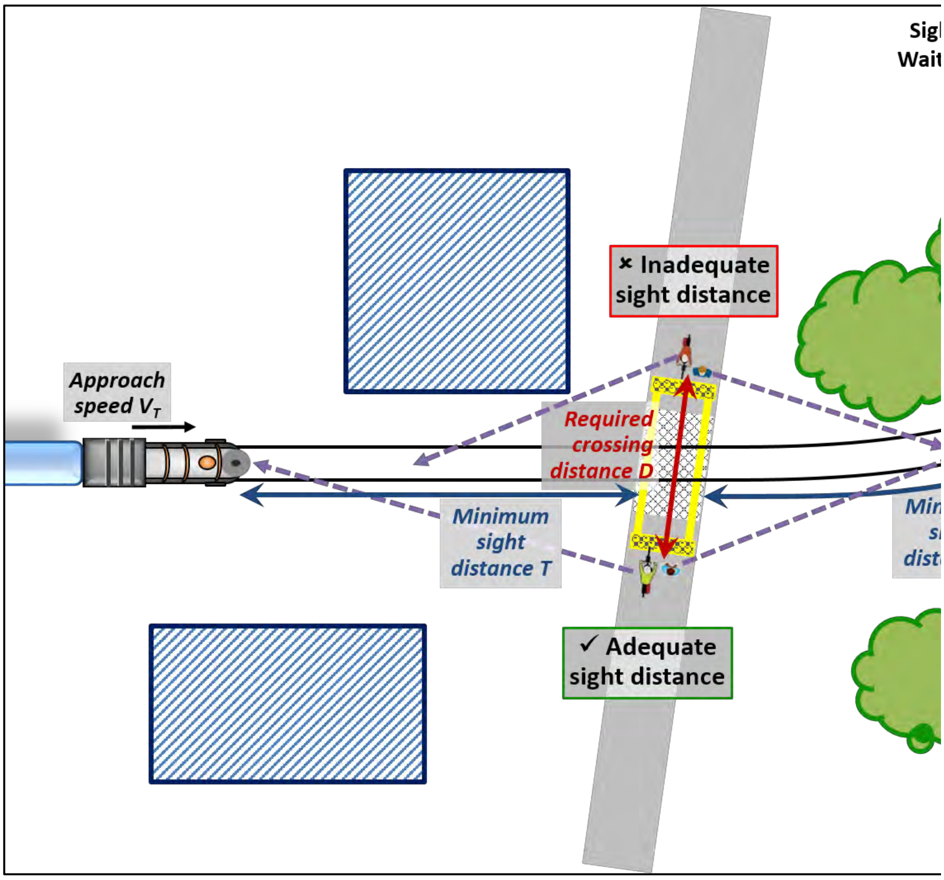


Figure 12: WX3 sign

Figure 11: Examples of adequate and inadequate starting sight distance

Typically, a **slow pedestrian** is the design user that should be considered for pedestrian/cycle crossings. Refer to section 4.1.6 for further discussion on this. Table 2 summarises the train sight distances required for a typical pedestrian to cross clear of one or two rail tracks at various approach train speeds, assuming a walking design speed of 3 km/h (0.8 m/s) and a reaction time of 2 s.

*Table 2: Minimum sight distances **T** for a typical waiting pedestrian to be clear of the rail tracks (perpendicular crossing)*

Maximum train speed $\mathbf{V_T}$	50 km/h	60 km/h	70 km/h	80 km/h	90 km/h	100 km/h
Sight Distance **T** – 1 rail track	187 m	225 m	262 m	300 m	337 m	374 m
Sight Distance **T** – 2 rail tracks	254 m	305 m	355 m	406 m	457 m	508 m

Design Assessment of Sight Distance Scenarios

At ***all*** new or upgraded crossings, a designer has to consider the available sight distances along the rail corridor both at the crossing limit line and at a distance ***S*** back from this point.

If there is adequate sight distance for all scenarios above, then a LOOK FOR TRAINS sign is the minimum control needed at the crossing. However, if there is insufficient sight distance to safely judge adequate crossings, then some form of active warning is required to inform users of approaching trains, e.g. flashing lights and bells (see Section 5.4). If the crossing itself (and any physical barriers) are not visible with sufficient warning to approaching users, then additional crossing warning signs should also be provided (e.g. Figure 12).

Note that all sight distance calculations should take into account vertical impediments to clear sight lines. In particular, consider the eye height of a child or seated user (approximately 1.0 m) when checking available sight distance. The target object should be the train headlight, located 2.6 m above the rails.

4.2.5. Approach gradients

Level crossings with downward approach gradients can increase the typical speeds of approaching cycles and other wheeled devices; allowances will need to be made to determine sight distances and placement of warning devices. Conversely, an uphill gradient to a crossing may reduce the expected approach speeds; it may also make it more difficult to clearly see the crossing and any approaching trains.

Steep gradients and crowns should be avoided in the design of the path crossing itself. If a wheeled user has to stop before crossing (especially with a low-powered or unpowered device), it may be difficult to get moving again if starting on a steep uphill grade; a flat platform should be used at the waiting position. Mobility devices with low wheel-bases may also struggle to get over a crossing with a sharp crown, rendering the user immobile.

4.2.6. Crossing approach angles

Ideally all level crossings should be on a perpendicular path across the tracks, to largely eliminate the risk of wheels getting caught in the tracks or users slipping on the rail tracks. Where angled crossings are necessary due to approach constraints, an attempt should be made to square up the approaches so they are as close to perpendicular as possible (see Figure 14; note that TGSIs shown do not meet NZ guidelines). At worst, the acute angle between the path and the rail tracks should be no less than 60 degrees. If a shallower angle is required, then the use of flange-gap material (see section 5.7.2) is strongly recommended. A warning sign (e.g. WX40 / WX42) may also be warranted on the approach of a pathway (Figure 13).

Path approach angles also influence the alignment of warning devices; ensure that these are oriented for viewing from the appropriate approach location (or provide multiple warning devices if necessary). They also constrain the ability to see easily in one direction of the rail corridor; ensure that clear sight lines are provided and consider physical calming treatments that orient the approaching user in both directions.

Figure 14: A cycle lane is re-aligned to cross a railway closer to 90 degrees (Portland, OR, US)

Figure 13: WX42 sign

If there are maintenance issues on the crossing surface, then users may be forced to take a shallower angle than desired, or get caught on a high surface lip. Consider installing surfaces with reduced maintenance requirements and safer crossing properties (refer to section 5.7)

4.2.7. Parallel paths

Some pedestrian/cycle paths run alongside (parallel to) the railway corridor before crossing the tracks. If not designed carefully, there are a number of potential risks:

- Users may not be aware of a train approaching the crossing from behind them
- The path crossfall/gradient may sharply change at the crossing to meet the track level, increasing the likelihood of some mobility devices toppling over
- At road crossings, paths may also introduce additional desire lines to adjacent roads (including informal ones)
- There may be limited room for devices aimed at reducing speed and increasing user awareness if the path is close to the railway lines (less than 5 m from the nearest track centreline).

Where possible, a parallel path without active control should have some form of chicane or maze to force users to face both directions before crossing (refer to section 6.5). Ideally, a parallel path should move away from the rail corridor on approach, to make it easier to "square up" and to resolve crossfall/gradient issues. A suitable early warning sign may also be useful to display on the path approach e.g. WXL3/R3/L5/R5 (see Figure 15).

4.2.8. Number of tracks

Having multiple rail tracks introduces the additional risk that more than one train may be passing; a user may start crossing the tracks after the first train has passed, unaware that a second train is about to arrive.

In areas where commuter rail services are frequent, different tracks are typically allocated services in different directions. Regular crossing users accustomed to such operations may be less likely to check in both directions for the unusual occasion when a train has to use the "opposing" track (e.g. due to track maintenance works). For this reason, it is not appropriate to mark or sign the typical train direction (as is done in some overseas locations).

Additional tracks increase the crossing distance between safe clearance areas. Therefore, visibility calculations may require additional sight distance to be provided (see section 4.2.4).

Where multiple tracks are involved and there is a defined crossing point and waiting area between tracks, it is possible for detection systems to distinguish which track a train is on, so that users do not have to cross all tracks at once. This type of detection can help to reduce wait times.

4.2.9. Warnings on multi-directional facilities

As mentioned in section 4.2.1, some roadside path crossings may only provide warning devices in the direction of the adjacent traffic lanes. Most paths can be expected to have two-way usage; even where it is not designed for this (e.g. road with one-way cycle paths on both sides), there may still be people who use it in a contra-flow manner. Therefore, ***all*** path crossings should have some warning devices visible to users from both directions.

If multiple paths meet at a rail crossing, then it is important that all approaches have suitably located and oriented warning devices; alternatively, the paths should all be channelled into a single approach.

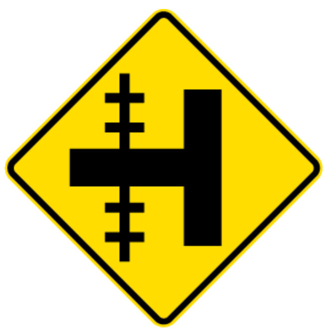


Figure 15: WXL3 sign

4.2.10. Storage space between crossings/roads

Some constrained locations have relatively little room either between an adjacent road and the rail corridor, or between parallel rail tracks that are separated by some distance (e.g. due to a branch line departing). Where site use is expected to be high, consideration needs to be given to the appropriate amount of storage space to safely hold the expected peak numbers of users. This should take into account peak use numbers (see section 4.1.2) and the space requirements of some larger wheeled devices (see section 4.1.7).

A simple estimate for the required storage space is:

Req'd storage = {Peak user flow (per minute)} / 60 x {Max. crossing closure delay (sec)}

where the crossing closure delay is the longest time for which a train may activate the warning devices. The peak user flow should reflect the highest flow rates observed during a short period of time, e.g. immediately after a train arrives at a station, or after a pedestrian crossing phase is activated on an adjacent road.

4.2.11. Path width and space

Rail crossings should ideally provide enough space for the peak user flows in each direction to be able to pass each other safely. This should assume that at least one user may have a larger device like a mobility scooter or pram. Crossings should also provide enough clearance on each side to prevent a wheel user from accidentally falling off the edge of the crossing surface and getting stuck in the tracks.

2.4 m is the minimum recommended width for a shared crossing facility, with more width for a higher use facility. Refer to NZTA (2008) and NZTA (2016) for more guidance on pedestrian and cycle path widths. Any adjacent vegetation should also be adequately trimmed back via regular ongoing maintenance.

4.2.12. Proximity to intersections and paths

Many pedestrian/cycle rail crossings are next to traffic intersections; with two road legs adjacent to the crossing this can create difficulties in having enough space for an optimal layout (especially if some kind of maze or chicane is required).

Traffic intersections also introduce additional distractions and noise, and crossing users may have just crossed the road; these can make it harder for users to notice the crossing or any approaching trains. Designers should consider whether additional warning devices or active controls may be needed.

Sites with additional road and path legs increases the number of possible origin/destination possibilities (see Figure 16 for an example). Consider the likely routes (both formal and informal) that people may take and design for them accordingly.

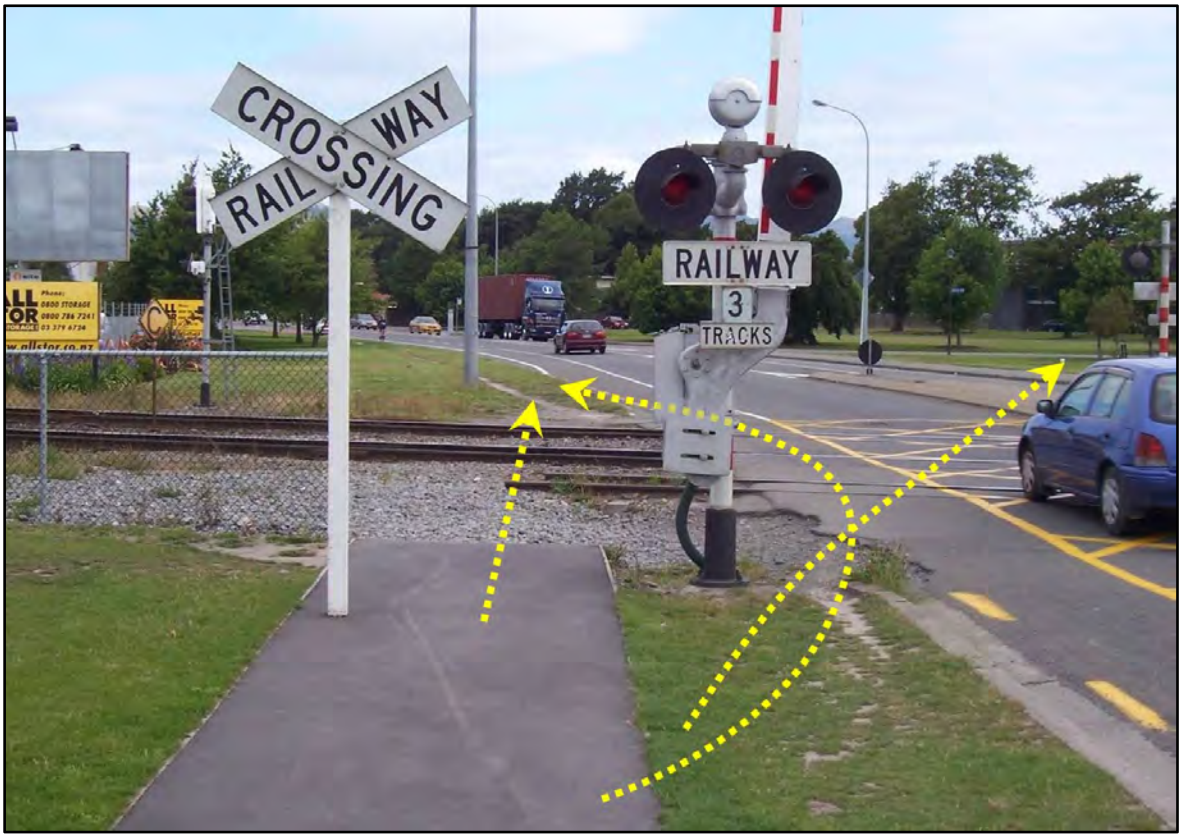


Figure 16: This crossing lends itself to multiple path options, depending on the user type and ultimate destination

4.2.13. Proximity to stations

Crossings are often located next to railway stations to allow access for passengers. This proximity to commuter rail services increases the risk of conflicts, particularly immediately before and after a train visits the station. The risk is exacerbated if a passenger is approaching the crossing when they see their train approaching; anxiety about missing their service may cause people to ignore, or choose to proceed against, warning devices.

Active control should certainly be considered at these crossing and, given the greater risks, grade-separated crossings may be more appropriate.

4.2.14. Proximity to distractions and other noise

There may be some crossing locations that are in close proximity to other features that create distractions or generate high noise levels. Examples of these include proximity to busy high-speed roads, areas with high pedestrian activity, and locations with dynamic advertising or other media. In these cases, additional efforts will be needed to attract the attention of crossing users or more active controls may be needed.

4.2.15. Future rail corridor development

The placement of rail crossing infrastructure may need to consider the potential for planned future development such as additional rail tracks, new underground cables, new signalling or electrification equipment, and new stations. Therefore, discussion is needed with KiwiRail to identify any proposed developments and to work around these. For example, approach signage and treatments may be placed on the assumption that an additional track will be installed at some stage.

4.3. Train factors

It is important to understand the various attributes of trains using a crossing site, to determine whether other site or user factors should be incorporated into the design.

4.3.1. Train speeds

Train speeds are dictated by KiwiRail on various track sections. Reducing train speeds could have some effect on the relative likelihood and severity of collisions with users crossing the tracks. However, the effect is likely to be relatively negligible for two reasons:

- The significant momentum of most trains (comprised of locomotives, carriages and/or wagons) makes it difficult for them to stop ahead of any track hazard identified in advance
- The size and momentum of most trains also means that most collisions with people on the tracks are fatal regardless of speed

It should also be noted that reduced train speeds would limit KiwiRail's ability to manage its freight business and mean that trains would take longer to clear level crossings, thus creating greater delays.

4.3.2. Train length and frequencies

Long trains result in delays at level crossings. A short train (or single locomotive) still introduces a base delay due the advanced warning time signalled prior to the train's arrival. This base delay means that frequent train movements can reduce the amount of time available to other users at crossings, e.g. on some sections of the Auckland urban commuter line, level crossings are closed for nearly 40 minutes in the hour. As the proportion of available time for crossing users decreases (especially in areas with high crossing user counts), grade-separation may be more appropriate.

As discussed in section 4.1.9, crossings with very high or very low frequencies may have user behaviour problems in terms of complacency or over-familiarity.

If a crossing user is able to see that an approaching train will be quite long, they may be more tempted to cross before the train arrives.

4.3.3. Nature of train operations (shunting, commuter, freight)

Locations near shunting yards may be subject to trains that stop on the crossing and then change direction; this can also add delay to crossings. Freight trains are also typically much longer than commuter services and thus result in greater delays.

As discussed in section 4.2.13, commuter services may be more likely to influence crossing user behaviour if some people are intending to board these services and see the train approaching.

4.3.4. Effects of trains on crossing delays/congestion

While safety is the main consideration in discussions about crossing treatments, locations with higher frequencies of trains and/or crossing users may also result in congestion and delays for crossing users. If that level of delay is considered untenable, some users may be tempted to ignore warning devices and cross while a train is approaching. It may be necessary to install more active controls (e.g. gates), or convert to a grade-separated crossing instead.

Crossing treatments that provide little room for oncoming users to pass each other (especially those with cycles or other wheeled devices) may also suffer from significant delays, even without many train movements. Cyclists may feel compelled to dismount due to the delays incurred, leading to lower satisfaction with the route. This may be an appropriate response in the circumstance; however, RCAs may wish to provide treatments that are designed to manage congestion better. One alternative option may be to provide duplicate crossing facilities that allow movements in both directions concurrently.

4.3.5. On-street light rail or trams

At present, there are relatively few on-street light rail or tram systems in New Zealand; however, that may change in the future. On-street rail systems introduce different risks for active modes due to a lack of specific crossing locations and the ability to share the same road space.

Figure 17: Light rail in central Freiburg, Germany

Further guidance will be considered in the future but, for now, the following advice should be considered:

- Tram speeds in areas with high numbers of active modes should never be greater than 20 km/h; lower in shared spaces; higher if physical separation is provided (e.g. separate corridor delineated by a kerb).
- Primary warning of users about an approaching tram (or one about to start moving) is via audible signals on the tram itself.
- There is a greater risk of cycles and wheeled devices getting caught in on-street tracks due to shallower crossing angles. Consider the use of flange-gap treatments (see Section 5.7.2) and warning signage e.g. WX5 (see Figure 18).
- Tactile ground surface indicators should be used to indicate to vision-impaired users where they are safely clear from a passing tram.

4.3.6. Train collision protection systems

Generally, trains do not have any kind of frontal protection systems to minimise injury to crossing users. In the future, it is possible that new Intelligent Transport Systems (ITS) developments will see train - vehicle - infrastructure communication technologies in use that warn and possibly control both users and trains of any potential collisions.

Figure 18: WX5 sign

5. General crossing design features

The following features need to be considered for ***all*** pedestrian/cycle rail crossings (regardless of the overall treatment selected from section 6) to determine the most appropriate design for the site. Further design guidance can also be found in KiwiRail (2015) and KiwiRail (2016c).

5.1. Purpose of path and crossing layouts

Dependent on the form of crossing control, the layout of the approach to the crossing may aim to:

- Making users aware of the presence of the crossing
- Facilitate appropriate speeds for stopping at the crossing point.
- Encourage users to keep to the left side of the path (to avoid confusion / conflict with other users coming from the opposite direction)
- Orient users towards the relevant warning devices
- Orient users in the direction(s) of approaching trains
- Encourage users to stop at the appropriate location to wait for passing trains

Design reviews and audits of existing or proposed crossings should assess whether the layout successfully achieves these aims.

5.2. Rail corridor clearances

KiwiRail (2013, Appendix E) provides details of the minimum clearances from the track to structures and other infrastructure. For final detailed design, information regarding clearances should be sourced from this reference. However, generally speaking, for new construction on main lines and loops, a minimum horizontal clearance of 2.75 m from the track centreline to the edge of adjacent fixed structures above rail level is ***required***; in practice, a minimum of **5.0 m** is recommended (or 4.4 m from the nearest rail track) for continuous structures such as cycleway fences. At pinch points (i.e. localised narrowings), a minimum of 3.0 m may be acceptable (or 2.4 m from the nearest rail track), but approval from KiwiRail is required for this. Isolated short obstructions such as columns and track signs/signals may be located no less than 2.6 m away. Overhead structures such as bridges need a minimum clearance of 4.9 m above track level, or 5.5 m in areas with (or with the prospect of) overhead electrification.

Clear indication of the extents of the clearance zone should be provided using a limit line and tactile ground surface indicators. Where trains may pass at speed, it might be prudent to locate these limits further back, to allow for wind buffeting.

*Note: These dimensions may be subject to change or local specifics. In **all** cases, designers should liaise with KiwiRail staff to confirm appropriate clearances.*

5.2.1. Emergency escape areas/gates

For any treatments that involve gates or barriers where users may inadvertently be caught on the rail side of the crossing, a separate means of escape is ***required***, or suitable waiting space clear of the rail corridor. Typically, a manually operated swing gate is provided, which pushes away from the railway crossing, with suitable signage to direct people to it when the main gate/barrier is shut (see Figure 19). Where possible, the layout design should discourage people from normally using this route, by making it a longer path (albeit still easy to locate when necessary); another alternative is to locate the main gate or barrier so that it blocks off the emergency route when in the "normally open" position.

In calculating the time before a gate or barrier is closed, the distance required to clear the rail corridor needs to be considered. A rough estimate of the clearance time $\boldsymbol{T_C}$ required is:

$$\boldsymbol{T_C} = \{ [2 + 4\boldsymbol{N_T}] / \boldsymbol{V_P} \} + \boldsymbol{R_T}$$

where

- $\boldsymbol{N_T}$ = Number of rail tracks to be crossed (assuming they are all adjacent)
- $\boldsymbol{V_P}$ = Speed (m/s) of slowest target user (refer to section 4.1.6 for more details)

- R_T = Reaction time for users to assess the situation and act (normally assume 2.0 seconds)

It can be seen that, to enable a pedestrian travelling at 0.8 m/s (the slowest pedestrian speed from section 4.1.6) to cross a single track, a minimum clearance time of 9.5 seconds is required from this equation.

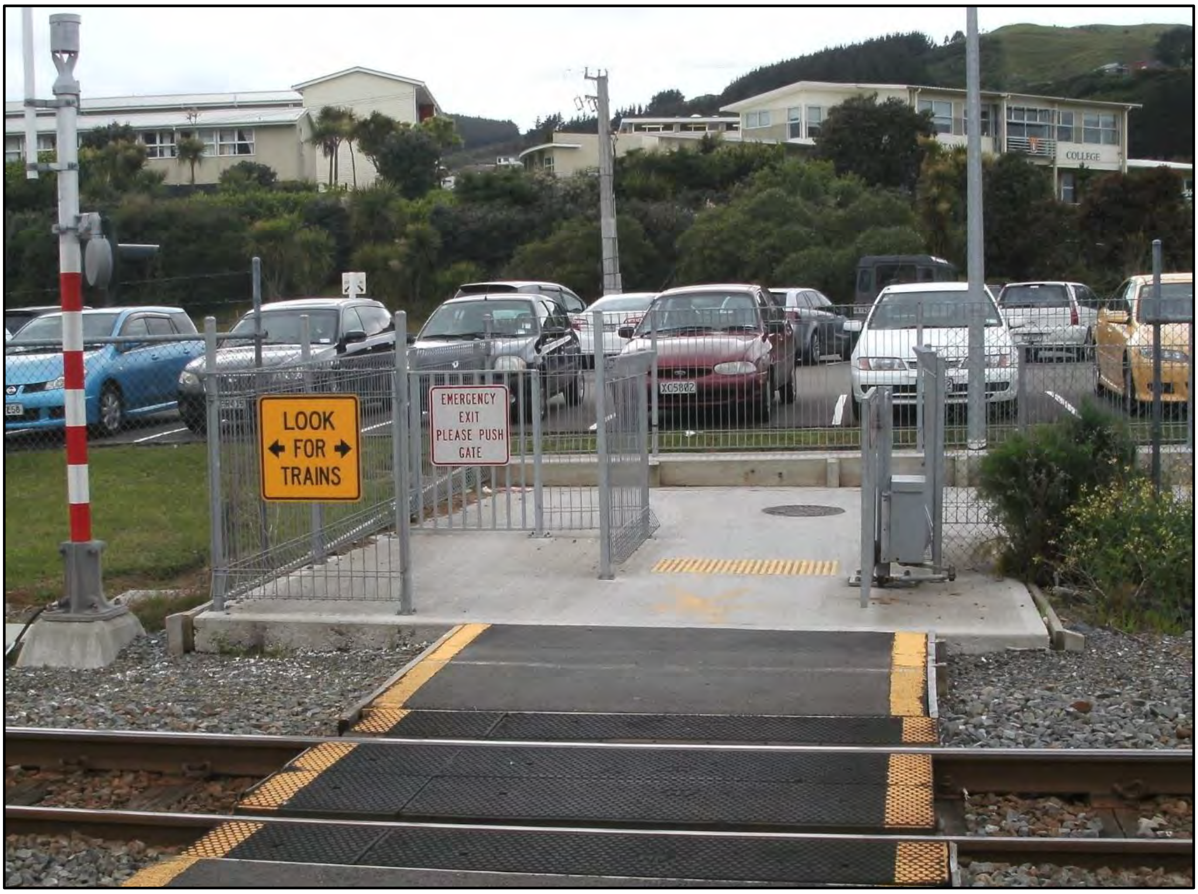


Figure 19: Emergency exit gate to the left; only used when main gate (currently open) is shut

5.3. Passive warning options

Passive warning devices are static and present all the time, i.e. they are no different when a train is present/approaching compared with when no trains are present.

5.3.1. Warning signs

The signs used at level crossings are presented in section 4.3 of the *Traffic Control Devices Manual* part 9 (NZTA, 2012); signs used in advance of level crossings are presented in section 4.4 of the Manual. *TCDM Part 9* also gives guidance on sign size and placement.

Figure 20: Look for trains (WX8) sign

The only sign required at a stand-alone pedestrian/cycle level crossing is the “LOOK FOR TRAINS” sign (WX8) shown in Figure 20. For a new/upgraded crossing without active controls, a railway cross-buck (WX6) with a GIVE WAY sign (RP2) is also an option that could be trialled (see Figure 21); where there is limited sight distance (see section 4.2.4) then some form of active warning should be installed instead (see section 5.4).

Where cyclists cross on a skewed angle with the train tracks (see section 4.2.6), a “cyclists take care” (WX5) sign may be used, to warn cyclists about the danger of their wheels falling into the flange gap and tripping them (see Figure 22).

Figure 21: RPX3 level crossing GIVE WAY sign assembly

Figure 22: Cyclists take care (WX5) sign

5.3.2. Path markings

TCDM Part 9 (NZTA, 2012) specifies: *"Where practicable, one white limit line should be provided across the footway at a distance of 2.4 m (and no less than 1.9 m) from the nearest rail edge"*. Typically, this line should be 200 mm wide.

Immediately behind the limit line (i.e. on the path side, not the railway side) should be a set of tactile ground surface indicators (refer to NZTA 2015 for installation guidelines), and textured yellow crosswalk lines should also extend through the crossing (see section 5.3.4).

Figure 23: Example of Queensland Rail pedestrian marking trial

An option that could be trialled is to replicate the standard "LOOK FOR TRAINS" sign as a path marking, to catch the attention of users looking down. A "GIVE WAY" triangle is another potential marking to consider at passively-controlled crossings. Any path marking materials must have adequate skid resistance.

Where directional path control is desired, a centreline marking may also be considered to separate the two directions.

Queensland Rail (2016) is trialling additional pedestrian safety measures, whereby an additional longitudinal strip is used together with some "footprint" markings. However, additional features like this may create visual clutter that confuses people with visual or cognitive impairments.

5.3.3. Rumble strips

If there are problems with cyclists and users of other wheeled devices not noticing the rail crossing, consideration could be given to installing transverse rumble strips across the approach path to alert the user. However, introducing these rumble strips could produce greater problems for cycle handling and stability. For example, rumble strips installed on the cycleway on Hawthorne Bridge, Portland, OR, US were subsequently removed following numerous concerns by users.

5.3.4. Tactile ground surface indicators

Tactile ground surface indicators (TGSI) are used to provide guidance to blind and vision-impaired crossing users on where to stand clear of the rail corridor and the orientation of the crossing path.

RTS 14 (NZTA, 2015) specifies the TGSI devices to be used at rail crossings. Warning indicators are typically situated immediately behind the limit line and ***must*** be aligned perpendicular to the crossing direction. They should extend the full width of the available crossing path.

In addition, textured contrasting crosswalk lines in safety yellow colour should be installed right across the crossing path to delineate the width of the crossing. Typically, 150 mm wide lines are used (see Figure 24).

If necessary, additional directional TGSI devices may be installed to direct vision-impaired users to the crossing. This is particularly useful where pathways run parallel to the railway corridor, i.e. perpendicular to the crossing.

Figure 24: TGSI at level crossing - note no limit line applied (Grove Road, Christchurch)

5.3.5. Physical calming devices

Vertical devices such as bollards, handrails, and fencing can be used to create awareness of the rail crossing by approaching users and to encourage faster users to slow down to appropriate speeds (see also section 6.5 regarding chicane approaches). At the crossing point itself, handrails and fencing can also provide useful holding points for riders whilst remaining on their bikes; at least one suitable holding point should be considered at all level crossings.

However, care needs to be taken to ensure that these devices don't create unnecessary hazards for unsuspecting users, particularly when located in the middle of the path (which may also limit the ability of wider pushchairs and mobility devices to get past). All devices on pathways ***must*** be of high contrast to the immediate background in all lighting conditions, a minimum of 1 m in height, reflectorised for visibility in darkness, and edgeline path markings may also be needed to divert users around an obstacle. Fencing and rails should include horizontal or solid elements no more than 200 mm above the ground, to allow for detection by vision-impaired users with long canes.

5.3.6. Approach kerb extensions

Pathways that closely parallel a railway corridor (or approach it at an acute angle) may lead to desire lines at crossings that encourage faster speeds and discourage proper checking in both directions. Where feasible, it is desirable to introduce kerb extensions that force the path away from the railway before squaring it more perpendicularly at the crossing.

5.4. Active warning options

Active warning devices are triggered by a train is approaching the crossing point. Active warning devices are fixed in place at the crossing point or on the approaches to it. *TCDM Part 9* (NZTA, 2012) states that the types of active protection for pedestrian level crossings may include bells plus flashing lights or flashing indicators, "second train coming" illuminated signs, and automatic pedestrian gates. It also states that the level of protection is largely determined by the pedestrian (and cycle) demand and the frequency of train use. Active warning devices should be **fail-safe**, i.e. designed with backup features that operate when the main control fails. At the very least, passive warning devices should be used as backup features.

5.4.1. Flashing lights and bells

Section 6.3.1 of the *Traffic Control Devices Manual* Part 9 (NZTA, 2012) specifies the use of flashing lights and bells (FLBs, see Figure 25). Normally, both lights and bells are installed together, with two exceptions: in urban locations, quiet bells may be installed if agreed between KiwiRail and the RCA; and for pedestrian level crossings there is the option of using bells only, in conjunction with a "LOOK FOR TRAINS" (WX8) sign (see section 5.3.1).

Figure 25: FLBs (Napier)

Pathways next to roadways often only feature FLBs in the same direction as the adjacent traffic lanes. Where there is strong user demand in both directions of a path, particularly for higher speed users like cyclists, designers should consider an additional FLB unit facing in the opposite direction (possibly smaller than normal).

For crossings with multiple approach pathways, designers should consider installing additional FLBs to face the different users. An additional FLB facing across the crossing is another option to consider (see Figure 26).

Figure 26: Multiple FLBs oriented in different directions (Auckland)

Section 6.4 describes in more detail crossings controlled only by audible and visual warnings such as FLBs.

5.4.2. Traffic signals for road crossings

If the level crossing is close to a signalised road intersection, it may be necessary to integrate the two forms of control. *TCDM Part 9* mentions the usefulness of integrating the railway signalling circuits with the traffic signal phases at adjacent intersections, i.e. to improve efficiency of the road corridor. Normally, integration will be required where the signalised intersection is within 30m of the level crossing, and should be considered where this distance is up to 60m. It is also important to consider how the different traffic control devices are integrated spatially. Where the level crossing and road intersection are very close (particularly where there is insufficient queuing space between them), it may be necessary to treat the two as one signalised intersection. For example, the traffic signals and limit lines on an approach could be placed further back from the intersection centre than they would be if the railway line were not present.

In these locations, it is important that train drivers are not distracted/confused by the traffic signals for the adjacent road; louvres may be used on the traffic signals to shield them from view of train drivers, or polarised signals that are only visible from a certain angle may be used.

Motorists should also be able to distinguish the two forms of control (traffic signals and whatever control is used across the railway crossing) from their approach angle. It must be clear that the traffic signals may display red for road traffic even when no train is present and the railway controls are not operated. Conversely, it may be possible to give a red light to some movements on the adjacent road while the rail crossing is operated, but any movements that cross the railway line ***must*** be given a red light.

5.4.3. Path signals for parallel pathways

Where a pathway runs adjacent and parallel to a railway and both intersect a road, there may be a signalised crossing for the pathway across the road directly adjacent to the level crossing of the road across the railway, for example the road crossings along the Northern line railway cycleway in Christchurch (see Figure 27).

Figure 27: Fendalton Road signalised crossing adjacent to level crossing for road (Christchurch)

In these locations, it is important that train drivers are not distracted/confused by the traffic signals for path users; louvres may be used on the traffic signals to shield them from view of train drivers, or polarized signals that are only visible from a certain angle may be used.

It is possible that path users could use the parallel crossing at the same time as road traffic is stopped for the rail crossing. In these situations, it is imperative that path users do not turn off the pathway and inadvertently into the path of a crossing train. To reinforce this, any path signals should include a red arrow to operate during these times (see Figure 28). However, designers should also rely on additional warning devices to alert path users, or prohibit the movement when a train is approaching / present, including FLBs and gates or barriers.

Figure 28: Cycleway signals with red turn arrow

5.4.4. Voice messages

Many users might respond better to a specific verbal warning rather than a visual device that may get ignored if distracted or not looking for it. An automated voice message allows particular information to be relayed more directly. For example, urban crossings with multiple tracks may have more than one train in close proximity. A user may start to cross after the first train has passed, but a verbal *"warning: another train approaching"* may attract their attention before it is too late. Specialist advice should be sought regarding the appropriate voice tone, volume and speaker location of the audible message system.

5.4.5. Active warning signs

Active warning signs are static signs with dynamic components, e.g. flashing lights, that activate in response to an approaching train. For example, Figure 29 shows a variation on the "look for trains" (WX8) sign that includes flashing lights. Care needs to be taken to balance the light levels so as not to cause unnecessary or disabling glare.

Figure 29: active warning sign

Section 4.4.12 of *TCDM Part 9* (NZTA, 2012) states that *"Active warning signs are intended to highlight a particular hazard where the standard signs are ineffective and, in this case, where full railway level crossing flashing signals cannot be justified."* It appears that this policy and the discussion on active warning signs is intended primarily for roads at railway level crossings. As the only traffic control device specified for stand-alone pedestrian level crossings is a static sign, it follows that using active warning sign would be an improvement.

Typically, active warning signs are triggered by the approach of a train. However, another type of device could simply be triggered by the path user, resulting in a warning reminding of the need to check for trains. Such devices have recently been trialled in New Zealand.

Figure 30: Example of an active warning sign

5.4.6. In-ground warning lights/markings

KiwiRail has commissioned a project to develop in-ground illuminating pads to display words or symbols to warn pedestrians at level crossings. Some options also feature flashing studs. Word options include “WAIT”, “STOP”, “LOOK” and “TRAIN”. Symbols may include a train, a red person/cyclist, or arrows. The prototypes are being trialled from 2017 (3i, 2016), and may prove to be a useful treatment. Again, care is needed to ensure that such devices do not create undue glare or confusion by users.

5.4.7. Pedestrian/puffin signals

Although not currently found in New Zealand, other locations have used traffic signals similar to those at signalised pedestrian road crossings to inform and warn users of approaching trains (see Figure 31).

Figure 31: Example of pedestrian signals used with a barrier (Germany) (Wikimedia Commons)

5.4.8. Barriers and gates

With respect to pedestrian (swing) gates, *TCDM Part 9* (NZTA, 2012) states: *“Where pedestrian and train movements are high, automatically activated pedestrian gates may be justified. These* *provide positive control of pedestrian movements and also provide good levels of pedestrian (and cycle) service across the railway line(s) when the gates are open."* More details about these treatments can be found in section 6.3.

Cantilevered barriers, commonly known as Half Arm Barriers (HABs) or booms, provide an automatic restriction across the roadway or pathway when a train is approaching. The barrier arms usually only extend across one half of the roadway (i.e. the side that traffic is approaching from) to allow any remaining traffic to exit on the other side, but it is possible to provide full-width barriers and this is common overseas for pathway treatments. ***Currently KiwiRail does not support the use of raised barriers across pathways; automatic swing gates should be considered instead***.

5.5. User-activated warning options

There are also warning devices that are activated by the presence or action of crossing users. User-activated devices are not considered 'active warning devices', as these latter devices detect trains, not people.

User-activated warning devices can include voice messages (section 5.4.4), active warning signs (section 5.4.5) or in-ground warning lights / markings (section 5.4.6) adapted to activate when a user is present (as detected by using infra-red, video or pressure sensors) or when a user presses a button to request more information (this could be especially useful to assist visually-impaired pedestrians). The message conveyed could focus on either warning the user that they are approaching a crossing, the appropriate crossing behaviour to adopted (e.g. "stop", or "look both ways for trains") or inform a user that they have entered the crossing at an inappropriate time.

Note that some user research has indicated confusion about user-activated warnings, with people thinking that they have been activated by an approaching train. This could lead to users either waiting unnecessarily at a crossing, or eventually ignoring the requirement to check to trains. Therefore, further work is required to trial these in New Zealand.

5.6. Security issues

Pedestrians and cyclists are not protected in the way drivers are by their motor vehicles, and thus more vulnerable to personal threats from other users. The nature of some users and their relatively agile movements mean that they are also more able to depart from the "official" route and interfere with rail crossing equipment if so motivated.

5.6.1. Personal security

Increasingly, design for active modes needs to consider two important personal security concepts:

- Crime Prevention Through Environmental Design (CPTED) aims to develop public urban environments that reduce the impact (and threat posed) of crime in these spaces. Typical treatments include using generous lighting, encouraging passive surveillance of sites, removal of hidden spaces, and providing alternate escape paths.
- Injury Prevention Through Environmental Design (IPTED) focuses on a design management system that seeks to reduce both likelihood and severity of potential injury-causing incidents. Typical treatments include non-slip/trip surfaces, removal of sharp protrusions and edges, and eliminating difficult manoeuvres.

5.6.2. Site lighting

Adequate lighting of crossings will encourage their use at night and deter vandalism and other anti-social activities. Lighting of these areas must adhere to AS/NZS 1158.3.1 (Standards Australia/NZ 2005), with the lighting standard to be used dependent on the relative level of crossing use and concern about personal crime. LED lighting is highly recommended; any decision not to provide lighting at all ***must*** be clearly justified.

It is important that site lighting is located such that it doesn't confuse people and they mistake an approaching train light as an overhead light instead. Similarly, lighting should be oriented to minimise glare that prevents users from noticing an approaching train (or for train staff to notice crossing users). Refer to KiwiRail (2015) for further guidance.

5.6.3. Fencing and vegetation

Secure fencing near crossings is an important component of keeping people out of the rail corridor other than at designated crossing points. KiwiRail ***requires*** a **1.2-1.8m high** mesh fence between a pathway and the rail corridor (refer KiwiRail 2015). A sturdier design (e.g. all vertical bars, such as a palisade fence) should be considered where trespassing or vandalism is common or expected.

Vegetation such as hedges and bushes should not be used as a barrier on its own, as people are able to get through it more easily. Overgrown vegetation near crossings may also obscure sight lines, warning devices and lighting, and may also provide hiding opportunities for anti-social behaviour.

5.6.4. Vandalism of crossing controls

Crossing sites may be subject to vandalism by users or passers-by, particularly at isolated locations. Authorities will need to be particularly careful with relatively innovative, restrictive or fragile crossing equipment that may be the target of attention. For example, in Melbourne, pedestrian barriers were being damaged by waiting people. Fencing may also be damaged if it is blocking a strong desire line.

Many of the standard treatments for CPTED (lighting, surveillance, etc) may help to reduce vandalism problems at a crossing. If a site is particularly susceptible to damage, installation of security cameras may be able to help identify the perpetrators.

5.7. Path surface treatments

Adequate construction and maintenance of crossing path surfaces are critical for the safety and convenience of active users, many of whom use wheeled devices. If the surface quality is poor, users may trip up or get wheels caught in the rail tracks (see Figure 32). Attention also needs to be given to surfacings used on approach paths, to ensure that users are able to slow down and stop safely and to negotiate any physical calming treatments (especially in the wet and when icy).

Figure 32: Poor pathway maintenance affects the safe available path for many users

5.7.1. Crossing surface materials

A variety of different materials have historically been used for level crossing surfaces. They vary in regards to their durability, ongoing maintenance and safety for users. Although timber and asphalt are still occasionally used for pedestrian/cycle crossings (especially alongside roadways), increasingly concrete and specialised rubber components are now specified.

Table 3 outlines the surface treatments that KiwiRail considers appropriate for various types of level crossings for active users. Detailed construction plans for the relevant treatments are available in KiwiRail (2016a).

Table 3: Types of active user crossing surfaces (table 9.2 from KiwiRail 2016a)

Option	Type	High Use Urban Metro and Station	Medium Use Urban or High Use Local	Local Use
D	VeloSTRAIL	Skew <70° or disabled access	Skew <70° or disabled access	Skew <50° or disabled access
E	PedeSTRAIL / Holdfast Pedestrian	Skew 90° – 70°	n/a	n/a
F	EPflex Railseal w/asphalt	n/a	Skew 90° – 70°	If road adjacent
G	EPflex Railseal w/concrete	n/a	Skew 90° – 70°	If road adjacent
H	Concrete panels	n/a	Skew 90° only	High use Skew 90° only
J	Asphalt	n/a	n/a	If road adjacent
K	Timber panels	Not to be used for public access crossings		

Notes:

- Option D requires site specific risk profile due to the risk of derailing hi-rail vehicles (i.e. vehicles that can operate on road or rail).
- Options F or J are to be used for pedestrian crossings immediately adjacent to Option I Road Crossings.
- Option E can be used singularly or for pedestrian crossings immediately adjacent to Options A, B or C (see road crossing treatments in KiwiRail 2016a).
- All pedestrian crossing and maze layouts shall have Warning TGSI installed with safety yellow textured contrasting crosswalk lines as per RTS 14 (see Section 5.3.4).

5.7.2. Flange gap treatments

The flange gap (i.e. the gap between the rail and adjacent crossing surface) can be a hazard for crossing users, especially those with wheeled devices such as cycles, wheelchairs, push-chairs, skateboards or scooters. This is even more so when the crossing is at an angle relative to the tracks. Typically, a minimum flange gap of 60 mm is specified, although some passenger-only train routes may have less. If a material prone to deterioration or deformation is used for the flange edge (e.g. asphalt) the gap may become even larger.

The AASHTO Bike Guide (1999, cited in Birk *et al*, 2002) notes, *"The crossing surface itself should have a riding quality equivalent to that of the approach roadway. If the crossing surface is in poor condition, the driver's attention may be devoted to choosing the smoothest path over the crossing. This effort may well reduce the attention given to observance of the warning devices or to the primary hazard of the crossing, which is the approaching train."*

Figure 33: Rubber panel crossing treatment for road and path (CBD, Tauranga)

Products such as *veloSTRAIL*, which involves rubber parts that compress under the weight of a train but not under the weight of a pedestrian or cyclist, can ensure that the flange gap is not present for pedestrians and cyclists, whilst still providing the necessary functionality for a passing train. **This treatment should be considered for *all* new or upgraded pedestrian/cycle crossings**, particularly when acute crossing angles are involved. One potential issue that has been noted with these products is the potential for grease from the train wheels to get spread across the path, creating a slipping hazard. Therefore, regular maintenance may be required.

Figure 34: Epflex railseal used on asphalt railway level crossing (Kaiapoi)

5.8. Non-infrastructure treatments

At some locations, it may be prudent to apply some non-infrastructure techniques (namely education and enforcement) to rail crossing issues.

5.8.1. Education/promotion campaigns

Many people are unaware of the relative dangers of rail corridors. Children in particular may be prone to not checking for trains or lingering around crossing areas. Public promotional campaigns or targeted education campaigns may help to raise awareness and improve behaviour.

TrackSAFE (http://www.tracksafe.co.nz/) is a charitable trust that aims to raise awareness about rail safety in New Zealand and educate the public on how to keep themselves safe around tracks and trains. Throughout the year, it undertakes various education and awareness raising activities, including school visits and Rail Safety Week. The TrackSAFE website also has resources that other agencies can use.

5.8.2. Crossing enforcement

If there is a particular problem with behaviour at/around a rail crossing, one option is to engage the Police to undertake enforcement activities. People can be fined $150 or convicted up to a maximum of $20,000 for walking or driving across a level crossing when there is a risk of a collision with a train or other rail vehicle. People can also be fined $150, or convicted up to a maximum of $1,000 for doing the following:

- Failing to stop at a stop sign at a level crossing
- Failing to remain stopped at a stop sign until the level crossing is clear
- Failing to give way to a rail vehicle at a level crossing controlled by a give way sign
- Entering a level crossing when the red lights are operating
- Entering a level crossing when the barrier arm is lowered
- Entering a level crossing when the passage or exit is blocked

5.8.3. Crossing marshals

Where a crossing has an unacceptable risk for its current treatment (possibly due to short-term changes in demand or crossing provision), a sensible way of managing the risk may be to engage people to act as crossing marshals. For sites near a school, parents, teachers or senior children could be co-opted for undertaking this role. Their tasks can be to ensure that crossing users are aware of the presence of the crossing and any approaching trains and to ensure that users behave appropriately when waiting or crossing.

Figure 35: A crossing marshal escorts schoolchildren across Peraki St crossing, Kaiapoi

6. Pedestrian/cycle crossing treatment options

There are five main treatment options to consider for pedestrian/cycle crossings:

- **Grade separation** – either via an overbridge or underpass
- **Automatic barriers** – active protection either via swing gates or raised boom barriers
- **Audible and visual warning** – active protection using flashing lights and bells or similar
- **Physical calming** – passive protection using chicane or maze layouts on approaches
- **Simple passive control** – passively protected crossing using signs and markings only

Essentially these treatment options are listed in order of decreasing effectiveness as well as decreasing cost. The following sections provide an overview of each of the main options available for pedestrian/cycle rail crossings; in each case a basic description is provided and their respective merits (or otherwise) are discussed. Note that many of the design features discussed in section 5 can be used with most of these treatments; their use should be considered on a case-by-case basis.

Typical layout design details for the crossing treatments discussed in this section are presented at the appropriate points, together with tables of appropriate dimensions. Indicative locations and orientations for flashing lights & bells (where they are warranted) are shown, but each site will need to be determined on a case-by-case basis. Dimensions have generally assumed a shared pathway configuration featuring pedestrians, cycles and other wheeled devices. If a pedestrian-only or low-volume crossing is being considered, then it may be feasible to use the smaller dimensions indicated. Designers should also review some of the “real world” examples presented in Appendix A1 and consider how their particular site constrains use of the standard layout designs exactly as provided.

Figure 36 provides a simple options chart for determining what treatment options might be appropriate given the particular circumstances of the site. As well as indicating the merits of the five treatment options listed above, guidance is also provided when various active and passive signs and markings might be warranted, as well as consideration of “second train” warning devices and layouts that allow for higher capacity of crossing users. For context, an indication of the likely existing Level Crossing Safety Score (LCSS) risk band is also shown at the bottom.

Note that most combinations of treatment will be mutually exclusive, e.g. grade separation or automatic barriers generally don’t require physical calming. However, ***all*** level crossing treatments require at least passive warning devices in addition to other controls.

Note that further engineering judgment is needed to confirm the appropriateness of the selected treatment, particularly having due regard to the various factors described in section 4. There is some overlap between the various treatment options presented and, even then, there may be exceptional cases where a different treatment is warranted. Available funding may also constrain the option selected, although this should not be to the detriment of appropriate levels of safety for the site.

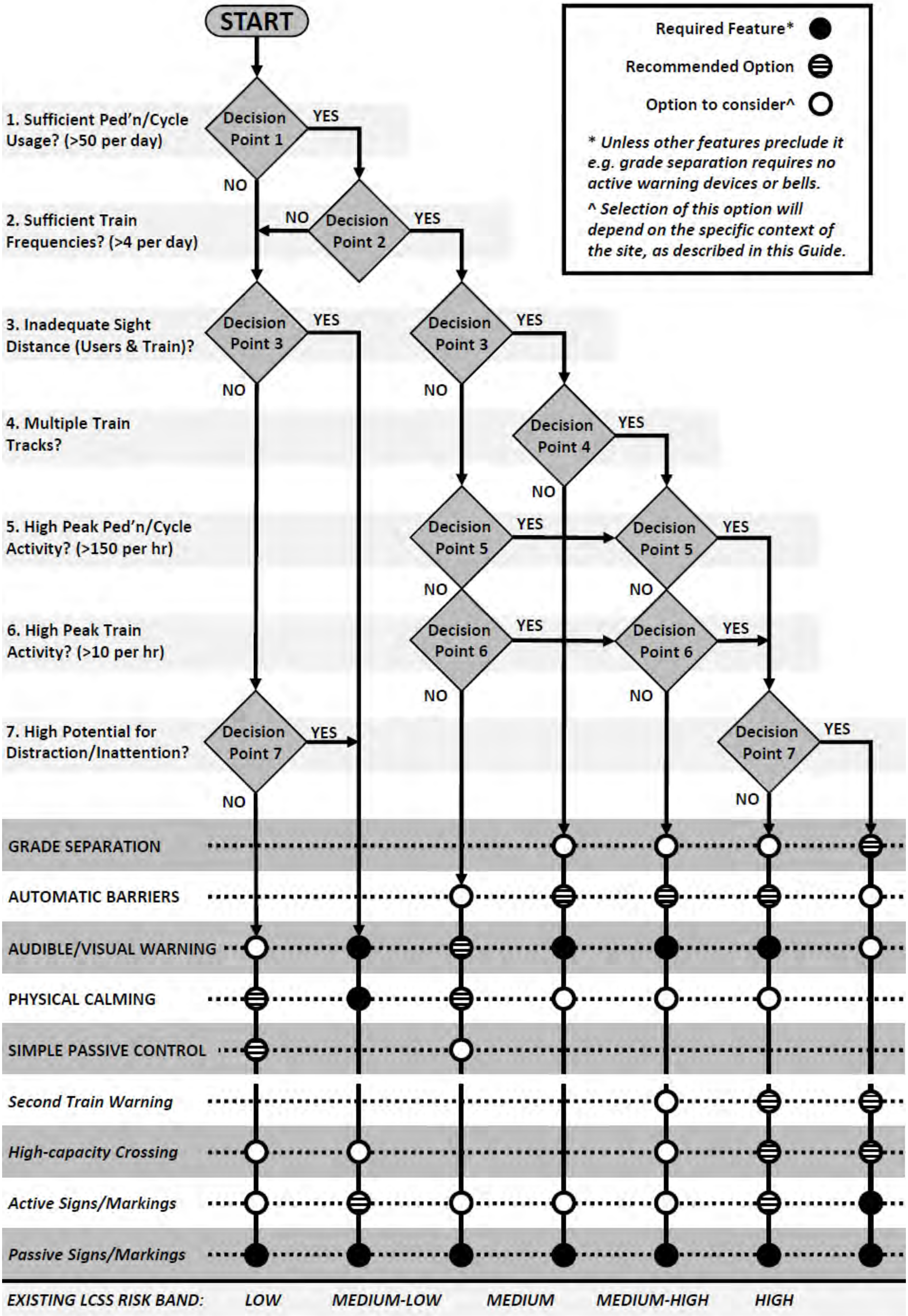


Figure 36: Indicative options chart for selecting crossing treatments

6.1. Grade Separation - overbridge

6.1.1. Description

An overbridge goes over the rail tracks by means of a structure; this could be by either raising the road/path above the existing rail line or by lowering the rail tracks below the road/path level. Access up to a raised structure is typically either by steps or ramps, although elevators may also be provided near busy stations. Any overhead structure ***must*** comply with the required minimum clearance above the tracks (refer to section 5.2).

6.1.2. Examples where used

Many metropolitan urban rail corridors have pedestrian overbridges, such as Petone (Wellington), Waimairi School in Bryndwr (Christchurch), and Kingsland (Auckland). Crossings over sunken rail corridors can be found in New Lynn and Panmure in Auckland.

Figure 37: Overhead crossing with steps and an elevator (Kingsland, Auckland)

6.1.3. Advantages and disadvantages

Providing an overhead crossing largely removes the risk of train conflicts at this location. However, this assumes that users use the elevated crossing; if some people continue to cross at ground level (e.g. due to the perceived increase in effort/distance to use the overbridge) then the risk change may be negligible, or even increased.

An overhead crossing with ramps can require a very long additional distance to achieve the required height clearance and ramp gradients. This might reduce its appeal. Some locations may also be constrained spatially to achieve such ramps. If there are space or cost constraints, it may be difficult for councils to maintain low gradients along a shared path.

If an overhead crossing makes certain walk/cycle trips considerably longer or inconvenient (e.g. the presence of steps), then some trips may become suppressed.

6.1.4. Other considerations

Although not physically touching the railway, overbridges still ***require*** agreement from KiwiRail regarding their location and design. A Grant of Right with KiwiRail is also required.

Crossings likely to be used by cycles, wheelchairs and mobility scooters must have ramps or at least elevator access. One option for cycle users is to provide wheeling ramps alongside the steps (see Figure 38) so that cycles can be wheeled up and down the slope (the design needs to ensure they do not present a hazard to other stair users i.e. those who are blind or have low vision and those using the handrails for support and balance). Regular level platforms are also important to allow unpowered users to rest while travelling uphill.

Figure 38: Example of wheeling ramps (Delft, Netherlands)

Overhead crossings (particularly long ones) can be very exposed to weather such as wind and rain. Consider the installation of overhead cover and/or wind-barriers - transparent/translucent material is best for light and security (see Figure 39). Side barriers also reduce the risk of people throwing items onto the tracks or attempting to jump off.

Figure 39: This overbridge features overhead and side protection from the elements (Auckland)

General design guidance about pedestrian/cycle bridges (e.g. NZTA 2008, NZTA 2016) is applicable in railway situations, e.g. maximum gradients, path widths. NZTA (2016) provides guidance on minimum heights for handrails adjacent to bridge structures; typically, a person on a cycle is the tallest design user to accommodate. Handrails introduce a “shy space” next to them, so it is important to provide adequate extra path width to account for this.

6.1.5. Risk assessment

The risk change at a site where a level crossing is converted to an overbridge crossing will reduce to zero unless some illegal crossing still continues there. This also presumes that the overhead structure doesn’t introduce some new risks such as falling off it.

6.2. Grade Separation - underpass

6.2.1. Description

Underpasses provide a path for users below the railway corridor, accessed either by ramps or stairs. They are typically either rectangular or arched in cross-section. A sufficient level of clearance is necessary for the tallest users; typically, 2.4 m is recommended. Discussions will be needed with KiwiRail to determine the minimum thickness above the ceiling required for supporting the rail structure above.

6.2.2. Examples where used

Bellvue Ave, Papanui, and Kyle Park (both in Christchurch) have rail underpasses (see Figure 40). Many rail stations along the Hutt line in Wellington also feature underpass access.

Figure 40: Railway underpass at Kyle Park with good sight lines, Christchurch

6.2.3. Advantages and disadvantages

Underpasses are susceptible to anti-social behaviour, particularly if they have dark or concealed areas. They can be perceived as unsafe by some pedestrians, due to lack of natural surveillance and visibility. Therefore, good sightlines and lighting are crucial to good design.

Generally, there is less vertical distance required to go down to an underpass compared with up to an overbridge. Therefore, shorter approach ramps may be required.

For riders of unpowered wheeled devices such as cycles, an underpass allows for building up speed on the downhill approach to provide momentum on the uphill departure.

Underpasses in low-lying areas may be prone to flooding, so good drainage design is necessary.

6.2.4. Other considerations

General design guidance about pedestrian/cycle underpasses (e.g. NZTA 2008, NZTA 2016) is applicable in railway situations. Underpass walls introduce a “shy space” next to them, so it is important to provide adequate extra path width to account for this.

Underpasses likely to be used by cycles, wheelchairs and mobility scooters must have ramps or at least elevator access. Regular level platforms (refer to NZ Standard NZS4121:2001) are also important to allow unpowered users to rest along the uphill leg.

Good lighting (both natural and artificial) is essential for underpasses to ensure their attractiveness. Refer to section 5.6.2 for lighting standards. Daylighting between tracks is an option, although a clear covering could be warranted to reduce noise and rail debris.

6.2.5. Risk assessment

The risk change at the site in question will reduce to zero unless some illegal crossing still continues here. This also presumes that the underpass doesn’t introduce some new risks such as personal assaults.

6.3. Automatic barriers - swing gates

6.3.1. Description

Automatic swing gates are electro-mechanically operated barriers that are normally held open when no trains are present. When a train approaches, the gates slowly swing shut to prevent entry into the crossing area. A separate escape path using a manual swing gate is usually provided for anyone caught on the wrong side of the gate (refer to section 5.2.1). Automatic gates are also accompanied by flashing lights and bells (refer to section 5.4.1).

Figure 41: Automatic gate, normally open, with emergency exit to the right (Tawa, Wellington)

Figure 42 and Table 4 provide layout details for automatic gate crossings. Where the crossing demand is high, consideration should be given to providing a wider gate access or a double-gate arrangement.

6.3.1. Examples where used

Automatic gates are increasingly being used along metropolitan rail corridors, including Crayford St, Avondale, Auckland and Camp St, Trentham, Wellington.

6.3.2. Advantages and disadvantages

Gates that are closed for a long time relative to the actual time for the train to pass may be subject to greater levels of non-compliance by users.

Automatic gates can be subject to electrical or mechanical failure (e.g. power outage); in such a case, an ideal design would keep the gate in the closed position by default with ability for people to manually open (or to use the emergency exit gate).

6.3.3. Other considerations

Generally, swing gates close a few seconds after other audible and visual warning devices are operated; this allows users to clear the crossing. Refer to section 5.2.1 for calculating an appropriate clearance time. Note that it is not standard practice to require a “second train coming” active sign in conjunction with an automatic gate.

6.3.4. Risk assessment

Automatic gates reduce most of the crossing risk by blocking the path of users. However, that effectiveness is dependent on the likelihood of users staying behind the barriers (rather than, say, using the emergency escape gate to enter the crossing when the barriers are lowered); any aspect of the site layout or design that encourages non-compliant behaviour will increase the risk level.

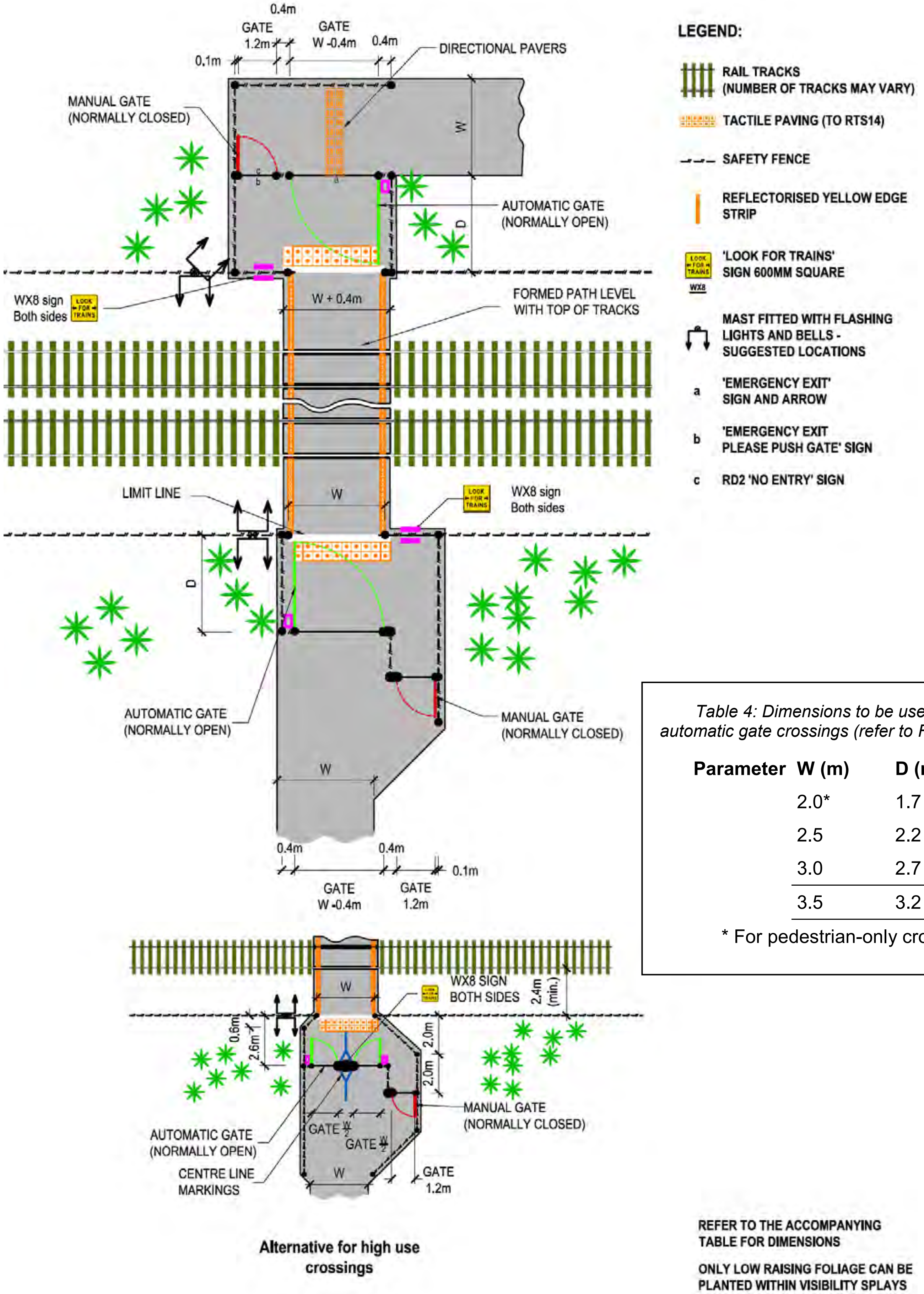


Table 4: Dimensions to be used for automatic gate crossings (refer to Figure 42)

Parameter	W (m)	D (m)
	2.0*	1.7
	2.5	2.2
	3.0	2.7
	3.5	3.2

* For pedestrian-only crossings

Figure 42: Layout plan for automatic gate crossing

6.4. Audible and visual warning

6.4.1. Description

Even in the absence of any other treatments, flashing lights and bells (FLBs) provide active warning (via both sound and lights) to crossing users that a train is approaching (see Figure 43). Section 5.4.1 provides more details about this warning device.

Figure 43: Flashing lights and bells on a path approach (Kaiapoi)

6.4.2. Examples where used

Crossings only controlled by FLBs are more commonly found on lower volume roads and paths, such as rural crossings. Pathways that are adjacent to a road with FLBs typically do not have separate warning devices.

6.4.3. Advantages and disadvantages

FLBs help crossing users identify when a train is approaching; this is particularly useful for users with sensory or cognitive impairments (unless someone has both hearing and vision impairments). However, they may not be sufficient for users who are distracted by personal devices with headphones.

An FLB-controlled crossing without automatic barriers provides no physical obstruction to a user still crossing the railway if they choose.

6.4.4. Other considerations

FLBs are particularly important where sight distance is not sufficient for crossing users to be able to judge adequate gaps to trains themselves; see Section 4.2.4 for further guidance on this.

Ideally, FLBs should be located right at the crossing point (i.e. parallel to the hold line) as this requires the least amount of crossing time for the user should the warnings activate just after they have passed them. If it is better for approach sight line requirements to place the warning devices in advance of the hold line, the designer must ensure that sufficient train arrival warning time is available from that position to the other side of the tracks. A suitable walking speed rate, catering for the elderly and slower walking demographic should be used to calculate the warning time required.

Additional flashing light units oriented at different angles may be necessary where users can approach a crossing from multiple directions, e.g. where multiple paths and roads intersect near a crossing. Although the layout drawings in this guide provide indicative locations for FLBs should they be required, the exact location should be determined on a case-by-case basis.

6.4.5. Risk assessment

FLBs help raise awareness of approaching trains to crossing users; thus, they reduce the risk compared with passively protected crossings. However, not every user may be sufficiently warned by just FLBs, and there is still nothing physically preventing users from encroaching onto the railway when a train is passing. If it is necessary to improve awareness and compliance, then other improvements to the site layout should be considered, for example adding audible warning messages (section 5.4.4).

6.5. Physical calming - chicane approaches

6.5.1. Description

The aim of chicane approaches is to slow down faster users and to orient them in both directions of the railway prior to crossing. Historically in New Zealand, mazes have been used to achieve this (see Section 6.7); however, simpler approach layouts can be achieved with gentler chicane approaches and less extreme constrictions. **KiwiRail is interested in trialling such layouts in New Zealand, and will be seeking Council participation.**

"Z-crossings" are one means of achieving these aims, by using roughly 90-degree turns to partly orient users in each direction of the railway. Although not in use yet in New Zealand, they have been applied in the United States and other locations (FRA 2016).

Figure 44: Example of a Z-crossing approach, albeit too narrow for easy cycle use (FRA 2016)

Figure 45 and Table 5 provide layout details for Z-crossing approaches. Where there is high use at a crossing, a double Z-crossing (effectively a diamond) can be used instead.

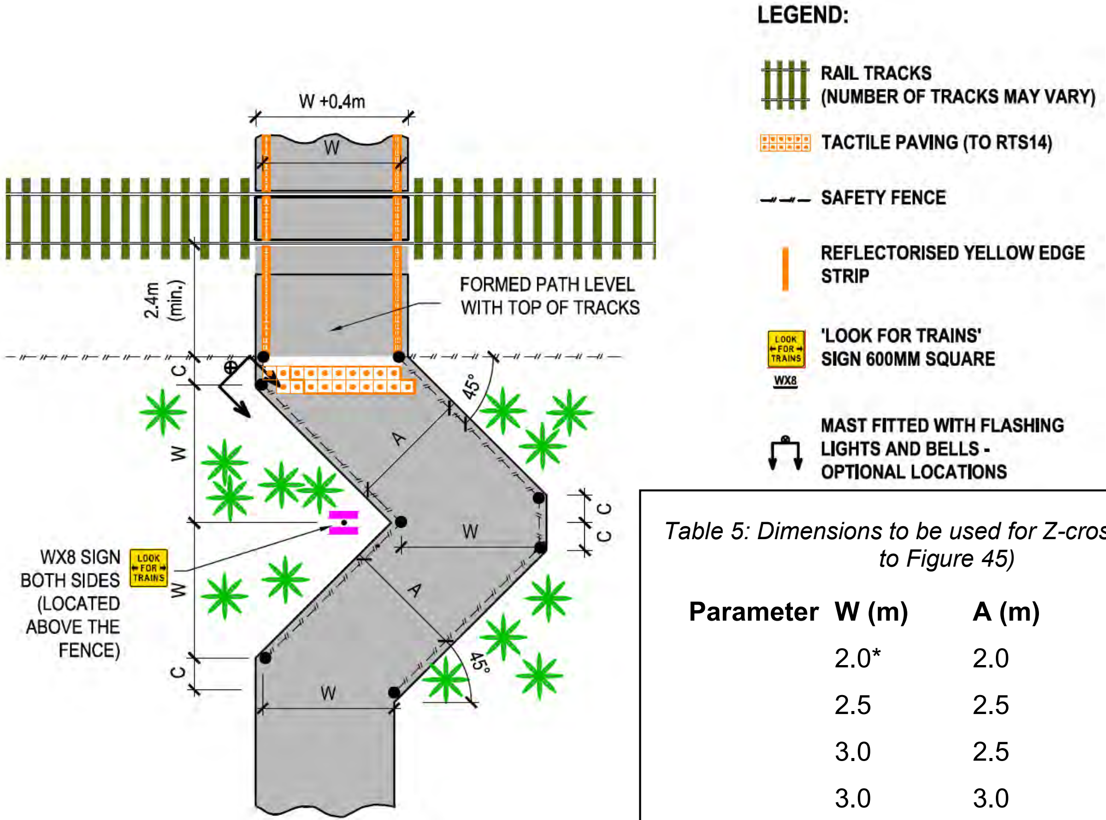


Table 5: Dimensions to be used for Z-crossings (refer to Figure 45)

Parameter	W (m)	A (m)	C (m)
	2.0*	2.0	0.85
	2.5	2.5	1.05
	3.0	2.5	0.55
	3.0	3.0	1.25
	3.5	3.0	0.75
	3.5	3.5	1.45

* For pedestrian-only crossings

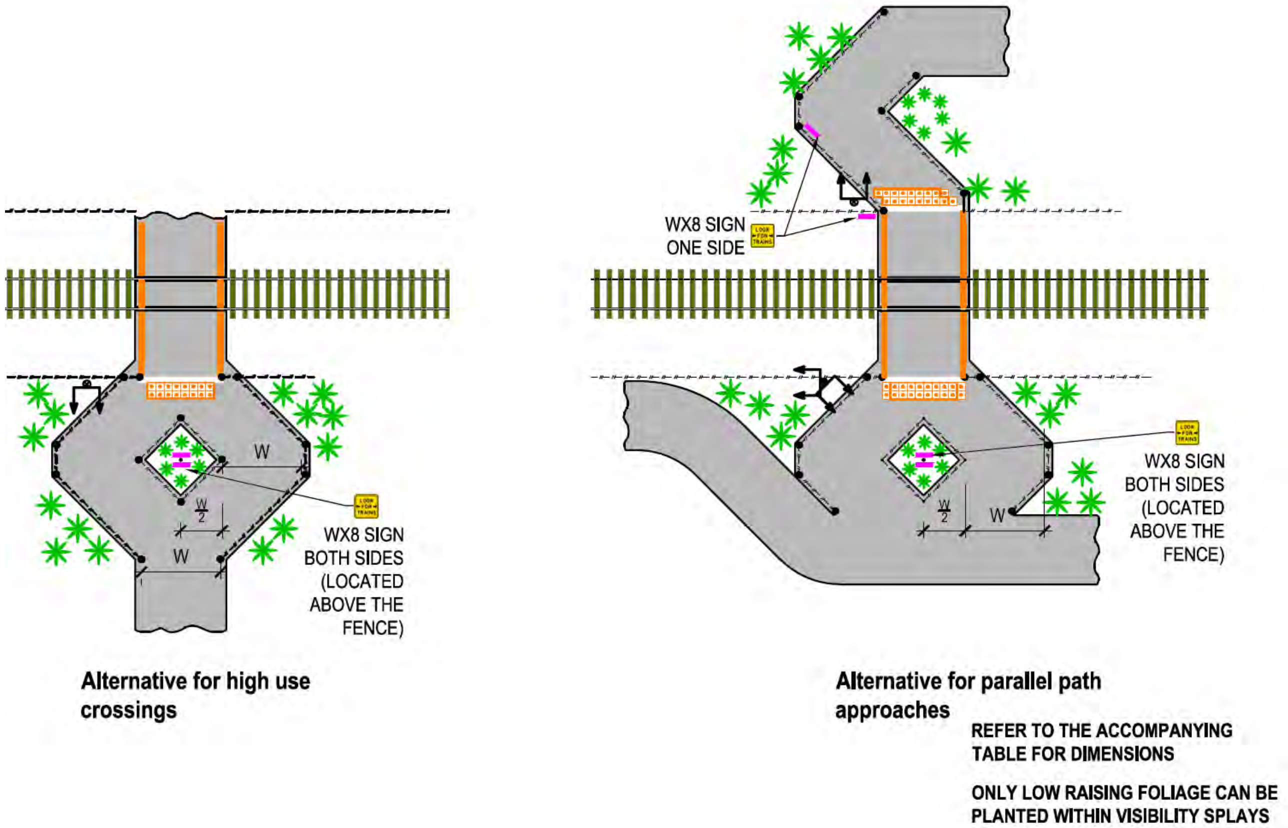


Figure 45: Layout plans for a Z-crossing approach

Chicanes can be achieved by introducing some deflection to the approach paths. Although not generally forcing users to check in both directions, they can at least help to improve awareness of the crossing by raising the cognitive workload on approach. Figure 46 provides layout details for a curved deflection chicane (path width ***W*** could range from 2.0 m to 3.5 m).

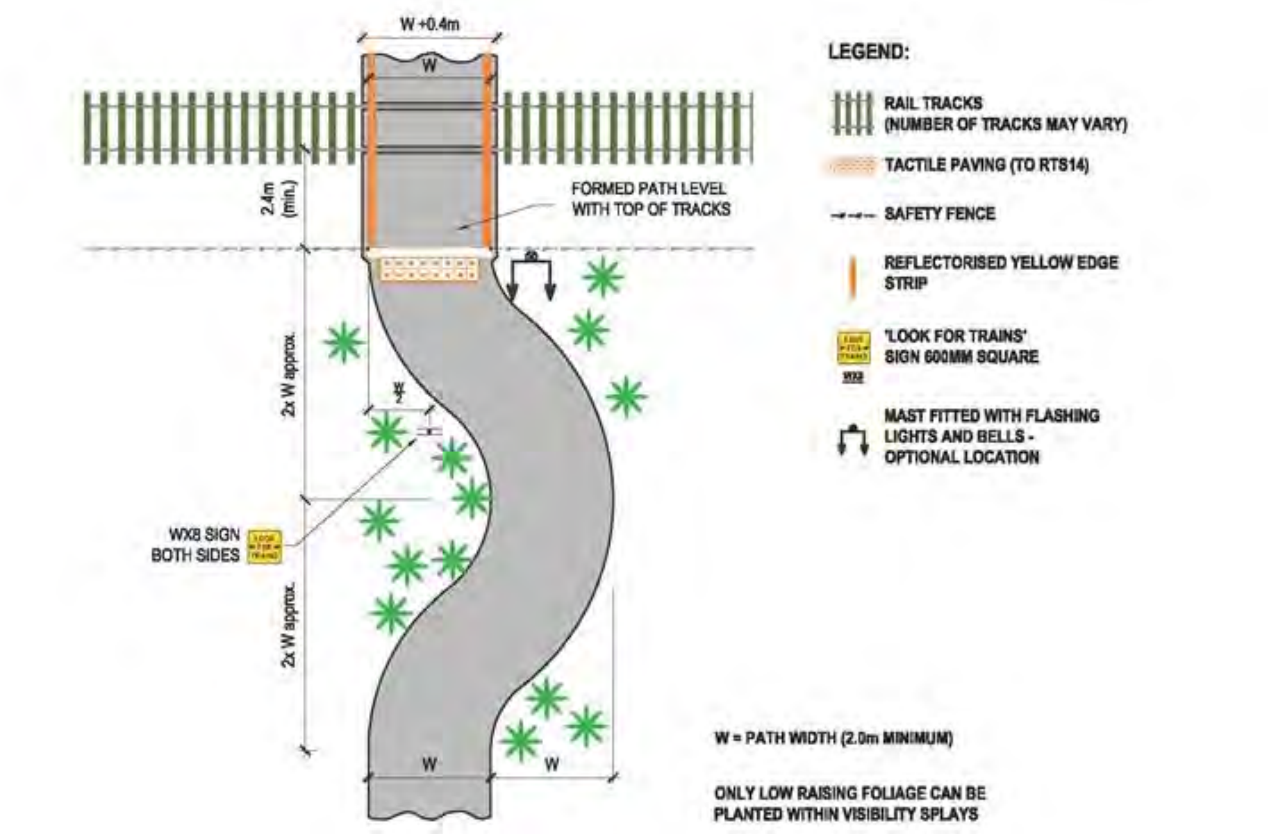


Figure 46: Layout plans for a curved deflection approach

Another way to provide simple chicane-style treatments is to introduce transverse handrails (aka “staples” or “hoops”) on an existing straight path (see Figure 47; note this example is not long-cane detectable near the ground, and may require a larger gap to allow for larger wheeled devices to get through).

Figure 47: Example of alternating staples (may require side-fencing to avoid bypassing)

Figure 48 and Table 6 provide layout details for a handrail deflection treatment. Note that barriers of uneven width can also be provided instead, so long as the *average* width of the two barriers is equal to the specified ***B***.

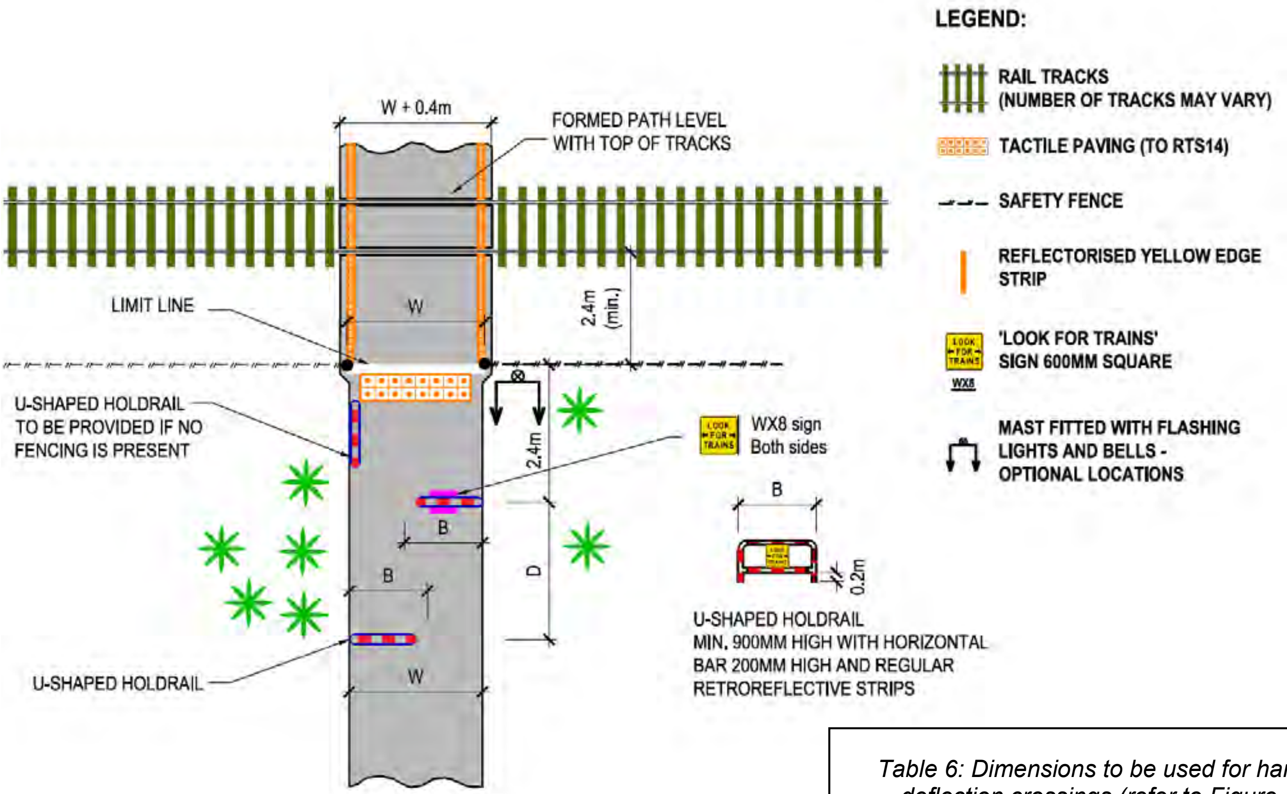


Table 6: Dimensions to be used for handrail deflection crossings (refer to Figure 48)		
Parameter		
W (m)	**D (m)**	**B (m)**
2.0*	2.0	0.90
2.5	2.0	1.15
"	2.5	1.40
3.0	2.0	1.40
"	2.5	1.65
"	3.0	1.90
3.5	2.5	1.90
"	3.0	2.15
"	3.5	2.40

* For pedestrian-only crossings

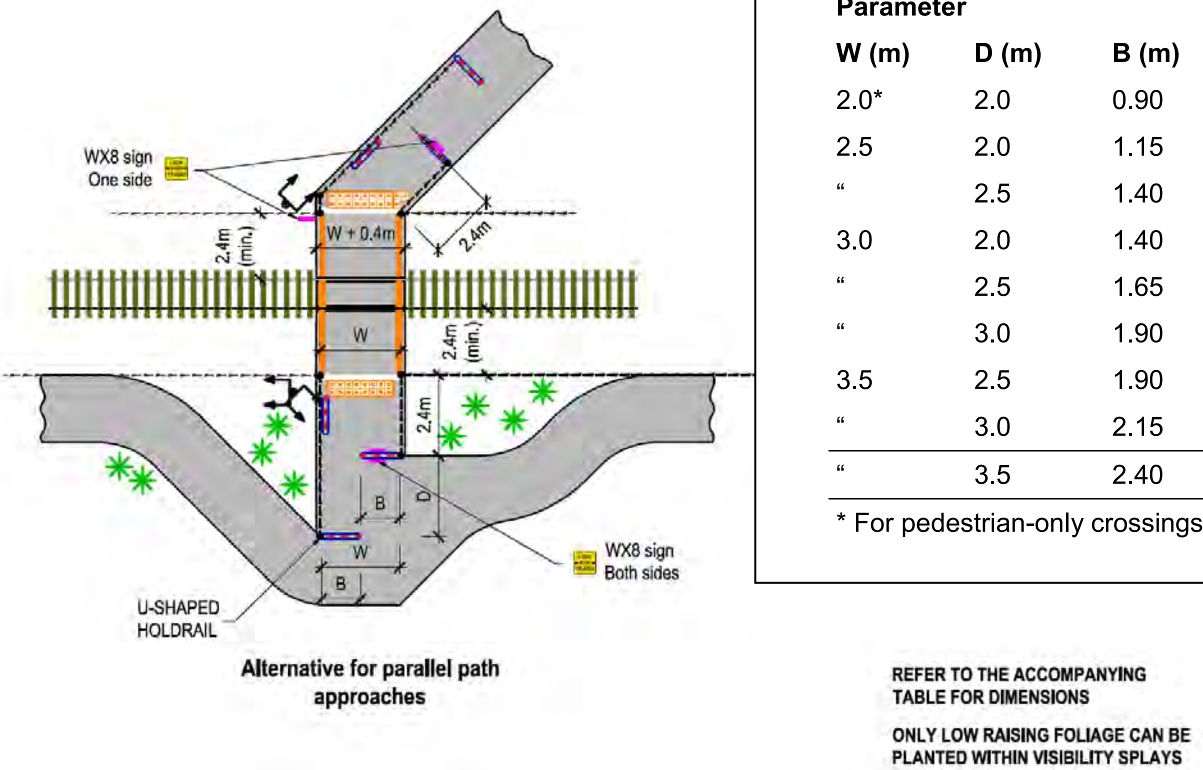


Figure 48: Layout plans for a handrail deflection approach

6.5.2. Examples where used

Grove Road, Christchurch, has planned chicanes in the cycleway on approach to the rail crossing, with flashing lights and bells but no maze or barriers. Halswell Junction Road, Christchurch, uses handrail barriers on the shared path crossing adjacent to the roadway.

6.5.3. Advantages and disadvantages

Although chicanes generally slow down approaching users somewhat, it is still not clear how much they encourage checking for trains in both directions.

6.5.4. Other considerations

Z-crossings have not yet been trialled in New Zealand, so further investigation is required to confirm their effectiveness.

6.5.5. Risk assessment

A chicane provides a direct obstruction to crossing onto the rail corridor, thus reducing the risk of a completely unprotected crossing. However, there is nothing physically preventing users from encroaching onto the railway when a train is passing; thus, it still relies on awareness and compliance (refer to section 4.1.1). If it is necessary to improve these attributes other improvements to the site layout should be considered.

6.6. Physical calming - manual swing gates

6.6.1. Description

While not a chicane in the traditional sense, manual swing gates do invoke a similar response to crossing users whose path is blocked. These gates are normally closed (by means of a spring mechanism or latch) and require users to push or pull them to enter and exit the rail crossing area (see Figure 49). They may provide an inexpensive alternative to automatic gates as well.

Figure 49: Manual swing gate at Beach Road (Paekakariki)

6.6.2. Examples where used

Beach Road in Paekakariki, near the railway station, has manual swing gates on the western (coastal) side of the railway crossing).

6.6.3. Advantages and disadvantages

Strong winds might move a swing gate, which could be hazardous for people near the gates. Young children may be able to open the gate without safely judging when to cross. A safety latch may be useful to address either of these problems.

Many gates only open in one direction; thus, people have to determine whether to push or pull them. For some users with wheeled devices (especially the mobility impaired), having to pull open a gate while still on their device can be exceptionally difficult. One option could be to provide two gates that open in different directions, allowing people to choose the most convenient one; however, that may be confusing to some users. Alternatively, gates that swing open both ways (with springs to centre them by default in the closed position) could be investigated (see Figure 50); however, over time they may become prone to getting “stuck” in an open position. They can also still cause difficulties for wheeled users getting through.

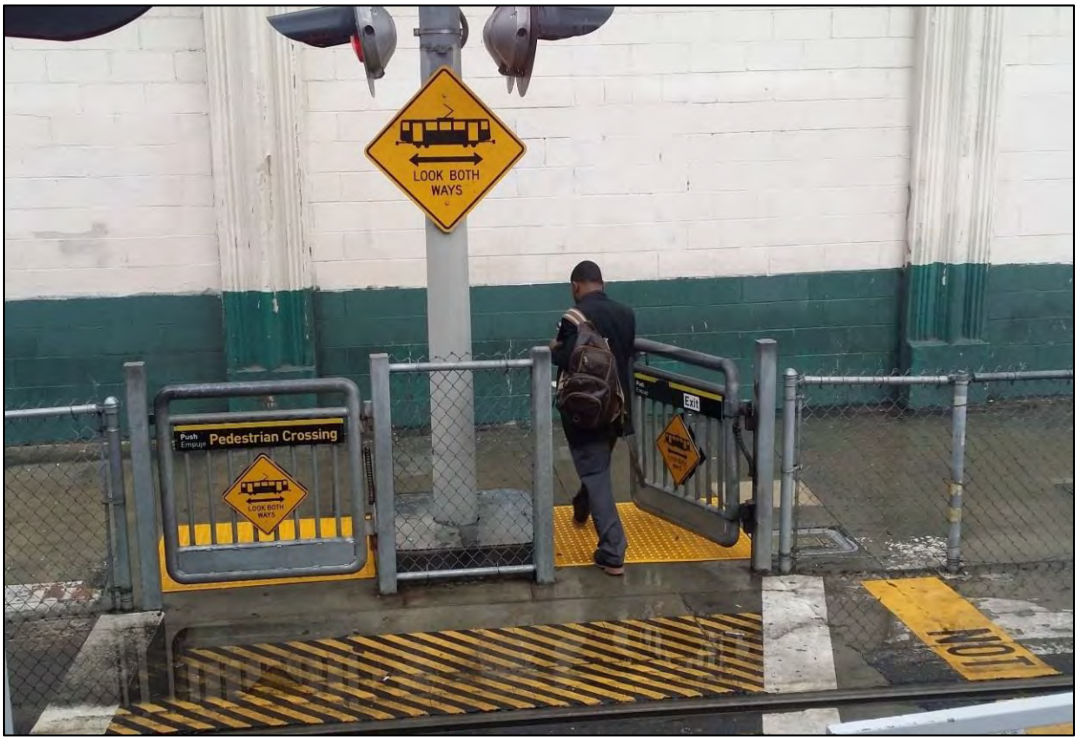


Figure 50: Spring-restrained manual swing gates in Los Angeles (US)

6.6.4. Other considerations

Manual swing gates have not been commonly used in New Zealand and may require some further local testing.

Without adequate active warning controls, regular users of a manual gate may become complacent and stop checking for trains when using the gate.

6.6.5. Risk assessment

Manual gates reduce much of the crossing risk by blocking the path of users, thus requiring their attention. However, that effectiveness is dependent on the likelihood of users staying behind the barriers when necessary; any aspect of the site layout or design that encourages non-compliant behaviour will increase the risk level. Active warning controls may still be needed to make users aware of the presence of trains.

6.7. Physical calming – maze approaches

6.7.1. Description

Mazes have been commonly used in New Zealand to provide an obvious physical barrier to walking/riding directly onto a level crossing. They typically involve a 180 degree turn to ensure that approaching users are oriented towards both directions of the adjacent track(s). However, given the cognitive effort often required to negotiate them, there is some dispute about whether their design achieves the intended purpose of user awareness. Recent observational studies in New Zealand have found a significant proportion of maze users not checking for trains appropriately before crossing (Cook 2016).

Currently KiwiRail recommend that designers consider trialling alternative treatments to the use of maze approaches, such as the chicanes described in section 6.5.

Section 8.5 of the *Traffic Control Devices Manual* Part 9 (NZTA, 2012) specifies the current requirements for pedestrian mazes at level crossings; this design has been amended below.

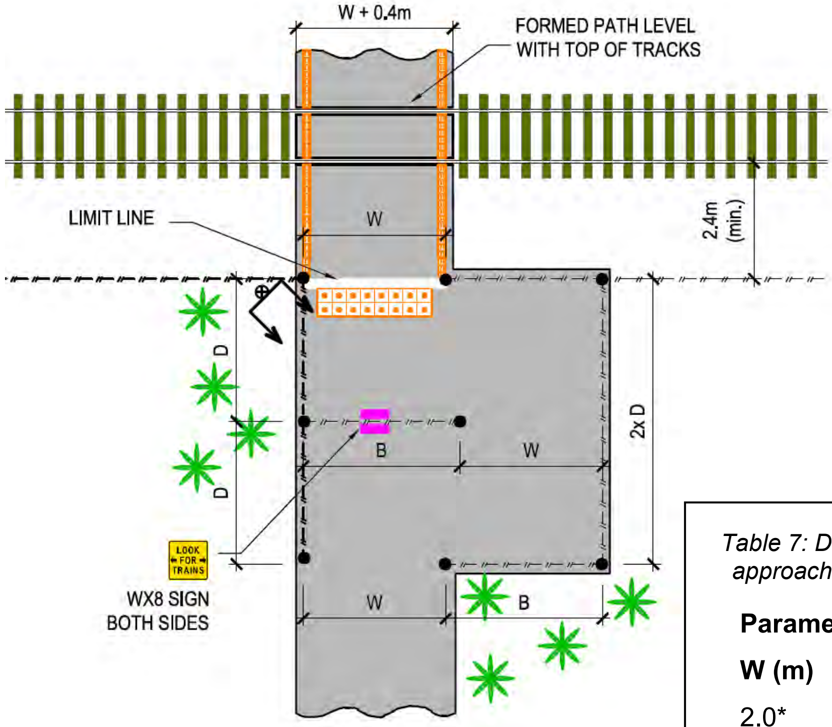
TCDM Part 9 also specifies that maze fencing is not appropriate when:

- site dimensions do not allow sufficient space to construct a maze
- it is not practical to install sufficient fencing to encourage most pedestrians to use the maze, e.g. adjacent to a station platform
- peak pedestrian traffic flows regularly exceed the capacity of a 2-m wide footway so that the maze may form an obstruction to persons wishing to clear the railway line or lines.

While *TCDM Part 9* states that the maze design has been developed to cater for wheelchairs and mobility devices, it does not state any specific considerations for accommodating bicycles (see Figure 51). With the increasing popularity of cargo bikes and extended bikes, mazes of insufficient width and length can cause significant problems to some users. The *NZ Cycle Trail Design Guide* (MBIE 2015) proposes a longer and wider layout that is more accommodating for larger bikes.

Figure 51: Consider the manoeuvre room available for a bicycle to get through a maze

Figure 52 and Table 7 provide layout details for maze approach crossings.



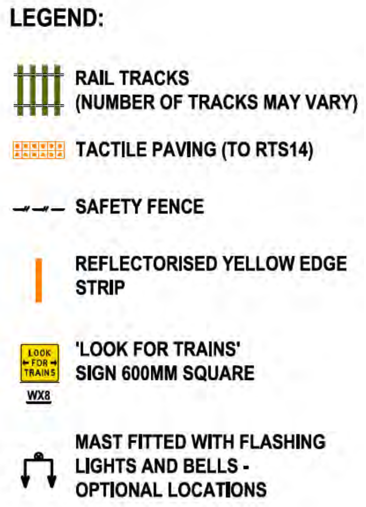


Table 7: Dimensions to be used for maze approach crossings (refer to Figure 52)

Parameter

W (m)	D (m)	B (m)
2.0*	2.0	2.3
2.5	2.5	2.8
3.0	3.0	3.3
3.5	3.5	3.8

* For pedestrian-only crossings

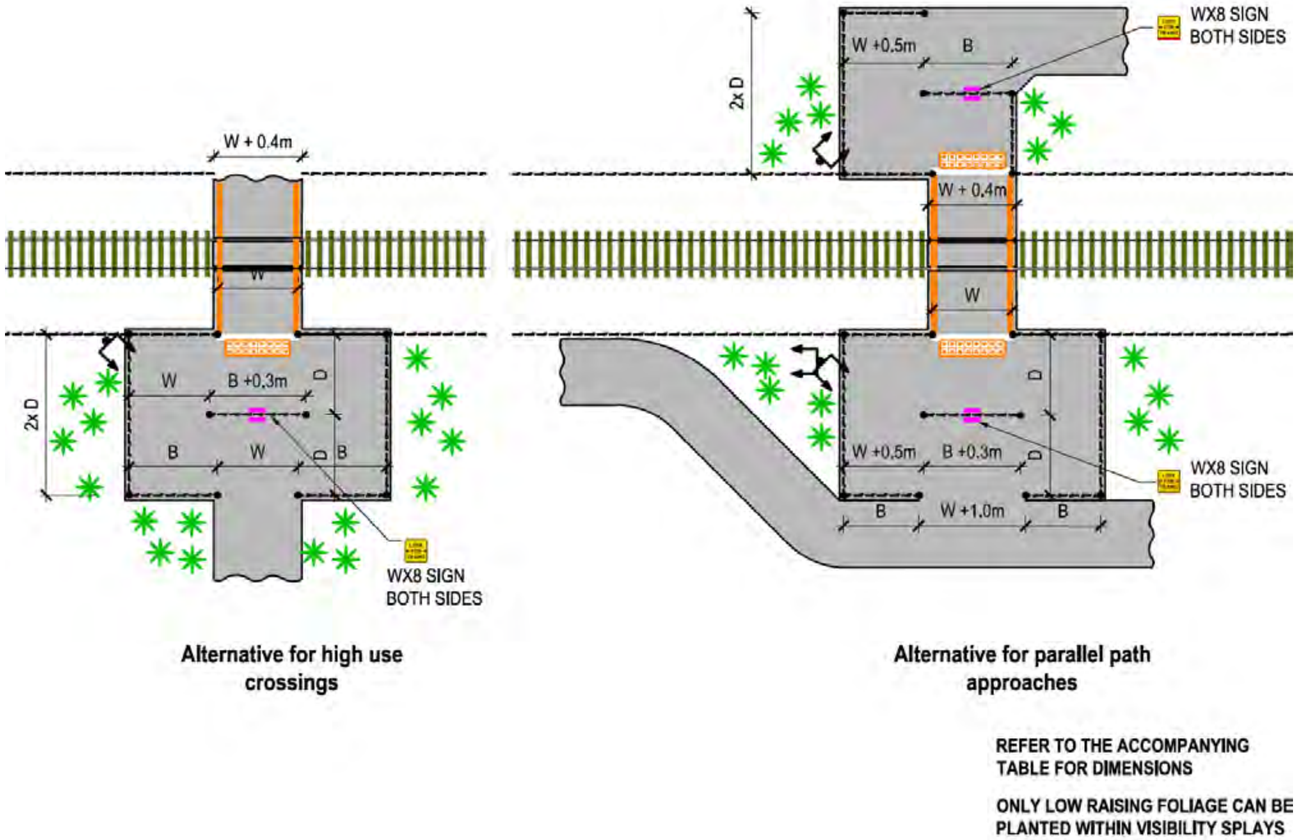


Figure 52: Layout plans for maze approaches

6.7.2. Examples where used

Mazes have been used in most New Zealand urban areas for pedestrian crossings, including St Jude St, Avondale, Auckland and Blenheim Rd, Riccarton, Christchurch. Some Christchurch crossings feature wider than normal turn areas to improve manoeuvrability for cycles.

6.7.3. Advantages and disadvantages

Mazes are largely effective at preventing people from walking directly onto the rail crossing unaware of its presence. However, it is not clear whether it ensures that people have checked for trains in both directions, and there is nothing physically preventing people from stepping out in front of a train.

Small mazes that are constrained in their layout can be difficult for larger wheeled devices to negotiate (refer to section 4.1.7 for typical device dimensions). Many cyclists may need to dismount or could risk injury if they fail to take the sharp turns involved.

Maze crossings with high use (especially larger wheeled devices like cycles and wheelchairs) may suffer from large delays at peak times when users are crossing in both directions. One option is to provide a pair of adjacent maze approaches to the same crossing (see Figure 53), thus allowing users travelling in different directions to avoid each other.

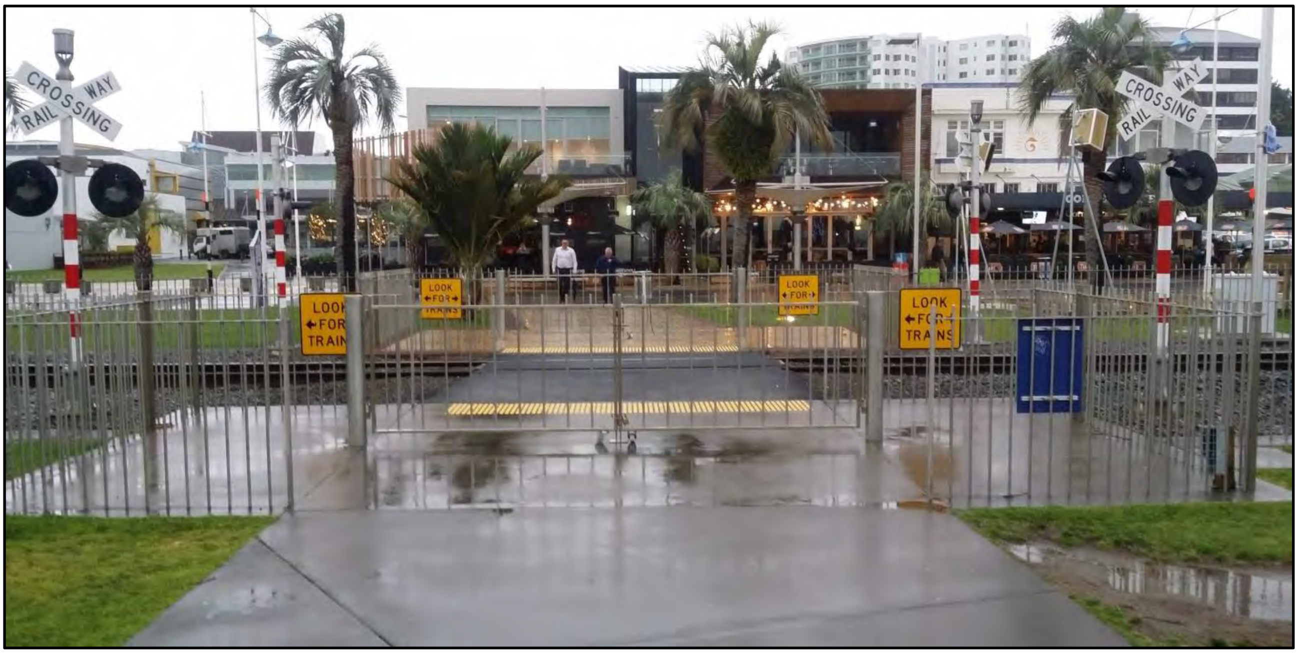


Figure 53: A double maze layout provides increased capacity at busy crossings – the design shown also provides an access gate for rail service vehicles (CBD, Tauranga)

A maze with adequate manoeuvre space requires adequate depth and width away from the crossing. In some constrained locations (e.g. next to roads), this space may not be achievable, thus requiring other treatment options or only partial maze layouts.

6.7.4. Other considerations

Usage of a maze is likely to be low if there is an adjacent roadway crossing with less restriction (see 4.2.1).

6.7.5. Risk assessment

A maze provides a direct obstruction to crossing onto the rail corridor, thus reducing the risk of a completely unprotected crossing. However, there is nothing physically preventing users from encroaching onto the railway when a train is passing; thus, it still relies on awareness and compliance (refer to section 4.1.1). If it is necessary to improve these attributes other improvements to the site layout must be considered.

6.8. Simple passive control

6.8.1. Description

This treatment involves no physical measures to stop or restrict access over the crossing, simply warning devices only. It is the lowest form of crossing treatment available, relying solely on active or passive warning controls to inform the user and encourage appropriate behaviour.

6.8.2. Examples where used

Unprotected crossings are typically found on lower-volume roads and paths with few crossing users, such as rural locations.

Figure 54: Unprotected crossing with minor chicanes and warning signs (Stoney Creek, Palmerston North)

6.8.3. Advantages and disadvantages

An unprotected crossing generally has no impediment for users going across it, resulting in the least delay at all times. However, that lack of impediment also increases the chances that users do not even notice the presence of the crossing (or a train) or do not slow down to check first.

6.8.4. Other considerations

Any unprotected crossing requires adequate sight distance of the rail corridor, to allow approaching users to properly discern whether the way is clear (see section 4.2.4). If this is not possible, then more active measures should be included to encourage users to stop and check closer to (or at) the crossing.

Because of the lack of active controls to alert users at a passive crossing, greater consideration should be given to providing additional pavement markings on each approach (see section 5.3.2)

6.8.5. Risk assessment

This treatment provides no direct obstruction to crossing onto the rail corridor. There is nothing physically preventing users from encroaching onto the railway when a train is passing, so it relies on awareness and compliance (refer to section 4.1.1). Consider improvements to the site layout if need be, to improve these attributes. Typically, an unprotected site will only be used where train and crossing user numbers are both low; therefore, the overall crossing risk at the site will still be relatively low.

6.9. Other options - remove (close) crossing

6.9.1. Description

Where an existing level crossing is no longer in demand, or an unacceptable crossing risk has developed, one option is to remove the crossing infrastructure. The closed crossing might be replaced with an alternative grade-separated crossing or be replaced by a new crossing located elsewhere.

6.9.2. Examples where used

In Newmarket, Auckland, an existing level crossing at Sarawia St (one of the busiest rail crossings in the country) connecting to a small number of residences on Laxon Terrace is being replaced by an overbridge.

6.9.3. Advantages and disadvantages

Removing a crossing largely removes the risk of train conflicts at this location. However, this is based on the assumption that users move to an adjacent formal crossing; if some people continue to cross at the same location then the risk change may be negligible.

If the replacement crossing is not grade-separated, then much of the crossing risk may simply have been transferred to the adjacent crossing location(s). If the adjacent location has more optimal site features, then the overall risk is likely to improve.

There are ongoing maintenance and operational advantages of having one less crossing on the network.

If a closed crossing makes certain walk/cycle trips considerably longer or inconvenient to make, then some trips may become suppressed (or undertaken by motor vehicle). Therefore, the relative amenity and 'reasonableness' of closing a crossing needs to be carefully evaluated.

6.9.4. Other considerations

Generally, all properties must have access to the road network, and so alternative access means might be needed if road access has been cut off by closing a crossing. This may not be such an issue for a standalone pathway crossing being closed.

6.9.5. Risk assessment

The risk change at a site where the crossing is removed will reduce to zero unless some illegal crossing still continues there. This must be balanced by the change in risk at other crossings, due to shifts in user flow patterns.

6.10. Other options - relocate crossing

6.10.1. Description

Where a site has particular problems related to its location (e.g. poor sight distance, personal security, localised distractions), it may be prudent to consider relocating the crossing to a more optimal location.

6.10.2. Examples where used

No permanent relocations of level crossings in New Zealand have been identified (although a number have been replaced with grade separation as part of road realignments). However, some crossings have been temporarily relocated while railway construction works have been undertaken.

6.10.3. Advantages and disadvantages

Assuming it is well designed and located, the relocated site should improve the relative safety of users.

If there is still a strong demand for crossing in the old location rather than the new one, then strong fencing and other barriers may be needed to persuade use of the new facility.

6.10.4. Other considerations

Discussion will be required with KiwiRail and the relevant RCA to get agreement regarding their location and design.

If there are other nearby crossings, it may be that some users of the current site may switch to another crossing rather than the relocated one.

The treatment option for the relocated crossing may not necessarily be the same as the original crossing; the options discussed above should be considered based on the site specifics.

Where a crossing is relocated there must be clear guidance given to all users of the new route, particularly vision-impaired pedestrians i.e. tactile ground surface indicators and other environmental cues to indicate changes in direction and to locate the new crossing position.

6.10.5. Risk assessment

The aim of relocating a crossing is usually to address site-related problems at the current location. Therefore, it would be expected that a LCSIA review of both sites should identify a reduction in crossing risk resulting from the shift. However, this assumes that no-one continues to cross at the old location after it is decommissioned.

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7.2. Acknowledgments

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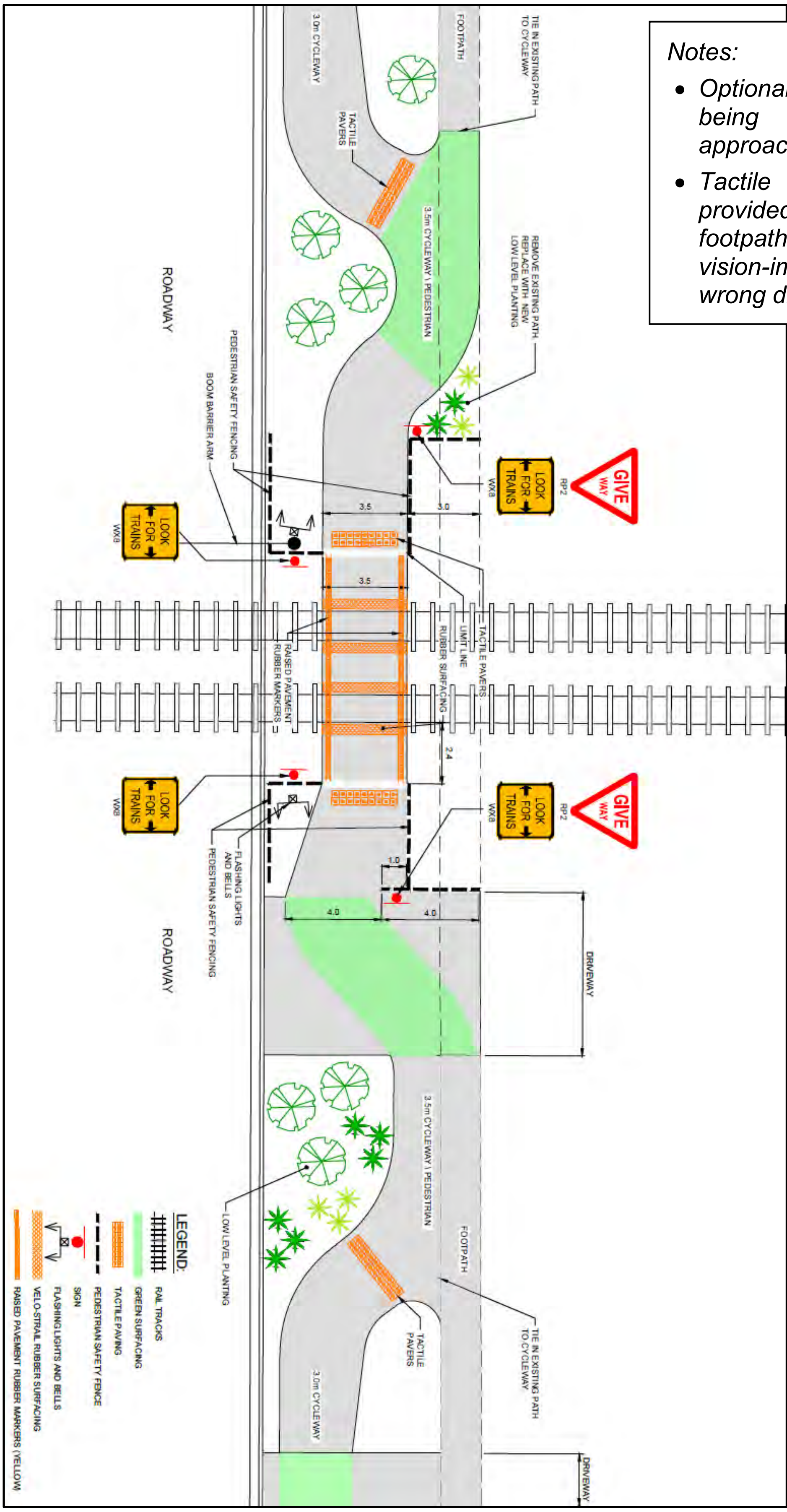
- Representatives from the Active Modes Infrastructure Group (Christchurch, Auckland, Whangarei, Palmerston North)
- Representative from rail operator (Transdev)
- Representatives from walking/cycling/mobility sectors (Cycle Action Network, Living Streets Aotearoa, Blind Foundation, CCS Disability Action)
- Christchurch City Council, Auckland Transport and KiwiRail for the supply of various rail crossing plans
- Staff from the PELOTON Major Cycleway design consortium, Christchurch
- Staff from KiwiRail and the New Zealand Transport Agency

Appendices

A1 Sample "real world" design plan details

The standard crossing treatment layout plans found in Section 6 present fairly standard perpendicular alignments with simple crossings. The following pages provide some examples of how the guidelines in this document might be applied to "real world" examples of crossings where there are additional complications such as oblique angles and additional side-roads and paths. They serve to illustrate that the standard drawings **should only be a starting point** from which the additional guidance in this document and professional engineering judgment should be applied to modify them to suit.

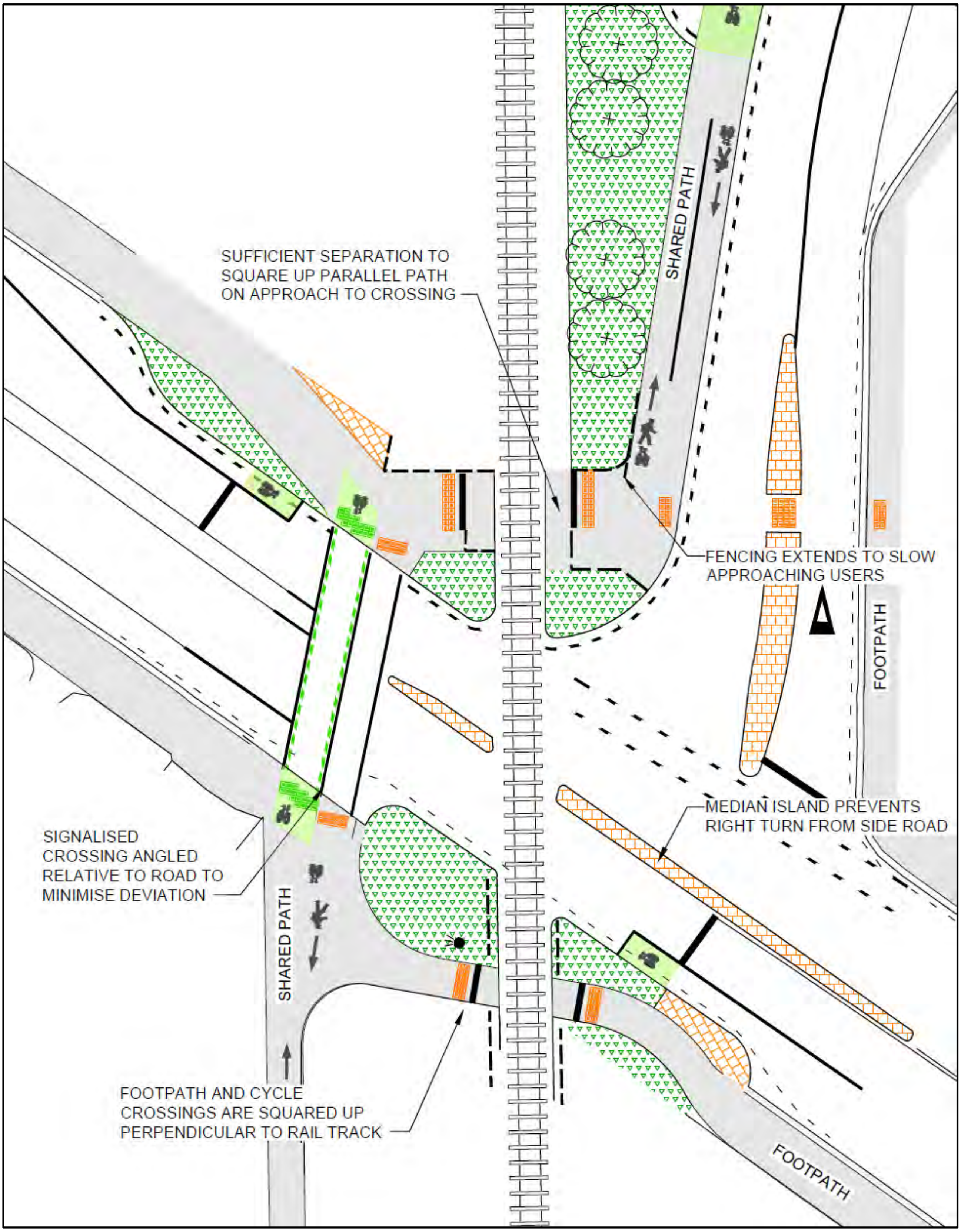
A1.1: Chicane crossing with combined paths



Notes:

- *Optional GIVE WAY signs are being trialled on the path approaches.*
- *Tactile pavers have been provided at the merger of footpath and cycleway to warn vision-impaired users of the wrong direction.*

A1.2: Example real world application - parallel pathway



A1.3: Example real world application - skewed low-volume crossing