New Zealand Cycle Trail Design Guide

prepared for

Ministry of Business Innovation and Employment

February 2015 (4th edition)

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This is the fourth edition of the design guide. The first edition was published in March 2010. The considerable efforts of Jonathan Kennett in revising the design guide are greatly appreciated.

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Cover photo: Hawke's Bay Trails (photographer: Jonathan Kennett)

Nga Haerenga THE NEW ZEALAND CYCLE TRAIL

VIASTRADA

Explanatory Note to Cycle Trail Design, Fourth Edition

The *New Zealand Cycle Trail Design Guide* was first published in February 2010 to assist people involved in planning, designing or building cycle trails that would make up the New Zealand Cycle Trail (NZCT).

During the construction of the "Great Rides" lessons have been learnt along the way and this fourth edition updates and clarifies key technical information, particularly relating to trail grades. A list of significant amendments is provided below.

Schedule of Amendments

Second edition (August 2011)

- Simplified and more consistent guidance on gradients (Sections 3 and 4);
- Introduction of a Grade 5 on-road trail type (Section 4);
- Amended guidance on gravel roads (Section 4.4);
- Guidance for audio tactile profile road markings and raised reflective pavement markers (Section 4.5);
- Information on seasonal traffic volume variations (Section 4.6); and
- Provision of an appendix summarising trail gradient information (Appendix 1).

Fourth edition (February 2015)

- Gradient table (Table 4) amended to include greater slope.
- Further guidance added to section on chipseal (section 3.9.3) and amalgamated with section on asphaltic concrete
- Inclusion of framework to assess viability of open roads to accommodate NZCT routes (section 4.7), and associated updates to other tables and figures.
- Addition of “squeeze barrier” specifications to prevent motorcycle use of cycle trails (section 6.7.4).
- Various photo updates

Executive Summary

The *New Zealand Cycle Trail Design Guide* draws on a wealth of trail design and construction techniques from New Zealand and around the world. It will help you and your team build the best possible trail with the resources available.

This guide compiles information from a number of existing guides, referring directly to them for more detail if needed. These other guides provide specific information relating to different components of the NZCT, whether they be mountain bike tracks, rail trails, urban cycle paths or sections of quiet country roads.

The basis for trail design is the selection of a trail grade, and recognition of the trail criteria that define that grade. This selection will reflect the chosen target audience, from "renaissance riders" seeking easy Grade 1 trails to mountain biking enthusiasts looking for higher grade trails to test their fitness and skill.

Consistency is the key to the NZCT's success. The NZCT comprises trails throughout the country and cyclists will form their impression of the NZCT based on their experiences of individual trails. On a well-designed trail, users will enjoy the beautiful scenery and riding experience, without being distracted by design flaws, such as a gap in signage or uncharacteristically difficult sections. Their memories will be of the scenery, the camaraderie and the sense of accomplishment, not whether the trail was too hard for them in places, or they got lost along the way. The *Cycle Trail Design Guide* explains the how to avoid these pitfalls, and plan a trail that will be consistent, not only from one end to the other, but also within the whole NZCT network.

Many trails are in remote parts of New Zealand, allowing access to pristine environments and iconic landscapes. The cycle trails in these locations need to be designed, built and maintained appropriately to fit into their natural surroundings.

This guide streamlines the design process and provides an invaluable range of criteria and techniques to ensure you build sustainable trails that meet the expectations of the target audience, and require minimum ongoing maintenance. It includes chapters on:

- Route planning
- Off-road trails
- On-road trails
- Crossings and intersections
- Structural design
- Signage
- Supporting facilities
- Path and road maintenance
- Monitoring and evaluation

The *Cycle Trail Design Guide* also encourages collaboration amongst trail builders and will be updated periodically. Suggestions for amendments should be sent to: info@nzcycletrail.com

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Glossary

Term	Definition or explanation
AC	Asphaltic concrete, a relatively-expensive road surface usually used for higher-volume roads. Because it provides a smooth and durable riding surface it may be suitable for high-volume or more urban cycle trails.
Austroads	The association of Australian and New Zealand road transport and traffic authorities. It aims to promote improved road transport outcomes.
Berm (or superelevation)	Term used by mountain bike trail designers for a slope across a trail provided to assist cornering on bends. An inwards slope or berm on a bend allows higher speeds of travel than would otherwise be possible with a flat track. See also “superelevation”.
Carriageway	The portion of road where vehicles travel (i.e. the width of seal or gravel of a formed road).
Clearance	The distance (vertical or horizontal) between a trail and an obstruction (e.g. overhead bridge, fence, tree).
Climbing turn	A curve in a trail located on a sloped section.
Cycle lane	A type of on-road trail for cyclists, delineated by paint, where motor vehicles are not permitted.
Cycle route	A course of direction for cyclists between two key locations or connecting a series of key locations. May comprise on-road and / or off-road sections.
Cycleway	A route for cyclists.
DOC	Department of Conservation
Gateway	A feature used to provide an attractive threshold at the start of a trail.
Gradient reversal	Deliberately-designed section of trail where long slopes are interrupted by short sections where the gradient reverses.
Grade separation	Where a cycle trail crosses a road at a different elevation by way of a bridge or underpass.
Greenway	See path. This term is commonly used in the UK.
Ground Effect	A company specialising in cycle clothing and accessories that will generally provide copies of the IMBA guide to non-profit trail-building groups.
IMBA	International Mountain Biking Association
Intervisibility	The ability of two road or trail users to see each other as they approach each other.
Key attraction	An “iconic” location that will generate cycle tourism
Level of Service	The quality of use experienced by someone on a trail.
Midblock	A section of road between (not at) intersections.
Mode	A form of transport e.g. cycling, walking, motor vehicle.
New Zealand Cycle Trail (NZCT)	An initiative started by the New Zealand government and managed by the Ministry of Economic Development to create a series of iconic cycle routes throughout the country.
NZTA	New Zealand Transport Agency

Term	Definition or explanation
Path	An off-road trail for cyclists and or pedestrians. This is the official engineering term, as opposed to "track". See also "trail".
Pedestrian	Any person on foot or using a powered wheelchair or scooter or a wheeled means of conveyance propelled by human power, other than a cycle.
Pinch point	A localised section of a trail where width provision for cyclists is substandard.
Rail trail	A path formed along a railway corridor (the railway may be either active or disused).
Route	A link between two key locations or connecting a series of key locations. In the NZCT context "routes" are provided specifically for cyclists, although they may also be used by pedestrians.
RRPM	Raised reflective pavement marker.
Segregated path	A type of off-road trail for cyclists and pedestrians where the two modes are designated their own sections through use of "soft" measures (e.g. paint markings) rather than physical separation.
Separated path	A type of off-road trail for cyclists only, running parallel and adjacent to a similar facility for pedestrians only.
Shared path	A type of off-road trail for cyclists and pedestrians without separation or segregation of the two mode groups.
Singletrack	A mountain biking path designed for cyclists to ride single file, sometimes in one direction only.
Superelevation (or berm)	A slope across a trail often used to assist cornering on bends. An inwards slope allows higher speeds of travel than would otherwise be possible with a flat track. See also "berm".
Sustrans	UK charity that administers its national cycle trail.
Switchback	A curve in a trail on level ground, even if the approach and departure to the curve are on sloped sections.
Track	This term is commonly used for natural surface cycle paths or mountain biking trails. See also "path" and "trail".
Trail	This term is used for the NZCT and, at a broad level, technically includes on-road cycle routes as well. In general NZ use, "trail" is usually associated with paths aimed at a broad cross-section of cyclists and potential cyclists, e.g. "Rail Trails". See also "path".

1 Introduction

1.1 Cycle Trail Design Guide Purpose

This cycle trail design guide is intended to help anyone planning, designing or building parts of the New Zealand Cycle Trail (NZCT). It is also useful for those applying for NZCT funding.

Consistency is the key to the NZCT's success. The NZCT comprises multiple routes throughout the country and cyclists form their impression of the NZCT (and even of New Zealand) based on their experiences on individual routes. On a well-designed route, users will not be distracted or endangered by design flaws or the task of riding and will be able to enjoy the iconic scenery and riding experience. Their memories will be of the scenery, the camaraderie and the sense of accomplishment, not whether the surface was too rough, the gradients too steep or the trail too narrow.

1.2 Related Documents and Design Guides

Besides this design guide, designers are also likely to require access to other manuals and design guides as outlined below. These sources contain useful information related to design and construction of NZCT routes but none of them provides comprehensive, stand-alone guidance for the NZCT. This design guide aims to tie together the relevant parts of various existing manuals. It also supplements and advises on their use where necessary. These manuals are cited throughout this guide, with full references and web-links, where appropriate, given at the end of the document. This guide is intended to represent best practice and should be used for guidance where other documents indicate different advice or values for design parameters. Designers should always use "sound engineering judgement" in their designs and seek external qualified advice where necessary.

1.2.1 NZCT Funding Process Guide

This design guide is intended to be used in conjunction with the NZCT Funding Process Guide (Ministry of Tourism, 2009) which, amongst other things, specifies certain design requirements for different grades of trail so that routes meet the NZCT objectives. Well-designed routes are more likely to obtain NZCT funding.

The NZCT Funding Process Guide (Ministry of Tourism, 2009) is freely available online from the Ministry of Economic Development website.

1.2.2 DOC Track Construction and Maintenance Guidelines

Designers of off-road trails should also use the Department of Conservation's (DOC) Track Construction and Maintenance Guidelines (2008) in conjunction with this guide. The DOC guide gives a comprehensive account of all major steps in the development of an off-road trail, including landscape considerations, design, construction, water management and maintenance. It is intended principally for trails used by walkers but sometimes includes advice for mountain bike trails. Not all sections in the DOC guide are considered relevant to the NZCT, for example steps (covered in Chapters 19 and 33) are not recommended on the NZCT.

The DOC Track Construction and Maintenance Guidelines (DOC, 2008) are freely available online from the DOC website.

1.2.3 IMBA Trail Solutions

Designers of off-road trails may also find the International Mountain Bicycling Association's (IMBA) Trail Solutions (2004) guide useful. The IMBA guide provides appropriate guidance for NZCT trails in some circumstances, however the important concepts are all covered in the DOC Track Construction and Maintenance Guide (Section 1.2.2) which is freely available and tailored to the New Zealand context. The IMBA guide principally covers the design of mountain bike tracks but is less useful for less "technical" or demanding off-road trails (such as rail trails), or on-road facilities.

Ground Effect (a company specialising in cycle clothing and accessories) supplies the IMBA guide free of charge to "worthy" non-profit trail developers.

1.2.4 Connect2 and Greenways Design Guide (Sustrans)

The Connect2 and Greenways Design Guide (Sustrans, 2009) was developed by Sustrans, the organisation responsible for the 20,000 km national cycle network in the UK, to aid in the design, construction and ongoing use of both off-road and on-road trails. It is a useful guide with direct applications for NZ and is referenced throughout this guide.

The Connect2 and Greenways Design Guide (Sustrans, 2009) is freely available from the Sustrans website.

1.2.5 Standards New Zealand HB 8630:2004

The discussion on design of structures on off-road trails in Chapter 6 is based on the New Zealand Handbook for Tracks and Outdoor Visitor Structures – SNZ HB 8630:2004 (Standards New Zealand, 2004) but only designers requiring a more detailed understanding need to purchase the standard. HB 8630 is due to be updated in the near future.

Structural design for on-road structures (including "clip-on" paths to road bridges) should follow NZS 4121:2001 (Standards New Zealand, 2001), AS/NZS 1170 (Standards NZ, 2004) and the Transit NZ Bridge Manual (2003) with geometric features of cycle trails designed according to the Austroads Guide to Road Design (2009) (primarily parts 3, 4 and 6), modified where appropriate by the NZ Supplement to Austroads Part 14: Bicycles (Transit, 2008a).

HB 8630 and other standards are available for purchase from Standards New Zealand. MOTSAM and the Transit NZ Bridge Manual are freely available through the NZTA website.

1.2.6 Austroads guides

Austroads Guide to Road Design Part 6A: Pedestrian and Cyclist Paths (2009) is a useful reference and is referred to in this design guide, particularly for easier (Grade 1 and 2) trails. For on-road facilities, the Guide to Road Design, Parts 3 and 4 (including sub-parts) and the superseded Austroads Guide to Traffic Engineering Practice Part 14: Bicycles (1999) with the accompanying NZ Supplement to Austroads Part 14: Bicycles[1] (Transit, 2008a) should be referenced.

The Austroads guides are available for purchase through Austroads.

[1] Austroads GTEP Part 14 has been superseded by the Austroads Guide to Road Design (GRD) series, however the advice on cycle design within the associated NZ Supplement, is considered more appropriate than the GRD series for New Zealand conditions in some contexts.

Figure 1: Cyclists on Otago Central Rail Trail (photo: DOC)

1.3 Terminology

This design guide uses many terms specific to designing for cyclists. The glossary gives descriptions of important terms.

Some terms can have different meanings associated with them by people of different disciplines. Types of off-road cycle provision in particular can be called by many different names. In the traffic engineering industry, the usual name for an off-road cycle route is "path". This term covers both urban and rural routes that are usually (but not always) shared with pedestrians. It applies to the flat, wide paths built on railway corridors ("rail trails") as well as paths built on more adventurous terrain for mountain biking, which are often termed "tracks".

In the UK, paths are called "greenways" and in the USA they are called "trails". The use of the word "trail" in the New Zealand Cycle Trail, however, is not limited to off-road paths as the NZCT includes on-road routes also.

This guide uses the term "path" to describe an off-road route, unless quoting another source or a commonly used term such as "rail trail" or "mountain biking track".

Thus "trails" in the NZCT can be either off-road paths or roads.

2 Route Planning

2.1 Identifying Key Attractions

For a cycle route to be acknowledged, branded and funded as an NZCT route, it should give access to “iconic” locations that will generate cycle tourism. One of the objectives of the NZCT project is “to provide high-quality assets that offer a world-class cycling experience and enhance New Zealand’s competitiveness as a visitor destination.”

Routes should be developed to include key attractions. These key attractions should be chosen to showcase New Zealand’s:

- Environment;
- Iconic natural landscapes; and
- Heritage and culture.

Some key attractions may be specific locations, for example, a historic settlement, a lake viewing point or a wildlife sanctuary. Some key attractions may be continuous features along a large part of a route, for example, a view of a mountain range, a coastline, river or native forest.

Figure 2: NZCT routes can showcase our heritage - Galloway shed, Otago Central Rail Trail (courtesy of Otago Central Rail Trail Trust)

It is important to determine:

- The type, variety, quality and number of key attractions on a route;
- The cyclist types to which these key attractions will most appeal;
- How the route can provide access to or through these key attractions; and
- The “spacing” of key attractions along a route (i.e. if attractions are clustered around a particular part of a route, the rest of the route may not be seen as “iconic”).

2.2 Leg and Route Distances

The lengths of NZCT routes (or individual segments of them) should not be so long that they discourage cyclists who may be considering riding them. The most important consideration is the distance between accommodation facilities; i.e. the distance that must be cycled in one day.

An NZCT route takes one of two main formats, as described in Table 1:

Table 1: Route formats for NZCT routes

	Single trip	Multi-trip
Description	A route (either generally linear or circular) made up of a series of "legs" (i.e. sections of the route between successive accommodation locations)	A series of individual routes centred around a specific accommodation location and used by location-based cyclists (the "hub and spoke" model)

For single trip routes, those that have frequent opportunities for accommodation and services (such as shops, cafés and public toilets) along their length offer more flexibility for cyclists to choose their daily trip distances. Novice or less energetic cyclists may choose to cycle the minimum distances and stay overnight at each successive location that provides accommodation. More experienced or stronger cyclists, on the other hand, may choose to pass by some accommodation locations (perhaps stopping for refreshments) in favour of longer daily cycling distances.

Similar principles apply for multi-trip routes. At least some of the route options should be of appropriate lengths for novice or less energetic cyclists. Experienced or stronger cyclists may choose to complete several routes in one day, so it is important to provide multiple trips to encourage cyclists to spend multiple nights in the location.

Accommodation opportunities may come in many forms, ranging from motels and hotels in towns or cities to rural bed and breakfast locations. Before individual routes become well established it is likely that the only accommodation opportunities will be those already existing. In some cases, the relative locations of accommodation opportunities and key attractions may result in desired route legs being longer than the maximum daily distances some cyclists can easily travel. In such cases, measures should be taken to ensure the routes are still accessible to a broad cross-section of cyclists. Possible measures include:

- Establishment of a new bed and breakfast provider in a desirable location (for example, a farm stay, perhaps with initial financial and planning assistance);
- Provision of optional shuttle services to transport trail users to the nearest accommodation provider; and
- Establishment of a camp site with huts or shelters and cooking facilities between accommodation locations. This is the least desirable option as it will generate less revenue for the local community and will prohibit cyclists who do not wish to carry the required equipment or prefer the comfort of commercial accommodation.

NZCT route lengths are designed to ensure the trails provide multi-day cycling trips and therefore generate accommodation revenue.

Preferably, NZCT routes are 150 km or longer to ensure multi-day trips. The Market Research report (Tourism Research Consultants, 2009) commissioned by the Ministry of Tourism, identified an average cycle tourism stay of four nights for domestic visitors and 45 nights for international visitors. No single route will cater for the average international trip length but it is likely that visitors will prefer to spread their time among a few longer routes than travel between a large number of short routes.

2.3 Links with Towns and Cities

Some NZCT routes may pass through towns or cities which do not have accommodation opportunities exactly located on the route. In such cases, subsidiary routes that are appropriately signposted and link the main route with services and accommodation are desirable.

The entire trip made by cyclists needs to be considered in the planning and design of NZCT routes, not just on the route itself but also travel through towns or cities on their way to or leaving the NZCT. It is likely that completely off-road solutions will not be available through existing urban areas. But novice cyclists in particular are likely to be uncomfortable transferring from an off-road route to busy roads. It is not advisable to lead cyclists, via an off-road route, to the edge of an urban area and then expect them to "fend for themselves" to reach their accommodation or to continue on the route beyond the urban area. This would be potentially unsafe and may deter cyclists from visiting the route in the first place, returning for a second trip, visiting other NZCT routes or recommending NZCT routes to others.

All cycle trails (both off- and on-road) used for subsidiary links between main routes and accommodation locations should be designed according to the same standards used for the main route. It is likely that some on-road links will be located within busier road environments than the main routes themselves. Therefore, further guidance for on-road routes in particular may be required. Sources such as MOTSAM (Transit NZ, 2008b), and the NZ Supplement (Transit NZ, 2008a) to Austroads GTEP part 14: Bicycles (Austroads, 1999) should be used in association with the Austroads Guide to Road Design series.

Small towns are not likely to pose as much of a problem as it is likely that cyclists will only need to travel on-road for short distances on roads with low traffic volumes and urban speed limits.

Larger towns or cities, however, will offer more accommodation choices that require cyclists to travel longer distances on roads with higher traffic volumes. It should not be assumed that cyclists will want to stay at locations in the immediate vicinity of the NZCT but it will not be possible to improve facilities for routes leading to all possible accommodation locations.

If the road network of a town or city is likely to be seen as a major barrier to cyclists it may be useful to develop an arrangement with accommodation providers to transport cyclists and their bikes to and from an appropriate location with links to the main route. A trip end facility with appropriate vehicle access, parking, phone booths and an area for cyclists to rest and wait for shuttles could assist such an arrangement. This kind of facility also serves as a "gateway" to the NZCT route and could take the form of a recreational park.

2.4 Links with Existing Cycle Networks

Components of some NZCT routes are parts of, or connect to, existing cycle networks. Consideration should be given to whether these existing components satisfy the required cyclist target markets if they are to be billed as NZCT routes. Most existing cycle networks have been designed for local users with some cycling experience rather than the novice or less energetic cycle tourists being targeted for the NZCT. This is especially the case for on-road trails. It may be necessary to improve existing network components, including signage.

If an NZCT route is developed in a location near an existing major off-road trail the opportunities for linking the two should be considered. This would give cyclists on the NZCT route more opportunity regarding the length and coverage of their trip and may open up more opportunity to stimulate local business.

2.5 Off-Road and On-Road Trails

The NZCT will consist of off-road and on-road cycle trails. These two categories provide differently for cyclists and have different design requirements:

- Off-road trails ("cycle paths") are discussed in Chapter 3; and
- On-road trails (including "quiet roads, cycle lanes and road shoulders") are discussed in Chapter 4.

Chapter 4, which discusses crossings and intersections, is also particularly important as it examines the interactions of trails (both off- and on-road) with roads.

2.6 Choice of Provision

The decision as to whether a trail with the NZCT brand should be on-road or off-road (and if off-road, its degree of separation from roads) is based on the cyclist and trip types to be catered for by the route.

The vast majority of NZCT routes are off-road. The market research performed by Tourism Research Consultants (2009) indicates that off-road routes are preferred by most types of cyclists being targeted by the NZCT. Therefore, the higher the degree of separation between paths and road carriageways, the better.

If on-road trails are included in NZCT proposals, the traffic speeds and volumes and available road widths should be carefully considered and discussed in applications and feasibility studies. Further advice is contained in Chapter 4.

Figure 3: Cyclist on Little River Rail Trail, Canterbury

2.7 Identification of Road Crossings

There are four main road crossing types that occur on NZCT routes (both off-road and on-road) crossing roads:

- "Uncontrolled" crossings;
- "Stop" or "Give Way" crossings;
- Signalised crossings; and
- Grade-separated crossings such as bridges or subways.

In practice, gravel roads have relatively low traffic volumes (typically averaging under 250 vehicles per day, although peak daily volumes may be significantly higher if the road leads to a popular recreational area) and cycle crossings are fairly easy for adult cyclists, so long as good visibility exists.

In some circumstances, priority may be given to cyclists on the trail as opposed to road traffic. These instances are likely to be rare and would generally occur in large urban areas where there are already significant numbers of cyclists. Examples of such crossings can be found in Nelson.

Crossings and intersections are discussed further in Chapter 5. At the planning stage, it is important to identify locations where NZCT routes will cross roads and have an idea of the type of crossing provision that will be required at each location.

The NZCT must be safe and be perceived as safe. Road crossings are critical locations as they involve potential conflict between cyclists and motor vehicles. Road crossings are intersections, either between a cycle path and a road or between two roads (at least one of which being a cycle route). For urban, on-road cycling networks, the majority of crashes involving cyclists occur at intersections as opposed to “midblock” (in the middle of a block, i.e. not at an intersection) locations.

For many NZCT routes, the majority of the route will consist of off-road trails and therefore cyclists will only encounter motor traffic at road crossings. This exaggerates the distinction between the midblock and intersection situations even further than what is experienced for urban on-road cycling networks. Therefore it is imperative that road crossings are designed to a high level of safety for both cyclists and motorists.

While being such a small component of the overall route in terms of distance, crossings have the potential to tarnish an NZCT route. The market research report (Tourism Research Consultants, 2009) identified traffic safety as one of the main barriers to cycle tourists in New Zealand. If cyclists perceive a road crossing to be unsafe it may unfavourably colour their impression of the rest of the route or NZCT routes in general. Thus it may be necessary to modify an NZCT route from that initially intended to avoid creating a road crossing in a certain location. Careful planning at the early stages of route development can help prevent expensive retrofits later.

3 Off-Road Trails

3.1 Preliminary Considerations

3.1.1 Sharing with Pedestrians

It is common in New Zealand that off-road provision for cyclists is combined with pedestrian provision. The term “pedestrian” is used in New Zealand to cover all people travelling by foot (e.g. walkers and runners) or on small wheeled devices such as skateboards, push-scooters or mobility scooters, plus wheel chair users and people pushing baby "prams".

Most trails on the NZCT will be available for people walking, although in many of the more rural trails the numbers of pedestrians is expected to be low. In general, with good design for cyclists, no particular provisions for pedestrians will be needed on the NZCT.

There are four general off-road trail types that cater for cyclists:

1. Shared (the most common type);
2. Segregated (by mode or by direction);
3. Separated; and
4. Exclusive

Shared paths are available to both cyclists and pedestrians, without any form of segregation of users. This is a common type of path on the NZCT. An example of a shared path is the Nelson unsealed path shown in Figure 4.

Figure 4: Shared path, Nelson

Segregation can occur in two distinct forms: by mode or by direction. Paths segregated by mode allocate different spaces for pedestrians and cyclists by signs, markings or guidance measures such as varied surface types. Path users are supposed to remain in their allocated section but are not physically prevented from crossing over to the other section.

Generally segregation by mode has a poor level of compliance as users tend to travel where best suits them in terms of their course of travel or scenic opportunities and often prefer to keep left. Segregation by mode can also be confusing for some users, for example those on roller skates or parents walking beside small children on bikes who don't know whether to walk on the side of the path for pedestrians or the side for cyclists.

Segregation by direction of travel is a more effective mechanism that divides the path in two and requires users to keep to the side on their left, similar to a two-lane road operation. This minimises conflicts between users by fostering a more orderly approach.

Segregation by direction of travel is a suitable treatment for paths of high volume but it is generally not necessary to specify it for rural paths. Segregation by direction may be a useful localised treatment for sections leading up to intersections, for example the Nelson Rail Reserve shown in Figure 5. Designers should not assume that the keep left principle will come naturally to users; many overseas users will be from countries where they drive on the right side of the road and need to be reminded that we use the left in New Zealand.

Figure 5: Segregation by direction - Nelson Rail Reserve

Separated paths are similar to segregated paths in that they allocate different spaces for pedestrians and cyclists. However separated paths divide pedestrians and cyclists by physical measures so that it is difficult or impossible for users to cross to the other mode's path. Separation can be achieved through use of physical structures such as kerbs or even fences, or by wide gaps between the two paths, with grass berms or plantings in between. An example of a separated path is Christchurch's Tennyson Street path, as shown in Figure 6. The cycle path (coloured red) is adjacent to the carriageway and separated from the footpath (next to the property boundary) by a grass berm with trees.

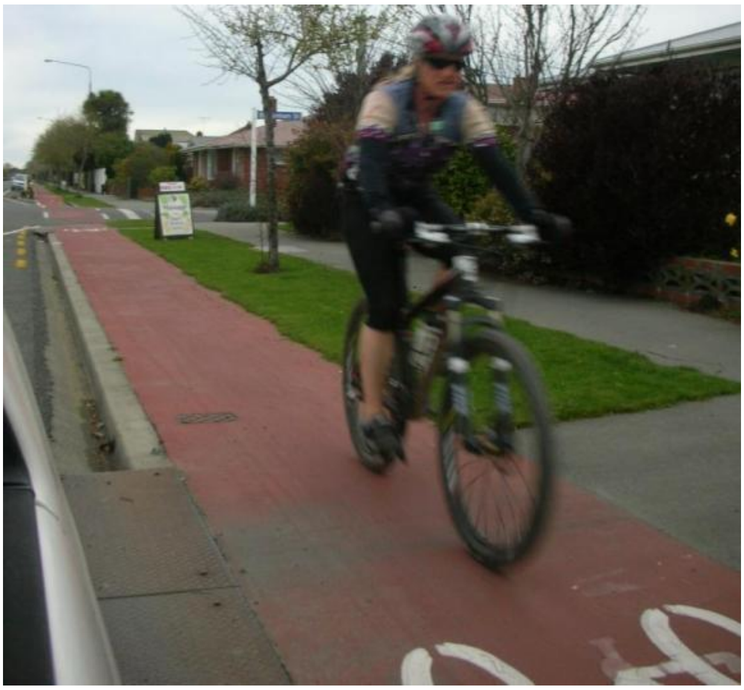


Figure 6: Separated paths on Tennyson Street, Christchurch

Exclusive cycle paths, as the name suggests, cater solely for cyclists without any nearby pedestrian path. Such paths are rare as pedestrians are generally provided for in some way, even for purely recreational trails.

3.1.2 Sharing with Equestrians

It is not recommended that NZCT routes be designed to accommodate equestrian use. Horses can damage track surfaces, requiring more intensive maintenance or reducing surface quality from a cycling perspective. Sharing the trails with horses requires a much wider track and can have safety issues if horses are spooked by approaching cyclists.

The path specifications in this guide are not intended to accommodate horses and horse-riding. In particular, paths designed to include equestrians would require wider widths, higher overhead clearances, increased loadings for structural design and alternative gateways for horses at cattle stops.

If a path is already established, or terrain allows for dual cycle and equestrian paths, accommodation of horses is at the discretion of trail designers, owners and operators.

There are fewer complications for on-road trails as roads are strong enough to accommodate horses and equestrians are legally allowed to ride on-road shoulders.

3.1.3 Sharing with Motor Vehicles

NZCT off-road trails should be designed to exclude public motor vehicle access along the trails – this includes motorbikes and four wheel drive vehicles – as motorised vehicles result in increased path maintenance costs, safety issues due to greater speed differential of users, and noise pollution. However, at some points it will be necessary for off-road trails and roads to cross, as discussed in Chapter 4. The design of access points will need to consider how to exclude motor vehicles.

3.1.4 Relationships to Roads

There is a spectrum regarding how "off-road" an off-road trail really is. There are two main levels of "off-road" trails:

1. Adjacent to the road carriageway (whether within or adjacent to the legal road); and
2. Completely separate from any roads.

Where cyclists are expected to use the road or road shoulder, this is classified as an on-road trail and is dealt with in Chapter 4.

An off-road trail within the road corridor is similar to a footpath. An example of an off-road trail within the road corridor is the Birchs Road pathway in Selwyn District which forms part of the Little River Rail Trail, as illustrated in Figure 7. This path is shared with pedestrians and is separated from the adjacent road carriageway by a grass verge.

Figure 7: Off-road trail within road corridor - Little River Rail Trail (photo: Jonathan Kennett)

An off-road trail adjacent to (but not within) the road corridor follows the same general alignment of the road corridor. However, it will have greater separation from the carriageway (and perhaps fewer opportunities of accessing the carriageway) than a path within the road corridor. An example of an off-road trail adjacent to the road corridor is Palmerston North's Pioneer Highway, as shown in Figure 8; note the separation of cyclists and pedestrians.

Figure 8: Off-road trail adjacent to road – Tennent Drive, Palmerston North

If an unsealed or poorly-surfaced cycle path is provided beside a quiet, rural sealed road and it has little or no separation from the road, it will be unlikely to be used by cyclists (refer Figure 9). Most cyclists will prefer to use the sealed road, as it has an easier riding surface. Therefore, if a cycle path is to be built right beside a sealed road, the path should also be sealed. Alternatively, the path could be well separated from the road or the road itself could be used for the trail (so long as the conditions identified in Section 4 are met).

Figure 9: Poorly-surfaced cycle paths next to low-volume roads will not be used by cyclists

Alternatively, an off-road trail may be completely separate from any road corridors. Such paths provide cyclists and pedestrians with the ability to access locations where motorists cannot drive. They may provide shortcuts or access to scenic attractions. An example of an off-road trail separate from roads is the New Plymouth coastal pathway, as shown in Figure 10.

Figure 10: Off-road trail separate from roads – New Plymouth

3.1.5 Aesthetics

To be iconic, a route should "fit" naturally with the surrounding landscape, emphasise the local scenic attractions and, in some cases, provide additional visual stimulation. For example, placement of artwork, vegetation or a viewing platform can emphasise the surrounds. Path alignment and width should be developed with respect to natural attractions and historic structures.

Figure 11: Cyclist on Prospect Hill track – Kopuwai Conservation Area (photo: John Robinson)

DOC (2008, Chapters 5 and 6) describes the important components of landscapes and different types of landforms. It also details how landscape features such as "anchors", "edges", "gateways" and historic features can be used to produce a more aesthetically pleasing path and more enjoyable riding experience. Landscape is an important component of initial route planning.

Trails should always include some curvature as curved trails look better than long straight lines across a landscape; however, they should not be so convoluted that cyclists create shortcuts from one section to another and damage the trail surface and surrounding landscape.

"Gateways" are features used to provide an attractive threshold at the start of a trail. Sustrans (2009) outlines useful techniques for establishing gateways (in its Chapter 10) and important considerations for the "travelling landscape" (Chapter 13).

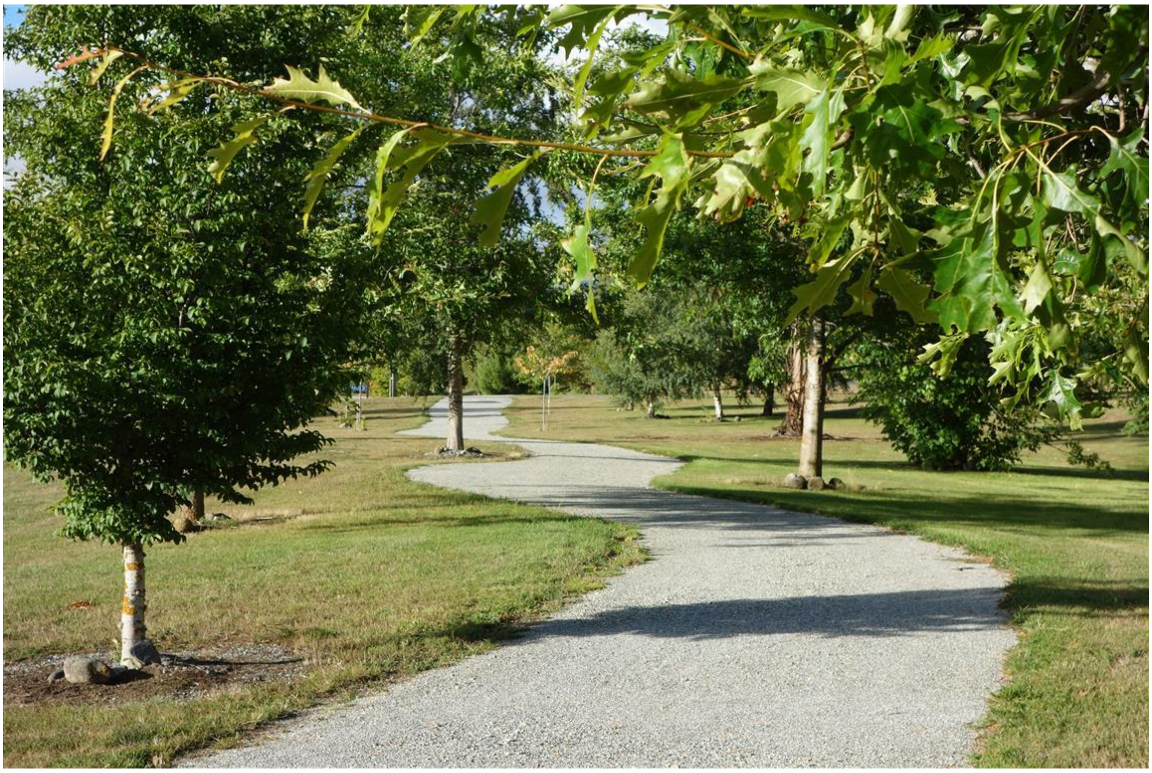


Figure 12: Curvature on the Around the Mountains Cycleway, Garston (photo: Jonathan Kennett)

Figure 13: Sculptures adjacent to Nelson Rail Reserve pathway

Figure 14: Railway hut and wagon on Little River Rail Trail, Canterbury (photo: Chris Freear)

3.2 General Design Specifications

Six grades of off-road trail relating to level of difficulty are presented in Table 2. These grades have been derived from the International Mountain Bike Association's trail rating system. Guidelines from the Department of Conservation, and Mountain Bike New Zealand were used when developing these criteria and characteristics.

The grade system is important for distinguishing between users' abilities and desired ride characteristics. From an economic point of view, it may be best to design routes for less experienced or less energetic riders to maximise market potential (Grades 1 and 2). Additional challenges can be built in for more advanced riders to ensure their appreciation of the trails (Grades 3 and higher).

DOC's Track Construction and Maintenance Guidelines (2008) provides a comprehensive account of the various stages of producing off-road trails. Designers are directed to sections of the DOC guide for subsequent considerations.

It is most important that the trail's grade does not change more than one grade over the course of the route. It is acceptable to have short sections of a trail one grade more difficult than the intended grade, but it is generally undesirable to have harder sections of trail as some riders are likely to be forced to walk these sections. There is no point building a path that incorporates Grades 2 to Grade 4, as the Grade 4 sections will be impossible to negotiate by those riders whose level of experience and skill is suited for a Grade 2 trail. It will be necessary to improve the Grade 4 sections to Grade 3 standard, or it will not be necessary to build Grade 2 sections, as Grade 3 features will suffice.

Table 2: Design specifications for off-road trails

Grade	Grade Description
1.  	**Description**: Flat, wide, smooth, trail. Trail feels safe to ride. Ideal as a first ride for non-cyclists, and those wanting an easy gradient or experience. Trail allows for cyclists to ride two abreast most of the time, and provides a social component to the ride. Cyclists will be able to ride the total distance of the trail without dismounting for obstacles. **Gradient**: 0-2 degrees for at least 98% of trail; between 2 and 3 degrees for no more than 100 metres at a time, and between 3 and 4 degrees for no more than 10 m at a time. If the track is designed and promoted to be ridden predominantly in one direction then the downhills can be steeper (up to 4 degrees for up to 100 m). Sealed trails can be steeper (same as the equivalent grade of on-road trail; see Table 11). **Width**: 'Double trail' preferred = 2.5 m to 4 m for 90% of trail, where cyclists may ride side by side. 'Single trail' width of 1.5 m, with 1.2 m minimum. Horizontal clearances as in Section 3.5. **Radius of turn**: 6 m minimum to outside of turn. **Surface**: Compacted/stabilised base course or similar, with maximum top course aggregate of 20 mm. **Watercourses**: All water courses bridged **Bridge Width:** Recommended bridge width of at least 1.5 m, absolute minimum width of 1.2 m. **Obstacles**: None. No stiles. Cattle stops should preferably be at least 1.5 m wide, and minimum 1.2 m wide. **Length**: 3.5-4.5 hours/day (30-50 km/day). **Barriers/Guard rails**: Areas such as bluffs or bridges where a fall would result in death or serious harm require hand rails.

2. EASY	**Description**: Some gentle climbs, smooth trail. Suitable for beginner riders, the trail is predictable with no surprises. Social component with riders able to ride side by side at times, but possibly large sections of single trail. **Gradient**: 0-3.5 degrees for at least 95% of trail; between 3.5 and 5 degrees for no more than 100 metres at a time, and between 5 and 6 degrees for no more than 10 m at a time. If the track is designed and promoted to be ridden predominantly in one direction then the downhills can be steeper (up to 6 degrees). Sealed trails can be steeper (same as the equivalent grade of on-road trail; see Table 11). **Width**: Between 0.9 m and 1.5 m for single trail and minimum 2.2 m for double trail sections with adequate clearances. Horizontal clearances as in Section 3.5. **Radius of turn**: 4 m minimum with at least 5 m desirable to outside of turn. **Surface**: Compacted/stabilised base course, with maximum top course aggregate of 30 mm. **Watercourses**: Watercourses bridged, except for fords with less than 100 mm of water in normal flow which can be easily ridden. Surface should be as smooth as adjacent trail. **Bridge Width:** Recommended bridge width at least 1.5 m, minimum width of 1.2 m. **Obstacles**: Some rocks/roots/ruts that can either be avoided, or are less than 50 mm high. No stiles. Cattle stops should be minimum 1.2 m wide. **Length**: 4-5 hours/day (30-50 km/day). **Barriers/Guard rails**: Areas such as bluffs or bridges where a fall would result in death or serious harm require hand rails.
3. INTERMEDIATE	**Description:** Narrow trail, there will be some hills to climb, obstacles may be encountered on the trail, and there may be exposure on the edge of the trail. Suitable for riders with intermediate level skills. **Gradient:** 0-5 degrees for at least 90% of trail; between 5 and 7 degrees for no more than 100 metres at a time, and between 7 and 8 degrees for no more than 10 m at a time. If the track is designed and promoted to be ridden predominantly in one direction then the downhills can be steeper (up to 8 degrees). Sealed trails can be steeper (same as the equivalent grade of on-road trail; see Table 11). **Width:** 0.9 m for 90% of the trail, 0.6 m minimum with adequate clearances. Horizontal clearances as in Section 3.5. **Radius of turn:** 2.5 m minimum, with at least 4 m desirable to outside of turn. **Surface:** Generally firm, but may have some muddy or loose sections. **Watercourses:** Watercourses bridged, except for fords with less than 200 mm of water in normal flow, which can be easily ridden. **Bridge Width:** Recommended at least 1.2 m; minimum 1.0 m. **Obstacles:** Occasional rocks/roots and ruts may be up to 100 mm high/deep and may be unavoidable. **Length:** 4-6 hours/day (30-50 km/day for an intermediate cyclist). **Barriers/Guard rails:** Areas such as bluffs or bridges where a fall would result in death require hand rails. Areas where a fall would likely result in serious harm require either hand rails or sight rails or a warning sign, depending on the nature of the drop off and likelihood of a fall.

4. 	**Description:** Steep climbs, with unavoidable obstacles on a narrow trail, and there will be poor traction in places. Possibly some walking sections. Suitable for intermediate and advanced riders. **Gradient:** 0-6.5 degrees for at least 90% of trail; between 6.5 and 8 degrees for no more than 100 metres at a time, and between 8 and 10 degrees for no more than 10 m at a time. If the track is designed and promoted to be ridden predominantly in one direction then the downhills can be steeper (up to 10 degrees). Sealed trails can be steeper (same as the equivalent grade of on-road trail; see Table 11). **Width:** 0.6 m average, 0.4 m minimum. Horizontal clearances as in Section 3.5. **Radius of turn:** 2 m minimum, with 3 m desirable to outside of turn. **Surface:** Firm and loose. **Watercourses:** Watercourses bridged, except for fords with less than 300 mm of water in normal flow, which can be easily ridden. **Bridge Width:** Recommended 1.0 m; minimum 0.8 m. **Obstacles:** Many rocks/roots and ruts up to 200 mm high/deep. Also some purpose built obstacles to liven things up, such as sea-saws and jumps. **Length:** 4-8 hours/day for advanced cyclists. **Barriers/Guard rails:** Areas such as bluffs or bridges where a fall would result in death require hand rails. Areas where a fall would likely result in serious harm require either hand rails or sight rails or a warning sign, depending on the nature of the drop off and likelihood of a fall.
5. 	**Description**: Technically challenging, and suitable for advanced/expert riders. Physically tough. Big hills, lots of rocks, some walking likely. **Gradient**: 0-8 degrees for at least 90% of trail; between 8 and 10 degrees for no more than 100 metres at a time, and between 10 and 14 degrees for no more than 10 m at a time. Sealed trails can be steeper (same as the equivalent grade of on-road trail; see Table 11). If the track is designed and promoted to be ridden predominantly in one direction then the downhills can be steeper (up to 14 degrees). **Width**: 0.4 m average, 0.25 m minimum. Horizontal clearances as in Section 3.5. **Radius of turn**: 1.5 m minimum, with more desirable. **Surface**: Huge variety of surfaces. **Bridge Width:** Recommended 0.8 m; minimum 0.6 m. **Obstacles**: Many rocks, roots and ruts, up to 0.6 m high/deep. If there are not obstacles then they are likely to be added afterwards (i.e. jumps, and wooden structures). **Length**: 4-12 hours/day.

6. 	**Description**: Purpose built extreme Downhill/Free ride trails. Extremely steep and dangerous jumps and obstacles. Fear factor is essential. High risk of injury. Suitable for extreme riders. **Gradient**: 0-10 degrees for at least 90% of trail; between 10 and 15 degrees for no more than 100 metres at a time, and between 15 and 20 degrees for no more than 10 m at a time. If the track is designed and promoted to be ridden predominantly in one direction then the downhills can be steeper (up to 20 degrees). **Width**: Minimum of tyre width. **Radius of turn**: 1 m absolute minimum, but the more the better. **Surface**: Anything – likely to be unsustainable. **Obstacles**: 'North Shore' wooden obstacles, big jumps, etc **Length**: Trail may take less than a minute to ride, but will be ridden over and over again.

Notes:

1. Any sections of trail that are harder should only be one grade harder, but only in short sections of no more than 100 m.
2. Maximum downhill gradient applicable only if trail is designed and promoted to be ridden in one direction.
3. If a short section of a trail is steeper than that recommended for the trail grade, this may be compensated for by making the trail wider, easing the turns, improving the surface or other compensatory measures. Other criteria can be similarly compensated for to allow the trail to meet the requirements for a lower trail grade.
4. The widths given are minimum widths. If the terrain beside a track is rideable for the target market (i.e. flat mown grass beside a concrete path for grade 1), then the minimum width can be reduced if need be (e.g. from 2.5 m down to 2.2 m for grade 1). In some cases it will be possible to provide wider paths. However, care should be taken to not make the path too wide as cyclists will feel they are on a road rather than a cycle trail – see Section 3.11. In natural environments overly wide trails also impact on the scenic values that are sought by visitors.
5. An acceptable alternative to barriers, guardrails or handrails at bluffs, steep drop-offs or water bodies is adequate horizontal clearance of at least 1.5 m for grade 1 from the edge of the trail.

3.3 Gradients

Gradient requirements from Table 2 for off-road unsealed trails (and gravel roads) are summarised in Table 3:

Table 3: Gradient requirements for off-road trails

Trail Grade	Main uphill gradient range	Steeper slopes up to 100 m long	Steeper slopes up to 10 m long	Maximum Downhill Gradient for slopes up to 100 m long
1	0 – 2 degrees for 98% of length	2 – 3 degrees	3 – 4 degrees	4 degrees
2	0 – 3.5 degrees for 95% of length	3.5 – 5 degrees	5 – 6 degrees	6 degrees
3	0 – 5 degrees for 90% of length	5 – 7 degrees	7 – 8 degrees	8 degrees
4	0 – 6.5 degrees for 90% of length	6.5 – 8 degrees	8 – 10 degrees	10 degrees
5	0 – 8 degrees for 90% of length	8 – 10 degrees	10 – 14 degrees	14 degrees
6	0 – 10 degrees for 90% of length	10 – 15 degrees	15 – 30 degrees	

Notes:

1. This table applies to off-road unsealed trails and gravel roads.
2. Uphill sections of trail that are steeper than these gradient criteria should only be one grade harder and only in sections of up to 100 m length. It is undesirable to have harder sections of trail as some riders are likely to be forced to walk these sections.
3. Maximum downhill gradient applicable only if trail is designed and promoted to be ridden in one direction.
4. IMBA recommends a maximum gradient of 10% (5.7 degrees) to ensure a trail is sustainable. Steeper trails will require more maintenance due to skidding tyres and water scour.

This table is repeated in Appendix 1 along with the comparable table for on-road trails.

One of the key factors that determines whether a route will suit less experienced and less energetic cyclists is the gradient. Disused railways are ideally suited to conversion to cycle trails (coined "rail trails") and are especially popular because the gradients are gentle. Rail trails typically have gradients less than 2 degrees. It is also possible to form rail trails along live rail corridors adjacent to the railway line; this requires fencing and the greater the separation distance between the path and the railway line the better.

Clinometers (instruments to measure the gradient) are essential for track design and construction, especially for Grade 1 and 2 trails. Gradient is one of the most important distinguishing characteristics for the different grades of trail so it is important to assess and maintain appropriate trail grades accurately, and advise riders accordingly.

Designers typically use degrees, percent or slope to indicate gradient; this guide uses degrees. The relationship between degrees, percent and slope with the corresponding off-road grades is shown in Table 4. Table 5 and Figure 15 provide further methods of converting between the three gradient measures.

Table 4: Relationship between off-road grade, degrees, percent and slope

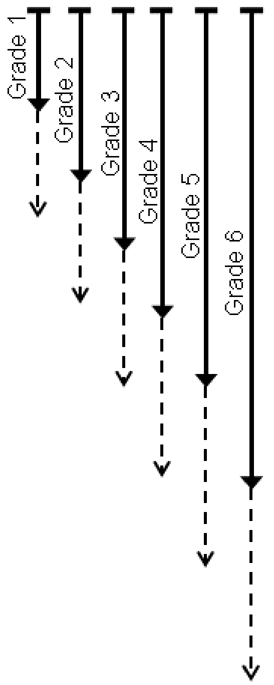
Indicative off-road trail grade	Degrees	Percent	Slope
	0º	0%	NA
	1º	1.7%	1:57
	2º	3.5%	1:29
	3º	5.2%	1:19
	4º	7.0%	1:14
	5º	8.7%	1:11
	6º	10.5%	1:10
	7º	12%	1:8
	8º	14%	1:7
	9º	16%	1:6
	10º	18%	1:6
	12º	21%	1:5
	15º	27%	1:4
	20º	36%	1:3
	30º	58%	1:2

Table 5: Conversion between degrees, percent and slope

Percent	Degrees	Slope
1%	0.6º	1:100
2%	1.1º	1:50
3%	1.7º	1:33
4%	2.3º	1:25
5%	2.9º	1:20
6%	3.4º	1:17
8%	4.6º	1:13
10%	5.7º	1:10
12%	7º	1:8
15%	9º	1:7
20%	11º	1:5
30%	17º	1:3

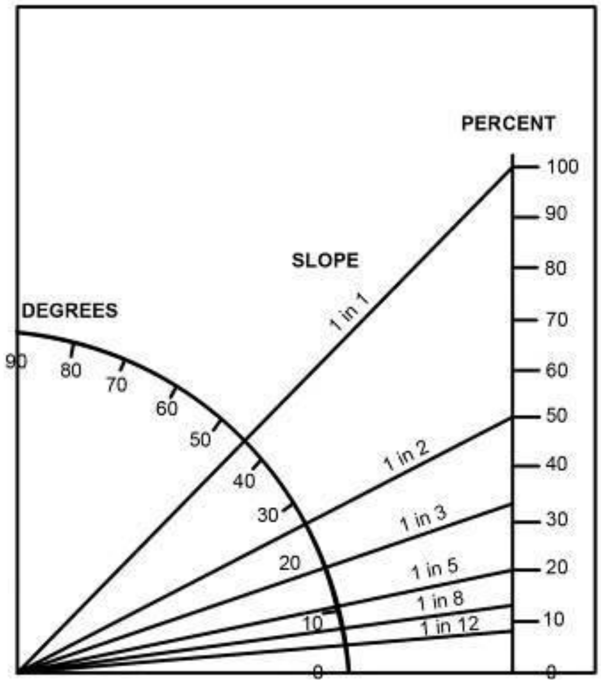


Figure 15: Relationship between degrees, percent and slope

Example – Gradients on Otago Central Rail Trail

The Otago Central Rail Trail is a 150 km off-road trail created along a disused rail corridor in Central Otago. It is popular among a wide cross-section of cyclists and is used by around 20,000 people per year. Situated on a previous rail route, its gentle gradients make it accessible to most.

The Otago Central Rail Trail has a maximum gradient of 1.1 degrees (2%) over a 6 km stretch. This trail satisfies the criteria for a Grade 1 off-road trail. Figure 17 **shows the elevation of the trail.**

Figure 16: Cyclists on Otago Central Rail Trail (photo: DOC)

Figure 17: Otago Central Rail Trail Elevation Map (courtesy of OCRT Trust)

3.4 Pinch Points

It may not always be practicable to provide the required width for the entire path length. Large trees, rocks, bluffs, steep cross slopes or other geographic features may produce “pinch points” on a path. These features can be tolerated as long as there is adequate visibility leading to them or advance signage and safe opportunities for path users to stop before the pinch point and give way to oncoming users or wheel their cycles. Particular care should be taken to avoid pinch points on Grade 1 or 2 paths.

However, pinch points can be specifically incorporated in the design to enhance safety by slowing down cyclists at approaches to hazards such as road crossings or blind corners. These deliberate pinch points are termed “chokes” and are covered also in Section 3.8.

3.5 Horizontal Clearances

Figure 18 shows the operating space required for cyclists. An important aspect of the operating space is the angle between the pedals and handlebars; the handlebars protrude further than the pedals and are more likely to catch on adjacent objects. This is why banks should be “battered” (i.e. sloped, not vertical) and fences should ideally slope away from the path.

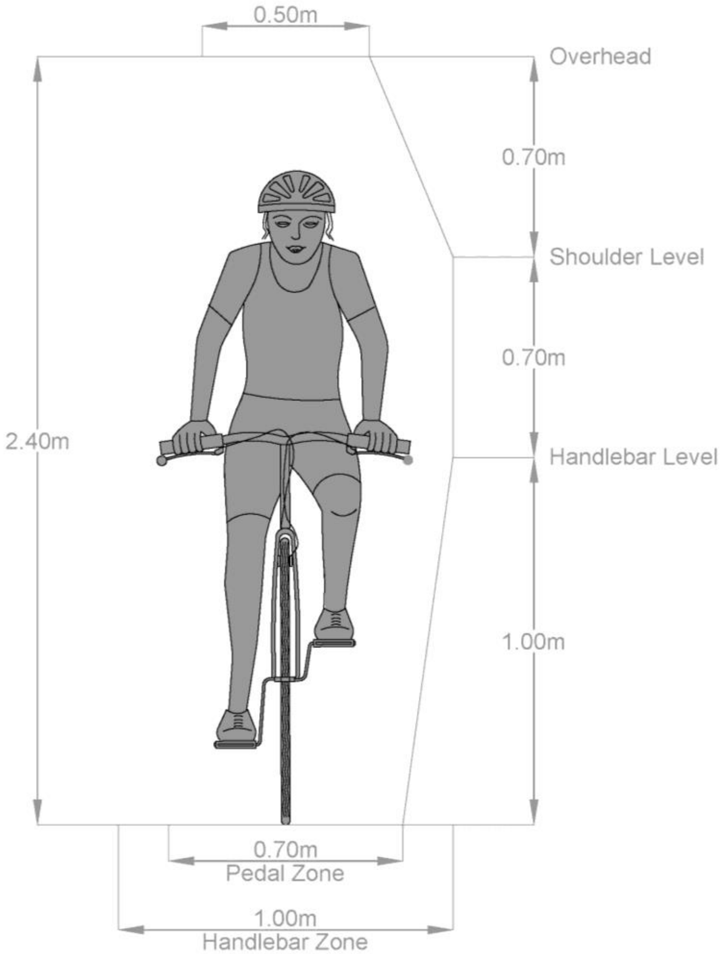


Figure 18: Bicycle operating space

When travelling on a lean (for example when travelling around a banked corner) the relationship between the cyclist's head and shoulders is also important. Cyclists may hit their heads or shoulders on trees placed too close to the inside of a curve. This can also be a conflict issue between cyclists and pedestrians on banked curves, as cyclists will be leaning while pedestrians are walking upright.

Cycle travel is dynamic. It is difficult to ride exactly in a straight line and less experienced users, in particular, require a fair amount of "wriggle room" or manoeuvring space.

If a path is restricted horizontally, for example by fences, bridge rails or discrete features such as trees or large rocks, an additional "shy space" is required. Shy space is needed because cyclists are physically unable to ride on the edge of the path due to their handlebars and pedals extending further than their tyres. Cyclists also need space to allow for a certain amount of wobble and to ensure that they do not need to focus so hard on keeping to the trail that they are unable to appreciate their surroundings. Slower and less experienced cyclists wobble more than faster and more experienced ones.

As it is expected that the majority of cyclists will not choose to ride in the "shy space", the clearance does not necessarily need to be constructed from the same materials as the actual path itself. Depending on the context, the shy space could be a grass verge or strip of compacted aggregate. In an urban area, maintenance requirements (e.g. mowing of grass verges) will generally make it more appropriate to create the shy space from the same material as the path. However In rural areas, there is no point in building a trail right beside a fence as the native ground cover will need no special maintenance.

Horizontal constraints to a path also limit the ability for path users to deviate from the path in extreme circumstances where the path is not wide enough to accommodate all users.

Thus, in addition to the path width given in Table 2, further width should be added for situations where at least one side of the path is constrained by adjacent elements. These elements may be either continuous or discrete and examples are given in Table 6, along with the required clearances:

Table 6: Off-road trail horizontal clearance requirements

Feature Type	Continuous	Discrete
Examples	Fences Walls Bridge handrails Guard rails Steep slopes Rock faces Parallel drains Lakes, rivers and coastlines Hedges Buildings	Trees Large rocks Bridge abutments Sculptures Power and light poles Sign posts Perpendicular drains
Recommended clearance	1.0 m	0.3 m
Minimum clearance	0.5 m	0.15 m
Note: Extra space should be allowed on bends, where cyclists will lean into the corner.		

Note that the clearances presented in Table 6 relate to each side of the path. That is, if the path is constrained on both sides, double the width prescribed in Table 6 should be added to the total path width. For example, on a path with fences (i.e. continuous features) on either side the width between the fences should be the width of the path plus 1.0 m. Clearances for continuous or discrete features in Table 6 should be measured at handlebar and shoulder height relative to the path edge.

Bridge handrails are considered as continuous features in Table 6. However it is often not practical to achieve this clearance plus the path width for a bridge structure and thus the minimum bridge widths presented in Table 2 govern. A way of increasing the effective width of a bridge is to provide flared handrails. This is discussed further in Section 6.3.1.

Fences need to be carefully considered when designing cycle trails. It is impossible to ride within 0.5 m of a fence and requires unnecessary concentration to ride close to a fence (especially at speed, such as on a downhill track), reinforcing the need for ample clearances as shown in Table 6.

Where fences are used on both sides of an off-road trail (for example on a rail trail adjacent to farmland) it is preferable to locate them as far from the path as possible, ideally 5 m away or more. If the path must be built next to a fence on one side, it should be at least 1.0 m away so that there is room for manoeuvre when passing other cyclists and to allow for clearances as discussed above. Experience from the Otago Central Rail Trail shows that fences placed immediately adjacent to the path make some cyclists feel like they are being channelled down a stock route. Fences placed at the extent of the corridor (which is generally 40 m wide in Otago Central), however, contribute to a more spacious feeling and allow cyclists more opportunity to enjoy the surrounding views.

If a trail is built on hill with a side slope it is preferable to situate the trail with trees on the downhill side rather than close to the uphill side. This means cyclists are more likely to naturally keep clear of the drop at the edge of the path.

3.6 Vertical Clearances

Overhead hazards can include tree branches, overbridges, tunnel soffits, signs, wires and cables. A minimum vertical clearance of 2.4 m to overhead hazards is recommended for all trail grades. However, a 2.0 m vertical clearance may be used for "discrete" overhead hazards, such as tree branches. Users should be advised of such hazards in advance.

3.7 Horizontal Alignment

When a path must bend or turn a corner there are four main methods that can be used; standard bends, switchbacks, climbing turns and superelevated ("insloped" or "berm") turns. These are summarised in Table 7. Switchbacks, climbing turns and super-elevated turns are discussed in Chapters 20-22 of DOC's Track Construction and Maintenance Guidelines (2008).

Table 7: Types of curve

Corner Type	Description	Application and Notes
Standard bend	The curve and its approaches are on level ground, no specific treatment is required.	Flat sections of trail. Most common on Grades 1 and 2.
Superelevated ("insloped" or "berm") turn	The outer edge of the curve is banked to allow for faster travel around the corner.	Curves where a high speed is required. Especially important for Grades 4-6.
Switchback	The curve of the path is on level ground while the approach and departure to the curve are on sloped sections.	The most appropriate method of providing turns on steeply sloped trails. Especially important for Grade 1 and 2 where gradients are involved.
Climbing turn	The curve itself is located on a sloped section of path (which possibly includes superelevation / a berm). DOC (2008) recommends a curve radius of at least 6 m and a maximum gradient of 4 degrees (6%) for a climbing turn.	Can be applied to gently sloping hills. Easier to construct but may require more maintenance than switchbacks.

Gradient reversals are deliberately-designed features of trails where long slopes are interrupted by short sections where the gradient reverses, ideally for 2-4 metres length and 0.5-1 metre high. Gradient reversals should be provided on either side of all superelevated turns, switchbacks and climbing turns to aid drainage and improve the trail's sustainability. On natural surface trails, grade reversals are the best possible insurance against water scour, and if well built, they are also fun to ride.

Berms In some cases, trail users or designers mistakenly refer to superelevated turns as switchbacks. Technically switchbacks do not have banked corners.

Generally a "berm" or superelevated turn has a curved (rather than straight) cross sectional profile, as illustrated in Figure 19; this allows slower, less confident cyclists to ride on the flat part near the inside of the curve and faster, more experienced cyclists to ride on the outer sloped sections. The slope of berm should be dictated by the grade of the trail. For example: Grade 1 berm slope of 2-5 degrees; Grade 2 berm slope of 3-10 degrees; Grade 3 berm slop of 4-15 degrees, Grade 4 berm slop of 5-30 degrees, Grade 5 berm slope of 5-45 degrees; Grade 6 berm slope of 5-60 degrees.

A superelevation of 30 degrees is generally appropriate for Grade 4 off-road trails. Superelevation on bends also keeps water off the track, as it will run around the inside of the corner.

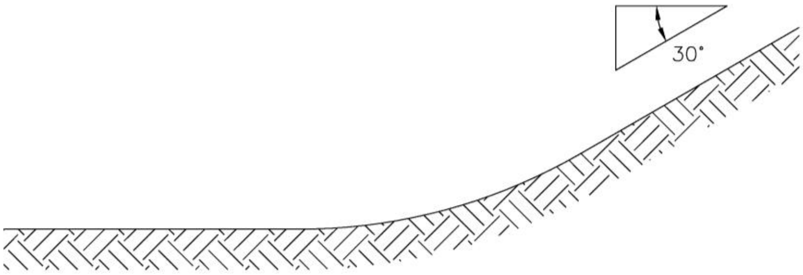


Figure 19: Cross section for Grade 4 superelevated turn

3.8 Sight Distances and Visibility

Path safety depends on users being able to detect a potential hazard and either stop safely before encountering it or manoeuvre safely around it. The required distance is called "stopping sight distance" (SSD). A stopping sight distance of at least 15 m should be achieved on NZCT off-road trails.

If visibility is limited around corners it may be necessary to set back vegetation or fences so that cyclists can maintain the appropriate line of sight around the corner. However, it may be difficult to achieve this and the result might damage the trail's aesthetics. An alternative is to provide two separate trails around a blind corner, with signs advising users to keep to the left (or in some cases, the right), of the trail. Or, if a trail is reasonably wide, keep left signage in itself may be sufficient.

"Chokes" (localised narrowings) or gradient reversals can be used to slow cyclists down on approaches to blind corners, intersections or other potentially dangerous locations.

For mountain bikers part of the enjoyment comes from the challenge of having to react quickly rather than having plenty of warning before encountering a path feature. This should be balanced with the likelihood of two cyclists (or a cyclist and a walker or jogger) encountering each other head on without sufficient warning.

In urban areas, visibility of trails by the public is also important for personal safety and security.

3.9 Surface Materials

3.9.1 Compacted Gravel or Crushed Limestone

These paths are formed by laying a compacted gravel layer and thus have a semi-loose surface. It is imperative that the gravel is relatively fine and crushed, as round stones do not "bind" to make a firm surface and will result in a difficult riding surface.

Uncrushed river gravels, or any other material with round stones, should not be used. Often "dirty rock" with a range of aggregate sizes from a local quarry can be a cheap, effective trail-building material.

A component of fine material (limestone or clay) is required in compacted gravel to aid binding. Limestone has the advantage of having natural cement properties but will not be cost-effective unless it available locally.

The top layer of these surfaces is generally constructed with a crown at the centre and very little material at the sides. Over time, as cyclists generally ride on the centre of the trail, the trail flattens out.

Users of off-road NZCT routes are expected to be using mountain bikes, which have wider tyres than road bikes, so compacted gravel can be one of the more cost-effective and appropriate surfaces. Coarse or loose gravel surfaces are unsuitable for bicycles with narrow tyres such as road cycles, which are favoured by most touring and long-distance, multi-day cyclists. Designers should determine what type of bike (and therefore tyre) will be used on the trail and specify materials accordingly.

Gravel is often a cheap option, especially if rocks excavated on-site can be crushed and used to surface adjacent sections of trail. Another advantage of using naturally-occurring surface materials is that the surface looks natural and fits into the environment. However, the low capital cost required for these trails can be offset by high operational costs to maintain them. It is important that compacted gravel paths are cleared of vegetative matter during construction and plants are prevented from growing in them. The aggregate is likely to spread and thus it may be necessary to sweep loose aggregate back onto the path where it spreads onto drainage features, roads, driveways, or other critical locations.

Figure 20: Compacted gravel section of Little River Rail Trail at Catons Bay

Gravel should be at the optimum moisture content when compacted. If it is too wet it will stick to the plate compactor machinery and hinder the process. If it is too dry it will not bind. Gravel should be of mixed size to facilitate "binding" into an dense and firm riding surface.

The material beneath the surface is also important. Gap graded aggregates (like railway ballast used on rail trails) form a good structural base with excellent drainage properties and can provide surplus water storage if there is a known flooding problem in the area. However, too much drainage in dry environments can also cause problems. Experience on the Otago Central Rail Trail (OCRT) shows that a very dry surface can prevent the establishment of a firm, cohesive surface. To counter this, the OCRT operators use a consolidated AP 40[2] layer between the railway ballast and surface material (well-graded AP 20 with a high clay content).

There is no single formula that provides the solution for all trail surfaces. The appropriate surface for a section of a trail will depend on underlying substrate, topography, trail grade and climate. Solutions that may give the best maintainability and surface longevity may be prohibitively expensive for the number and type of users on a given trail. Over the length of a trail there is likely to be a variety of substrates so the trail surface and underlying layers will need to vary as well.

3.9.2 Natural Surface

Low volume farm roads with natural (i.e. uncovered soil) surfaces, where motor vehicles provide compaction and prevent vegetation from growing, may also be appropriate for off-road trails. In most cases, natural soil surfaces are likely to be only applicable to mountain biking paths of higher grade. More detail regarding the properties of natural surfaces and construction and maintenance of paths formed on them can be found in Chapter 7 of the Track Construction and Maintenance Guidelines (DOC, 2008).

The natural surface may be a more rocky surface, such as gravel or even large rocks. Such surfaces can be appropriate for paths of higher grade trails where riders are experienced in riding on loose surfaces. Figure 21 shows an example of a path with a natural gravel surface.

Figure 21: Natural surface, Great Lake Trail, Taupo (photo: Jonathan Kennett)

Natural surfaces can also include the volcanic soils commonly found in the central North Island. Regardless of the soil type, all organic matter should be removed and only mineral material used. Organic matter decreases a soil's strength and promotes vegetation growth.

Stabilising products can be used on natural surfaces in critical areas to strengthen the trail and provide higher skid resistance for cyclists. Figure 22 shows a "geomat" applied on a steep track with loose surface in Tongariro National Park. Geotextiles are useful at sites

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[2] A specification for medium-sized gravel – "all passing 40 mm" sieve. Will ideally contain a mix of stone sizes, including clay.

with high use, extreme weather conditions and erodible soil. More information can be found in Chapter 16 of DOC (2008).

Figure 22: "Geomat" surface stabilisers, Tongariro National Park (photo: John Bradley)

A more natural alternative to surface stabilisation is to apply "rock armouring" or "stone pitching" whereby rocks are used to pave the ground surface. Finer gravel or sand can be applied on top of the rocks to produce a smoother surface, depending on the target skill level of riders. This is, however, generally a labour intensive treatment. Figure 23 shows an example of a rock armoured path. Additional guidance on this technique can be found in Section 15.2 of DOC (2008).

Figure 23: Rock armoured path - Nichols Creek Track, Dunedin (photo: Kennett Brothers)

3.9.3 Chipseal and Asphaltic Concrete (AC)

Chipseal and Asphaltic Concrete (AC) are two surface types that are commonly used for paving roads and can be appropriate for NZCT routes. They have similar construction methods and requirements for underlying base courses.

Chipseal will generally provide a much superior ride compared with gravel and costs much less than an asphaltic concrete surface. Figure 24 shows a path where a suitable grade of chipseal has been applied to produce a high quality and natural looking riding surface.

Figure 24: Chip seal path in Queenstown

When providing a chipseal surface, attention should be paid to the evenness and strength of the underlying surface and the size of chip (a smaller chip allows for a smoother ride). The chip used should be at least a grade 3 chip with a grade 5 fill. For an even smoother surface (which is also suitable for road bike tyres) a grade 4 chip with a grade 6 fill can be used.

Asphaltic concrete (AC) is a common-road surface which contractors are familiar with. It is faster to construct than concrete or pavers and has a lower capital cost. It is also suited to paths with limited space or constrained topography, or paths in urban areas with utilitarian trips by local residents (to work or school, for example). It may be suitable for urban trails but generally not for most NZCT rural trails.

For both chipseal and AC paths, the design of the underlying surface, a metal (aggregate) course, is generally dependent on the size of the construction or maintenance vehicles that will travel along the path. Heavy duty paths (those likely to cater for maintenance vehicles) also require a sub base layer of a larger aggregate. This is an important consideration that is often overlooked, and can result in significant damage, as shown in Figure 25.

Figure 25: Heavy truck causing edge break on new pathway during construction

Where ground material is either wet or soft (e.g. swamp or peat), then a filter fabric should be added to stop the construction metal course from mixing with the ground and thus achieve a long-lasting path. Where a high proportion of clay is present and vehicles cross the pathway (e.g. at driveways), construction depth needs to be increased. Advice from a roading engineering should be sought in these situations, to avoid high construction and maintenance costs.

Table 8 shows the required AC thicknesses or chip sizes and aggregate types for footpaths and cycle paths.

Table 8: AC and chipseal path requirements

Path Type	Surface type		Metal course	Sub base
	AC	Chipseal		
Footpath	20 mm	Grades 3&5 chip (rougher) or grades 4&6 chip (smoother)	75 mm AP 20	NA
Light duty cycle path	20 mm		125 mm AP 40	NA
Heavy duty cycle path	20-25 mm		125 mm AP 40	150 mm AP 65

Figure 26 shows an example of an asphaltic concrete path. Note that this path is not bordered by timber battens along the grassy edge.

Figure 26: Asphaltic concrete path on the Little River Rail Trail (photo: Jonathan Kennett)

Treatment with timber edging battens has been traditionally used on AC paths (as shown in Figure 24), but a new methodology has recently been developed without timber battens whereby a base course is laid and the AC surfacing is set on top. The base course should extend 200 mm wider than the intended path width with edges battered at a 1:3 gradient. The contractor will square up the edges of the AC (with a spade or temporary timbers) to achieve an even thickness of surfacing. This treatment provides adequate strength to the edge of seal and allows topsoil to be placed right to the edge of the path. Experience shows that this technique is cheaper to construct, requires less maintenance, and is less prone to vegetation sprouting through the surface. This method could also be applied to a chipseal path. An indicative cross-section of this is shown in Figure 27:

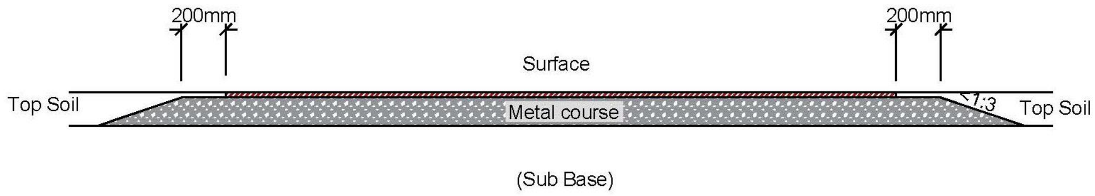


Figure 27: Cross section for chipseal or AC path without timber edging battens

3.9.4 Concrete

Concrete paths are strong and highly durable. The construction and capital costs are however typically higher than for other path types. Construction joints from one panel to the next can produce an uncomfortable, bumpy ride. Concrete is unlikely to be cost-effective for NZCT routes.

3.9.5 Paving Stones

Paving stones provide a high quality, durable and attractive surface for paths. They can be easily removed and reinstated for access to sub-surface services. Maintenance is still required for clearing the path of debris and spraying weeds that may grow between the pavers.

The high cost of this treatment is likely to make it an unsuitable option for most NZCT routes. It may however be appropriate for small sections where aesthetics are particularly important, for example end treatments at urban locations. Some trails may be able to make use of wide, flat stones found locally to serve as paving stones.

3.9.6 Recommended Surface Types for Path Grades

Table 9 outlines the recommended surface types for various path grades. The appropriateness of natural surfaces also depends on site and user characteristics; stabilising materials may be required.

Table 9: Recommended surface types for off-road trails

Grade	Recommended Surface Type
1. EASIEST	Compacted gravel / limestone Chipseal Paving stones (even surface essential) Asphaltic concrete Concrete
2. EASY	Compacted gravel / limestone Chipseal Paving stones Asphaltic concrete Concrete
3. INTERMEDIATE	Compacted gravel / limestone Natural surface (except loose gravel)
4. ADVANCED	Natural surface Compacted gravel / limestone
5. EXPERT	Natural surface Compacted gravel / limestone
6. EXTREME	Natural surface Compacted gravel / limestone

3.10 Drainage

It is best practice to design gradient reversals into trails from the very start. Gradient reversals reduce the watershed of each section of the trail so that less rain water is collected. Water can then be drained across the trail more easily, rather than running down the trail and causing erosion.

Gradient reversals should mimic the natural water run-off. They enhance long-term asset management, as they will work to stop water running down a track for decades into the future, even if maintenance is not done on culverts. Also, gradient reversals can be fun to ride if they are designed well (i.e. long and shallow).

When a trail crosses a stream, it should drop into the stream and then climb out. This is, in effect, a gradient reversal. When crossing a spur, a trail should climb over it. If the trail drops down to a spur and then climbs out, water will pond on the track and a bog will develop.

Grade 1 and 2 off-road cycle trails need particular attention to drainage beyond what is required for more conventional mountain bike trails, because these trails have greater widths, higher geometric standards and higher user expectations. In particular, ponding and flooding need to be prevented by careful consideration of surface types, longitudinal and transverse gradients, camber, culverts and bridges.

Chapter 8 of DOC's Track Construction and Maintenance Guidelines (2008) describes the erosion, displacement and compaction processes that damage tracks and Chapter 9 describes the methods of predicting water volume and how to design tracks to withstand effects of water. This is useful information to understand how and why tracks become damaged and why drainage is important.

Designers of off-road trails, particularly those of Grade 3 and above, are encouraged to read Chapter 10 of DOC's guidelines (2008) for a more comprehensive discussion of cycle trail drainage issues, solutions and approaches. Chapter 14 of DOC (2008) should also be used for design and construction of drainage systems. For Grade 1 or Grade 2 paths, designers are also encouraged to read sections 7.3-7.5 of the Connect2 and Greenways Design Guide (Sustrans, 2009) with regards to drainage.

Use of conventional open cross drains is not advised. These drains may be easy to construct and initially effective, but will soon block with material flowing down the track.

3.11 Construction

DOC (2008) outlines ten useful guiding principles for track construction. These are discussed in Chapter 4 of the Track Construction and Maintenance Guidelines and summarised below:

1. Keep water away from the track surface
2. Construct sustainable gradients
3. Make the track flow
4. Provide a suitable surface
5. Maintain a good surface
6. Maintain when required
7. Be environmentally astute
8. Protect your investment
9. Train staff
10. Respect and keep historic values

Chapter 13 of DOC (2008) outlines methods of constructing tracks of various formation types.

The Connect2 and Greenways manual (Sustrans, 2009, Chapter 7) also contains useful design and construction guidance. This includes consideration of cut and fill materials used to achieve the required path gradients and alignments. Excess cut material can be used creatively to create landscape features or "viewing mounds" that add to the aesthetic attraction while minimising transport or disposal of waste soil.

Cyclists on the Otago Central Rail Trail have indicated that they like to feel as if they are exploring the "wilderness" but not as if they are biking on a country road. It is important to communicate this message to contractors who may be tempted to provide extra but unnecessary width. Contractors normally involved in road construction may not understand the specific requirements of Grade 3 and above trails; whereas roads are built to be smooth, straight, level and consistent, mountain bikers appreciate some challenges in the form of curves, gradient reversals, slopes and changes in path alignment.

The best way to communicate the trail requirements to a contractor may be to ask them to ride a trail of a similar grade with a trail designer and then discuss the trail's characteristics and desirable aspects from a design perspective.

3.12 Livestock

It is recommended that, to the extent possible, sheep, cattle and other farm animals be excluded from off-road trails. Experience from the Otago Central Rail Trail shows that stock damage the path surface by walking and defecating on it. They also trample watertables and increase the amount of rock and stone pushed onto the trail in cuttings. The presence of stock on a trail leads to increased maintenance costs.

If stock are allowed to use the trail, in winter especially, livestock may prefer to stay on the path surface (rather than adjacent verges) which can intimidate cyclists, especially overseas visitors who may not be accustomed to large farm animals. Winter stock access should also be discouraged because stock will dirty the track surface, which makes it unpleasant to ride across.

3.13 Markings and Delineation

Painted markings can be used on permanent solid path surfaces (e.g. asphaltic concrete, concrete or paving stones) to:

- Segregate users (e.g. logos used to identify separate areas for cyclists and pedestrians)
- Segregate directions of travel (e.g. by using painted line and arrow markings)
- Convey instructions (e.g. keep left, warn when approaching – see Figure 28)
- Delineate intersections (e.g. "Give Way" limit lines)

Figure 28: Shared path markings, Nelson

Such treatments are not required on most NZCT paths, and the nature of most path surfaces precludes the possibility. Painted markings are, however, useful on sealed paths with higher user volumes, especially paths near urban areas and for paths of lower grades where users may require more guidance.

Coloured surfacing treatments are also useful to emphasise large areas of trail, particularly for on-road situations. Coloured surfacing can be used either to attract users' attention or serve as a warning to motorists or conflict zones in on-road trails or crossings. MOTSAM (Transit, 2008b) gives further guidance on the application of coloured surfacing.

3.14 Path End Treatments

Path end or "terminal" treatments are used at ends of off-road trails (paths) to warn cyclists of the approaching transition to on-road trails (or simply a road, without cycle provisions) and to prevent motor vehicles from accessing the paths.

Path end treatments should not necessarily be designed with the aim of slowing cyclists down and should not provide an "obstacle" that distracts cyclists' attention from the impending transition to the roadway. Circumstances where cyclists should be required to dismount are rare so route end treatments should allow cyclists to comfortably ride through without awkward manoeuvring.

Bollards and staggered fences or U-rails are preferred path end treatments. These devices can be designed to prevent access by motor vehicles, including motorbikes. It is recommended that designers seeking further guidance in this area read VicRoads Cycle Note No. 17: Terminal Treatments for Off-Road Paths (2005) which is freely available online.

Figure 29: Path end treatments, Hawkes Bay Trails (photo: Jonathan Kennett)

3.15 Environmental Considerations

Trail designers and builders should consider the environmental impact of the trail construction (for example vegetation clearance, rare plants, wildlife, siltation of streams and wetlands). This is particularly important for natural surface or compacted trails (i.e. those not covered with "hard" surfaces such as asphalt or concrete – see Section 0 for more discussion on various surfacing types). For a natural surface trail to be sustainable it should incorporate the principles of sustainable gradients (as discussed in Section 3.2), frequent gradient reversals (to aid drainage – as discussed in Section 3.10) and weed control (as discussed in Chapter 9).

In areas of native forest the environmental values should be assessed first. Also, mitigation can enhance a track and the users' experience. At Makara Peak Mountain Bike Park in Wellington a native tree is planted for every metre of track built. This mitigation measure is very popular as it results in a combination of recreation and conservation that people appreciate. The Otago Central Rail Trail Trust and DOC have planted trees along the rail trail for amenity value.

Tree planting provides shade, bird habitat and wind breaks. Over time, native trees also replace undesirable introduced plants such as gorse and blackberry.

The danger of cut branches and stumps on or near trails cannot be overstated. Potential injuries include stab wounds, broken bones, facial lacerations and lost eyes. All trimmed branches near trails should be cut flush with the main branch or tree trunk. Stumps should be dug out of the ground or cut at or below ground level.

It is preferable to fill between roots rather than digging them out. It is inevitable that roots will be uncovered and ruts will form throughout a trail’s life. Regular maintenance will be required to improve these features, as discussed in Chapter 9.

As discussed in Section 3.1.5, the natural landscape is an important factor that should be considered during initial design stages. There are often opportunities to “recycle” local materials (e.g. crushing excavated rocks to be used as basecourse or surfacing) when building trails. This adds continuity to the trail, decreases environmental impact and can cost less than importing materials.

Councils have rules restricting the amount of earth that can be removed and the maximum cross slope of terrain that a track can be built on. Trail designers and builders need to become familiar with these rules which make sense from both environmental and track sustainability standpoints.

Opening a natural surface trail to light can encourage weed growth. The natural tree canopy should not be disturbed if possible. Some weeds (for example African Clubmoss and Dydimo) are easily transferred from one trail to another by bicycle tyres. At the design and construction stage, these weeds need to be identified and eradicated or controlled. If infestations occur after the trail has been built, on-going control techniques will be required.

4 On-Road Trails

4.1 Introduction

On-road trails (quiet roads, cycle lanes or sealed road shoulders) provide for cyclists within the road “carriageway” (i.e. that portion of the road where motor vehicles travel). In urban areas, the carriageway is often defined by kerbs; in rural areas the carriageway is either the sealed area or the gravel area available for vehicles.

In **urban** areas, no special physical measures are needed if motor vehicle operating speeds and traffic volumes are low. At higher speeds and volumes, the main type of on-road provision that caters for urban cycle travel is a cycle lane. Although there are several different ways of distinguishing a cycle lane from adjacent general traffic lanes (e.g. painted line or coloured surfacing) cycle lanes are, by definition, on-road. Cycle paths, conversely, are off-road. Cycle lanes are given legal weight by the presence of white bicycle logos painted at frequent intervals along the lane.

Sustrans (2009, Chapter 11) gives an excellent description of how to create cycle-friendly urban on-road provisions such as green streets and home zones.

On **rural** roads, no special cycling provisions are needed if motor vehicle operating speeds and traffic volumes are below 1000 AADT. Otherwise, sealed shoulders are the main type of provision for cycling on country roads. It is essential that good intervisibility between cyclists and motorists is achieved, particularly for higher speed locations.

It may be sufficient for cyclists to use low volume, low speed rural roads without any specific form of provision. In some cases it will be necessary to provide marked cycle lanes or wide shoulders so that cyclists have a designated cycling space. Many cyclists on the NZCT will be inexperienced cyclists, from New Zealand, Australia or North America. Others, especially those from continental Europe are likely to be experienced cyclists used to off-road paths, but not experienced in on-road rural cycling.

Figure 30: Cyclist on rural road with wide shoulder, OTT Trail, Taihape (photo: Jonathan Kennett)

4.2 General Design Specifications

Table 10 presents the design specifications for on-road trails according to the first five trail grades. These grades are designed to correspond to the off-road grades but no on-road facilities will be designed for an “extreme” (Grade 6) level as this level would not be conducive to the NZCT "brand" in the on-road context. If a route involves both on-road and off-road sections, the grades of the two components should be consistent.

Table 10: Design specifications for on-road trails

Grade	Grade Description
1. 	**Description**: On-road route suitable for cyclists with little on-road cycling experience and low level of fitness. Mostly flat. **Traffic conditions**: Low motor traffic volumes and speeds and high quality trails, as shown in Figure 33. **Width**: As shown in Section 4.4. **Gradient**: 0-2.5 degrees for at least 98% of trail; between 2.5 and 3.5 degrees for no more than 100 metres at a time, and between 3.5 and 4.5 degrees for no more than 10 m at a time. If the track is designed and promoted to be ridden predominantly in one direction then the downhills can be steeper (up to 4.5 degrees). Unsealed trails should be less steep (same as the equivalent grade of off-road trail; see Table 3). **Surface**: Gravel roads in low volume, low speed situations. Asphaltic concrete or concrete is smoother than chipseal. **Road requirements**: No multi-lane roundabouts. Cyclist provision at signalised intersections. Crossing facilities if cyclists required to cross roads. **Length**: 3.5-4.5 hours/day (30-50 km/day)
2. 	**Description**: On-road route suitable for cyclists with little on-road cycling experience but reasonable level of fitness. Some gentle climbs. **Traffic conditions:** Low motor traffic volumes and speeds and high quality trails, as shown in Figure 33. **Width**: As shown in Section 4.4. **Gradient:** 0-4 degrees for at least 95% of trail; between 4 and 5 degrees for no more than 100 metres at a time, and between 5 and 7 degrees for no more than 10 m at a time. If the track is designed and promoted to be ridden predominantly in one direction then the downhills can be steeper (up to 7 degrees). Unsealed trails should be less steep (same as the equivalent grade of off-road trail; see Table 3). **Surface**: Gravel roads in low volume, low speed situations. Asphaltic concrete or concrete is smoother than chipseal. **Road requirements**: No multi-lane roundabouts. Cyclist provision at signalised intersections. Crossing facilities if cyclists required to cross roads. **Length**: 4-5 hours/day (40-60 km/day)

3. 	**Description:** On-road route suitable for cyclists at least 12 years old with some on-road cycling experience and reasonable level of fitness. Moderate exertion levels expected. Some steep climbs. **Traffic conditions:** As shown in Figure 34. **Width**: As shown in Section 4.4. **Gradient:** 0-6 degrees for at least 90% of trail; between 6 and 8 degrees for no more than 100 metres at a time, and between 8 and 10 degrees for no more than 10 m at a time. If the track is designed and promoted to be ridden predominantly in one direction then the downhills can be steeper (up to 10 degrees). Unsealed trails should be less steep (same as the equivalent grade of off-road trail; see Table 3). **Length**: 4-6 hours/day (50-80 km/day)
4. 	**Description:** On-road route suitable for cyclists at least 12 years old with some on-road cycling experience and reasonable level of fitness. Considerable exertion levels expected. Some steep climbs. **Traffic conditions:** As shown in Figure 34. **Width**: As shown in Section 4.4. **Gradient:** 0-8 degrees for at least 90% of trail; between 8 and 10 degrees for no more than 100 metres at a time, and between 10 and 13 degrees for no more than 10 m at a time. If the track is designed and promoted to be ridden predominantly in one direction then the downhills can be steeper (up to 13 degrees). Unsealed trails should be less steep (same as the equivalent grade of off-road trail; see Table 3). **Length**: 4-8 hours/day (60-100 km/day)
5. 	**Description:** On-road route suitable for cyclists at least 12 years old with considerable on-road cycling experience and reasonable levels of fitness. Considerable exertion levels expected with some steep climbs. The speed and volume of adjacent motor vehicle traffic will be considered unpleasant and/or unsafe by many Grade 1 and Grade 2 trail users. **Traffic conditions:** As shown in Figure 35. **Width**: As shown in Section 4.4. **Gradient:** 0-10 degrees for at least 90% of trail; between 10 and 15 degrees for no more than 100 metres at a time, and between 15 and 18 degrees for no more than 10 m at a time. If the track is designed and promoted to be ridden predominantly in one direction then the downhills can be steeper (up to 18 degrees). Unsealed trails should be less steep (same as the equivalent grade of off-road trail; see Table 3). **Length**: 4-8 hours/day (70-120 km/day)

4.3 Gradients

Gradient requirements from Table 10 for sealed on-road and off-road trails are summarised in Table 11:

Table 11: Gradient requirements for on-road trails

Trail Grade	Main uphill gradient range	Steeper slopes up to 200 m long	Steeper slopes up to 20 m long	Maximum Downhill Gradient
1	0 – 2.5 degrees for 98% of length	2.5 – 3.5 degrees	3.5 – 4.5 degrees	4.5 degrees
2	0 – 4 degrees for 95% of length	4.5 – 5 degrees	5 – 7 degrees	7 degrees
3	0 – 6 degrees for 90% of length	6.5 – 8 degrees	8 – 10 degrees	10 degrees
4	0 – 8 degrees for 90% of length	9 – 10 degrees	10 – 13 degrees	13 degrees
5	0 – 10 degrees for 90% of length	12 – 15 degrees	15 – 18 degrees	18 degrees

Notes:

1. This table applies to on-road sealed trails and off-road sealed (concrete or asphalt) trails.
2. Uphill sections of trail that are steeper than these gradient criteria should only be one grade harder and only in sections of up to 100 m length. It is undesirable to have harder sections of trail as some riders are likely to be forced to walk these sections.
3. Maximum downhill gradient applicable for 100 m and only if trail is designed and promoted to be ridden in one direction.

This table is repeated in Appendix 1 along with the comparable table for off-road trails.

Example – Gradients for Christchurch to Akaroa Cycle Route

To understand the suitability of the on-road gradients presented in Table 10**, consider "Le Race", a popular road cycle race which covers 100 km from Christchurch to Akaroa. It has several steep sections (as illustrated in** Figure 32**) and is generally ridden by cyclists of at least intermediate ability and experience.**

Figure 31: Cyclist on Summit Road, near Akaroa

Short sections of the course have gradients of up to 7 degrees (12%), which is within the Grade 4 on-road specification. This suggests that the Grade 4 and 5 on-road categories offer the right amount of challenge for serious road cyclists. Note that the gradients shown in Figure 32 **have been calculated over long sections and larger localised gradients exist.**

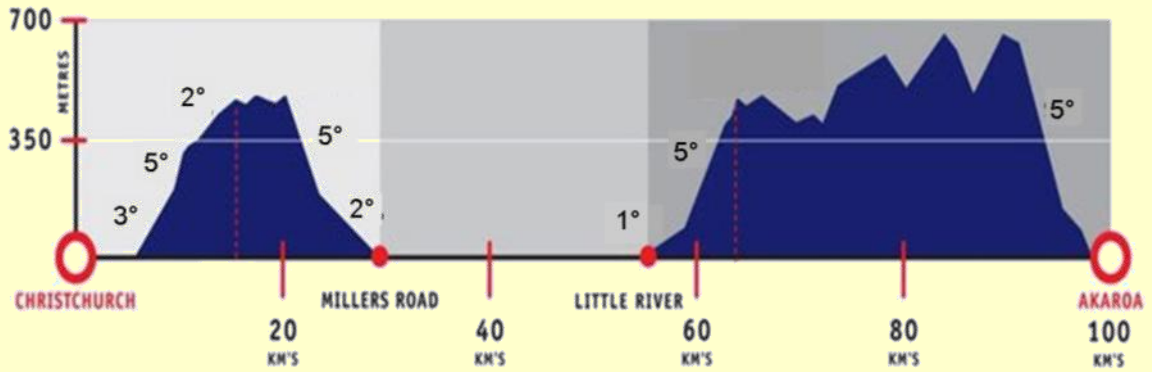


Figure 32: "Le Race" Gradient Map (courtesy of Le Race)

4.3 On-Road Trail Types

Figure 33 shows the motor vehicle traffic speed and volume characteristics for Grade 1 and 2 on-road trails. At low combinations of traffic volume and speed, no special provisions for cyclists, other than NZCT signage and branding, are required. At higher levels, a cycle lane or wide shoulder is required. Figure 34 gives the equivalent values for Grade 3 and 4 trails. Figure 35 covers Grade 5 on-road trails. Where cycle lanes or wide shoulders are required these should be provided according to Table 12.

Gravel roads can be considered appropriate if their characteristics fit in the "mixed traffic" areas of the figures.

These figures should also be read in conjunction with the notes that follows them. Note that the Y-axes are at different scales.

Traffic volumes in the figures are two-way. As traffic volumes increase, so do the chances of cyclists meeting two cars from opposite directions at the same time. This is when road space is at a premium; thus two way traffic volumes are just as important to cyclist safety and perception of safety as the traffic volume on the adjacent lane.

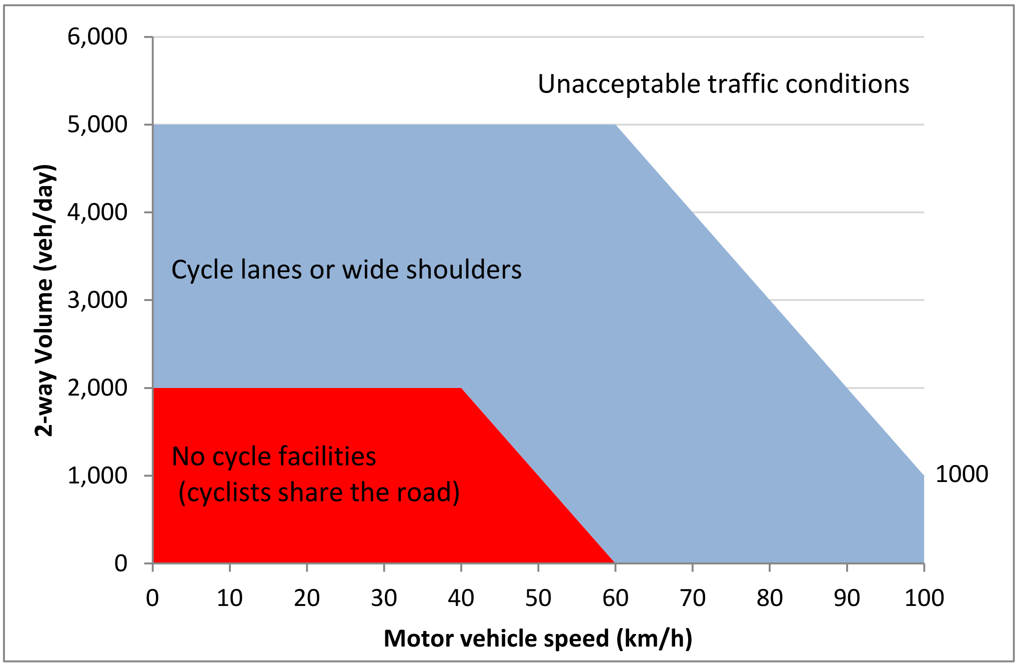


Figure 33: Trail type for Grade 1 and 2 on-road trails

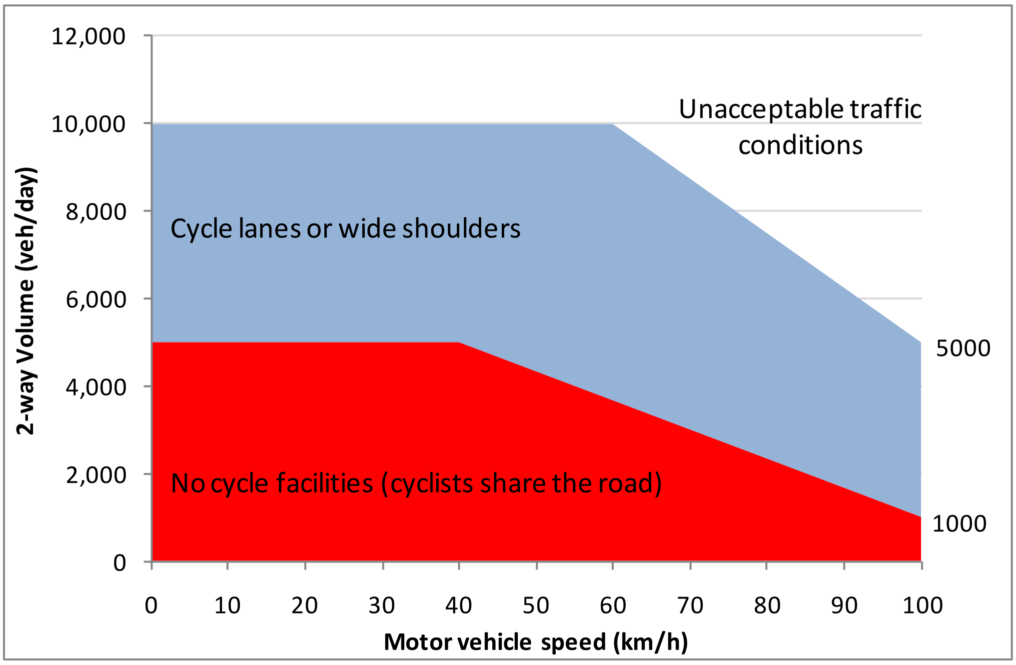


Figure 34: Trail type for Grade 3 and 4 on-road trails

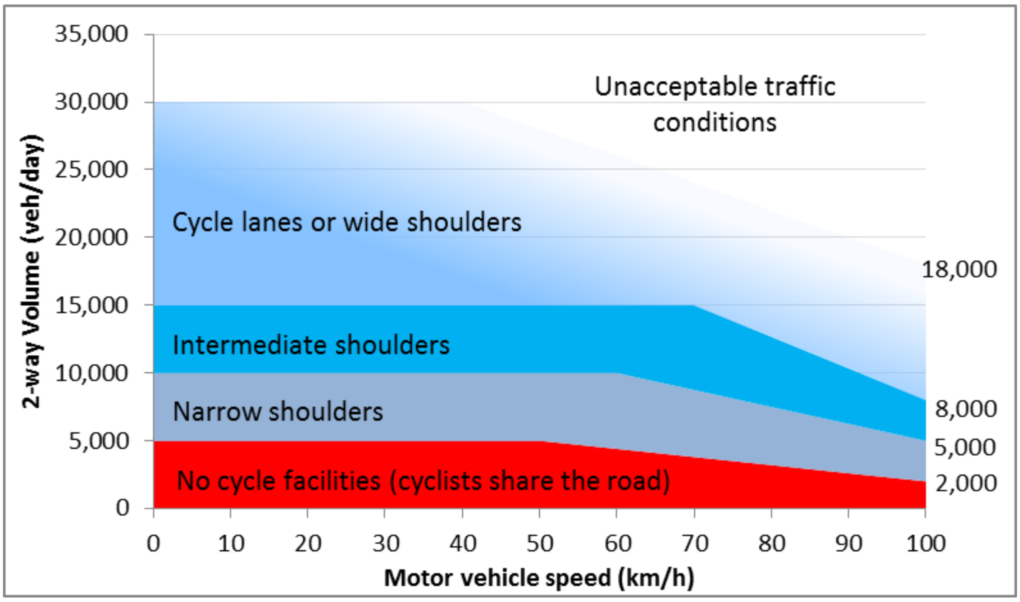


Figure 35: Trail type for Grade 5 on-road trails

Notes:

1. Where the 85th percentile operating speed is known it should be used (on the X-axis) in Figure 33 to Figure 35, otherwise the speed limit should be used.
2. Traffic volumes (Y-axis) are two-way motor vehicle traffic volumes, per day.
3. A road with a motor vehicle volume and speed combination outside the shaded areas in Figure 33 is not suitable as a Grade 1 or 2 trail on an NZCT route. Likewise, a road with a motor vehicle volume and speed combination outside the shaded areas in Figure 34 is not suitable as a Grade 3 or 4 trail.
4. Where necessary, measures should be taken to reduce the motor vehicle speeds or volumes to achieve a combination appropriate to the desired trail type. If this cannot be achieved an alternative route should be considered.
5. Paint marking cannot be applied to unsealed (gravel) roads and therefore unsealed roads cannot include cycle lanes or shoulders suitable for cycling. Gravel roads satisfying the "mixed traffic" requirements in the figures may be used for the appropriate on-road trail grade.
6. Grade 5 trails are typically links between "Great Rides" and will not necessarily be iconic rides in their own right.

4.4 Gravel Roads

Some NZCT routes will include gravel roads; these may be appropriate under the mixed traffic category in Figure 33 to Figure 35. There must be a commitment by road controlling authorities and their contractors that these gravel road sections will be maintained to a standard that is suitable for cycling, consistent with the route grade. This may require changes to design, construction and maintenance practices, including the selection, application, compaction and maintenance of road metal, and to inspection frequencies. The road camber, especially at bends, may need to be reduced to improve cycle stability.

Regular maintenance should be undertaken to ensure the edge of the road where cyclists ride does not experience a build-up of loose gravel. This can occur as gravel migrates to the side of the road and can result in an unstable, uncomfortable and potentially dangerous surface.

This can be a particular problem where uncrushed graded river gravels are used for road metal. Excessive gravel build-up on parts of the carriageway (such as dips and the inside of bends) should be removed. Crushed or stabilised gravels bind much better and provide a more stable riding surface, for motor vehicles and cycles alike.

Trail designers, operators and roading authorities will need to consider the surface quality of gravel roads both immediately after resurfacing and after the road surface is worn. It is preferable for gravel roads to be bordered by a flat, mown or grazed grass verge where cyclists can pull over if necessary.

4.5 On-Road Shoulder or Cycle Lane Widths

Where shoulders are provided on sealed roads for NZCT trails, their widths and the widths of adjacent general traffic lanes should be as described in Table 12. In determining how much width is available for cycling in a shoulder on an existing road, or on a road redesigned to accommodate cyclists, the effective shoulder width should be considered. This is exclusive of raised reflective pavement markers (RRPMs), and should be measured from the centre of the edge line to the edge of seal. If RRPMs exist or are planned, then the available width should be measured from the RRPMs to the edge of seal.

Table 12: Shoulder or cycle lane widths

Grade	Shoulder or cycle lane width	Speed Limit		
		50 km/h	70 km/h	100 km/h
	Minimum adjacent traffic lane width	**3.0 m**	**3.3 m**	**3.5 m**
1 and 2	Desirable minimum width	1.5 m	1.9 m	2.5 m
	Acceptable range	1.2 – 2.2 m	1.6 – 2.5 m	2.0 – 2.5 m
3 and 4	Desirable minimum width	1.2 m	1.5 m	2 m
	Acceptable range	1.0 – 1.5 m	1.0 – 1.7 m	1.0 – 2 m
5 (Narrow shoulder for 2000-10,000 AADT)	Desirable minimum width	1 m	1.2 m	1.5 m
	Acceptable range	0.6 – 1 m	0.6 – 1.5 m	0.6 – 1.8 m
5 (Intermediate width shoulder for 5000-15,000 AADT)	Desirable minimum width	1.2 m	1.5 m	1.8 m
	Acceptable range	1.0 – 1.5 m	1.0 – 1.8 m	1.0 – 2 m
5 (Wide shoulder for 8000-30,000 AADT)	Desirable minimum width	1.5 m	1.8 m	2 m
	Acceptable range	1.2 – 2 m	1.5 – 2 m	1.5 – 2.2 m

Notes:

1. The speed limit is used unless the 85th percentile speed is significantly higher.
2. Interpolation for different speed limits is acceptable.
3. Wider cycle lane or shoulder widths than the minima are recommended.

4. When greater than 2.5 m of shoulder or cycle lane exists, chevron pavement markings should be provided to suggest a cycling area of between 1.5 m and 2.0 m in width and to separate the cycling area from the general traffic lane. In such cases, the chevron markings should be at least 1.0 m wide.
5. Additional shoulder or cycle lane width is required if on-road parking is present. NZTA (Transit NZ (2008b)) Table 4-2 applies for both the desirable minimum width as well as the acceptable range, instead of the values given in Table 12.
6. Adequate shoulder or cycle lane width is required if on-road audio tactile profile (ATP) road marking is present. Ideally a shoulder width of at least 1.5 m (but a minimum 1 m) should be present before ATP road markings are used. Whichever is the greater requirement (Table 12 or this note to the table) should be applied.
7. Where RRPMs (raised reflective pavement markers) are present in or near the shoulder, the shoulder width should be measured from the road edge to the RRPMs, rather than to the edgeline, whichever is less.
8. The lower end of the acceptable shoulder or cycle lane ranges may be used for NZCT on-road cycle trails where it is not practicable to provide the desirable minimum width shoulder or cycle lane. Where the full width of the shoulder or cycle lane is not available (e.g. next to a kerb), then the desirable minimum width should be used.
9. The lower end of the acceptable range should only be used when motor vehicle traffic volumes are relatively low. These shoulder widths do not comply with "best practice" for cycle lanes or sealed shoulders but may be all the width that is available on some NZCT routes. Designers should use sound engineering judgement to satisfy themselves that such shoulder widths will be safe.
10. For Grade 5 trails, different shoulder widths are specified depending on the traffic volume and operating speed environment. The wider shoulder width should be considered for uphill sections of the trail to allow for “wobble” factors..
11. Where minimum traffic lane width requirements are not met, the desirable minimum cycle lane / shoulder width should be increased accordingly.
12. Where compromises from desirable minimum width are necessary, consider providing more shoulder width in the uphill direction, to accommodate cyclist "wobble".
13. Heavy vehicles (trucks, buses and camper vans) are wider than cars and cause more discomfort to cyclists in terms of side drafts, noise and vibration. Additional width allowance should be made on roads with a significant proportion of heavy vehicles, with considerable effort expended where necessary to ensure that desirable minimum widths according to Table 12 are provided.
14. 14. Where the surface beside the shoulder is easily rideable (i.e. flat mown grass, or compacted gravel) for mountain bikes, and the cycle route is one for which mountain bikes are required (e.g. Mountains to Sea) then the minimum shoulder required can be reduced for short pinch points.

4.6 Seasonal Traffic Volume Variations

All roads experience uneven traffic volume distributions over time. Some roads at some times of day or year may be unsuitable for most cyclists (because of the intensity of traffic), but may be perfectly acceptable at other times of the day or year. If potential NZCT trail users are made aware of the normal traffic variations and patterns, they may be able to safely and enjoyably, simply by choosing a quieter time of day.

The following methodology is applicable to Grade 5 routes only and takes account of traffic conditions experienced by cyclists. An Average Annual Daily Traffic volume (AADT) can be used in conjunction with Figure 35, but what matters to cyclists is the volume of traffic experienced at the time of riding a route. There are two considerations to take into account:

- Cyclists themselves can have an influence on the traffic volume by avoiding busy times on the road. For this to be realistic, they need to have the appropriate information.
- Some roads have a distinctly seasonal nature. Where this is the case, the busy times to be avoided may be longer during the holiday period than for the rest of the year. That is, an AADT may not necessarily be sufficient when determining what advice to give to cyclists.

Figure 36 shows an example of seasonal road traffic volumes.

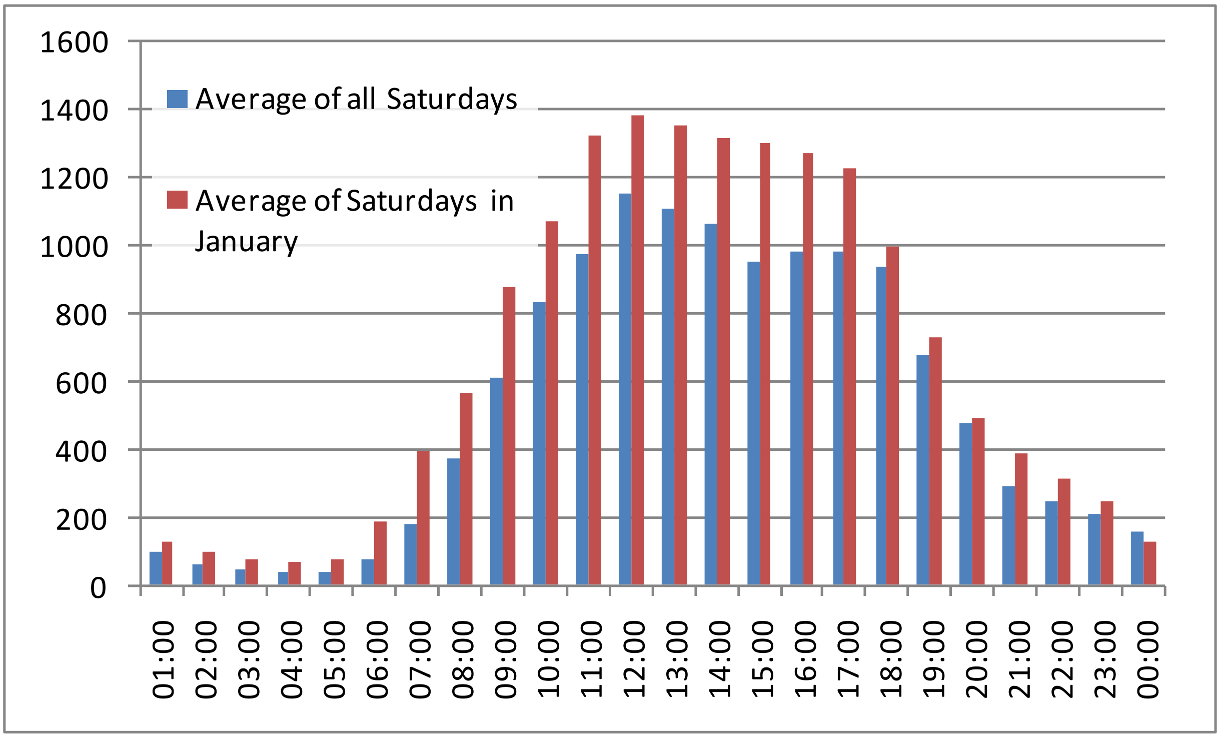


Figure 36: Hourly traffic volume distribution in January and the remainder of the year

In this example, a trail operator may decide that cyclists should be advised to avoid using the road when traffic volumes exceed 1,000 vehicles per hour (roughly equivalent to 10,000 vehicles per day). The blue bars show that cyclists should thus avoid the road between 12 noon and 3 pm.

It can be seen that being aware of hourly volume distributions, and how these may vary during peak times of the year, can possibly be an important management tool.

4.7 Assessing Cycle Routes on Open Roads (100 km/h speed limit)

The chart presented in Figure 37 below provides some initial guidance for assessing the viability of roads with a 100 km/h speed limit for accommodating on-road cycle routes for the New Zealand Cycle Trail (NZCT) network.

The volume of traffic (Average Annual Daily Traffic or AADT) and shoulder width are key factors in determining the suitability of roads for the NZCT. These have been discussed in the preceding sub-sections of Chapter 4.

Important points to note:

- This chart is for assessing cycle routes using open roads with a 100 km/h speed limit. Where the speed limit is lower than 100 km/h the required shoulder width will reduce (refer to section 4.5).
- Gravel roads and many minor sealed roads have no shoulder. If such roads are to accommodate an NZCT route, the AADT must be less than 2,000 veh/day to fit the NZCT criteria.
- Roads that have an AADT over 18,000 veh/day are not acceptable for NZCT routes.
- <u>This chart is an outline only.</u> There are a number of factors that determine the final grade assigned to an on-road cycle route, in addition to the AADT and shoulder width. The other considerations outlined in this *Cycle Trail Design Guide* should be considered in decision making.

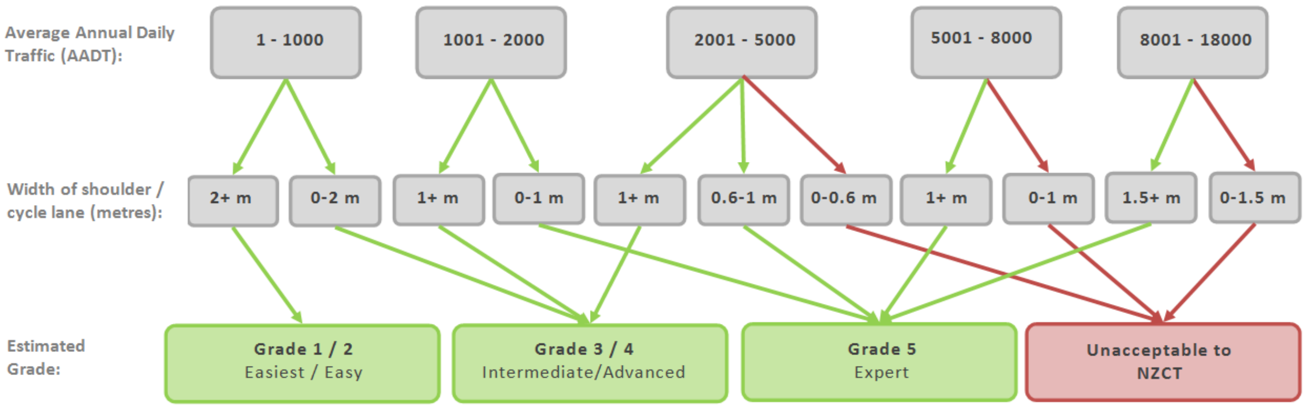


Figure 37: determination of viability of cycle routes on open roads

4.8 Pinch Points

A pinch point is a localised narrowing of a trail due to physical features restricting the width. These can occur on- or off-road. Off-road pinch points can cause conflict between users travelling in different directions; generally this is not a great problem especially if visibility is sufficient to recognise the pinch point and take action before encountering other users.

For on-road pinch points, the greatest danger to cyclists is that of passing motor vehicles. Narrow bridges are common on-road pinch points. If it is not possible to provide the appropriate cycling width on-road (as outlined in Section 4.5) then off-road alternatives should be considered.

However, mitigation treatments may be applied to short sections of on-road trails where the required standard is not met and it is not feasible to provide off-road alternatives (in the immediate future). These are good short term improvements while a more permanent solution is developed.

Such treatments may include active warning signs, such as those shown in Figure 38 and Figure 39. These signs may be activated either by a push button which the cyclist must ride up to or an inductive loop sensor in the pavement which must be positioned so that the cyclist will ride over it. Inductive loop detectors are preferred as they do not require cyclists to stop, however the loop positioning must be carefully determined and detection equipment must be able to detect cyclists but not motor vehicles.

Figure 38: Push button activated warning sign at vertical crest, SH 60 near Nelson (photo: NZTA)

Figure 39: Inductive loop activated warning sign on narrow Appleby bridge, SH 60, near Nelson (photo: NZTA)

Active warning signs can also be useful at complicated on-road sites where there are many demands on motorists' attention and cyclists might not otherwise be noticed, such as at locations where cyclists cross the open road, or at intersections. Figure 40 shows an active warning sign used at the Ngauranga interchange on State Highway 2, near Wellington. Cyclists cross the motor vehicle on-ramp but motorists are warned to look out for cyclists by the sign, which is activated by inductive loops on the cyclist approach plus a push button option at the crossing.

Figure 40: Active warning sign at Ngauranga interchange, SH 2, Wellington (photo: NZTA)

Reducing the motor vehicle speed limit can also mitigate the effect of on-road pinch points although this requires a thorough technical and legal process. It may suitable on some rural roads, however, where traffic operating speeds are already well below the 100 km/h rural limit and an 80 km/h limit may be more appropriate for motor vehicle (as well as cyclist) safety.

While “chokes” may be used on off-road trails (as outlined in Section 3.8) pinch points should not purposefully be designed into on-road trails as this will put cyclists into danger from motor vehicles.

4.9 Markings and Delineation

Markings and delineations for on-road cycle trails and road shoulders should be designed according to MOTSAM (Transit NZ, 2008b). This includes specifications for line styles, cycle logos, application of coloured surfacing and intersection treatments. It also has advice on raised reflective pavement markers (RRPMs) and audio tactile profile (ATP) markings.

Draft advice from NZTA for audio tactile profile (ATP) markings notes:

- Attempt to maintain a 1 m clear shoulder width outside of ATP wherever possible. This shoulder width needs to be clean, clear and well maintained. Where a 1 m shoulder width cannot be achieved then clear reasons for installing the ATP need to be well documented (includes consideration of cycle use and the crash history).
- 150 mm wide ribs at 250 mm centres to be laid either on or immediately outside of the edgelines, depending on the available shoulders.
- Maintain a 3.35 m minimum clear traffic lane between any centreline and edgeline ATPs.
- Edgeline ribs are to be stopped well in advance (preferably 30 m minimum) of any shoulder narrowing, bridge structures, intersections etc.
- It is strongly recommended that consultation is undertaken with local cycle advocacy groups where ATP is being laid, particularly when the shoulder width is less than 1m. This will also help to determine the cycle frequency on these corridors and whether or not ATP should be laid.

5 Crossings and Intersections

5.1 Introduction

For the purposes of this guide, a “crossing” is a junction between an off-road cycle path and a road. An “intersection” is either a junction between two off-road cycle trails or a junction between two roads (one or both of which may be an NZCT on-road cycle trail). Crossings are the most common form of junction on the NZCT.

"At grade" crossings are the most common crossing type, where cyclists cross the road surface. More expensive crossings are "grade separated', where the cycle path is at a different elevation to the road, as in a bridge or underpass.

In practice, gravel roads have relatively low traffic volumes and cycle crossings are fairly easy for adult cyclists, so long as good visibility exists.

5.2 Crossings

5.2.1 “Uncontrolled" Crossings

Uncontrolled (i.e. without Stop or Give Way signs or other traffic controls) crossings of roads by cycle trails are usually safe for all users if the traffic volumes are low (under 1,000 vehicles per day) and visibility is good. Where these conditions do not exist, crossings should be controlled. Some trails, for example in forests, have poor visibility of approaching road crossings and may thus need to be controlled, even when traffic volumes are low.

5.2.2 “Stop” or "Give Way" Crossings

At "Stop" or “Give Way” crossings, cyclists on the trail will either have to give way to traffic on the intersecting road or vice versa. The situation where cyclists have to give way gives the lowest level of service to cyclists. Yet “Stop” and “Give Way” crossings are likely to be common given the low costs required and that they generally provide adequate safety levels and levels of service.

Median islands will be required at some “Stop” or “Give Way” crossings where the road traffic volume is too high to provide sufficient opportunities for cyclists to cross the entire road in one movement. They will also be required at some “Stop” or “Give Way” crossings where high traffic speeds may make it difficult to judge a gap in both directions of traffic. Median islands allow cyclists to cross half of the road then wait in safety at the centre for a gap in the traffic on the other side of the road. The median should include a cycle holding rail to aid cyclists waiting in the median.

Median islands should be designed to allow cyclists ample room to wait at the centre of the road. Designers may consider using a group of five cyclists as the design standard; this will mean there is also ample room for tandem cycles or cyclists towing trailers.

Additional treatments may also be required to ensure cyclists are aware of the presence of opposing traffic and their obligations to give way. Some international cyclists (especially continental Europeans) will be unfamiliar with this arrangement as in some countries it is uncommon for roads to have priority over major cycle paths. Therefore it is important that the message is clear. Treatments where users of off-road trails must give way to traffic on intersecting roads, especially where traffic speeds and / or volumes are high, should include:

- A change in path alignment leading up to the crossing that requires cyclists to slow down (i.e. combination of curves of decreasing radii);
- “Give Way” (or “Stop”) signs and limit lines; and
- Adequate intervisibility between cyclists and motorists.

Treatments may also include:

- A change in path surface texture and / or colour;
- Introduction of a centreline on path approaches to separate directional flows;
- Introduction of a bollard or gateway on path approaches to assist separation of directional flows and prevent motor vehicles from accessing the trail; and
- Kerb extensions on the road to reduce the crossing distance.

Paths should cross roads at right angles (90°) to minimise the crossing distance and ensure appropriate visibility in each direction.

In most cases it will not be necessary to force cyclists to dismount at a crossing. If there is sufficient visibility then cyclists should be given the opportunity to ride across a crossing. However, in some circumstances (for example, at the bottom of downhill slopes) cyclists may not easily judge the safety implications and the trail design should require them to slow down to check for motor vehicles. This can be done by providing bollards, gradient reversals or curves on the crossing approaches.

Situations where “Give Way” or “Stop” crossings with and without median islands are recommended, based on motor vehicle volumes and speeds, are outlined in Section 5.2.5.

The case of a crossing where road users must give way to trail users will be rare in urban areas and is not recommended on roads with speed limits over 50 km/h, as motorists will have difficulty seeing cyclists about to cross in sufficient time to stop. If designers are considering this type of crossing for a rural road, preference should be given to providing "grade separation" (a bridge or underpass).

If the trail has priority over the road (by requiring motorists to give way or stop at the trail crossing) cyclists have a better level of service (theoretically they will face no delay) but the crossing may have compliance and therefore safety issues. This treatment is likely to be acceptable only if the volume of cyclists using the trail is comparable to (or higher than) the volume of motor vehicles on the road. It is uncommon in New Zealand for roads to give way to cycle paths and thus the message should be clearly communicated to motorists.

The frequency of use of the crossing by cyclists is also an important factor in considering giving a trail priority over a road at a crossing. Like zebra crossings for pedestrians, crossings where the trail has priority over the road are likely to have poor motorist compliance if they have a low rate of use.

5.2.3 Signalised Crossings

Signalised crossings may be safer than "Give Way" or “Stop” crossings in some locations. However, signalised crossings should not be used in locations with speed limits greater than 80 km/h (Austroads, 2003) because of the high risk and potential severity of crashes if signals are not complied with at these speeds. Signalised crossings are therefore not appropriate for a large number of NZCT road crossings.

In rural settings, even where speed limits are 80 km/h or less, traffic signals may be inconsistent with surrounding intersection controls and thus may take drivers by surprise which can result in poor compliance. Signals in rural locations require a high degree of conspicuity. There is a danger that low numbers of trail users at signalised crossings will result in motorists becoming "conditioned" to green lights and not stop when they (rarely) receive a red light to allow users to cross.

Signalised crossings will be most appropriate in or near large urban areas, where motorists are used to experiencing traffic signals and the surrounding infrastructure supports their installation. In these circumstances, signalised crossings can improve the level of service for cyclists, especially in situations with high traffic volumes that would offer few gaps for crossing opportunities under a scenario where road users have priority. Cyclists can be detected by inductive loops positioned prior to the crossing so that the crossing phase can be called as they arrive. A good example of this is seen on Christchurch's Railway Cycleway, as illustrated in Figure 41.

Alternatively, a push button arrangement or inductive loop detector can be provided for cyclists at the crossing location. Advanced detection via inductive loops is recommended but it is also advisable to provide detection at the crossing as a back-up.

Situations where signalised crossings are recommended, based on motor vehicle volumes and speeds, are outlined in Section 5.2.5.

Figure 41: Advance cycle detection for signals, Railway Cycleway, Christchurch

5.2.4 Grade Separated Crossings

Grade separation (bridges or underpasses) are useful techniques for crossing busy or high-speed roads but they are expensive. Most crossings of the NZCT will be "at grade" (i.e. cyclists and motorists share the same surface), but in some circumstances grade separation can be justified.

Grade separation can take two main forms:

- Underpass for cyclists; or
- Overpass (or bridge) for cyclists.

Underpasses for cyclists require less vertical deviation than overpasses due to the height required for overpasses to clear large trucks. Cyclists also generally prefer the geometric characteristics of underpasses as they can gain momentum on the initial downward slope which aids in climbing the subsequent upwards slope. In contrast, overpasses require cyclists to first cycle uphill.

Recent advances in design and installation of stock underpasses can be applied to providing cost-effective underpasses for cyclists. However underpasses may be more expensive to construct than overpasses if the water table is high. If flooding is not an issue there may be opportunities to convert existing culverts into trail underpasses.

Security issues are more prevalent for underpasses than overpasses. Underpasses should have clear visibility from end to end and on the approaches. It may be necessary to provide lighting within the underpass. Provision of ample width is also important so that cyclists feel comfortable and shy space due to the walls is accounted for (see Section 3.5).

If an NZCT route is intended to provide for commuter cyclists in urban settings it is important that the deviation imposed on cyclists is minimised, otherwise cyclists may choose to forgo the route and cross the road at-grade. This is less important for cycle tourists who are generally willing to travel longer distances for the sake of the journey and favour safety over directness. What is more important for those cyclists is the gradient of the slopes involved in a structure. Section 4.2 gives more guidance on suitable gradients for isolated sections such as underpasses and overpasses as well as the trail generally.

Figure 42: Otago Central Rail Trail underpass (courtesy of OCRT Trust)

The structural design aspects of bridges and underpasses are discussed further in Section 6. Situations where grade separated crossings are recommended, based on motor vehicle volumes and speeds, are outlined in Section 5.2.5.

5.2.5 Selection of Crossing Type

When determining the type of crossing provision, the following factors should be taken into account:

- Traffic volumes;
- Proportion of heavy vehicles;
- Speed environment;
- Intervisibility;
- Crossing distances (width of road);
- Surrounding environment (e.g. urban / rural); and

- Crossing provision at other nearby locations along the trail and intersection controls along the road.

Figure 43 shows the suggested crossing types for trails according to various combinations of traffic volume and speed limit. This should be applied to Grade 1 and 2 trails in particular. At existing intersections it can be assumed that the current provision is suitable for Grade 3-5 users. New crossings for Grade 3-5 uses will have to be designed on a case-by-case basis. The appropriateness of the treatments shown in Figure 42 may vary with site-specific factors, especially those listed above. The boundaries between the various treatments are not rigidly defined and a 10% tolerance either side is considered acceptable. The minimum level of provision possible for an NZCT crossing is to have “Give Way” signs on the trail approaches without any additional treatments.

Figure 43 does not include the situation where road traffic must give way to cyclists. These situations will be uncommon and should only occur in locations where the speed limit is 50 km/h or less and cycle volumes are equal to or greater than motor vehicle volumes and there are at least 50 cyclists per hour in the peak hour of traffic each day, throughout the year.

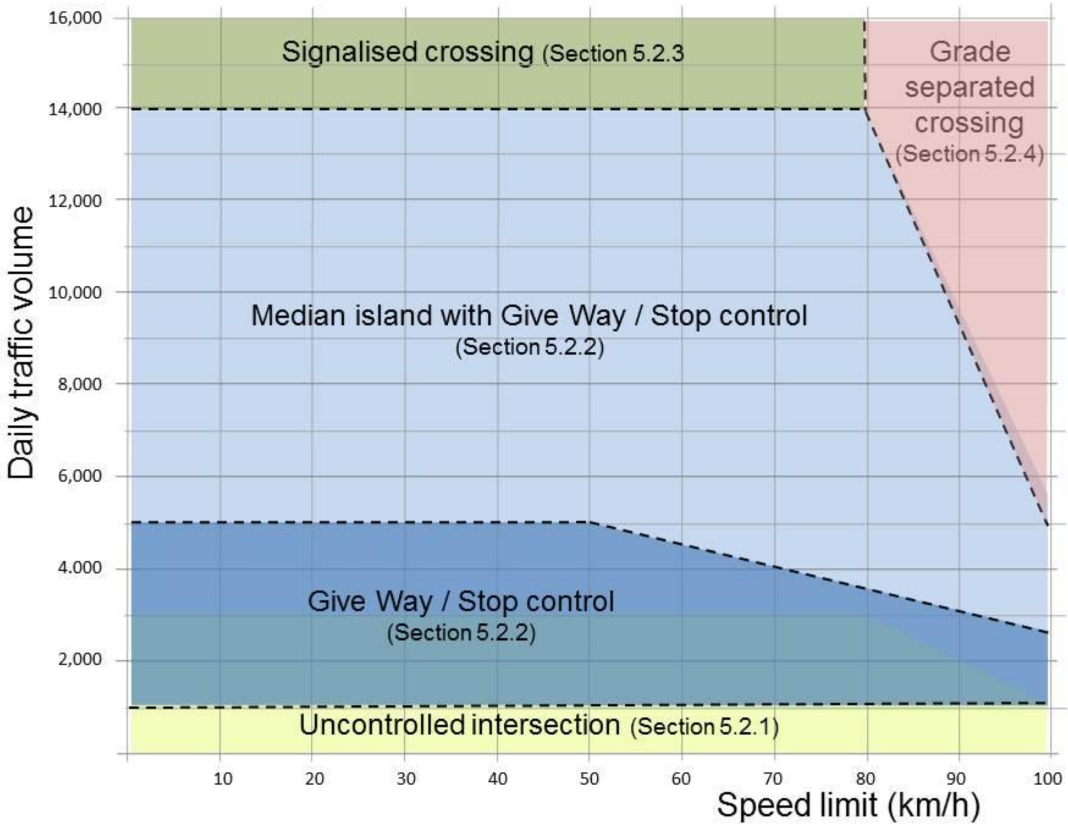


Figure 43: Crossing types (for Grade 1 and 2 trails)

Notes:

- A 10% tolerance either side of the boundaries shown can be used
- Speed limit is specified, however if the operating speed is known, the 85th percentile speed should be used instead.
- The maximum crossing distance to a median island is 4.5 m at up to 60 km/h; 5.0 m at 80 km/h and 5.5 m at 100 km/h.

5.3 On-Road Intersections

Where cyclists remain on-road at intersections the markings and delineations should be designed according to MOTSAM (Transit NZ, 2009). The Austroads Guide to Road Design (Parts 4, 4A, 4B and 4C) provide guidelines for the treatment of a wide range of intersections and interchanges.

The type of crossing provision will be governed by the motor vehicle interactions on the intersecting roads and therefore on-road NZCT routes are likely to have intersections controlled by "Give Way" or "Stop" signs (the route may have priority over or may have to give way to the intersecting road traffic) or by traffic signals. Small roundabouts are also acceptable but intersections with high volume or multi-lane roundabouts should be avoided for NZCT routes.

It may be necessary to provide separate cycle facilities at the intersection, for example creating an off-road section that takes cyclists around the corner of the intersection and provides a midblock crossing facility with median island or grade separation.

Where cycle trails are on a road that does not have priority over an intersecting road, the guidelines outlined in Section 5.2.1 for off-road trails also apply.

On-road cycle facilities at signalised intersections include advanced stop boxes, advanced stop lines, hook turn boxes and dedicated signals for cyclists. Design of these facilities is outlined in MOTSAM (Transit NZ, 2009).

5.4 Path Intersections

The key consideration for intersections between off-road trails is intervisibility between users. Even for rural paths with low volumes there will be situations where users approach the intersection from each path simultaneously. If they have sufficient warning of each other they can adjust their paths and negotiate the intersection safely. There is usually no need to specify which path must give way, but this may be a useful treatment for paths with higher volumes and particularly poor visibility. Figure 44 shows an example of a path with poor intervisibility between the approaches; this is compounded by the slope of the bridge which will increase cyclists' approach speeds at the intersection.

Figure 44: Poor intervisibility at path intersection – Auckland

5.5 Railway Crossings

Where off-road trails cross railway lines and train traffic volumes are low (under 20 trains per day), a simple level crossing is likely to be the most cost-effective solution. An example of such a crossing (from Hastings) is shown in Figure 45.

Figure 45: At-grade rail crossing installed in 2010 in Hastings (photo: Andrew Macbeth)

It will usually be desirable to control the approach speeds of cyclists before an at-grade rail crossing. A gentle chicane is all that is needed. Indicative designs for two treatments are shown in Figure 46 and Figure 44.

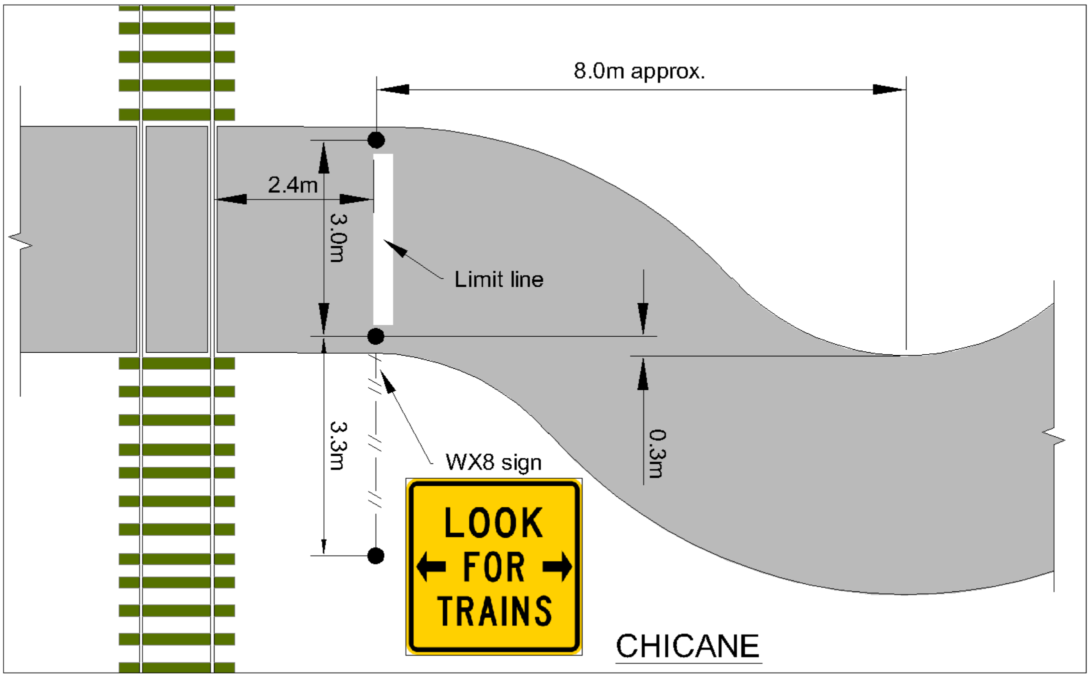


Figure 46: Chicane design; slows cyclists before crossing railway line

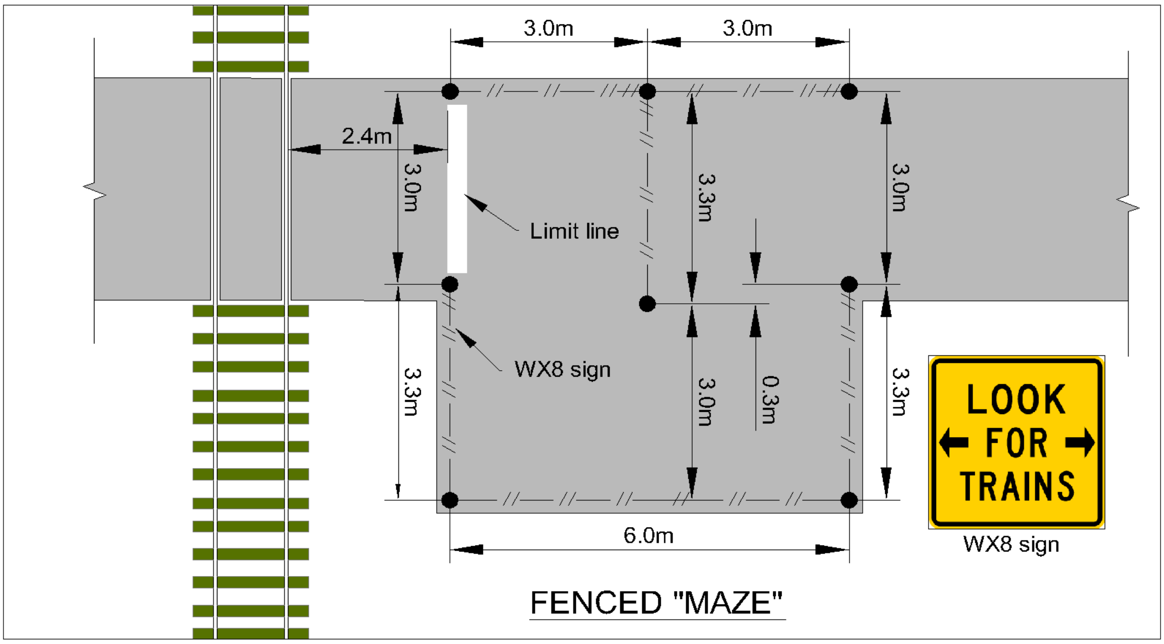


Figure 47: Fenced maze design; slows cyclists before crossing railway line

Some trails on roads cross railway lines on bridges. If road traffic volumes are low (fewer than 1,000 vehicles per day), cyclists may be able to share the bridge comfortably and safely with motor vehicles if adequate visibility and width exist.

Where road crossings carry higher traffic volumes, separation from motor vehicles should be considered by providing a separate, off-road at-grade crossing (as illustrated in Figure 45) or by providing clip-on bridges alongside the main bridge.

Separation from motor vehicles will be especially important if the trail is Grade 1 or 2. Many existing rail over-bridges have inadequate width for safe cycling (see Figure 48).

Figure 48: Many railway overbridges have inadequate shoulder width and may require clip-on bridges on each side for cyclist safety (photo: Jonathan Kennett)

6 Structural Design

6.1 NZ Handbook for Tracks and Outdoor Visitor Structures (HB 8630)

This section is designed to supplement the New Zealand Handbook for Tracks and Outdoor Visitor Structures – SNZ HB 8630:2004 (hereafter referred to as “HB 8630”) which is due to be updated in the near future. The Department of Conservation (DOC) was a major player in the development of this Standards New Zealand document.

HB 8630 is intended for off-road trails only and therefore should generally not be applied to on-road structures for cyclists. Structural design for on-road structures (including "clip-on" paths to road bridges) should follow the standard for design for access and mobility, NZS 4121:2001 (Standards New Zealand, 2001); structural design standard, AS/NZS 1170 (Standards NZ, 2004); and the Transit NZ (2003) Bridge Manual with geometric features of cycle trails and facilities (such as dimensions and gradients) designed according to the NZ Supplement to Austroads Part 14: Bicycles (Transit NZ, 2008a).

HB 8630 was developed principally for walking tracks and, while it mentions cycling as an allowable activity in some circumstances, it is not written primarily for cyclists. Some of the advice is inappropriate for cycling trails and the purpose of this section is to clarify when HB 8630 can be used and when other guidance is required.

Six track classifications are used in HB 8630 for six[3] “visitor groups” (also referred to as “user groups”). They describe the various abilities and motivations of track users. A useful summary of HB 8630's various track classifications and their design specifications is given in its Table 5. These track classifications and corresponding visitor groups are summarised for users of the NZCT in Table 13 below.

[3] There is also a seventh visitor group, “Overnighters” (“ON”) presented in HB 8630. This group includes both domestic and international visitors and local community visitors seeking an overnight experience in a predominantly natural setting. For the purposes of HB 8630 the DV (Day Visitors) category is used for ON visitors and ON itself does not feature in subsequent design tables. Therefore the ON category is not used for NZCT route design.

Table 13: DOC track classifications from HB 8630

HB 8630 Track Classification	User Group	Visitor Group	Description
Path	1	Urban Residents (UR)	Paths shall be well formed and provide for easy walking suitable for all ages and most fitness levels. Access shall be provided on a durable surface such as concrete, chip seal, asphalt or compacted gravel. Many Paths shall cater for people with mobility difficulties or limitations and children in mountain buggies or prams.
Short Walk	2	Short Stop Travellers (SST)	Short Walks shall be well formed and provide for up to one hour's easy walking suitable for most ages and fitness levels.
Walking Track	3	Day Visitors (DV)	Walking Tracks cater for those who want an extended walk that takes from a few minutes to one full-day return. These tracks are usually reasonably easy day trips and are required to be of a standard to enable use by relatively inexperienced visitors with a low level of backcountry skill and wanting a low level of risk. Some may be suitable for cyclists/ mountain-bikers as well as pedestrians.
Great Walk / Easy Tramping Track	4	Backcountry Comfort Seekers – Easy Tramping Track (BCC)	These tracks cater for less experienced trampers (DOC refers to them as Backcountry Comfort Seekers) expecting a low risk experience in the backcountry. The Great Walks and Easy Tramping Tracks will generally be multi-day tramping tracks. Some Easy Tramping Tracks may be suitable for mountain-bikers as well as pedestrians.
Tramping Track	5	Backcountry Adventurers (BCA)	These tracks cater for Backcountry Adventurers, including trampers, hunters, anglers and mountaineers. A few may be suitable for mountain-bikers as well as pedestrians. Tramping Tracks generally follow the lie of the land and are commonly not formed.
Route	6	Remoteness Seekers (RS)	Routes are generally unformed and lightly cut and cater for experienced backcountry users who have navigation and river-crossing skills.

The HB 8630 track classifications do not correspond directly with the NZCT off-road trail grades. Not all of the HB 8630 classifications will be appropriate for the NZCT, especially those intended for unformed tracks. Table 14 shows the relationship between NZCT trail grades and HB 8630 track classifications.

Table 14: Relationship of NZCT grades to HB 8630 track classes and visitor groups

NZCT Grade	Equivalent HB 8630 User Group and Track Classification	HB 8630 Visitor Group	Reasoning / comments
1. EASIEST	2. Short walk	SST	Easiest non-urban category in HB 8630. All watercourses bridged. NZCT route distances will be longer than those suggested in HB 8630.
2. EASY	3. Walking track	DV	Similar experience level. Similar steps between adjacent categories.
3. INTERMEDIATE	4. Great walk/ easy tramping track	BCC	Similar experience level. Moderate exertion levels Similar steps between adjacent categories.
4. ADVANCED	5. Tramping track	BCA	Similar experience level. Considerable exertion levels HB 8630 specifies some tramping tracks may be unformed – unlikely for NZCT trails.
5. EXPERT			
6. EXTREME	6. Route	RS	HB 8630 specifies routes as unformed – may be appropriate for extreme NZCT trails.

Table 15 shows the components of the design process in HB 8630 which depend on the visitor group classification (rather than track classification directly). Some of these components are adopted for the NZCT; others are modified as outlined in the following sections.

Table 15: Use of HB 8630 categories that depend on visitor group in the Cycle Trail Design Guide

HB 8630 category depending on visitor group	Cycle Trail Design Guide
Reduction of basic live load for ultimate limit state (Table 6 of HB 8630)	Adopted
Basic live loads for barriers (Table 10 of HB 8630)	Adopted
Re-inspection by engineer every six years (Table 16 of HB 8630)	Adopted
Minimum access widths (Table 17 of HB 8630)	Superseded by this guide – see Section 6.3.1
Maximum structure gradients (Table 18 of HB 8630)	Adopted
Stairway classification (Table 19 of HB 8630)	Superseded by this guide – stairways should be avoided on NZCT. See Section 6.7.3.
Barrier types (Table 22 of HB 8630)	Adopted. In addition, barriers / handrails should be 1.2 m high for Grades 1 and 2, or 0.8 m* for Grade 3 and above.

* Note that a 0.8 m high barrier is unlikely to prevent a cyclist from falling over it if hit as the cyclist's centre of gravity will most likely be higher than this. It will however guide cyclists' alignment and therefore provide some safety benefit.

6.2 Types of Structure

Figure 49: Bridge on Little River Rail Trail, Canterbury (photo supplied by Chris Freear)

Several types of structure are required for NZCT routes, including:

- Bridges and boardwalks (see Section 6.3)
- Cattle stops (see Section 6.4)
- Underpasses and tunnels (see Section 6.5)

The most obvious type of structure is bridges (crossing rivers or roads), but other types of water crossing include culverts and fords. Boardwalks are essentially a platform over a surface that is unsuitable for a track, for example sensitive alpine saddle environments, wetlands, or across areas prone to flooding.

Cattle stops are also common, relatively low-cost structures on rural cycle paths that allow cyclists to cross fences without needing to stop cycling to open a gate. They are not specified in other guides. Cattle stops are considered to be a form of bridge for geometric design purposes.

Underpasses or tunnels may be required in steep terrain or when crossing roads. Drainage will be particularly important in tunnels so that they do not become flooded and impassable.

6.3 Bridges and Boardwalks

6.3.1 General Requirements

The majority of bridges on the NZCT will be short (i.e. 10 m long or less) and be made from timber or steel. Swing and suspension bridges (Section 6.3.2) are typically cost-effective only for longer spans.

The widths specified for structures in HB 8630 are generally inadequate for cycle paths and should not be used. They are too narrow in many cases to allow any but the most skilled riders to cycle across and they are also too narrow to comfortably walk across beside a cycle. If bridges are too narrow, cyclists may need to unload their bikes of panniers and luggage and do multiple trips across a bridge to continue their journey.

Figure 50: Manuherikia Bridge, Otago Central Rail Trail (photo: DOC)

There are six important considerations for bridges and boardwalks:

- Width;
- Handrails;
- Passing / viewing bays;
- Vertical Clearance;
- Drainage; and
- Skid resistance.

Ideally bridge and boardwalk widths should be consistent with the overall path and therefore designed according to the path width requirements outlined in Section 3.1.5 plus additional clearances for "shy space" due to handrails or walls etc as outlined in Section 3.5. However, this may not always be feasible, especially for long spans or constrained locations, in which case the minimum bridge widths outlined in Table 16 (reproduced from Table 2) can be used.

It is usually relatively cheap to provide additional width for a cycle bridge. A bridge that is 50% wider than the minimum width will generally be much less than 50% more expensive, yet provide a much more pleasant cycling experience.

Table 16: Bridge and Boardwalk Widths (reproduced from Table 2)

Grades	Recommended Bridge Width	Minimum Bridge Width *
1, 2	1.5 – 2.5 m	1.2 m
3	1.2 – 1.5 m	1.0 m
4	1.0 m	0.8 m
5	0.8 m	0.6 m
* If handrails are provided, they should be flared out if minimum bridge widths are used		

It is preferable to slope handrails outwards (10-15 degrees from the vertical) to allow more space for handlebars and thus allow more of the bridge deck to be safely ridden on. Flaring the handrails in this manner increases the effective width of the structure at minimal cost and generally improves the appearance of the structure. As discussed in Section 3.5, the minimum bridge width (from Table 2) is required at the surface of the bridge but flaring the handrails allows more clearance at handlebar height (taken as 1.0 m) and therefore makes the experience more comfortable for riders.

If a bridge or boardwalk does not have handrails, cyclists will be wary of cycling too close to the edge for fear of falling and suitable clearances for "shy space" should be provided (see Section 3.5 – clearances). Table 2 indicates the recommended bridge width according to path grade. It may be appropriate to increase this width where possible, especially for bridges of length 20 m or longer or on curved sections as cyclists need more space when cornering. Passing / viewing bays should be provided at 50 m intervals on bridges (if feasible) and boardwalks; they should be 5 m long by 2.5 m wide and have handrails. It is not practicable to provide passing bays on suspension bridges and cyclists will need to ride in single file. If cyclists approach such a bridge from opposite ends, one direction will need to give way to the other.

Handrails should be used on significantly curved bridges or bridges 20 m or longer if only the minimum width is provided. If the bridge is 0.5 m or more wider than the minimum width, handrails are optional (unless the fall height governs). If a bridge or boardwalk is 0.5 m or more above the ground, handrails should be provided on Grade 1 and 2 trails. HB 8630 uses an equivalent value of 1.0 m but the risk and safety implications of falling off a bridge or boardwalk are likely to be more severe for cyclists than pedestrians. Cyclists travel at faster speeds and fall from a greater height (due to their position on the cycle) than pedestrians. Cycles can also complicate a fall by catching pedals or handlebars on a structure during the fall or hurting the cyclist on landing.

When designing these structures, consideration of the requirements for cyclists passing each other is needed. Similarly, the effects of cross-winds can make cycling unstable and this needs to be addressed when choosing appropriate widths and deciding whether or not to provide handrails.

A typical (although notably narrow) boardwalk is shown in Figure 51 – it would require handrails and passing bays for a Grade 1 or 2 trail.

Figure 51: Boardwalk – Twizel River Trail (photo: Kennett Brothers)

The vertical clearance of a bridge above a river should take into account the potential river flood height. In some cases it may be acceptable that a river level will occasionally rise above the bridge deck, but this risks the integrity of the structure. It is up to the trail owner to specify the appropriate design flood in this circumstance, to erect suitable warning signs and to ensure a suitable inspection and maintenance regime is in place.

NZCT path drainage guidance (Section 3.10) should be used for structures where appropriate, rather than HB 8630 track drainage standards which apply to natural surface walking tracks.

UV stable polymer mesh should be used on bridges and boardwalks to increase skid resistance. Wooden surfaces can be dangerously slippery when wet and make corners particularly difficult to negotiate. Wire netting is also a possibility but it tends to wear out quickly on wooden boardwalks. Boardwalks are very susceptible to frosts and can become hazardous for early morning users. Consideration should be given to surfacing treatments in frost sensitive areas to mitigate the effects of ice on the path surface.

6.3.2 Swing and Suspension Bridges

Swing bridges and suspension bridges mean different things to different people. In this design guide, a suspension bridge is a bridge suspended from cables with a fairly rigid deck and may be wide enough for two people to walk across side by side. A swing bridge is a lighter structure, also suspended from cables, but the deck is flexible and often made from steel cables and metal bars, perhaps with wire mesh. They are often used on tramping tracks and are just wide enough to walk across.

In some situations, the type of bridge to be used will be governed by physical features, financial considerations and possibly the logistics of getting construction materials to the site. A swing bridge is often the preferred bridge structure for walking tracks and may also be the best alternative for remote cycle trails of Grades 3 and 4, especially when crossing long spans.

Figure 52: Swing bridge on the Old Ghost Road (photo: Jonathan Kennett)

Due to their freedom of movement, swing bridges will generally not be suitable for cyclists to ride over. Some cyclists may try to ride over swing bridges, however, which could result in injury from impacts with the bridge sides. Thus, if swing bridges are used, they should be made as rigid as possible with signs to warn cyclists of the dangers of riding across.

Suspension bridges are more stable than swing bridges and can thus be used for all grades of trail. Suspension bridges are generally a cheaper option than solid timber or metal constructions for longer spans.

Figure 53: Suspension bridge, Oparara Valley Track

Swing and suspension bridges should comply with the requirements of HB 8630 (unless contrary guidance is provided in this guide).

6.3.3 Approaches

A bridge or boardwalk narrower than the path will require end treatments to ensure cyclists are channelled onto the structure rather than off the side. This can be achieved by guard rails on either side. A storage space for cyclists to pull over on the approach to the structure (to rest or avoid passing or overtaking inside the structure) would also be appropriate. If provided, this should be on the left side approaching the structure.

6.3.4 Aesthetics

Bridges provide the opportunity to add to a route's iconic nature. Chapter 8 of Sustrans (2009) shows some excellent examples of iconic bridges developed as part of the Connect2 project in the UK.

6.4 Cattle Stops

6.4.1 Design

Cattle stops are generally short structures, used instead of gates in farm fences. Bars of 30 mm galvanised pipe are recommended for a cattle stop 1.4 m wide, with a central (longitudinal) support. To achieve a wider structure either stronger bars or more internal supports are required. The bars should be placed with a 70 mm gap between bars (i.e. at 100 mm centres). The length of the structure should be at least 2.2 m to ensure stock will not jump over it. Details for a cattle stop are shown in Figure 54.

Handrails should be used on all cattle stops on the NZCT. This aids cyclist safety by protecting them against falling off the cattle stop and onto the adjacent fence or into the ditch below. It also prevents stock from jumping diagonally across the cattle stop from one paddock to the next, at the gap in the fence.

Cattle stops should be raised 200 mm above ground level. This ensures there is a pit below the bars and reduces the risk of sediment or debris from building up to the level of the bars, which would render the cattle stop useless. The pit should be at least 400 mm deep below the bars and the bars should be removable to allow the pit to be cleaned. The pit can include an internal ramp that provides an exit opportunity for hedgehogs or other wildlife that may walk into them.

An approach ramp should also be used to provide a smooth approach to the cattle stop deck and to provide an additional visual obstacle to stock, discouraging them from attempting to walk over the cattle stop. Approach ramps, however, should be relatively flat and meet the level of the cattle stop deck without an abrupt step. Ramps can be constructed out of timber or compacted trail material. The design should ensure that ponding does not occur at the bases of the ramps as this will lead to pot holes and undesirable path damage.

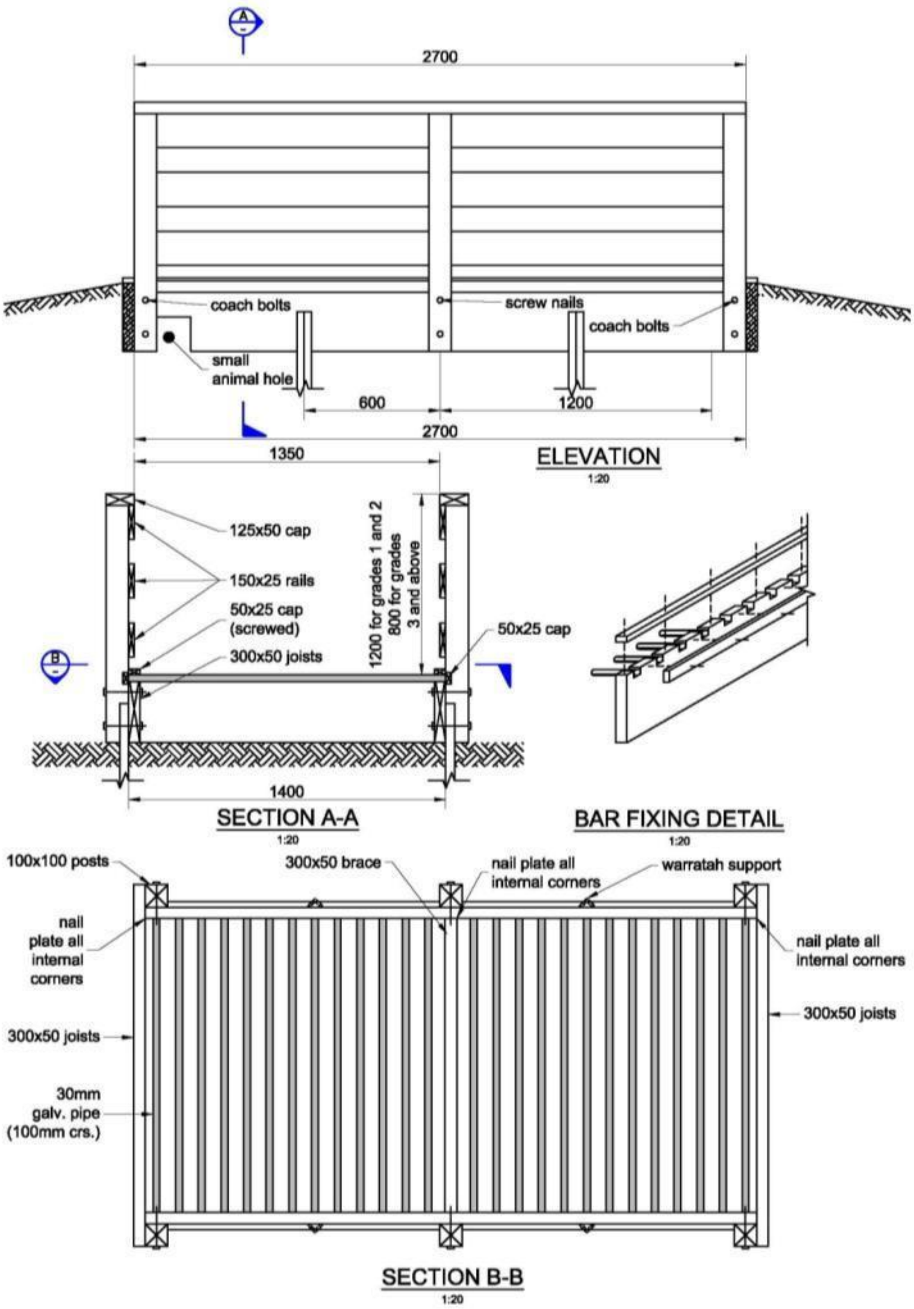


Figure 54: Cattle stop design – plan view (adapted from Christchurch City Council designs)

6.4.2 Positioning

The position of a cattle stop relative to the track is important. If a cattle stop is placed on a straight section of track it is possible for stock (sheep or cattle) to get agitated and achieve enough speed to jump over the cattle stop. Figure 55 shows an example of a cattle stop extending beyond a straight section of track. This is undesirable due to the risk of stock jumping the cattle stop and is compounded by the cattle stop being at ground level. Figure 56 shows a method taken to remove this risk after the cattle stop was installed – a gate placed at one end of the cattle stop. It is undesirable to use a gate in conjunction with a cattle stop as this requires cyclists to stop to open the gate.

This defeats the point of the cattle stop which is to allow cyclists to ride through a fence without having to stop. It also negates the need for a cattle stop as a gate alone would suffice to manage stock.

Figure 55: Cattle stop placed on straight alignment of track

Figure 56: Gate added – a poor solution for cyclists

It is better, therefore, to place a cattle stop on a bend in the track. This makes the path less obvious to stock and prevents them from achieving a high enough speed to jump over the stop. Obviously the bend should not be so severe that it forces cyclists to stop or causes any safety issues. Figure 58 shows a correctly aligned cattle stop (which could be improved by fixing the rut on the approach ramp) and Figure 58 shows the standard cattle stop used for the Otago Central Rail Trail (which is level with the path).

Figure 57: Cattle stop with good alignment, Port Hills (photo: Nick Singleton)

Figure 58: Best practice cattle stop, Otago Central Rail Trail (photo: DOC)

Cattle stops should not be placed in areas where stock gather (for example near the corner of a paddock) otherwise it is possible that an animal will be stampeded onto the cattle stop.

Figure 59 shows how motorcycle access can be discouraged from a trail. This solution will somewhat inconvenience cyclists and prevent access by wheelchair users and wider prams.

Figure 59: A central post and wing barriers help prevent motor-cycle access and reduce the likelihood of stock jumping the cattle stop (photo Jonathan Kennett)

6.4.3 Gates instead of Cattle Stops

Cattle stops are much more convenient than gates for cyclists, as they don't need to be opened or closed. In some situations, however, gates may be required or preferred by trail designers or landowners.

A variety of different gate options exist. "Kissing gates", such as the one shown in Figure 60, may be easier for cyclists to traverse than conventional gates. They can however be inconvenient for cyclists with pannier bags (as they require more room) or groups of cyclists (as it is difficult for more than one cyclist to make the transition at a time). Kissing gates should be designed with ample room within the enclosure to allow cyclists to pass through. They also can be an effective way to exclude motor bikes from cycle trails, if designed sufficiently tightly to just allow passage by a cycle, however such designs are likely to pose difficulty for riders of tandem cycles, bikes with trailers and tagalong bikes.

Figure 60: Kissing gate: Hawea Track; can be difficult for tandems and bikes with trailers

A double gate system, such as that shown in Figure 61, provides extra security to prevent stock from moving between paddocks but is less convenient for cyclists.

Figure 61: Double gate, Waikato River Trail

Springs can be attached to standard gates and kissing gates to make them "self-closing". This lessens the demand on cyclists to unlock the gate and lock it again after passing through and can be favoured by farmers worried about their stock getting through a gate accidentally left unlocked. Thus, for a variety of reasons, cattle stops are generally the preferred solution.

6.5 Tunnels and Underpasses

Tunnels and underpasses should comply with Section 3.6 and their gradients should match the requirements for the trail as specified in Section 3.1.5. The trail grade (which relates to target market) and length should be considered when determining the tunnel width. A longer tunnel feels more confined and is more likely to involve users passing each other than a shorter tunnel. The minimum recommended width of tunnels on trails of Grade 1 or 2 is 2.0 m but for trails of Grade 3 to Grade 5, tunnels are governed by the bridge widths given in Table 2.

Drainage is an important consideration for tunnels and underpasses, especially when they fall below the existing ground level. The water table level should be identified with respect to the planned underpass level; if the underpass is to be lower than the water table level water will need to be pumped out from the underpass. It is also important that surface water runoff is properly diverted so that it does not collect at the bottom of the underpass without any way of draining.

Lighting may be required if an underpass does not receive enough natural light for cyclists to adequately distinguish the path, other trail users or obstacles. It may be impractical to provide a powered lighting source in a remote location and thus cyclists should be informed prior to starting on the track that they will need bicycle or head lights. If path lighting is provided it should be vandal resistant and powered by a reliable source.

Figure 62: Tunnel on the Hauraki Rail Trail (photo: Jonathan Kennett)

6.6 Retaining Walls

Retaining walls may be required on paths cut into a sloped section to reinforce the path or prevent the adjacent wall from caving onto the path. Chapters 23 and 24 of DOC's Track Construction and Maintenance Guidelines (2008) provide information on stone and timber retaining wall construction and their construction.

6.7 Other Issues

6.7.1 Gradients and Crossfall

Structures should preferably be 0-3 degrees in gradient with a maximum of 5 degrees. Structures may have a gentle crossfall (up to 2 degrees) but may often be easier to construct without crossfall.

6.7.2 Visibility

The visibility requirements outlined in Section 3.8 also apply to structures. These requirements will have particular ramifications for underpasses, tunnels or bridges with high enclosed walls which may obscure views on crooked or curved path alignments. Safety and personal security are increased by being able to see all the way through an underpass or tunnel before entering. Thus there are benefits in having straight alignments for underpasses or tunnels.

6.7.3 Stairways

Stairways should not be used on the NZCT. Stairs require cyclists to dismount and carry their bikes (plus any luggage or panniers), increasing the difficulty and decreasing the enjoyment of the ride. Stairs can pose a hazard to cyclists travelling downhill in particular, especially if encountered unexpectedly. Some riders may be tempted to ride on stairs without understanding the risks and consequences involved; the first mountain biking related death in New Zealand occurred when a rider tried riding down steps.

6.7.4 Excluding Motorcycles

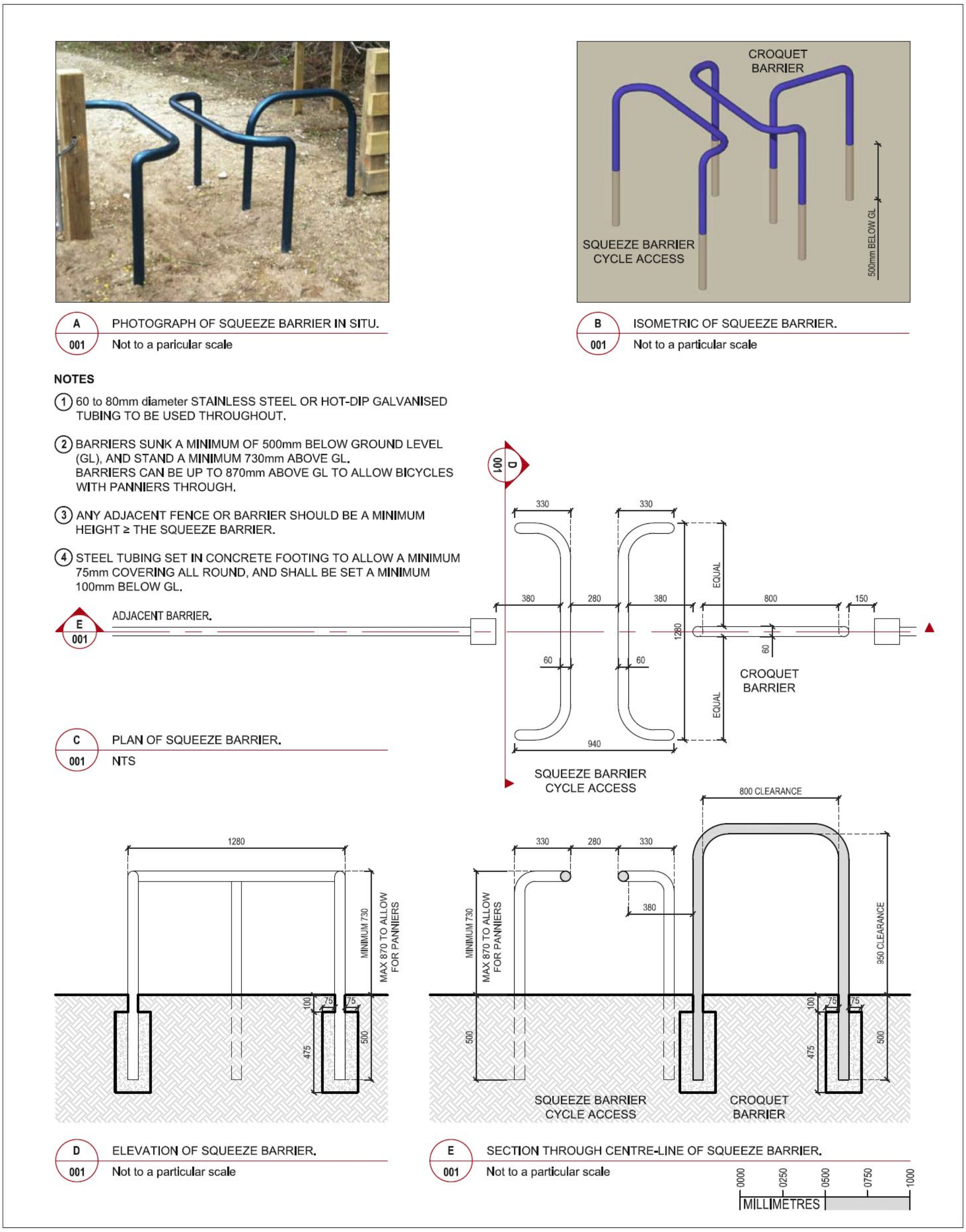
Motorcycles can be problematic on cycle trails. Various techniques exist to discourage this nuisance, including the positioning of central posts in trails and at gateways or cattlestops to discourage their use.

Another technique is illustrated in Figure 63, with the full design specifications given in Figure 64. Note that if this "squeeze barrier" arrangement is used on trails where many cyclists use panier bags, the horizontal bars should be installed at the maximum stated height of 870 mm.

Figure 63: "Squeeze barrier" to discourage motorcycles, Rimutaka Cycle Trail (photo: Jonathan Kennett)

Nga Haerenga THE NEW ZEALAND CYCLE TRAIL

VIASTRADA



JOB / DRG: 122 / 001	PROJECT NAME: MOTORISED VEHICLE BARRIERS FOR CYCLE TRAILS	DATE: 01 / 04 / 2012	DO NOT SCALE FROM DRAWINGS FOR CONSTRUCTION - USE WRITTEN DIMENSIONS ONLY
REVISION: D (16-05-2012), C (21-04-2012), B (10-04-2012), A (01-04-2012)	DRAWING NAME: SQUEEZE BARRIER AND CROQUET BARRIER	SCALE: NTS	THE CONTRACTOR / MANUFACTURER SHALL VERIFY ALL DIMENSIONS ON SITE PRIOR TO COMMENCING WORK
	CLIENT NAME: THE KENNETT BROTHERS	PROJECT STAGE: INFORMATION; DRAWN BY: HF	STUDIO FISHER emailstudiofisher@gmail.com 022 129 2602 studiofisher.weebly.com

Figure 64: Squeeze barrier and croquet barrier design

7 Signage

7.1 General Signage Principles

A comprehensive signage regime is required to make the NZCT successful.

A sign's size and level of information should be designed in accordance with the level of information that can be taken in by its viewer, given their travel speed and viewing distance. Providing too much information may serve as a distraction and therefore a hazard to the intended audience as well as surrounding road or path users. Conversely, it is sometimes necessary to convey a large amount of information to ensure route users are properly prepared for their journey; in which case signs should be placed in a location where viewers can stop and read them without inconveniencing other users.

Thus there are a variety of sign types that are used on NZCT routes for a number of different purposes. Guidelines for signage and the use of the New Zealand Cycle Trail brand will be issued when they are available.

7.2 Signs for Cyclists

7.2.1 Route commencement signs

These are used at the start of a route to describe the route's location, distance, expected time for completion and level of difficulty or experience required. Generally a large sign including a map and qualifying text is used. Connections with other nearby routes should be identified. The sign may also include additional information on the features or attractions encountered along the route, facilities provided and opportunities available at its end.

Figure 65: Route commencement signs within shelter, Great Lake Trail (photo: Jonathan Kennett)

7.2.2 Wayfinding signs

These can be used away from a trail to direct users to the start of a trail or used partway along a trail where there are several different route options available. Figure 66 shows an urban wayfinding map example from Nelson that also incorporates information on the development of the walking and cycling networks and the history of cycling in the area.

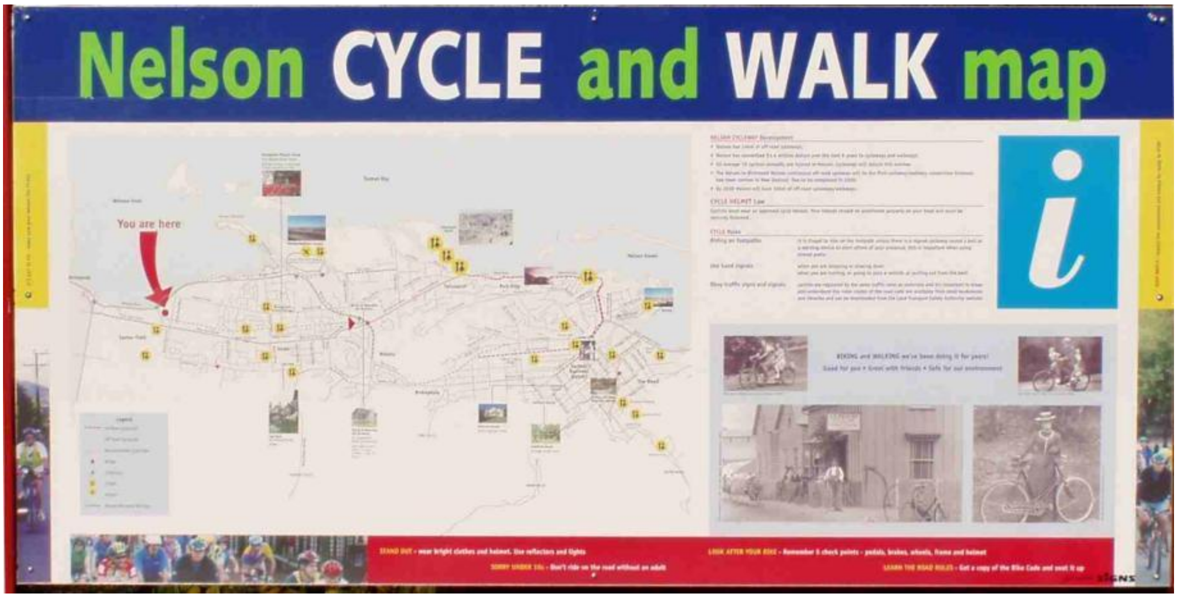


Figure 66: Nelson cycle and walk map

7.2.3 Information signs

These are used along a route to describe various features, such as iconic scenery, historical attractions, wildlife or other points of interest unique to the route. Generally these signs will be situated in places where visitors can stop and take time to view them. There is an important balance between providing interesting information and providing too much information that takes too long to read. Pictures and diagrams are a useful way of making educational signs more interesting and grabbing the attention of route users.

Figure 67: Information sign, Waikato River Trail

Figure 68: Information sign in shelter, Otago Central Rail Trail (photo: DOC)

Figure 69: Information sign, The Timber Trail (photo Jonathan Kennett)

Information signs can also be used to teach cycling techniques. This is particularly relevant to mountain biking tracks which tend to have various features that require technical expertise to ride effectively. Special tracks can be created that involve several mountain biking features and have an information sign at the start of each one explaining to cyclists how to best negotiate the feature.

7.2.4 Directional signs

These are used along a route to specify the route alignment when faced with a variety of options at an intersection or to confirm to cyclists that they are still on the route.

As well as specifying the route name, directional signs may direct cyclists to a particular location. Once a location has been indicated on a sign, all subsequent signs should include it until the location has been reached. Major locations such as towns, cities or important iconic features should be signposted for a greater distance than less important locations.

It is useful to include travel distances to the signposted locations. This gives cyclists an idea of how long they will have to travel to reach the destination and makes it easier to plan the journey. Cyclists can feel like they are "out in the middle of nowhere" and knowing how far it is until the next stop gives them peace of mind and improves their experience. Often it is the last hour that "makes or breaks" a cyclist's impression of the entire journey; route information can go a long way in making this impression a favourable one.

Directional signs should be installed prior to a trail's opening so that users do not get lost.

It may be useful to also specify on a directional sign the amount of time expected for cyclists to take; however designers should be aware that cyclists' travel speeds vary greatly according to their ability and the demands of the route. For longer trips, cyclists will also stop for breaks which increase the total travel time.

Generally it is best to predict travel times for a novice or less energetic cyclist, unless the route is specifically aimed at cyclists of higher abilities. The timing measures should be consistent throughout a trail so that individual users can gauge whether they are generally faster or slower than the stated times. A travel speed of 10 km/h is generally appropriate for slower cyclists travelling on a relatively flat route, but additional time is needed if cyclists are likely to take breaks or look at scenery, for example. However, it may be best to wait until the route has been established and monitor the journey times of route users to determine what values should be added to the directional signs.

Users should generally not have to stop to view a directional sign, consider the information it gives and make any necessary resulting decisions or actions. Therefore the information presented should be kept as simple as possible, with lettering legible from an appropriate distance.

Figure 70 shows a simple NZCT route marker that can be used along a route to confirm to users that they are still on the route. Where multiple routes exist in an area the marker should specify which route it belongs to; this can take the form of a route name, logo or specific colour. Figure 71 indicates the trail direction on the Waikato River Trail. Figure 72 is a good example of a directional sign that provides route length information.

Figure 71: Directional sign, Wilderness Trail

Figure 70: NZCT route marker

Figure 72: Directional sign, Nelson Rail Reserve

7.2.5 Regulatory signs

Regulatory signs are used to convey the rules of the road or path on which the route is located. They include “Stop”, “Give Way” and speed limit signs which apply to both cyclists and motorists. There are also regulatory signs that apply only to cyclists such as “no cycling” (RG-24 – shown in Figure 73) “all cyclists must exit” (RG-26b – shown in Figure 74) and path signs which apply to pedestrians also and specify whether the path is shared, segregated or separate. These signs are detailed in MOTSAM (Transit NZ, 2008b).

Figure 73: No cycling regulatory sign (RG-24) (Transit NZ, 2008b)

Figure 74: All cyclists must exit regulatory sign (RG-26b) (Transit NZ, 2008b)

Figure 75 shows a regulatory sign used at the Arapuni swing bridge on the Waikato River Trail. This sign also includes an informational aspect – historical facts about the swing bridge's construction.

Figure 75: Regulatory sign, Waikato River Trail

7.2.6 Advisory signs

Advisory signs emphasise aspects that are not regulated but are suggested for safety or courtesy reasons. They include warning signs at dangerous locations (e.g. road crossings) and behavioural signs (e.g. keep left, warn when approaching). Figure 76 gives two examples of advisory signs on the Nelson Rail Reserve path – one to advise of the low underpass (note that NZCT underpasses should have an overhead clearance of 2.4 m, as discussed in Section 3.6) and the other to warn that the path may be submerged due to tidal flows.

Figure 76: Advisory signs, Nelson Rail Reserve

Land owners may also require signs voiding them of responsibility in case of accident, warning of the presence of stock or advising that water is unsafe for drinking.

7.3 Signs for Motorists

NZCT signs for motorists are largely regulatory or advisory. There are also some signs directing those accessing routes by vehicle to the start of the route; these should be designed according to MOTSAM (Transit NZ, 2008) in particular section 7 on guide signs.

The most common sign for motorists regarding cycle trails is the PW-35 cyclist permanent warning sign (Transit NZ, 2008b) as illustrated in Figure 77. This is used at on-road locations where cyclists may be present but do not have dedicated cycle lanes or other provisions. It can also be used to draw motorists' attention to an NZCT trail road crossing location. It can also be used in the form of an active warning sign which is illuminated when cyclists are present, as shown in Section 3.4.

Figure 77: PW-35 permanent warning sign for motorists

Some regulatory signs are also directed primarily at motorists. These include the "cycle lane" (RG-26 – shown in Figure 78) and "cycles only" (RG-26a – shown in Figure 79) signs used for on-road applications.

Figure 78: Cycle lane regulatory sign (RG-26) (Transit NZ, 2008b)

Figure 79: Cycles only regulatory sign (RG-26a) (Transit NZ, 2008b)

7.4 Maps and Supplementary Information

Maps and supplementary information leaflets can be provided to assist cyclists in planning their journey and for reference along the route. This gives cyclists additional confidence as they can carry maps with them, rather than having to wait to encounter a directional or information sign. Maps should be accurate and consistent with the signage used. Ideally they will be specific to the NZCT.

All publicity for a particular NZCT route should be consistent and accurately convey the level of experience and fitness required to ride the route, as described in the grades referred to in Section 3.1.5. It is important to provide an indication of how long to allow for each leg of the journey. Service providers may be tempted to encourage anyone and everyone to ride the route but this may not always be appropriate. If a cyclist has a bad experience due to their fitness and competence levels not matching the demands of the trail it will decrease the likelihood of them or those they talk to of returning to an NZCT route and may tarnish the NZCT "brand". It may be useful to provide an example of a fitness test or training programme so that potential users can gauge a route's suitability, plan the legs of their journey appropriately or prepare physically for the ride.

Maps can include information regarding the attractions at towns and cities along the routes. Local businesses may sponsor their production as an advertising opportunity. Any information necessary for the journey should be provided freely to all cyclists using the route. Brochures involving supplementary, non-critical information may be charged for.

The guidelines for signage and the use of the New Zealand Cycle Trail brand (due for issue in 2010) will include further guidance on maps and supplementary information.

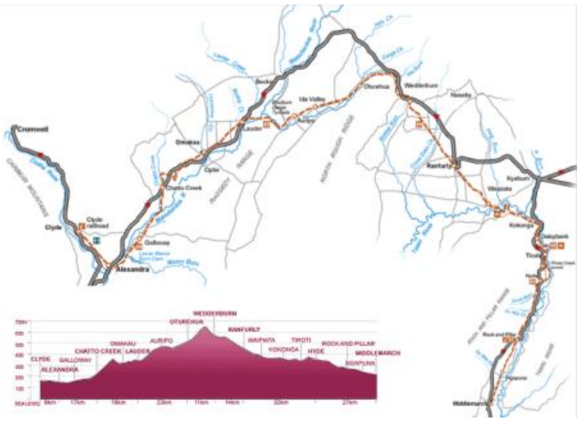


Figure 80: Otago Central Rail Trail map (courtesy of OCRT Trust)

Figure 81: OCRT interactive online map (courtesy of OCRT Trust)

Maps are also a useful tool for pre-planning and understanding journeys. Electronic media provide a useful interface to include additional information, for example the Otago Central Rail Trail interactive online map (Figure 81) which has links to information on each of the towns and attractions encountered along the trail. Trail descriptions developed on the hosts' websites can be referenced from the Ministry of Economic Development and other websites.

8 Supporting Facilities

8.1 Water Supplies

Cyclists need sufficient opportunities to replenish their water supplies while riding. A shortage of water can have extreme effects on a trail user's enjoyment of the journey and opinion of the NZCT experience.

At least one intermediate water station should be provided during a day's travel (see Table 2 for travel distances) and clear information should be given at the start of each leg regarding water supply. Taps or drinking fountains should be provided where there is no access en route to potable water. Drinking fountains should include water bottle fill stations as it can be difficult to fill bottles from standard water fountains.

8.2 Rest Areas

Providing rest areas along a route allows cyclists to stop, rest and enjoy the route's iconic scenery. In some locations, especially on remote routes, rest areas may allow for camping and thus facilities for cooking and toiletries may be considered.

Toilet opportunities should be provided according to Table 17; this is based on experience from the Otago Central Rail Trail and other similar trails. Designers should err on the side of over-provision rather than the opposite.

Table 17: Toilet provision

Grade	Distance between toilet facilities
1-2	7.5 – 10 km
3-6	15 – 20 km

It can also be useful to provide opportunities for shelter, from heat, rain or wind, along a route. The Otago Central Rail Trail uses old "gangers' sheds" or railway stations which provide shelter in an authentic and aesthetically pleasing way.

Figure 82: Shelter on Otago Central Rail Trail (photo: DOC)

Clearings and sheltered places for refreshment and lunch breaks are appreciated too. These could include picnic tables and toilets, as for roadside picnic areas. Opportunities for shade under existing or newly-planted trees are also valuable and contribute to users' overall impressions of the trail. Trail users may wish to meet up with non-cycling companions (who may be walking part of the trail or simply visiting the region) and therefore value rest areas near road access.

Figure 83: Volunteer built hut on the Old Ghost Road (photo: Jonathan Kennett)

8.3 Lighting

The rural, remote nature of most NZCT routes makes it difficult and cost-prohibitive to provide lighting along their lengths. In most cases visitors ride in daylight hours only.

However, it is advisable to provide lighting in locations where routes link to towns or cities if paths have low natural surveillance and little lighting gained from nearby sources (e.g. road lighting). Lighting will generally be impractical in tunnels (for example, refer to Figure 84), but opportunities for techniques for improving visibility in tunnels are provided in Section 6.5.

Figure 84: Cyclists with headlamps in tunnel on Otago Central Rail Trail

8.4 Rubbish Collection

It is up to trail operators to determine whether they want to provide and service rubbish bins along the trail or whether they will require users to carry all rubbish out with them. The first option may be more expensive but could possibly decrease the chance of litter along the trail. Either way, appropriate signage and forewarning will be required to properly communicate to users their responsibilities with regards to rubbish disposal.

8.5 Car-Parking Facilities and Transport Links

It is helpful for trails to start and finish near towns so that cyclists have access to accommodation, shops and service facilities. Many cyclists will drive to the trails and require somewhere to park their cars, preferably in a location with natural surveillance from nearby shops or houses. Other cyclists will rely on shuttle or bus services to drop them off and thus car parking areas should include locations for buses to park and manoeuvre.

In addition, some trail users will arrive or leave by cycle and so roads accessing trails should be safe for cycling.

It can also be advantageous to provide links with other transport modes. For example, it is popular among users of the Otago Central Rail Trail to journey on the train that runs between the Middlemarch end of the trail and Dunedin.

8.6 Off-Site Facilities

Cyclists travelling on NZCT routes and staying overnight along the way expect various services and provisions at their stops. Most of these requirements are satisfied by private business operators, but it can be useful for route designers to explain the various needs of cyclists to local businesses and accommodation providers to ensure that trail users are catered for from the route's launch.

Cyclists expect that their bicycles will be safely and securely stored during their stay when they are not riding. At smaller locations a simple bike stand will be sufficient to achieve this. In larger towns or cities, covered, secure parking will be preferred.

Cyclists also often need to purchase supplies and services for their trip, for example food, drink and bicycle maintenance and accessories.

9 Path and Road Maintenance

9.1 Introduction

The maintenance requirements for NZCT routes are highly site-specific and depend on a number of factors including the type of surface used, geographical features, weather conditions (especially rainfall), conditions of motor vehicle access and user volumes. Therefore this chapter aims to identify maintenance considerations but does not specify associated frequencies or costs for these items.

Regular maintenance makes trails more sustainable. A proactive approach in recognising and diagnosing problems and preventing them from recurring, rather than repeatedly reacting to problems, saves time and money over the life of a trail. Chapters 25 to 34 of DOC's Track Construction and Maintenance Guidelines (2008) should be referenced for maintenance issues, including:

- The principles of sustainable maintenance;
- Vegetation maintenance;
- Drainage system maintenance;
- Track surface maintenance; and
- Switchback maintenance.

Experience from existing off-road trails, such as the Otago Central Rail Trail and the Little River Rail Trail, testify that the quality of initial construction is a major factor in the amount of ongoing maintenance required. The lowest bidder for new trail construction will not necessarily provide the same quality of workmanship as other contractors; this can be avoided by constructing initial trial sections to determine these specifications and using the experience from these to develop detailed construction specifications. Experienced trail builders (at the grade and quality sought) will also generally be more cost-effective in the long run.

9.2 Maintaining Natural and Compacted Surfaces

Without maintenance, off-road trails built on natural surfaces will, over a year or two, deteriorate into a harder grade (e.g. change from Grade 3 to Grade 4). This is mainly due to the forces of compaction and displacement. Compaction is where the centre of the track is worn more frequently than the sides and thus sinks. Displacement is where material from the centre of the track is moved out to the sides. Both of these processes are due to people riding and walking along the centre of the track and both result in the development of a "dish" profile where the centre of the track is lower than the sides.

The problems of compaction and displacement can all be reduced, but not eliminated, through good trail design and construction (e.g. building a trail with a crowned profile, adding gradient reversals, ensuring good drainage and plate compacting the surface, etc).

Displacement also exposes rocks and roots at the surface. These apparently growing rocks and roots need to be dug out or covered with compacted basecourse. In the case of roots, it is generally better to cover them as they actually do a very good job of providing a type of "armouring" that stops ruts from forming. Also, some trees can die after having roots removed.

Water is the foremost destroyer of natural and compacted surfaces; it magnifies the problems of compaction and displacement by moving loosened material and wearing away at weak areas. Thus the level of drainage provided and its interaction with the path's geometry will have a big effect on the amount of material displacement and therefore the amount of maintenance required.

Trails in locations with high rainfall will generally require more maintenance than trails in low rainfall areas. The best time to inspect tracks for drainage issues is during rain. At this time it is apparent where the water is coming from and it can be directed off the track at strategic locations.

Motor vehicle access has a major influence on path stability. While none of the NZCT paths have public vehicle access some motor vehicles do still travel over them. These can be service vehicles related to path maintenance or adjacent facilities (e.g. railway trucks or farm vehicles on private farm roads). Vehicle access to paths should be minimised and restricted to smaller vehicles wherever possible. Heavy vehicles damage pavements much more than light vehicles.

On a natural surface trail, the ruts and berms that develop will need to be removed. A good way of doing this is to completely fill the central riding rut with a suitable basecourse. The rut should be overfilled by up to 100 mm and then compacted using a plate compactor.

If it is not practical to have basecourse delivered to site, then it may be possible to quarry some from beside the track in places. If on-site quarrying is not practical then the berms (high sides) of the track should be dug out to below the level of the centre of the track. It may be tempting to use the removed material to fill the centre rut, but this will not last long, as the material from the sides is lacking in strength.

9.3 Maintaining Hard Surfaces

Hard surfaces such as asphaltic concrete are more durable than natural or compacted surfaces and thus require less maintenance. However, underlying vegetation and tree roots can grow and damage asphaltic concrete surfaces and measures to prevent such occurrences should be taken during construction. Figure 85 shows a newly constructed asphaltic concrete path that was not properly prepared and now (within weeks of construction) has vegetation growing through its surface. Hard surfaces will also require regular sweeping of detritus that may come from the sides of the path, nearby roads or intersecting gravel driveways.

Figure 85: Vegetation growing through new asphaltic concrete path; good construction specifications and contract supervision are required

Sealed paths may have painted markings that will require remarking.

While on-road trails should be maintained according to existing road maintenance contracts, the specific maintenance requirements of new cycle trails may need to be written into maintenance contracts. Road debris often accumulates in cycle lanes or wide shoulders as it is pushed off the carriageway by passing motor vehicles; this can decrease the riding comfort to cyclists and increase the likelihood of punctures. Regular sweeping of on-road trials is required and it is imperative that contractors do not sweep debris into the space dedicated for cyclists.

Road re-seals should include consideration of on-road cycling trails, in particular that a smooth riding surface is maintained. Where active warning signs are used, inductive loop sensors may need to be replaced during a reseal and the equipment recalibrated afterwards to ensure it still works correctly.

9.4 Common Maintenance Requirements for All Trail Types

Trails need to be well maintained if they are to keep bringing people back and to encourage users to recommend the trails to others.

All trails will require upkeep of adjacent verges or vegetation. At least twice a year (during spring and autumn) vegetation growing into the riding corridor may need removing. Invasive weeds such as tradescantia, gorse, barberry and African clubmoss will need to be sprayed twice a year, to stop them from growing into the riding line, and spreading down the track.

After storms, trails should be inspected for fallen trees and branches and culverts and table drains may need clearing. The sooner this is done the better as a blocked culvert or table drain can send water onto the track, and in some cases a blocked culvert can result in major soil saturation and a land slip.

Signage will also need replacing, either due to vandalism, exposure to the elements or to include new information.

Wherever an off-road trail crosses a road and a bollard or similar threshold treatment is used it should be expected that motor vehicle damage to this treatment will occur periodically. At-grade road crossing facilities are particularly exposed to motor vehicle damage and are likely to require higher frequencies of maintenance than grade separated facilities.

10 Monitoring and Evaluation

10.1 Importance of Data Collection

The NZCT is targeted at cycle tourists (both domestic and international). It is expected that these cyclists will stay in local towns and cities and spend money on various goods, services and additional tourist attractions. This will stimulate the local economy and warrant the initial investment in developing the route and can be especially beneficial in small towns. Thus the viability of a cycle route depends on the number of cyclists using it.

Monitoring a cycle route by collecting data accurate about the cyclists using it is essentially an exercise in understanding the route better. Understanding how a route functions allows operators to manage and improve it.

Obviously a route cannot be monitored before it is built and thus the business case for establishing an NZCT route should be based on predictions of cycle volumes. By monitoring the actual numbers of cyclists who then go on to use the route, the prediction methods can be refined. Thus monitoring is important to inform those developing other trails and to the government for future funding decisions.

The data collected on a particular route will also be of great use to the route owner itself. Data can show seasonal trends and thus be used in preparing local accommodation, services and goods providers so that the level of demand is appropriately supplied each season. Maintenance requirements can be better understood by comparing the amount of wear on a trail with the amount of use it has been subjected to. This in turn can help in choosing the appropriate surfacing treatments and major maintenance opportunities.

10.2 Monitoring and Data Collection Methods

As displayed in Table 18, there are three methods that may be used to collect NZCT data:

1. Automatic counters
2. Manual counters
3. Surveys

Automatic counters are machines that, once installed and correctly set up, can count cyclists without requiring human assistance. This is advantageous as automatic counters can provide continuous data over long periods. However, they are effectively a “blind” technology that can count numbers of cyclists and possibly give information on speed and direction but cannot give additional information on cyclist gender, age or cycle type, for example.

There are a number of different technologies available for automatic counting. Pneumatic or rubber tube counters are currently the most common automatic device used in NZ for counting cycle traffic. To record cyclist direction and speed, two tubes located a short distance apart are used. The tubes are laid on the path or road surface and detect changes in air pressure when compacted. Pneumatic tubes are exposed and therefore vulnerable to general wear and tear or vandalism. Accordingly, they are generally not used for more than a couple of weeks for on-road situations but maybe suitable for longer off-road counts, although vandalism is still a potential issue. The counters are easily portable to different locations.

Figure 86: Pneumatic tubes installed on off-road trail bridge

Inductive loop detectors involve wires laid under the path or road surface that experience electro-magnetic induction when metal objects (including most bicycles) pass over them. This technology is becoming more common in NZ and has the advantage of being protected from vandalism. Inductive loop counters can provide long-term, continuous data. They do not detect pedestrians. Many road controlling authorities (especially NZTA) currently operate inductive loops for counting motor vehicles and the housing units employed may be able to also accommodate cycle counting equipment.

Pressure counters are also used in some parts of NZ, generally for detecting pedestrians although some applications for detecting cyclists on off-road trails also exist. Pressure counters rely on peizo-electric pads or strips buried beneath the path or road surface that detect changes in pressure when a cyclist rides over them. There is currently no pressure detection system that can be used to distinguish between cyclists and pedestrians.

Infra-red or pyro-electric detectors will detect both cyclists and pedestrians but cannot distinguish between the two groups. Some radio-beam products, however, claim to be able to do this accurately. The technology for counting pedestrians and cyclists is evolving rapidly, however.

Manual counters are people who record volumes of cyclists passing a site. Manual counts offer more flexibility in terms of data coverage as people can record supplementary information such as cyclist gender, age, cycle type, trip type, helmet usage and make notes on unusual behaviour.

Figure 87: Manual cycle counting

The disadvantage of manual counting is that it is difficult to sustain for long periods. A single person counting will require regular breaks (say every two hours) for food and toilet stops and should only be expected to work a standard shift per day. To conduct a week-long, continuous manual count, several staff working in shifts would be required – a prohibitively expensive process.

Surveys can be conducted on the spot, by using manual counters stationed on the route interviewing users as they pass by or local business people interviewing those who come into their shop or accommodation. Surveys can also be conducted after cyclists have completed their route by asking them to fill out a form and mail it back or to complete an online form.

Surveys can be used to interview cyclists and extract information on their home town and country, length of stay, trip origins and destinations, demographic data (such as age, employment status and income), expenditure and their impressions of the trail(s) travelled. Surveys can also be targeted at local business owners to determine the effect of the route on their business operations.

10.3 Types of Data

Cycle route monitoring can be informed by a number of different data types which have different uses and are collected or monitored in a variety of ways. Table 18 outlines the main data types that are collected on the NZCT.

Table 18: Data types and monitoring or collection methods related to cycle trails

Data Type	Purpose / Use	Monitoring / Collection Method
Volumes (including aggregation by time of day, day of week, season, year etc)	Inform operators, investors and designers of the effects of installing a cycle trail Aid in planning and maintenance Further understanding of daily, weekly and seasonal trends	Manual counter (for short periods, say 2 hours at a time) Automatic counter (for longer or even continuous periods)
Cyclist characteristics • Age • Gender • Ability level • Journey type / length	Understand the demographic of users Aid marketing campaigns	Manual counter User survey
Satisfaction ratings	Identify positive and negative aspects to further improve the trail and design better trails in future	User survey
Expenditure (on accommodation, supporting goods and services etc)	Understand the economic impacts of cycle trails Assist forward planning for goods and service provision	User survey Local business survey

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Appendix 1 – Gradient Summary Tables

Gradient summary for off-road trails (from Table 3, Section 3.3)

Trail Grade	Main uphill gradient range	Steeper slopes up to 100 m long	Steeper slopes up to 10 m long	Maximum Downhill Gradient (up to 100 m long)
1	0 – 2 degrees for 98% of length	2 – 3 degrees	3 – 4 degrees	4 degrees
2	0 – 3.5 degrees for 95% of length	3.5 – 5 degrees	5 – 6 degrees	6 degrees
3	0 – 5 degrees for 90% of length	5 – 7 degrees	7 – 8 degrees	8 degrees
4	0 – 6.5 degrees for 90% of length	6.5 – 8 degrees	8 – 10 degrees	10 degrees
5	0 – 8 degrees for 90% of length	8 – 10 degrees	10 – 14 degrees	14 degrees
6	0 – 10 degrees for 90% of length	10 – 15 degrees	15 – 30 degrees	

Notes:

1. This table applies to off-road unsealed trails and gravel roads.
2. Maximum downhill gradient applicable only if trail is to be ridden in one direction.
3. IMBA recommends a maximum gradient of 10% (5.7 degrees). Steeper trails will require more maintenance due to increased erosion from skidding tyres and water scour.

Gradient summary for on-road trails (from Table 11, Section 4)

Trail Grade	Main uphill gradient range	Steeper slopes up to 100 m long	Steeper slopes up to 10 m long	Maximum Downhill Gradient (up to 100 m long)
1	0 – 2.5 degrees for 98% of length	2.5 – 3.5 degrees	3.5 – 4.5 degrees	4.5 degrees
2	0 – 4 degrees for 95% of length	4 – 5 degrees	5 – 7 degrees	7 degrees
3	0 – 6 degrees for 90% of length	6 – 8 degrees	8 – 10 degrees	10 degrees
4	0 – 8 degrees for 90% of length	8 – 10 degrees	10 – 13 degrees	13 degrees
5	0 – 10 degrees for 90% of length	10 – 15 degrees	15 – 18 degrees	18 degrees

Notes:

1. This table applies to on-road sealed trails and off-road sealed (concrete or asphalt) trails.
2. Maximum downhill gradient applicable only if trail is to be ridden in one direction.