SECTION V:

Design

No national standards or guidelines dictate rail-with-trail facility design. Guidance must be pieced together from standards related to shared use paths, pedestrian facilities, railroad facilities, and/or roadway crossings of railroad rights-of-way. Trail designers should work closely with railroad operations and maintenance staff to achieve a suitable RWT design. Whenever possible, trail development should reflect standards set by adjacent railroads for crossings and other design elements. Ultimately, RWTs must be designed to meet both the operational needs of railroads and the safety of trail users. The challenge is to find ways of accommodating both types of uses without compromising safety or function.

The recommendations in this section are based on:

- Extensive research into all existing RWTs.
- In-depth case studies of 21 existing and planned RWTs.
- Interviews with railroad officials, trail managers, and law enforcement officials.
- Review of existing train and trail safety literature.
- Analysis of publicly-accessible trespassing and crash data.
- Input from a panel of railroad officials and experts, trail developers and managers, trail users, lawyers, railroad operators, and others.
- Extrapolation from relevant State transportation manuals, the American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities* (1999) (hereafter referred to as the AASHTO Bike Guide), Americans with Disabilities Act (ADA) publications for trails and pedestrian facilities, the *Manual on Uniform Traffic Control Devices* (MUTCD, 2000), and numerous Federal Railroad Administration (FRA) and other Federal Highway Administration (FHWA) documents.
- The experience and expertise of researchers and reviewers, including experienced railroad and trail design engineers, landscape architects, safety specialists, trail developers and managers, trail users, lawyers, railroad operators, operations officials, and others involved in this study.

The design recommendations should be considered a toolkit, rather than standards or guidelines. More research will be needed to develop standards that can be incorporated into AASHTO's design guides and the MUTCD. Each RWT project is different; the design should be based on the specific conditions of the site, requirements of the railroad owner, completion of a feasibility study (as discussed in *Section III*), State and other regulatory requirements, and engineering judgment.

Overview of Recommendations

1. RWT designers should maximize the setback between any RWT and active railroad track. The setback distance between a track centerline and the closest edge of the RWT should correlate to the type, speed, and frequency of train operations, as well as the topographic conditions and separation techniques.
2. Subject to railroad and State and Federal guidelines and the advice of engineering and safety experts, exceptions to the recommended setbacks may include:
    a. Constrained areas (bridges, cut and fill areas)
    b. Low speed and low frequency train operations

   In these cases and in areas with a history of extensive trespassing, fencing or other separation technique is recommended.
3. When on railroad property, RWT planners should adhere to the request or requirements for fencing by the railroad company. Fencing and/or other separation techniques should be a part of all RWT projects.
4. Trail planners should minimize the number of at-grade crossings, examine all reasonable alternatives to new at-grade track crossings, and seek to close existing at-grade crossings as part of the project.
5. RWT proposals should include a full review and incorporation of relevant utility requirements for existing and potential utilities in the railroad corridor.
6. The feasibility process should clearly document the cost and environmental impact of new bridges and trestles.
7. Trails should divert around railroad tunnels; if they need to go through a single-track railroad tunnel, they likely are not feasible.
8. Where an RWT is proposed to bypass a railroad yard (such as in Seattle, Washington), adequate security fencing must be provided along with regular patrols by the RWT manager. High priority security areas may need additional protection.
9. An environmental assessment should be conducted concurrent with, and usually independent from, the feasibility analysis, and should include project alternatives located off the railroad corridor, if at all possible.

Elliot Bay Trail. *Seattle, WA*

Rail Characteristics and Setting

Over half of the 65 existing trails run along Class I mainline or other freight railroad lines, with the remainder split between short lines and public transit (see **Figure 5.1**). Most of the RWTs are either adjacent to railroad property or on publicly-held land that is used or leased by freight or passenger railroad companies. At least 11 known RWTs (approximately 17 percent) are on privately held Class I railroad properties, and others are on privately-held Class II, shortline, or excursion lines (see **Table 5.1**). There is considerable

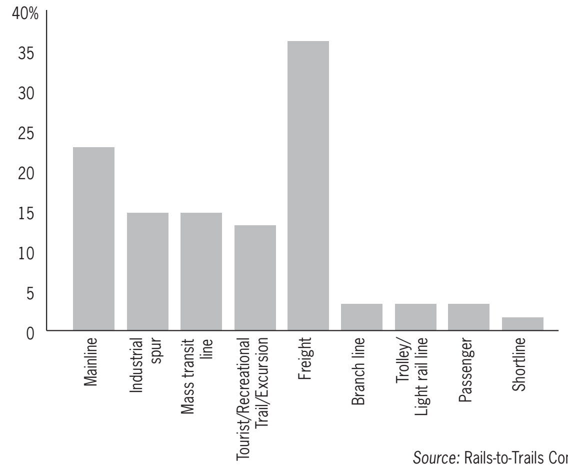
TABLE 5.1 Examples of Active RWTs by Corridor Type and Ownership

Trail Name	Corridor Owner	Railroad Operation	Location
Class I Railroads			
Arboretum Trail*	Norfolk Southern	Unknown	Pennsylvania
Cedar Lake Trail	Burlington Northern Santa Fe	Burlington Northern	Minnesota
Celina/Coldwater Bike Trail*	Norfolk Southern	RJ Corman	Ohio
Columbus Riverwalk*	Norfolk Southern	Railtex/GATX/Georgia Southwestern Railroad Company	Georgia
Eastbank Esplanade/Steel Bridge Riverwalk	Union Pacific	Union Pacific, Amtrak	Oregon
Elk River Trail*	Norfolk Southern	Norfolk Southern	West Virginia
Gallup Park Trail*	Norfolk Southern	Norfolk Southern	Michigan
Huffman Prairie Overlook Trail	CSX	CSX and Grand Trunk Western	Ohio
Schuylkill River Trail*	Norfolk Southern (3.2 km/2 mi)	Norfolk Southern	Pennsylvania
Stavich Bicycle Trail	CSX	CSX	Ohio and Pennsylvania
Union Pacific Trail	Union Pacific	Union Pacific	Colorado
Zanesville Riverfront Bikepath*	Norfolk Southern	CSX and Norfolk Southern	Ohio
Privately- owned, Class II or Other Freight			
Blackstone River Bikeway	Providence and Worcester Railroad	Providence and Worcester Railroad	Rhode Island
Central Ashland Bike Path	Rail TEX	Rail TEX	Oregon
Clarion-Little Toby Creek Trail	Buffalo to Pittsburgh Railroad	Buffalo to Pittsburgh Railroad	Pennsylvania
Heritage Trail	Illinois Central	Illinois Central	Iowa
Lehigh Gorge River Trail	Reading and Northern Railroad Company	Reading and Northern Railroad Company	Pennsylvania
Lower Yakima Valley Pathway	Washington Central	Washington Central	Washington
MRK Trail	Chicago & Northwestern	Chicago & Northwestern	Illinois
Railroad Trail	Lake State Railroad	Lake State RR	Michigan
Rock River Recreation Path	Chicago & Northwestern	CNW, Union Pacific and Soo Line	Illinois
Silver Creek Bike Trail	Dakota, Minnesota and Eastern	Dakota, Minnesota and Eastern	Minnesota
Tony Knowles Coastal Bicycle Trail	Alaska Railroad Corporation	Alaska Railroad Corporation	Alaska
Whistle Stop Park	Cimarron Valley Railroad	Cimarron Valley Railroad	Kansas
Excursion/Short-Line, Publicly or Privately Owned Land			
Animas River Greenway Trail	Durango & Silverton Narrow Gauge Railroad	Durango & Silverton Narrow Gauge Railroad	Colorado
Cottonbelt Trail	Dallas Area Rapid Transit	Fort Worth and Western Railroad	Texas
Eastern Promenade Trail	Maine Department of Transportation	Maine Narrow Gauge	Maine
Heritage Rail Trail County Park	York County	Northern Central Railway Inc.	Pennsylvania
Lowell Canal Trail	National Park Service	National Park Service	Massachusetts
Santa Fe Rail Trail	Santa Fe Southern	Santa Fe Southern	New Mexico

**Properties acquired by Norfolk Southern from Conrail.*

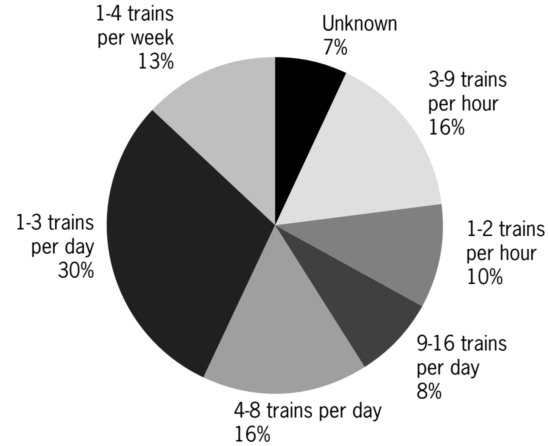
TABLE 5.1 Examples of Active RWTs by Corridor Type and Ownership (continued)

Trail Name	Corridor Owner	Railroad Operation	Location
Publicly Owned Railroad Corridors, Passenger or Freight			
Atchison, Topeka and Santa Fe Trail	Orange County Transportation Authority	Amtrak, Southern California Regional Rail	California
Bugline Trail	Waukesha County	Union Pacific	Wisconsin
Burlington Waterfront Bikeway	Vermont Agency of Transportation	Vermont Railway Company	Vermont
Cascade Trail (SR 20)	City of Burlington/Skagit County	Burlington Northern Santa Fe Railway	Washington
Duwamish Trail	City and Port of Seattle	Burlington Northern Santa Fe Railway	Washington
Eastern Promenade Trail	Maine Department of Transportation	Maine Narrow Gauge	Mane
Eliza Furnace Trail	City of Pittsburgh	CSX	Pennsylvania
Folsom Parkway Rail-Trail	Regional Transit Authority	Regional Transit Authority	California
Great Lakes Spine Trail	Iowa Dept. of Natural Resources, Dickinson County, Cities	Chicago Northwestern Transportation Company	Iowa
Heritage Rail Trail County Park	York County	Northern Central Railway Inc.	Pennsylvania
La Crosse River State Trail	State of Wisconsin	Canadian Pacific Railway, Amtrak	Wisconsin
Levee Walking Trail	City of Helena	Arkansas Midland	Montana
Myrtle Edwards Park Trail	City and Port of Seattle	Burlington Northern Santa Fe Railway	Washington
Platte River Trail	Regional Transit District	Denver Rail Heritage Society	Colorado
Porter Rockwell Trail	Utah Transit Authority	TRAX	Utah
Rock Island Trail	City of Colorado Springs	Denver & Rio Grande Western	Colorado
Rose Canyon Bike Path	Metropolitan Transit District Board	Amtrak and Santa Fe	California
Seattle Waterfront Pathway	City of Seattle	METRO Transit	Washington
Southwest Corridor Park	Massachusetts Bay Transit Authority	MBTA Commuter Rail and Amtrak	Massachusetts
Three Rivers Heritage Trail	City of Pittsburgh	CSX	Pennsylvania
Traction Line Recreation Trail	New Jersey Transit Authority	NJ Transit and Norfolk Southern	New Jersey
Traverse Area Recreation Trail (TART)	Michigan Department of Transportation	Tuscola & Saginaw Bay RR	Michigan
Watts Towers Crescent Greenway	Metropolitan Transportation Authority	Metropolitan Transportation Authority	California
West Orange Trail	Orange County Parks	CSX	California



Source: Rails-to-Trails Conservancy

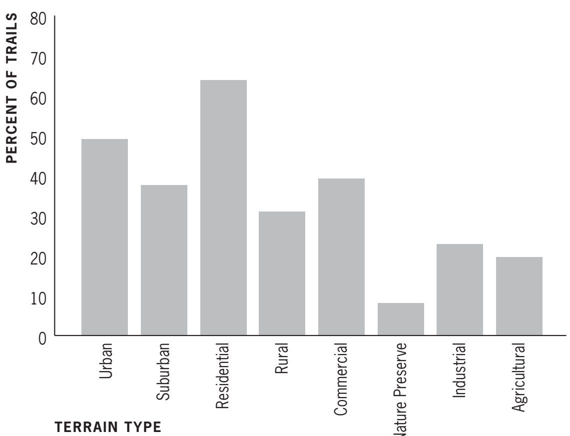
FIGURE 5.1 Type of railroad adjacent to existing RWTs (Note: Railroads identified their function by a variety of names. Because more than one type of railroad may operate in a corridor, percentages add up to more than 100%.)



NOTE: Where a range of frequencies was given, the most frequent service was taken.

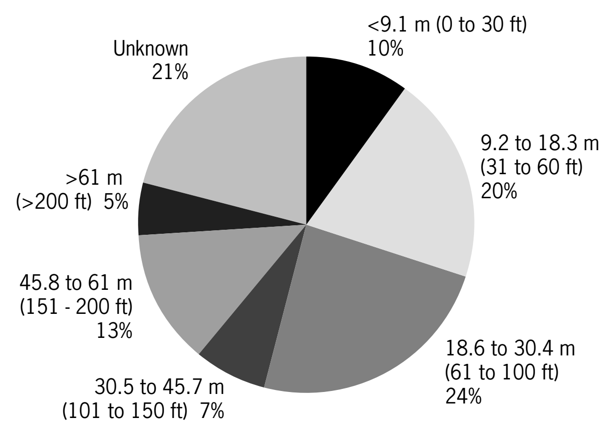
Source: Rails-to-Trails Conservancy

FIGURE 5.2 Frequency of trains, by percentage of existing RWTs



Source: Rails-to-Trails Conservancy

FIGURE 5.3 Type of terrain through which trails pass (Because trails pass through more than one type of terrain, percentages add up to more than 100%.)



(Total number of trails = 61)

Source: Rails-to-Trails Conservancy

FIGURE 5.4 Width of full corridor, by percentage of trails (Note: corridor widths often vary.)

variance in the frequency of train operation, from three to nine trains per hour (16 percent) to just a few trains a week (13 percent) (see **Figure 5.2**). In many cases, the peak hours of rail use correspond with peak trail use hours. The average maximum train speed is 51 km/h (32 mi/h), with a range of 8 to 225 km/h (5 to 140 mi/h). All but three trains in RWT corridors travel at speeds less than 97 km/h (60 mi/h). The three fastest trains are:

- Massachusetts Bay Transit Authority Commuter Rail and Amtrak (Southwest Corridor Park, Boston, Massachusetts), maximum speed 225 km/h (140 mi/h), setback over 6.1 m (20 ft), separated by concrete wall and chain link fence.
- Orange County Transportation Authority and Amtrak (see ATSF Trail case study, p.11).
- State of Wisconsin and Amtrak (see La Crosse River State Trail case study, p. 18).

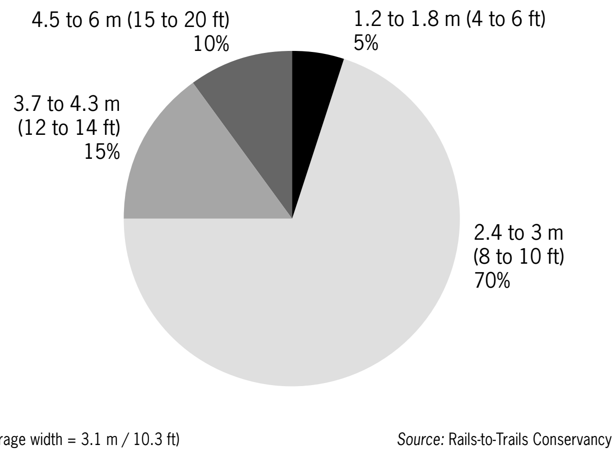


FIGURE 5.5 Width of RWT, by percentage of trails

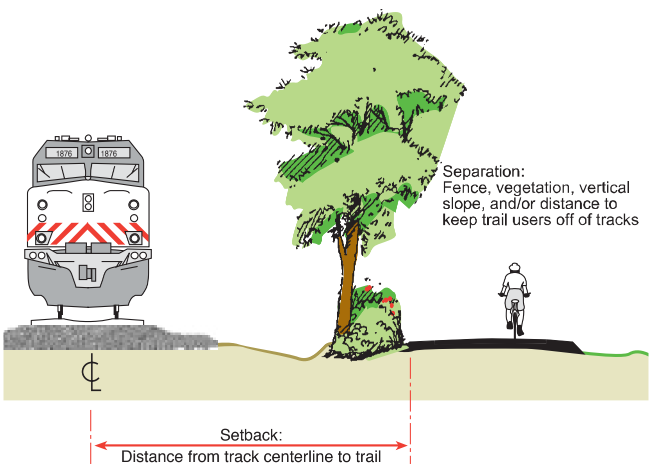


FIGURE 5.6 Setback and separation definition

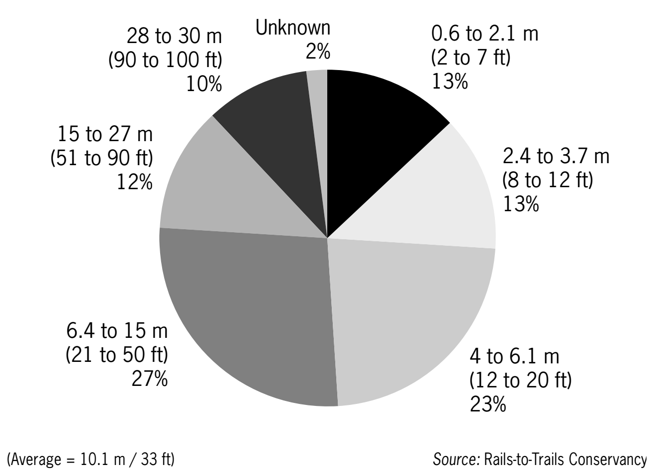


FIGURE 5.7 Distance between edge of trail and track centerline, by percentage of trails

The existing U.S. RWTs are located in 20 States, encompass 385 km (239 miles), and traverse a wide variety of terrain, including urban, suburban, residential, rural, commercial, nature preserve, industrial, and agricultural lands (see **Figure 5.3**).

The RWT corridor widths average 38 m (126 ft), while the trails are typically 2.4 to 3 m (8 to 10 ft) wide (see **Figures 5.4** and **5.5**).

Setback: Considerations

The term "setback" refers to the distance between the edge of an RWT and the centerline of the closest active railroad track while "separation" refers to the treatment of the space between an RWT and the closest active railroad tracks, including fences, vegetation, ditches, and other items (see **Figure 5.6**). When determining the minimum setback for a RWT, factors to consider include train speed and frequency, maintenance needs, applicable State standards, separation techniques, historical problems, track curvature, topography, and engineering judgment.

The range of trail setback on the existing RWTs varies from less than 2.1 m (7 ft) to as high as 30 m (100 ft) (see **Figure 5.7**), with an average of almost 10 m (33 ft) of setback from the centerline of the nearest track. A comparison of RWT setback distance to both train speed and frequency reveal little correlation; over half (33 of 61) of the existing RWTs have 7.6 m (25 ft) or less setback, even alongside high speed trains (see **Figures 5.8** and **5.9**). Many of the trails with little setback are ones that have been established many years. The trail managers for these well-established trails report few problems. However, interviews with train engineers in several areas indicate that they observe a tremendous amount of daily trespassing and problems in areas with little setback and no physical separation.

In comparison, RWTs in Perth, Australia, are typically 3 m (10 ft) wide, and separated from the adjacent railway line by a 1.8 m (6 ft) high chain link fence with three strands of barbed wire. The minimum setback from track centerline to the fence is 4.5 m (15 ft).

Researchers attempted to determine if narrower setback distances have a direct correlation to safety problems. However, based on the almost nonexistent record of claims, crashes, and other problems on any RWTs, they were unable to determine a correlation between setback distance and trail user safety. An

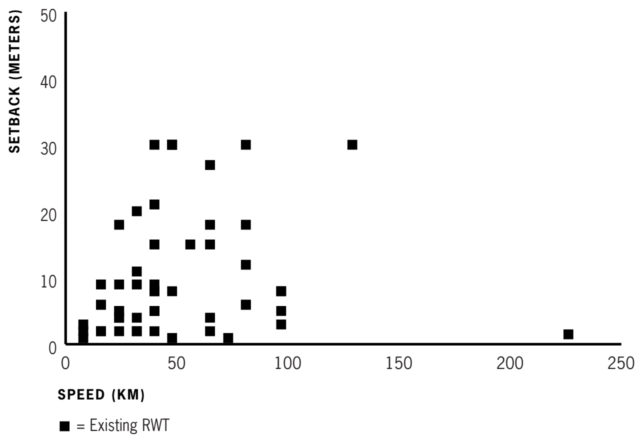


FIGURE 5.8 RWT setback/train speed correlation

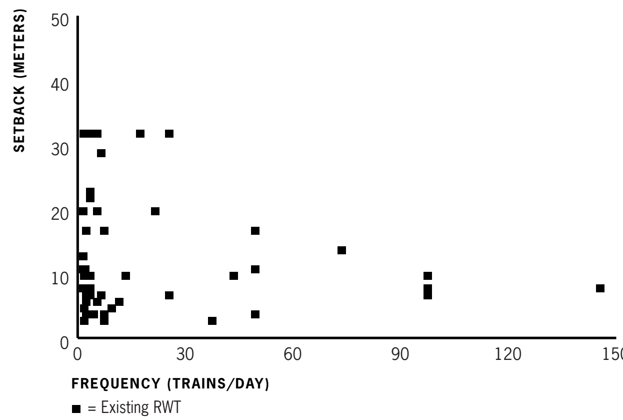


FIGURE 5.9 Setback/frequency correlation

FRA study on the impact of high train speed on people standing on boarding platforms concludes that induced airflow is a safety issue for a person within 2 m (6.5 ft) of a train traveling at 240 km/h (150 mi/h) (Volpe, 1999).

There is no consensus on either appropriate setback requirements or a method of determining the requirement. Some trail planners use the AASHTO Bike Guide for guidance. Given that bicycle lanes are set back 1.5 to 2.1 m (5 to 7 ft) from the centerline of the outside travel lane of even the busiest roadway, some consider this analogous. Others use their State Public Utilities Commission's minimum setback standards (also known as "clearance standards") for adjacent walkways (for railroad switchmen). These published setbacks represent the legal minimum setbacks based on the physical size of the railroad cars, and are commonly employed along all railroads and at public grade crossings. The minimum setback distance is typically 2.6 m (8.5 ft) on tangent and 2.9 m (9.5 ft) on curved track. However, FRA and railroad officials do not consider either of these methods to be appropriate for an RWT. This is because AASHTO's guidelines for motor vehicle facility design are not seen as comparable to rail design, and the setback distance for the general public should be much greater than that allowed for railroad workers.

Some railroads and States have established their own standards. For example, the BNSF's policy on "Trails with Rails" states, "Where train speeds are greater than 145 km/h (90 mi/h), trails are not acceptable. No trail will be constructed within 31 m (100 ft) of any mainline track where train speeds are between 113 km/h (70 mi/h) and 145 km/h (90 mi/h). Trails may be constructed between 15 m (50 ft) and 30 m (100 ft) where mainline train speed is 80 km/h (50 mi/h) to 113 km/h (70 mi/h). Trails may be constructed 15 m (50 ft) from centerline of track where train speeds are 40 km/h (25 mi/h) to 80 km/h (50 mi/h), and 9 m (30 ft) from any branchline track with speeds of 40 km/h (25 mi/h) or less. No trails less than 9 m (30 ft) from centerline of track for any reason." The Alaska Railroad Corporation rule of thumb for setbacks along main tracks is one railcar length, or 18 to 21 m (60 to 70 ft), unless careful analysis of the risks suggests otherwise. In contrast, the Maine Department of Transportation allows for trails to be set back a minimum of 5.5 m (18 ft) from track centerline, down to 4 m (12.5 ft) in constrained circumstances.

Other considerations when determining setback may be flying debris and maintenance access. Trains throw up debris from the roadbed, including rocks and other objects deliberately placed on the rails by trespassers. Fast-moving trains have thrown up large ballast rocks. Debris has been known to fall off trains, or, in some cases, to hang off rail cars. Railroad companies need access to tracks for routine and emergency maintenance, including tie and ballast replacement, cleaning culverts, and accessing switches and control equipment. While most railroad companies have the ability to maintain tracks from the tracks themselves, it often is more cost effective and less disruptive to access the tracks from maintenance vehicles operating alongside the tracks. At a minimum, railroads need at least 4.5 m (15 ft) from the track centerline to provide reasonable access to their tracks.

Further considerations when determining setback requirements may be physical constraints on or adjacent to railroad corridors, presence of separation techniques such as fencing, historical trespassing, and other problems. Finally, train densities can change at any time and location, and railroads require flexibility in their operations to meet customer requirements. Structures or right-of-way modifications that impede a railroad's ability to change or control its operations are unacceptable.

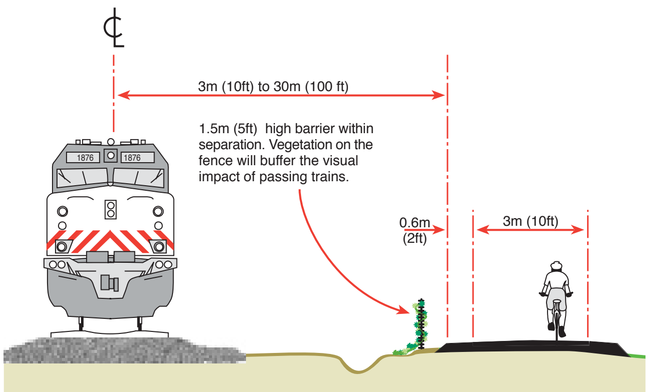


FIGURE 5.10 Minimum RWT setback depends on specific situation

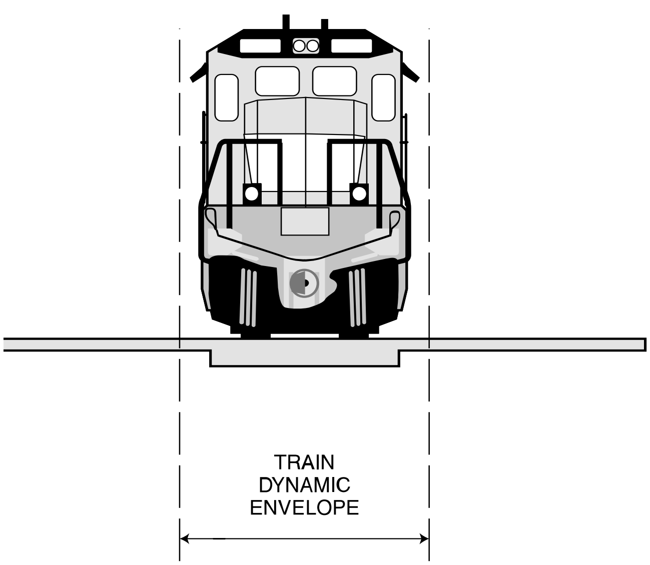


FIGURE 5.11 Dynamic envelope delineation (MUTCD Fig. 8A-1. Note: no dimensions given in MUTCD.)

Setback: Recommendations

Because of the lack of consensus on acceptable setback distances, the appropriate distance must be determined on a case-by-case basis (see **Figure 5.10**). Trail planners should incorporate into the feasibility study analysis an analysis of technical factors, including:

- Type, speed, and frequency of trains in the corridor;
- Separation technique;
- Topography;
- Sight distance;
- Maintenance requirements; and
- Historical problems.

Another determining factor may be corridor ownership. Trails proposed for privately-owned property will have to comply with the railroad's own standards. Trail planners need to be aware that the risk of injury should a train derail will be high, even for slow-moving trains. Discussions about liability assignment need to factor this into consideration.

In many cases, adequate setback widths, typically 7.6 m (25 ft) or higher, can be achieved along the majority of a corridor. However, certain constrained areas will not allow for the desired setback width. Safety should not be compromised at these pinch points – additional barrier devices should be used,

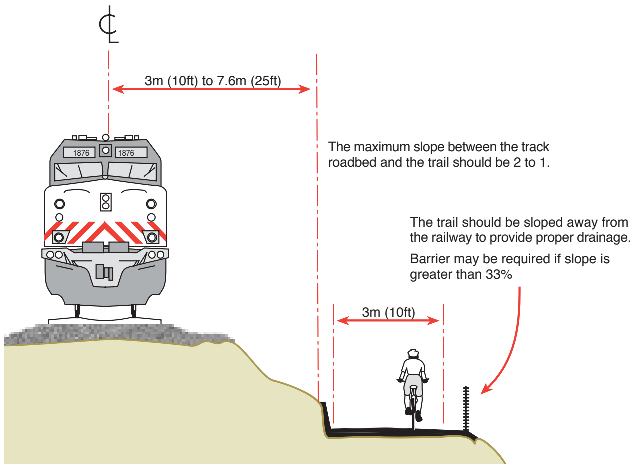


FIGURE 5.12 Minimum RWT setback – fill sections (depending on situation)

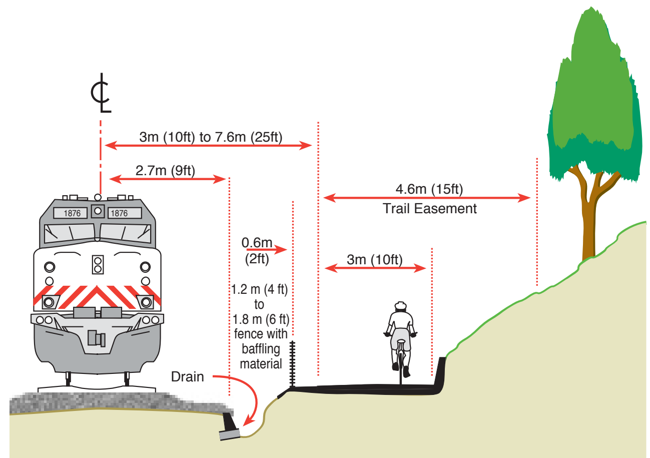


FIGURE 5.13 Minimum RWT setback – constrained sections (depending on situation)

and/or additional right-of-way purchased. In the case of high speed freight or transit lines, RWTs must be located as far from the tracks as possible and are infeasible if adequate setbacks and separation cannot be achieved.

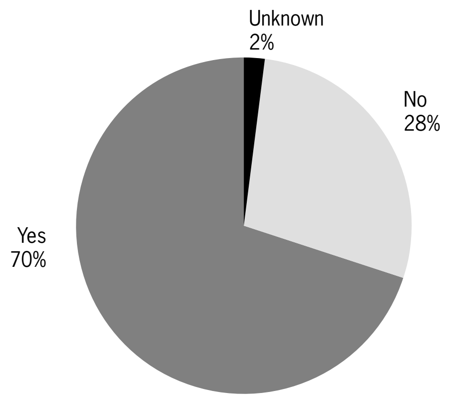
At an absolute minimum, trail users must be kept outside the "dynamic envelope" of the track – that is, the space needed for the train to operate (see **Figure 5.11**). According to the MUTCD (Section 8), the dynamic envelope is "the clearance required for the train and its cargo overhang due to any combination of loading, lateral motion, or suspension failure." It includes the area swept by a turning train.

Relatively narrow setback distances of 3 m (10 ft) to 7.6 m (25 ft) may be acceptable to the railroad, RWT agency, and design team in certain situations, such as in constrained areas, along relatively low speed and frequency lines, and in areas with a history of trespassing where a trail might help alleviate a current problem. The presence of vertical separation or techniques such as fencing or walls also may allow for narrower setback.

Constrained Areas

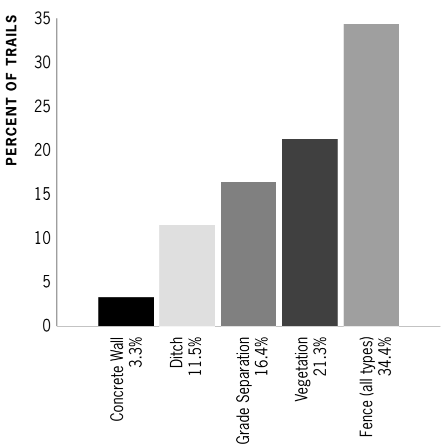
Many types of terrain pose challenges to an RWT design. While a railroad corridor may be 30 m (100 ft) wide or greater, the track section may be within a narrow cut or on a fill section, making the placement of an RWT very difficult. RWTs in very steep or rugged terrain or with numerous bridges and trestles simply may not be feasible given the need to keep a minimal setback from the tracks, meet ADA requirements, allow railroad maintenance access, and still have a reasonable construction budget. Exceptions may exist where the RWT is accompanied by a solid barrier, vertical separation, or ditch (see "Separation" section, page 66), in the case of very low speed/frequency railroad operations, or for very short distances (see **Figures 5.12** and **5.13**). The railroad company or agency should review the proposal to ensure that they will have adequate maintenance and emergency access to the tracks.

Setback (4.5m/15ft) and fencing along the Showgrounds Pathway RWT. *Perth, Australia*



NOTE: A "Yes" response does not necessarily indicate the presence of a full barrier. It includes some partial barriers and one instance of where a barrier is planned to be removed.
Source: Rails-to-Trails Conservancy

FIGURE 5.14 Percentage of existing RWTs with barrier



Source: Rails-to-Trails Conservancy

FIGURE 5.15 Barrier type, by percentage of existing RWTs

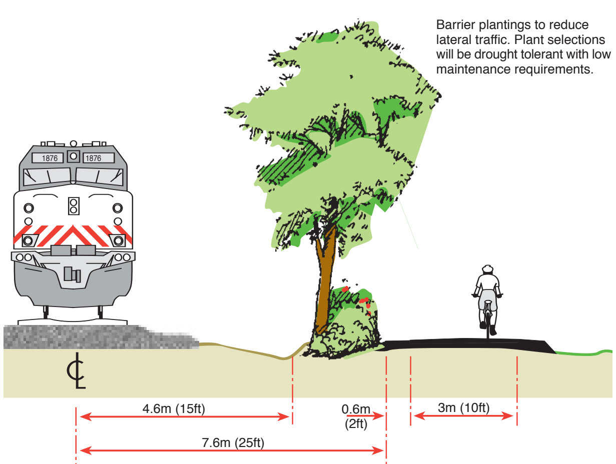


FIGURE 5.17 Trail separation example – using vegetation as a separation technique

Type of Rail Service

Lower speed and frequency train operations pose fewer hazards than higher speed and frequency trains. Numerous low speed line RWTs exist or are planned with relatively narrow setback distances. For example, Portland's Springwater-OMSI Trail, along the 32 km/h (20 mi/h) Oregon Pacific Railroad, is designed 3.2 m (10.5 ft) from the centerline to edge of trail, with a fence 0.6 m (2 ft) from the train edge the entire length. The narrower setbacks may be acceptable depending on feasibility analysis, engineering judgment, the railroad's future needs and plans, and liability assessment.

Areas of Existing High Trespassing

While trespassing on private railroad property is a common occurrence in virtually all settings, in some locations the historic pattern of trespassing has triggered legitimate concerns about the health, safety, and welfare of nearby residents. Research indicates that RWTs may be an effective tool to manage trespassing on corridors where it is physically difficult or impossible to keep trespassers off the railroad tracks. In these cases, the feasibility analysis may show that the risks of a narrower setback distance may be offset by the gains in trespassing reduction through trespasser channelization, using design features such as fencing or other barriers.

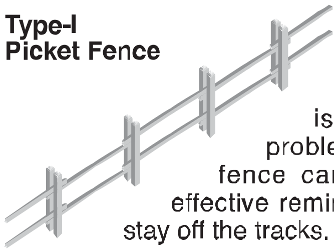
Separation

Over 70 percent of existing RWTs utilize fencing and other barriers such as vegetation for separation from adjacent active railroads and other properties (see **Figures 5.14** and **5.15**). Barriers include fencing (34 percent), vegetation (21 percent), vertical grade (16 percent), and drainage ditch (12 percent). The fencing style varies considerably, from chain link to wire, wrought iron, vinyl, steel picket, and wooden rail (see **Figure 5.16**). Fencing height ranges from 0.8 m (3 ft) to 1.8 m (6 ft), although typical height is 0.8 to 1.2 m (3 to 4 ft).

Most railroad companies require RWTs to provide fencing. Some railroad companies specify a requirement of 1.8 m (6 ft) high fencing, no matter what the setback distance is. Fencing may not be required where a significant deterrent to trespass is provided or exists. Examples include water bodies, severe grade differentials, or dense vegetation.

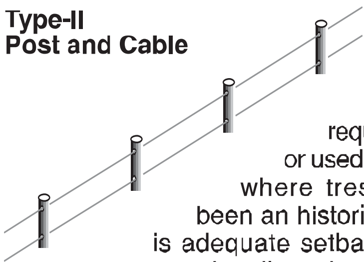
Other barrier types such as vegetation, ditches, or berms are often used to provide separation (see **Figure 5.17**), especially where an RWT is located further than 7.6 m (25 ft) from the edge of the trail to the centerline of the closest track, or where the vertical separation is greater than 3 m (10 ft). In constrained areas, using a combination of separation techniques may allow narrower acceptable setback distances.

Type-I
Picket Fence



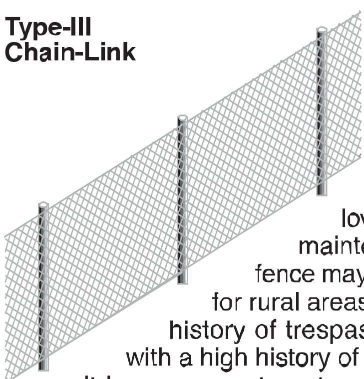
Where trespassing is not as much of a problem, a low wood rail fence can still serve as an effective reminder to trail users to stay off the tracks.

Type-II
Post and Cable



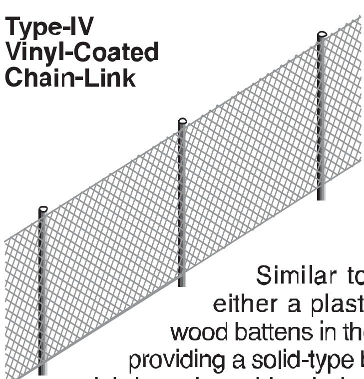
This inexpensive fence is occasionally requested by a railroad or used on a RWT primarily where trespassing has not been an historical problem, there is adequate setback, and the fence serves primarily to demarcate the railroad property boundaries. The fence does not provide any screening or anti-trespassing features.

Type-III
Chain-Link



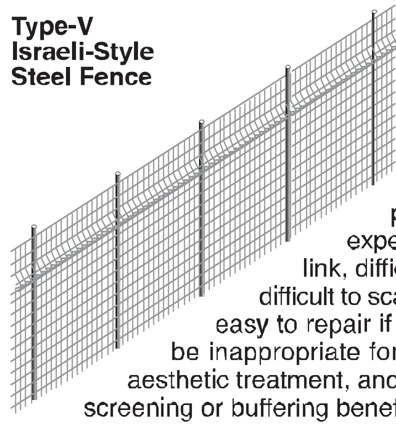
Chain-link fences are popular due to their effectiveness in keeping trail users off the tracks, relative low cost, and ease of maintenance. Chain-link fence may not be appropriate for rural areas where there is no history of trespassing, or for areas with a high history of trespassing, since it is very easy to cut and vandalize. Most chain-link fences are visually unappealing ñ and tend to project an image of an urban industrial environment. For this reason, trail designers should explore using other, more appealing types of fences whenever possible.

Type-IV
Vinyl-Coated
Chain-Link



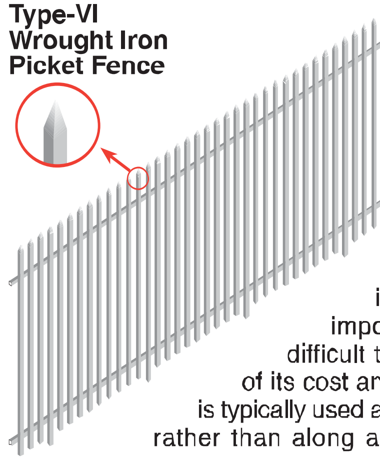
Similar to Type II, but with either a plastic woven fabric or wood battens in the chain-link material providing a solid-type barrier to help catch debris and provide wind and visual buffering.

Type-V
Israeli-Style
Steel Fence



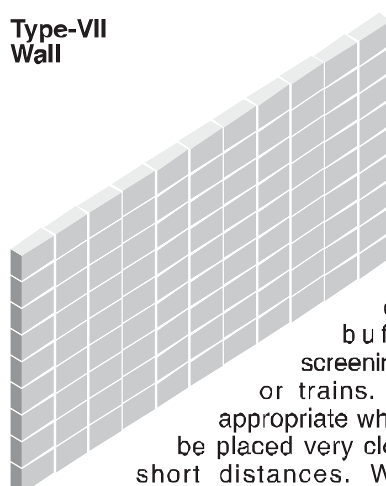
Sometimes referred to as ëIsraeli-styleí fencing for its use in Israel to protect kibbutzs, this product is more expensive than chain-link, difficult to vandalize, difficult to scale, and relatively easy to repair if it is cut. It would be inappropriate for areas requiring aesthetic treatment, and provides limited screening or buffering benefits.

Type-VI
Wrought Iron
Picket Fence



This is the ultimate in vandal-resistant fencing, and is used in locations that have a history of trespassing. It is virtually impossible to cut and difficult to scale. Because of its cost and visual impact, it is typically used at specific locations rather than along an entire corridor.

Type-VII
Wall



Very rarely used due to its cost and visual impact, solid concrete block walls are virtually indestructible and offer complete buffering and screening from rail debris or trains. A wall may be appropriate where a RWT must be placed very close to tracks for short distances. Walls are most commonly used in areas where a grade separation requires a retaining wall adjacent to the trail. Wall design in active rail corridors should be carefully coordinated with rail engineers, because they can have an effect on the structural integrity of the rail bed, alter drainage patterns in the rail corridor, and, in some circumstances, impede access by railroad maintenance equipment.

FIGURE 5.16 Fencing styles

When on railroad property, RWT planners must adhere to the request or requirements for fencing by the railroad company or agency. When not on railroad property, RWT planners still should coordinate with the railroad to determine appropriate fencing. On all existing RWTs, the trail authority is responsible for barrier installation and maintenance.

Vertical Separation

Grade separation along Schuylkill River Trail. *Norristown, PA*

Vertical or grade separation achieves many of the same benefits as horizontal separation, and is very common where an RWT is located along numerous cut and fill locations. For example, on a steep-fill section, the RWT may be located 6.1 m (20 ft) or more below the tracks (see **Figure 5.12** on page 65). In a case such as this, the setback becomes less important than the amount of vertical separation, which effectively addresses the elements of debris and wind. In cases with vertical separation of greater than 3 m (10 ft), the danger from falling objects may increase. A fence or barrier at the top of the slope may help prevent injuries on the trail below.

Vegetation and Ditches

Whether natural or planted, vegetation can serve as both a visual and physical barrier between a track and a trail (see **Figure 5.17**). The density and species of plants in a vegetative barrier determine how effective the barrier can be in deterring potential trespassers. A dense thicket can be, in some cases, just as effective as a fence (if not more so) in keeping trail users off the tracks. Even tall grasses can discourage trail users from venturing across to the tracks, although less effectively than trees and shrubs. Planted barriers typically take a few years before they become effective barriers. Separation between the trail and the track may need to be augmented with other temporary barriers until planted trees and hedges have sufficiently matured. Neither vegetation nor fencing should block the public's view of an approaching train at highway-rail crossings.

Many rail corridors contain drainage ditches that run adjacent to the tracks. The deeper and wider these ditches, the more difficult they are to cross on foot, and thus the greater deterrent to trespassing they provide. The presence of water in the ditch also will act as a deterrent. Trail and track drainage needs must be considered in the design process.

Fences and Walls

Fences and walls are the most common type of physical barrier used in RWT corridors (see **Figure 5.16**). Most railroads will require or request fencing, for which the trail management agency will be responsible. The height and type of material used on these barriers determines their effectiveness in discouraging trespassing and the resulting impact on required setback distance. A tall wall or fence constructed with materials that are difficult to climb should deter all but the most determined trespasser.

From the trail manager's perspective, fencing is a mixed blessing. Installing and maintaining fencing is expensive. Improperly maintained fencing is a higher liability risk than no fencing at all. In all but the most heavily-constructed fencing, vandals find ways to cut, climb, or otherwise overcome fences to reach their destinations. Fencing also detracts from the aesthetic quality of a trail.

At-grade crossing. *Dixon, CA*

The visual quality of fencing materials can have an impact on illegal activities along RWTs. For example, the Canadian Pacific Railway (CPR) Police Service has had dramatic results in reducing crime and trespassing through RWT designs that improved the aesthetic quality of an area. Their approach relies on the concept of "Crime Prevention through Environmental Design" (CPTED), meaning, "the proper design and effective use of the built environment can lead to a reduction in the incidence and fear of crime...." (Canadian Pacific Police Services, 2000)

Particularly for an urban trail in an area with crime problems, it may be important to maintain visual access to the trail corridor from adjacent land uses, so that portions of the trail do not become isolated from public view. Fence design in these instances should not block visual access to the trail corridor. Tall fences that block views can cause sight distance problems at intersections with roadways — both for motorists who must be able to view approaching trains, and for trail users who need adequate sight lines to view traffic conditions.

Railroad maintenance vehicles and/or emergency vehicles may need fence gates in certain areas to facilitate access to the track and/or trail (see **Figure 5.18**). Fence design should be coordinated with railroad maintenance personnel, as well as representatives from local utilities that extend along the corridor. Where trespassing is an issue, the fence should be at least 1.8 m (6 ft) tall, and constructed of a sturdy material that is difficult to vandalize.

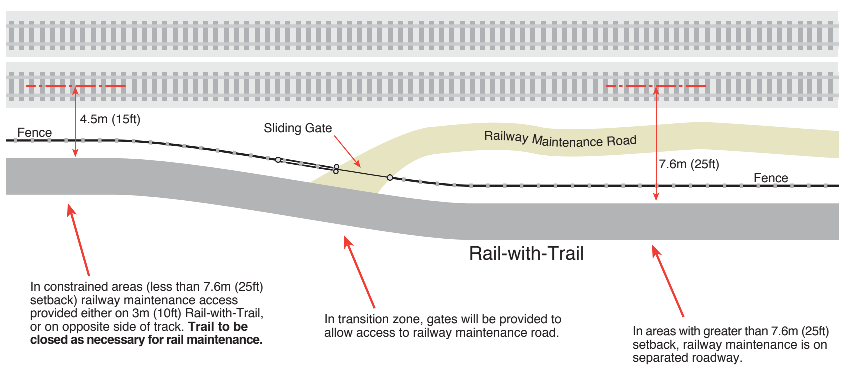


FIGURE 5.18 Sample maintenance access transitions

Railroad Track Crossings

The point at which trails cross active tracks is the area of greatest concern to railroads, trail planners, and trail users. Railroad owners, the FRA, and State DOTs have spent years working to reduce the number of at-grade crossings in order to improve public safety and increase the efficiency of service. RWT design should minimize new at-grade crossings

Crossing treatment on the suburban rail network in Perth. Gates automatically close when train is approaching. Users are alerted to the presence of approaching train by flashing lights and audible bells. Gates remain locked until trains have passed. *Perth, Australia*

wherever possible. Modifying an existing highway-rail crossing may be an option. Alternative options are below-grade (underpass), or above-grade (overpass) crossings, which are expensive and typically have been installed in limited circumstances, such as:

- Locations where an at-grade crossing would be extremely dangerous due to frequent and/or high speed trains, limited sight distances, or other conditions; and
- Locations where trains are regularly stopped at the crossing point, effectively blocking the trail intersection for long periods of time.

Some government agencies and railroad owners have adopted policies of no new at-grade crossings. In these cases, using existing crossings or building grade-separated crossings may be the only alternatives. Also, many railroads are actively working to close existing at-grade crossings to improve safety, reduce maintenance costs, improve operating efficiency, and reduce liability exposure. The RWT feasibility analysis should carefully evaluate all proposed crossings, with consideration given to:

- Train frequency and speed;
- Location of the crossing;
- Specific geometrics of the site (angle of the crossing, approach grades, sight distance);
- Crossing surface;
- Nighttime illumination; and
- Types of warning devices (passive and/or active)

The railroad company or agency, and State DOT or Public Utility Commission, will need to approve any new crossings, the design of which must be in compliance with the *MUTCD*.[1] Relevant information also is contained in the *Railroad-Highway Grade Crossing Handbook* (FHWA, 1986) and U.S. DOT Highway-Rail Grade Crossing Technical Working Group (TWG) document, *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings* (FHWA, 2002).

More than half the existing RWTs in the U.S. include some sort of track crossing, mostly at-grade (RTC, 2000). The Bugline Trail, Wisconsin, Southwest Corridor Park Trail, Massachusetts, Illinois Prairie Path, and Rock River Recreation Path, Illinois, have overpasses or bridges. The Tony Knowles Coastal Bicycle Trail, Alaska, has tunnels under the tracks, and the Springwater Corridor Extension, Oregon, will have two pedestrian underpasses.

Existing at-grade crossings typically have some sort of passive warning devices — railroad "crossbucks" or railroad crossing signs (see **Figure 5.24** on page 75). Examples are on the Burlington Waterfront Bikeway, Vermont, and Lehigh River Gorge Trail, Pennsylvania. Several have active warning devices such as gates or alarms. Planned trails such as the Blackstone River Bikeway, Rhode Island, and Springwater Corridor Extension, Oregon, will have higher quality at-grade crossings, with a full complement of automatic gates, warning alarms, and signage.

[1] The MUTCD (see *Appendix A* for detailed definition) contains standards for signs, pavement markings and other devices used to regulate, warn, or guide traffic, placed on, over, or adjacent to a street, highway, pedestrian facility, or bikeway by authority of a public agency having jurisdiction.

Many bicycle routes in Perth, Australia, cross perpendicular to the suburban railway lines. Gates automatically close upon the approach of a train. When open, they have a straight-through passage, facilitating ease of movement by cyclists, pedestrians, and people in wheelchairs. The crossings feature warning bells and flashing lights. Westrail also uses a variety of pavement treatments to offer visual cues to both motorists and trail users in transit station areas (Maher, 2000).

Crossing at the City West Station. *Perth, Australia*

Location of the Crossing

Trail-rail grade crossings should reduce illegal track crossings by channelizing users to safer crossing areas. Crossings must not be located where trains may be regularly stopped, since this would encourage trail users to cross between or under railroad cars — an extremely dangerous and unacceptable movement. Crossings should not be located on railroad curves where sight lines are poor. When new at-grade crossings are not permitted, the RWT design will need to channelize users to cross the tracks at roadway locations (see p. 81) or develop a grade-separated crossing (p. 79).

Sight Distance

Adequate sight distance is particularly important at trail-rail intersections that do not have active warning devices such as flashing lights or automatic gates. Bicyclists, pedestrians, and other trail users should be given sufficient time to detect the presence of an approaching train and either stop or clear the intersection before the train arrives.

Three elements required for safe movement of trail users across the railroad tracks are as follows:

1. Advance notice of the crossing

The first element concerns stopping sight distance, a common consideration in highway intersection design. The stopping sight distance is that distance required for a trail user to see an approaching train and/or the grade crossing warning devices at the crossing, recognize them, determine what needs to be done, and then come to a safe stop at a point 4.5 m (15 ft) clear of the nearest rail, if necessary. This point usually will be marked by a pavement marking in advance of the crossing. This sight distance is measured along the trail, and is based on a trail user traveling at a given speed, and coming to a safe stop as discussed above.

2. Traffic control device comprehension

The second element involves the recognition of the grade crossing warning devices by the approaching user. Trail users should be reminded of the meaning of all traffic control devices in use at grade crossings, such as the fact that the familiar crossbuck sign should be treated as a YIELD sign at any crossing, or that flashing lights without gates, when flashing, are to be treated the same as a STOP sign.

Transit station pedestrian crossing. *Beaverton, OR*

3. Ability to see an approaching train

The third element concerns the trail user's ability to see an approaching train in order to decide whether it is safe to cross. Two different kinds of sight distance considerations are involved for safe movement across the crossing. This third element involves the sight distance available in advance of the crossing, as well as the sight distance present at the crossing itself.

Approach sight distance (also known as corner sight distance) involves the clear sight line, in both directions up and down the tracks, that allows a trail user to determine in advance of the crossing that there is no train approaching and it is safe to proceed across the tracks without having to come to a stop. These sight triangles, dependent upon both train speed and trail user speed, are determined as shown in the *Railroad-Highway Grade Crossing Handbook* (FHWA, 1986).

Often these sight triangles are obstructed by vegetation, topography, or structures. If the clear sight triangles for a given trail user speed (bicyclists and skaters will probably be the fastest trail users) cannot be obtained, then the trail should have additional warning signs or a reduced speed limit posted in advance of the crossing. As another treatment, based upon local conditions and engineering judgment, STOP or YIELD signs may be placed on the trail at the crossing.

Clearing sight distance, which applies to all crossings without automatic gates, involves the clear sight line, in both directions up and down the tracks, present at the crossing itself. A trail user stopped 4.6 m (15 ft) short of the nearest rail must be able to see far enough down the track in both directions to determine if the user can move across the tracks, to a point 4.6 m (15 ft) past the far rail, before the arrival of a train. At crossings without gates that have multiple tracks, the presence of a train on one track can restrict a trail users' view of a second train approaching on an adjacent track.

A more detailed treatment of the sight distance problem at grade crossings may be found in the document titled, *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings* (FHWA, 2002).

In addition, most railroad safety books and FRA Roadway Worker Safety rules (49 CFR 214), specify that upon the approach of a train, enough warning must be given to allow someone on the track to have at least 15 seconds between the time they are clear of the track and the time the train gets to their location. This criterion applies only to railroad personnel who are working within their established limits and are prepared to vacate the track structure with proper warning. Because the average trail user most likely is not familiar with the hazards of rail operations, they would need additional warning time.

Approach Grades and Angle

The AASHTO Bike Guide and ADA specify grade requirements for shared use paths. Trail grades over 5 percent are allowed for short distances in specific circumstances. Grades over five percent are not recommended for crossing approaches. In general, the trail approach should be at the same elevation as the track (see **Figure 5.19**). Steep grades on either side of the track can cause bicyclists to lose control, may distract trail users from the conditions at the crossing, and may block sight lines.

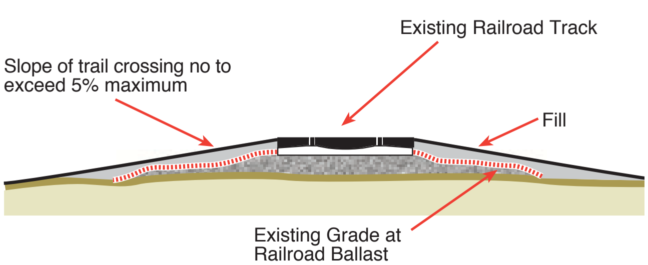


FIGURE 5.19 Approach grade at at-grade crossings

Another critical issue, particularly for bicyclists and people with disabilities, is the angle of crossing. The AASHTO Bike Guide makes the following statement with respect to the crossing angle of a bikeway at a railroad track:

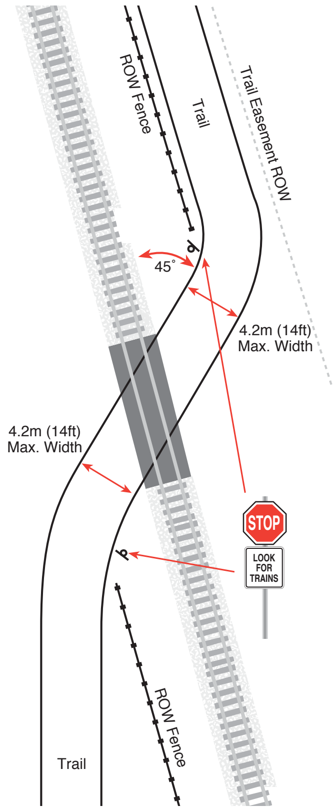


FIGURE 5.20 45° Trail-rail crossing

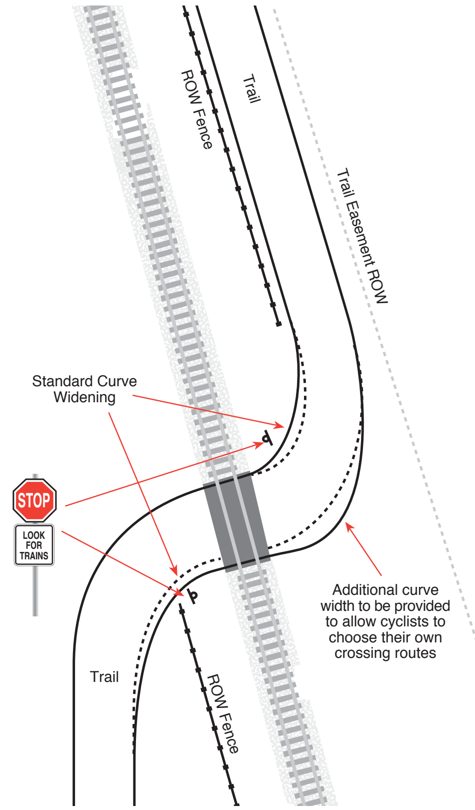


FIGURE 5.21 90° Trail-rail crossing

"Railroad-highway grade crossings should ideally be at a right angle to the rails....The greater the crossing deviates from this ideal crossing angle, the greater is the potential for a bicyclist's front wheel to be trapped in the flangeway, causing loss of steering control. If the crossing angle is less than approximately 45 degrees, an additional paved shoulder of sufficient width should be provided to permit the bicyclist to cross the track at a safer angle, preferably perpendicularly."

Flangeway is the term used for the space between the rail and the pavement edge. The standard flangeway width for commuter and transit railroad crossings is 63.5 mm (2.5 in), 76.2 mm (3 in) for freight railroads. These widths are greater than many bicycle tires and wheelchair casters. For this reason, acute angle crossings are not recommended. Also, according to the AASHTO Bike Guide, where active warning devices are not used to indicate an approaching train, the trail should cross the railroad at or nearly at right angles and where the track is straight (see **Figures 5.20** and **5.21**). Where the track is not straight (e.g., on a curve), complications exist: sight distance is restricted and the rails may be at different levels.

Dual track grade crossing.
Burlington, VT

Crossing Surface

The smoothness of the crossing surface has a profound effect on trail users. Sudden bumps and uneven surfaces can cause bicycle riders to lose control and crash. For pedestrians, trails that are designed to meet ADA Accessibility Guidelines must maintain a smooth surface.

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

Trail managers will be responsible for providing railroads with slip-resistant crossing surface materials. Accessible trails should include tactile warning strips prior to at-grade track crossings.

Nighttime Illumination

Most RWTs will experience nighttime use. Thus, lighting should be provided at trail-rail crossings. Refer to: *American National Standard Practice for Roadway Lighting, ANSI IESNA RP-8* (available from the Illuminating Engineering Society) for the appropriate location of lighting fixtures and recommended lighting levels for rail grade crossings. Lighting must be shielded from the locomotive engineer's view for safety reasons.

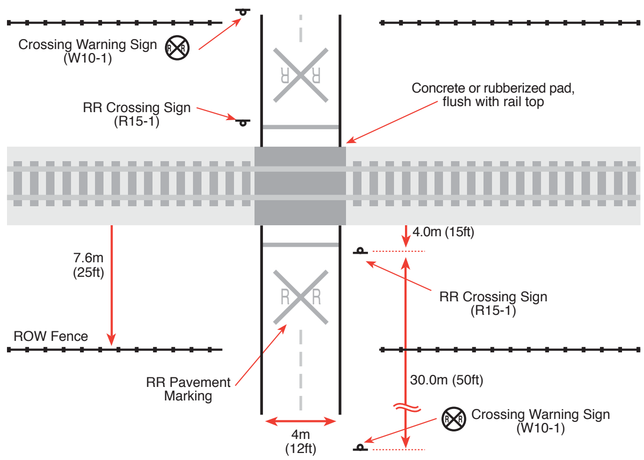


FIGURE 5.22 Crossing equipped with passive warning devices (MUTCD Fig. 9B-3)

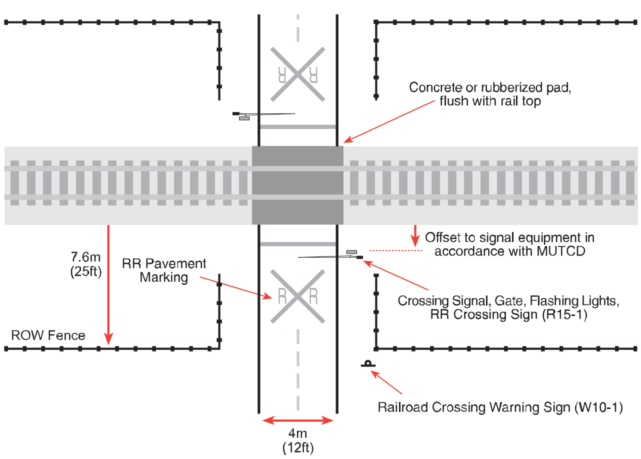


FIGURE 5.23 Crossing equipped with active warning devices and fencing

Advanced Warning Devices at Trail-Rail Crossings

A variety of warning devices are available for trail-rail crossings. In addition to the MUTCD standard devices, there are innovative treatments developed to encourage cautious bicyclist and pedestrian behavior. This report does not sanction one type of treatment as being appropriate for all trail-rail crossings, nor does the MUTCD provide a standard design for highway-track crossings. The MUTCD states, "Because of the large number of significant variables to be considered, no single standard system of traffic control devices is universally applicable for all highway-rail grade crossings. The appropriate traffic control system should be determined by an engineering study involving both the highway agency and the railroad company." The same applies for trail-rail intersections.

There are two categories of advanced warning devices:

- Passive warning devices: signs and pavement markings that alert trail users that they are approaching a trail-rail crossing and direct them to proceed with caution and look for trains (see **Figure 5.22**).
- Active warning devices: advise trail users of the approach or presence of a train at railroad crossings. These consist of bells, flashing lights, automatic gates, and other devices that are triggered by the presence of an approaching train (see **Figure 5.23**).

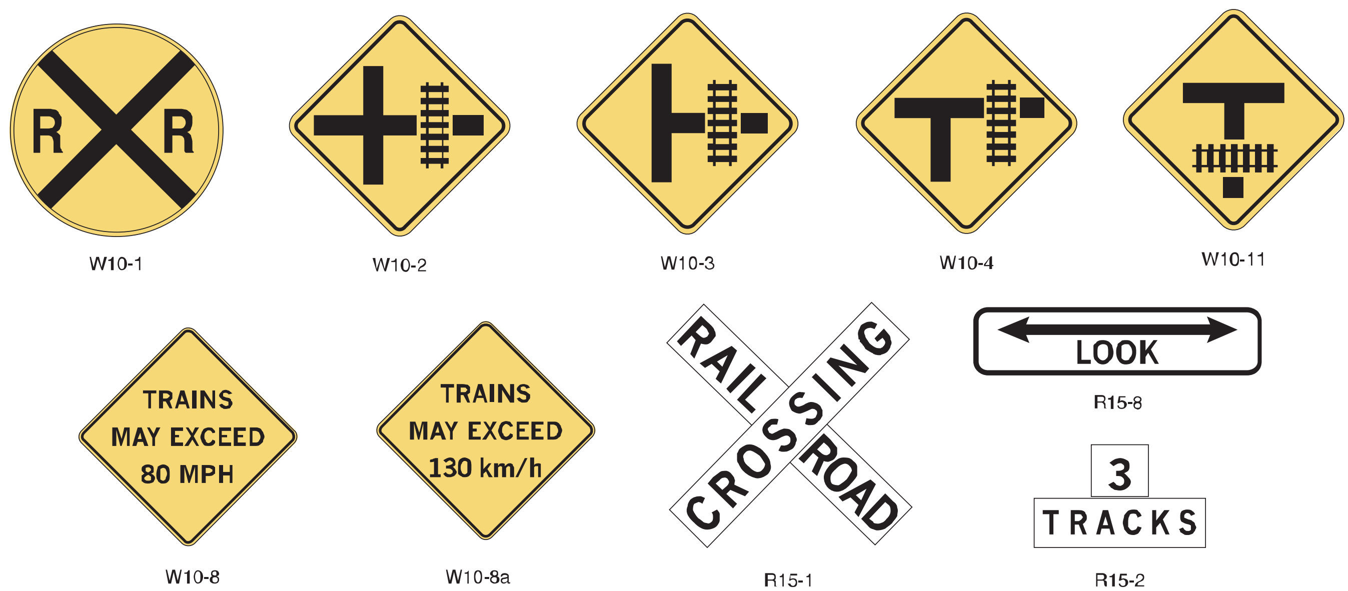


FIGURE 5.25 MUTCD-approved railroad warning signs that may be appropriate for RWTs

PASSIVE WARNING DEVICES AT TRAIL-RAIL CROSSINGS. Trail-rail crossings with passive warning devices should comply with the MUTCD's minimum recommended treatment at highway-rail grade crossings. The MUTCD states, "One Crossbuck sign shall be installed on each highway approach to every highway-rail grade crossing, alone or in combination with other traffic control devices."

The MUTCD also states that "if automatic gates are not present and if there are two or more tracks at the highway-rail grade crossing, the number of tracks shall be indicated on a supplemental Number of Tracks (R15-2) sign…mounted below the Crossbuck sign...indicated in Figure 8B-1" (see **Figure 5.24**). Refer to the MUTCD for further guidance regarding the location and retroreflectivity of these signs.

STOP AND YIELD SIGNS. The MUTCD makes the following statements about the use of STOP and YIELD signs at highway-rail grade crossings: "At the discretion of the responsible State or local highway agency, STOP or YIELD signs may be used at highway-rail grade crossings that have two or more trains per day and are without automatic traffic control devices." This may also apply to trail crossings, as determined by an engineering study that considers the number and speed of trains, sight distances, the collision history of the area, and other factors. Willingness of local law enforcement personnel to enforce the STOP signs should also be considered.

WARNING SIGNS. The MUTCD also contains a number of warning signs that can be used to indicate the configuration of the upcoming crossing, or to otherwise warn users of special conditions. Warning signs that may be appropriate for RWTs are shown in **Figure 5.25** (MUTCD signs: W10-1, W10-2, W10-3, W-10-4, W10-8, W10-8a, R15-1, R15-2, R15-8, and W10-11).

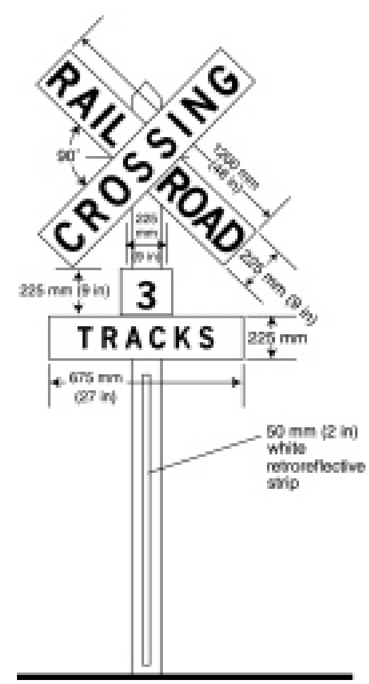
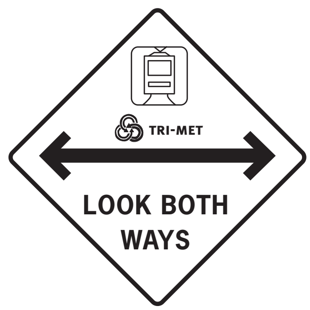


FIGURE 5.24 Highway-rail crossing (Crossbuck) sign (MUTCD Fig. 8B-1)

Steel Bridge Riverwalk. *Portland, OR*

ATSF Trail. *Irvine, CA*



Signs at transit stations. *Portland, Beaverton, and Gresham, OR*

Oregon Department of Transportation

Kennebec River Rail-Trail. *Farmingdale, ME*

FIGURE 5.26 Sample trespassing and other signs

OTHER SIGNS. The MUTCD applies to all signs that may be considered traffic control devices, whether on roads or on shared use paths. The MUTCD provides specifications on sign shapes, colors, dimensions, legends, borders, and illumination or retroreflectivity. Section 2A.06 notes that "State and local highway agencies may develop special word message signs in situations where roadway conditions make it necessary to provide road users with additional regulatory, warning, or guidance information."

Active warning devices at Burlington Waterfront Bikeway track crossing. *Burlington, VT*

The MUTCD does not apply to signs that are not traffic control devices, such as "No Trespassing" signs and informational kiosks. Many jurisdictions require "No Trespassing" signs to be posted along railroad tracks. **Figure 5.26** offers some examples.

Some railroad companies, trail developers, and State and local governments haved used a number of non-MUTCD-compliant supplemental signs at rail-trail crossings. Some of these have been adopted in State or local roadway and/or trail design guidelines. While these signs may provide information not available on MUTCD-compliant signs, they may increase the trail developer's or community's liability exposure.

The MUTCD recognizes that continuing advances in technology will produce changes that will require updating the Manual, and that unique situations often arise for signs and other traffic control devices that may require changes. Section 1A.10 describes the procedure to request changes or permission to experiment with traffic control signs and devices. Guidelines may be found on the Internet at http://mutcd.fhwa.dot.gov.

PAVEMENT MARKINGS. In the case of paved trails, pavement markings also are required by the MUTCD. At a minimum, they should consist of an "X," the letters "RR," and a stop bar line (see **Figure 5.25**, on page 75 and Parts 8 and 9 of the MUTCD).

For unpaved trails, consideration should be given to paving the approaches to trail-rail crossings, not only so that appropriate pavement markings can be installed, but also to provide a smooth crossing. If it is not possible to pave the approaches, additional warning devices may be needed.

ACTIVE WARNING DEVICES AT TRAIL-RAIL CROSSINGS. An engineering study is recommended for all trail-rail crossings to determine the best combination of active safety devices. Key considerations include train frequency and speed, sight distance, other train operating characteristics, presence of potential obstructions, and volume of trail users.

Active traffic control systems advise trail users of the approach or presence of a train at railroad crossings. Information regarding the appropriate uses, location, and clearance dimensions for active traffic control devices can be found in Part 8 of the MUTCD. In addition, Part 10 of the MUTCD contains specific recommendations for pedestrian and bicycle signals at light rail transit tracks, and should be referred to in cases where trails cross light rail transit corridors. Applicable diagrams from the MUTCD are shown in **Figures 5.27-5.30**.

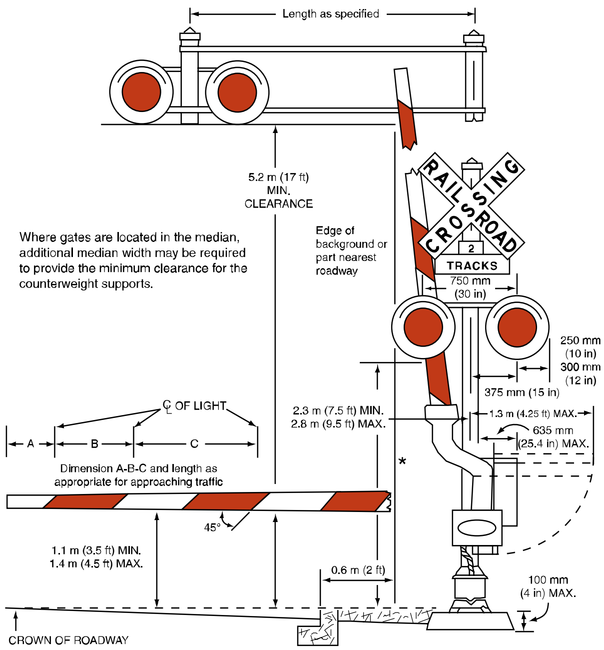


FIGURE 5.27 Composite drawing showing clearances for active traffic control devices at highway-rail grade crossings (MUTCD Fig. 8D-1)

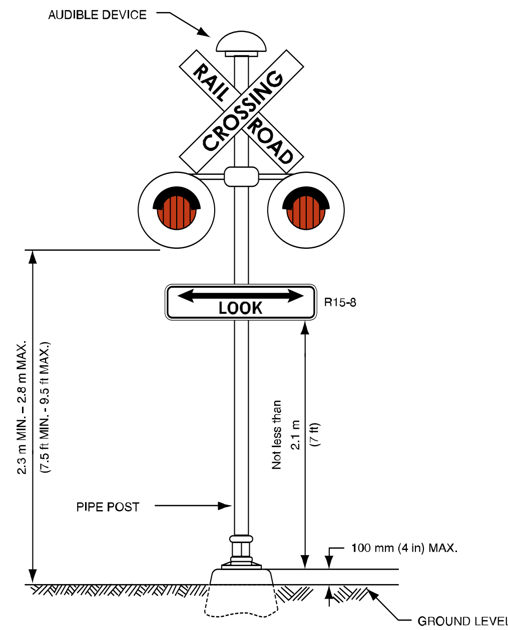


FIGURE 5.28 Typical light rail transit flashing light signal assembly for pedestrian crossings (MUTCD Fig. 10D-2)

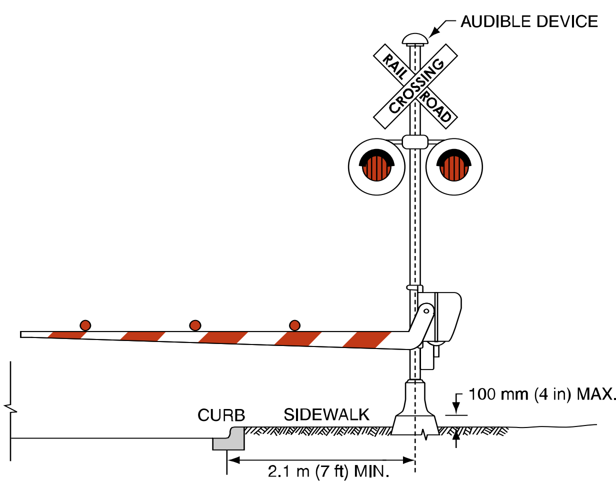


FIGURE 5.29 Typical pedestrian gate placement behind the sidewalk (MUTCD Fig. 10D-3)

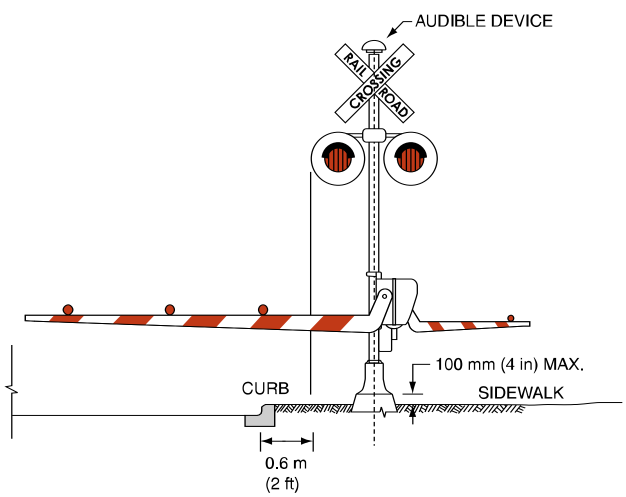


FIGURE 5.30 Typical pedestrian gate placement with pedestrian gate arm (MUTCD Fig. 10D-4)

See *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings* (FHWA, 2002) for information about selection of traffic control devices. Flashing light signals combined with swing gates (see **Figure 5.30**) may be needed in cases of high speed transit or freight rail, limited sight distance, multiple tracks, and temporary sight obstructions, such as standing freight cars.

Railroad and trail planners should note that the same controls that generally keep a motor vehicle from crossing a track may not keep a pedestrian or bicyclist from proceeding through a crossing. People on foot or bicycle are reluctant to stop at barriers and will often find a way to proceed over, under, or around barricades. Photos of effective treatments in Perth, Australia, are shown on pages 70 and 71 and in Burlington, Vermont, on page 73.

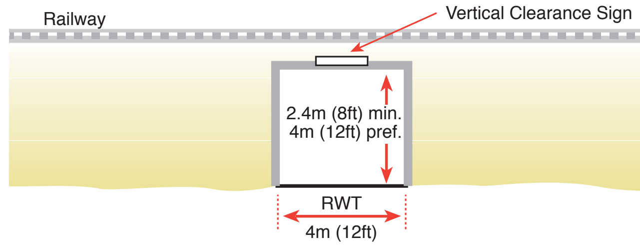


FIGURE 5.31 RWT culvert under tracks

Grade-Separated Trail-Rail Crossings

Grade-separated crossings (overpasses and underpasses) can eliminate conflicts at trail-rail crossings by completely separating the trail user from the active rail line. Refer to the AASHTO Bike Guide for specific design dimensions and lighting requirements for bridges and tunnels. In the case where a bridge or tunnel is constructed, a number of issues should be considered:

- EXISTING AND FUTURE RAILROAD OPERATIONS: Bridges and underpasses must be designed to meet the operational needs of the railroad both in present and future conditions. Trail bridges should be constructed to meet required minimum train clearances and the structural requirements of the rail corridor (see **Figures 5.31-5.34** and photos on page 80).
- SAFETY AND SECURITY OF THE FACILITY: Dark, isolated underpasses that are hidden from public view can attract illegal activity. Underpasses should be designed to be as short as possible to increase the amount of light in the underpass, and to decrease its attractiveness as a hidden area. Adequate lighting is extremely important.
- MAINTENANCE: The decision to install a bridge or underpass should be made in full consideration of the additional maintenance these facilities require.

According to the AASHTO Bike Guide, the minimum clear width of the pathway on a bridge or through a tunnel should be the same as the width of the approach path, with an additional 0.6 m (2 ft) clear area on the sides. Therefore, the minimum width of a tunnel or bridge on a 3 m (10 ft) wide trail would be 4.3 m (14 ft). Vertical clearance should be 2.4 m (8 ft) minimum (see **Figures 5.31** and **5.32**). Larger horizontal and vertical clearances may be needed for certain types of maintenance and emergency vehicles. Future needs for vehicular access should be taken into consideration when designing these structures.

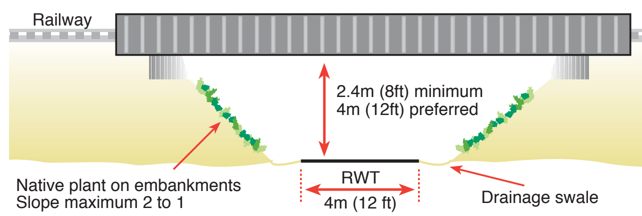


FIGURE 5.32 RWT track undercrossing

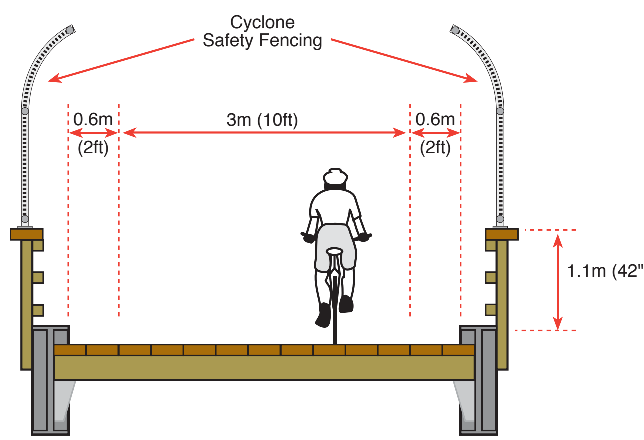


FIGURE 5.33 RWT track overcrossing

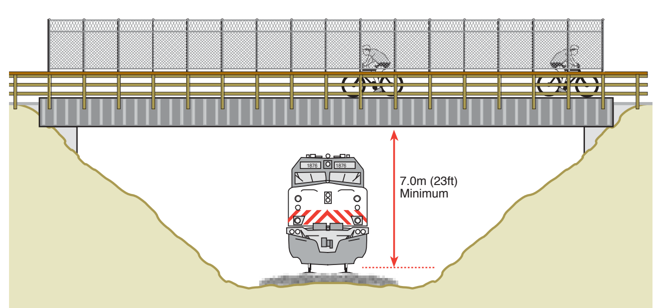


FIGURE 5.34 RWT track overcrossing (meets Amtrak required clearance height for non-electrified track)

SAMPLE UNDER- AND OVERCROSSINGS

Apple Tree Park. *Vancouver, WA*

Platte River Trail. *Denver County, CO*

Tony Knowles Coastal Rail Trail. *Anchorage, AK*

Trail-rail overcrossing. *San Luis Obispo, CA*

Bridge over Union Pacific tracks. *Portland, OR*

Approach grades for bridges and tunnels on RWTs should follow AASHTO guidelines and typically also must meet ADA Accessibility Guidelines. Again, a greater than five percent grade is not recommended.

Trail-Roadway Crossings

At-grade crossings between RWTs and roadways can be complex areas that require the designer to think from the perspective of all types of users who pass through the intersection: trains, motorists, bicyclists, and pedestrians. Trail-roadway intersections are covered in detail by both the AASHTO Bike Guide and the MUTCD. While these manuals do not specifically recommend solutions for RWT crossings, they cover basic safety principles that apply to all trail-roadway crossings.

Variables to consider when designing trail-roadway intersections include right-of-way assignment, traffic control devices, sight distances, access control, pavement markings, turning movements, traffic volume, speed, and number of lanes. Refer to the AASHTO Bike Guide for information regarding these design factors. All traffic control devices should comply with the MUTCD.

At-Grade Trail-Roadway Crossings

At-grade RWT-roadway crossings can be very complex, and typically require the involvement of both the roadway agency and the railroad company. Each must be evaluated on a case-by-case basis through engineering analysis. There are essentially three different methods for handling RWT-roadway crossings:

1. Reroute shared use path users to nearest signalized intersection (see **Figure 5.35**).
2. Provide new signal across roadway (see **Figure 5.36**).
3. Provide unprotected crossing (see **Figure 5.37**).

Another possible scenario (although undesirable) has trail users crossing both the roadway and tracks, as shown in **Figure 5.38**.

The appropriate crossing design should be selected based on the following considerations:

- Motor vehicle traffic must be warned of both types of crossings (railroad and trail). Care should be taken to keep warning devices simple and clear; ambiguous and overly complicated signage and pavement markings can distract both motorists and trail users.
- If a pedestrian-actuated traffic signal is warranted at a mid-block RWT-roadway crossing, the traffic signal should be integrated with the design of active warning devices that alert motorists of an approaching train. This may require redesigning several aspects of the intersection.
- If automatic gates are used, they should be placed in between the trail crossing and the active track(s). Where possible, the stop bar on the highway should be located behind the trail crosswalk. However, if the crossing is located at too great a distance from the automatic gate, the stop bar should be placed in a standard position near the gate, and a DO NOT BLOCK CROSSWALK sign should be used at the trail crossing.

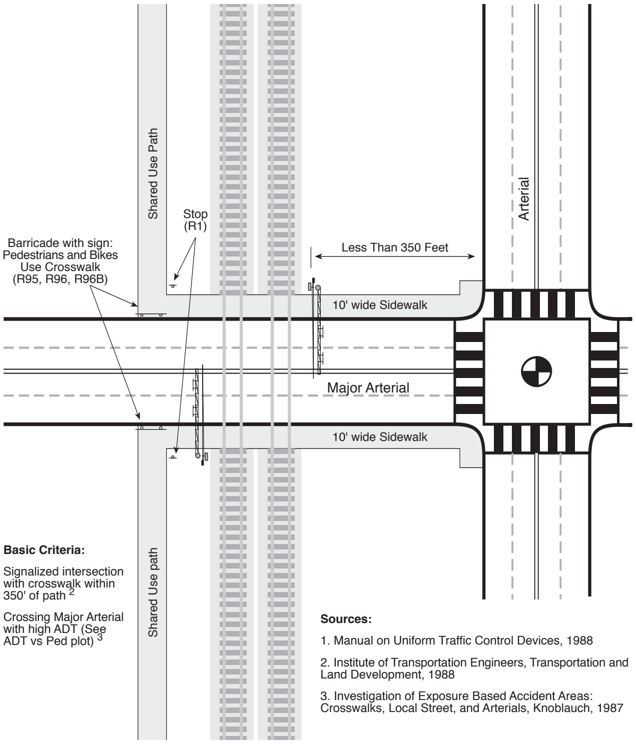


FIGURE 5.35 Roadway crossing type 1 (reroute to nearest intersection)

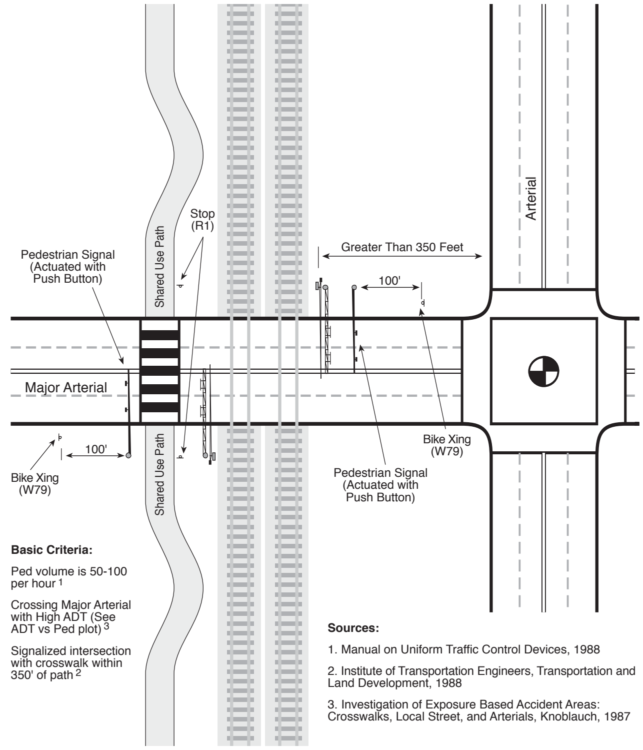


FIGURE 5.36 Roadway crossing type 2 (new signal)

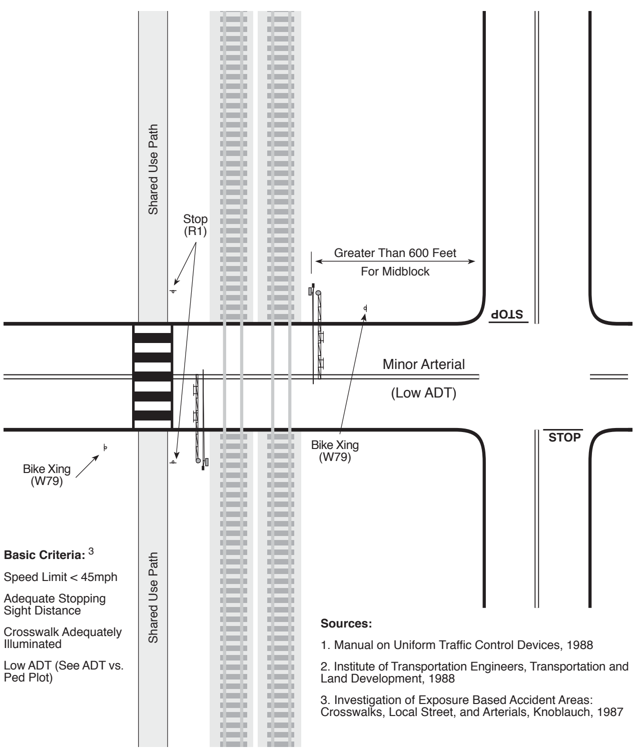


FIGURE 5.37 Roadway crossing type 3 (unprotected crossing)

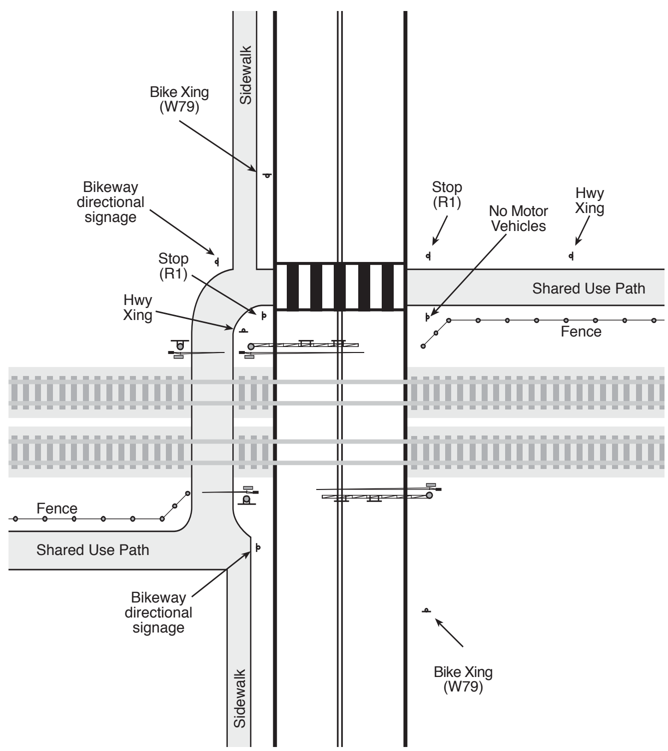


FIGURE 5.38 Roadway and track crossing

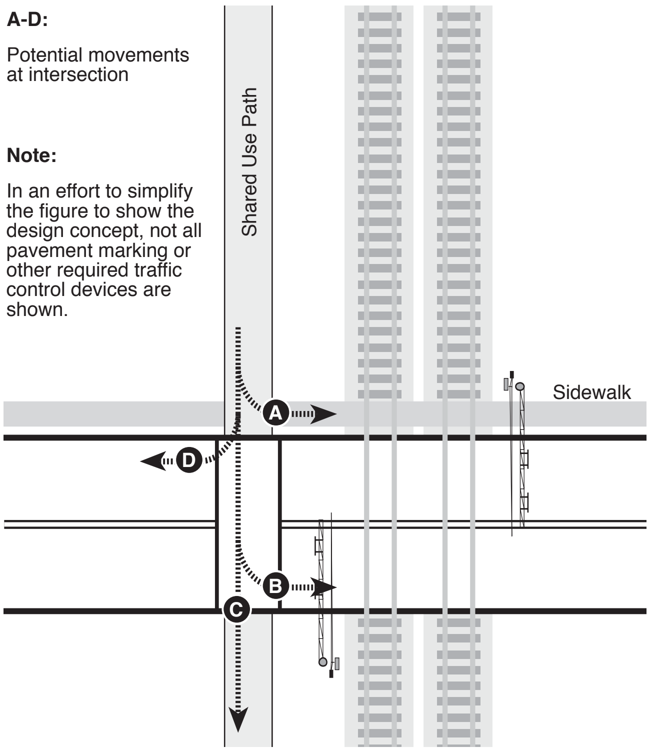


FIGURE 5.39 Summary of potential trail user movements

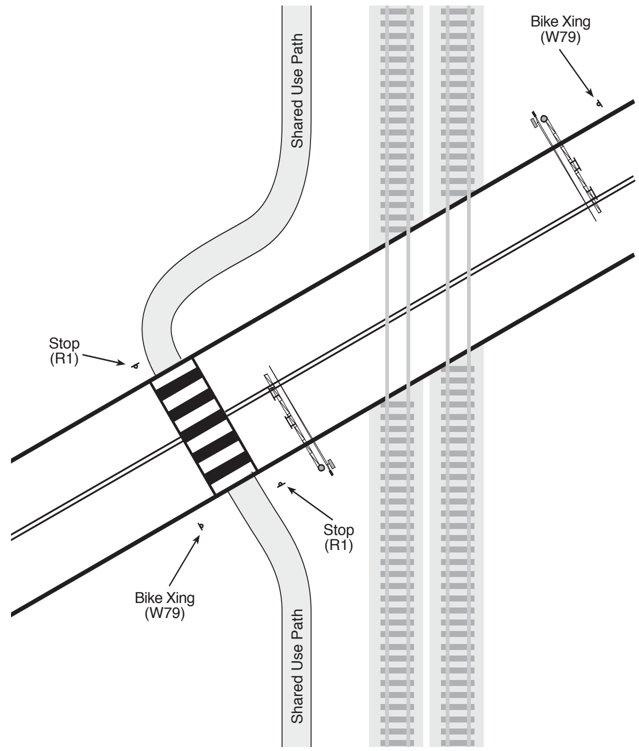


FIGURE 5.40 Angled intersection with roadway

- If active warning devices are used, the trail should be integrated so that trail users are made aware of approaching trains. Trail users may either elect to travel straight across the road, or may exit the trail and continue their journey on the roadway (see **Figure 5.39**). In this scenario, turning movements towards the tracks could be hazardous if the trail user is unable to view active warning devices, or if sight distances are restricted. The angle of approach for these trail users must be considered when placing warning devices. In cases where flashing light signals (post mounted) are used, it is important to locate these devices so that they can be seen by trail users, and to include bells and other audible warning devices to provide additional warning to bicyclists and pedestrians.

RWT-roadway intersections can become further complicated if the railroad crosses the roadway at an angle. Angled trail crossings are not recommended, because they increase the amount of exposure time in the roadway for pedestrians and bicyclists. **Figure 5.40** shows an alternative crossing design that permits trail users to cross perpendicular to the roadway at angled rail-highway crossings.

Grade-Separated Trail-Roadway Crossings

Where a proposed RWT will cross a major roadway or highway carrying heavy traffic volumes (typically more than 20,000 vehicles per day) and/or traffic at speeds greater than 72 km/h (45 mi/h), grade separation should be explored regardless of where the adjacent railroad tracks are located. The design issues related to these undercrossings or overcrossings are the same as on all other shared use paths, and are not covered in this document.

Utilities

Many railroad corridors have utilities that may impact the design, location, or even the feasibility of an RWT. At a minimum, most railroads have their own internal communication systems within their corridors, sometimes located on poles. Any RWT would need to either avoid these poles with a 0.9 m (3 ft) minimum shy distance, or relocate per specification by the railroad. Sometimes a railroad will require that their relocated communication lines be placed underground in new conduit.

Buried fiber optic cable, Washington & Old Dominion Trail. *Fairfax County, VA*

Surface and subsurface utilities often are located within the railroad right-of-way, impacting the location and construction of the RWT. Utilities include active and abandoned railroad communications cable, signal and communication boxes, fiber optic cable, and water, sewer, and telephone lines. Added to this mix, utilities may run parallel to the tracks on one or both sides of the right-of-way, and across, under, or over the tracks.

Trails may need to be closed temporarily to allow utility work. The manager of the Cottonbelt Trail, Texas, notes that one should expect to have interference when utilities companies perform maintenance. The Explorer Pipeline Company required the Cottonbelt Trail to have removable pavement where the trail crossed its pipeline.

Part of the initial feasibility study should identify existing utilities in the corridor, and specifically (a) ownership, (b) location, and (c) easement agreements with the railroad company. While it is not uncommon for a trail to be constructed on top of a subsurface utility, there typically are easement restrictions and requirements that will impact the trail design and location.

RWTs may be constructed with buried conduit under or adjacent to the path to serve existing or future utilities. Inclusion during initial construction saves immense cost and disruption in the future. Conduit and auxiliary equipment (e.g., repeater boxes) should not present slip, trip, or fall opportunities; visual obstacles; or other hazards. The feasibility study staff also must meet with both the railroad and utility representatives to discuss their concerns and requirements.

Accommodating Future Tracks and Sidings

A fundamental part of any feasibility study is to examine the possible addition of tracks and sidings (railroad car storage facilities) that will have a direct impact on RWT design and alignment. The RWT team must seek out information from the railroad operator about their future expansion plans. In many cases, a railroad company may not have specific plans but may want to reserve room to expand in the future if it is needed. In other cases, a railroad operator may have specific plans for additional tracks, either in the short, mid, or long term. In still other cases, a transit agency may have long range plans to use part of or the entire corridor for future transit or commuter rail service. Should a railroad company choose to reserve their land for future rail service, the trail project is not likely to be feasible.

The issue of sidings must be clearly understood by the feasibility study team. A corridor may have existing but unused sidings that either may be removed if the land use has changed significantly or reactivated if a new tenant comes in or economic conditions change. If a rail corridor traverses an industrial or warehouse area, there may be a future need for sidings to serve future land uses, impacting the proposed RWT.

Siding on site of proposed RWT.
Kelowna, BC, Canada

Should additional tracks or sidings seem a possibility even in the long term, they should be included in the RWT design process. In flat terrain, the additional tracks should be located on the opposite side of the proposed RWT, and there should be sufficient room for additional tracks if the RWT is located at the extreme edge of the right-of-way. In terrain with cut and fill, any future tracks would probably require major engineering that would most likely impact the overall feasibility of the RWT project within a typical 30 m (100 ft) wide railroad right-of-way.

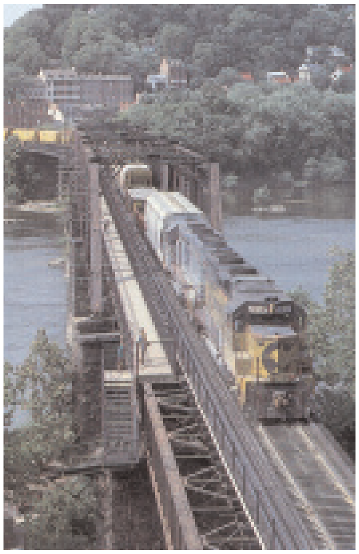
An RWT should be located and designed so as to avoid active, potentially active, or potential future sidings. RWTs that cross sidings pose operational and safety problems for the trail manager and rail operator alike. A railroad corridor with numerous sidings or industrial spurs on both sides of the existing tracks would be a poor choice for an RWT project.

One option is to include language in the easement or license agreement to remove or relocate the RWT in the event that there is a future need for additional tracks or sidings. If there are firm plans for future expansion, this is not likely to be attractive to the railroad operator because of the anticipated difficulty in removing or rerouting a popular path in the future.

Trestles and Bridges

As part of the feasibility analysis, the presence of trestles and bridges will loom large as major constraints to the overall feasibility of a project. Virtually all railroad corridors will have at least some minor bridges or culverts either as part of the local drainage system, or the local network of streams and creeks. In some cases, there will be longer trestles and bridges over roadways, highways, rivers, and canyons. In almost all cases, the railroad structures are not designed to accommodate pedestrians at all, let alone bicycles, and represent a real safety hazard (and attraction) to trespassers.

Simple prefabricated bridges over small streams, culverts, and other waterways are not expensive items. However, they may impact a project's feasibility from an environmental perspective. A new bridge over a highway or on a long trestle may have enormous costs, and may, in some cases, represent the single greatest cost on the project.



Harpers Ferry Bridge. *Harpers Ferry, VA*

Steel Bridge Riverwalk. *Portland, OR*

RWT bridges constructed over existing roadways or over corridors with existing trails or bikeways pose a special problem. Neighboring residents will want access to the RWT. Since these connections will need to meet ADA gradient standards, they may involve the construction of an expensive series of ramps.

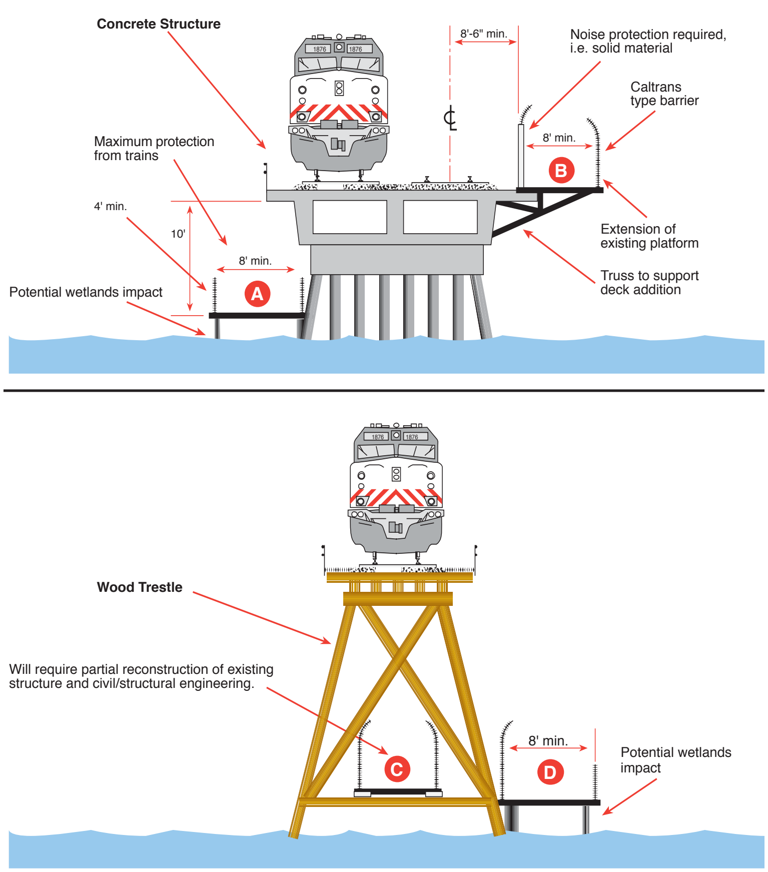


FIGURE 5.41 Trestle options

Engineers can design solutions to virtually any challenge (see **Figure 5.41**). Any trail facility that is to be appended to or otherwise incorporated into a bridge must maintain full and unimpeded bridge maintenance and inspection access. Some of the prototype solutions for RWTs on corridors with bridges and trestles include:

• *Use of existing structure.* In rare cases, an RWT has been constructed on an existing railroad structure. This has been accomplished in Harper's Ferry, Virginia, on a bridge where there were formerly two or more tracks by placing the RWT on the roadbed of the abandoned tracks and placing a security fence between the active tracks and the RWT. The other option is to construct a bridge structure that is attached in some fashion to the existing trestle or bridge. For example, in May 2001, the City of Portland, Oregon, opened a new 3 m (10 ft) shared use path, cantilevered onto the south side of the Union Pacific Railroad bridge (Steel Bridge), set back 3.7 m (12 ft) from the track centerline. While this may be less expensive than constructing a completely new

Single track tunnel on Lake Oswego Trolley Line. *Lake Oswego, OR*

bridge, the RWT developer must be prepared to make structural integrity improvements to the existing bridge and assume maintenance and liability protection for the new combined structure.

- *Construct a new structure.* This offers a simple, independent solution, rather than trying to utilize an existing railroad structure. This option may be very expensive and may have negative environmental impacts if it requires construction in a riparian or other habitat. If constructed over a State highway, it may require time-consuming permit approvals and strict design standards.

Tunnels

The presence of a single track tunnel on a railroad corridor typically signifies that an RWT is not feasible, at least on the segment where the tunnel is located. There is one known case of a shared rail-with-trail single track tunnel: the York County Heritage Trail, Pennsylvania, which is along an active tourist rail line. Trail users are required to wait when a train is in the tunnel. Usually, tunnels are constructed where the topography dictates the need for going through — rather than around — terrain, meaning that an RWT would have a difficult time traversing over or around the obstacle to avoid a tunnel.

In some cases, there is a roadway or even an abandoned railroad roadbed that could be used by an RWT to circumvent the tunnel. If the terrain is not too steep, an RWT could go over the tunnel hill. While multi-track tunnels with one or more abandoned tracks could conceivably serve dual usages, no known examples exist, and they should be avoided.

RWT designs must take endangered species into consideration. *Victorville, CA*

Environmental Constraints

If necessary, a full environmental assessment per State and Federal National Environmental Policy Act (NEPA) law should be included as part of the RWT feasibility study. Environmental impacts are not relegated simply to riparian zones, but include impacts to:

a. public safety
b. public expenditures
c. light and glare
d. geology, soils, and hydrology
e. biological resources
f. land use
g. cultural resources
h. aesthetics
i. transportation and circulation
j. economics
k. parks and recreation
l. noise levels

The environmental analysis should be conducted simultaneously with feasibility study to allow for the RWT design team to minimize or avoid significant environmental impacts. The environmental analysis also provides a good forum for public input and political approvals, and usually is a required activity if the project is to receive Federal funding. In some cases, the environmental impacts of a proposed RWT will be so great as to make the project unfeasible. In other cases, the RWT enhances a previously damaged site. Thus, the impacts may be offset by proposed mitigation and/or by the benefits accrued from the project.

Support Facilities and Amenities

Any new trail or RWT will require support facilities both to enhance the experience for trail users, and to serve basic user and manager needs. Some of these items could be considered extra amenities that are dependent on local desires and available budget, while others should be considered basic elements of any new trail facility.

Trailheads and Parking Areas

Any new RWT will attract people to drive and park near the facility, potentially impacting local neighborhoods. The best design will locate trailheads, parking areas, restrooms, and other such facilities on the same side of the tracks as the trail, so as to avoid additional crossings. A feasibility study should include a full analysis of access to the trail from local communities, along with a projection of future annual and peak day usage and

Tree-lined RWT looking north. *Burlington, VT*

modal split. Should the analysis reveal that a significant number of vehicles will be parking near the RWT, a trailhead parking scheme should be included as part of the feasibility study (see **Figure 5.42**).

Aside from parking, trailheads also offer amenities such as restrooms, entrance signs and maps, kiosks, drinking fountains, and other features. These and other details of trailheads are a standard element of most trail master plans and trailhead designs, which any landscape architecture or trail planning firm should provide as part of the design team.

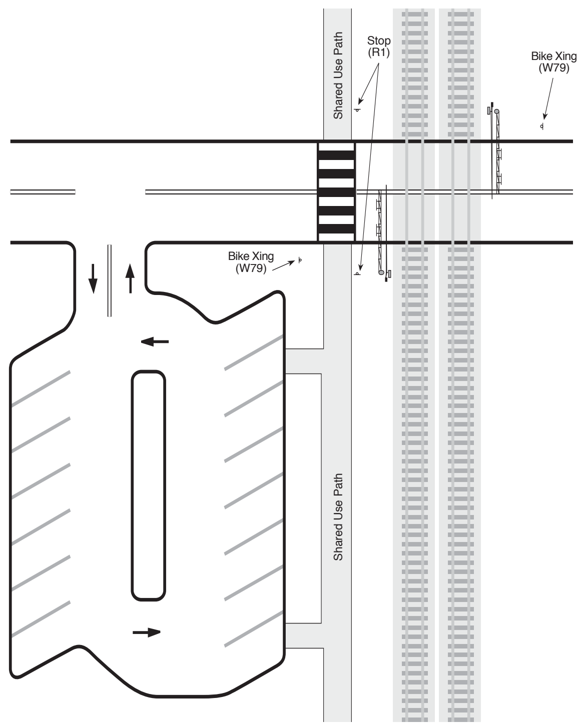


FIGURE 5.42 Trailhead and parking design

Landscaping

Landscaping is an optional but very important element of any new trail. Landscaping offers not only visual relief and aesthetic benefits, but also shelter from the sun and wind and assistance with erosion control. At the same time, landscaping can be very expensive to install and maintain, especially if it requires irrigation. Most trail projects utilize landscaping at gateways and specific areas along the corridor, and often use native, drought-resistant species that do not require irrigation. Landscaping should not interfere with track and roadbed maintenance or the visibility of motorists, trail users, or the locomotive engineers at crossings.

Lighting on Eastbank Esplanade. *Portland, OR*

Trailhead sign, Burlington Waterfront Bikeway. *Burlington, VT*

Signing on the Railroad Trail. *Gaylord, MI*

Drainage

Railroad corridors are constructed with both lateral and cross roadbed drainage in order to keep water off of the tracks and ballast. Lateral drainage consists of the ditches seen parallel to most tracks and ballast, which in turn feed into natural or built waterways. Cross-roadbed drainage pipes are used to connect lateral drainage ditches via a connection under the tracks.

Maintaining the integrity of the railroad drainage system is of paramount importance for any RWT. Since many RWTs are constructed where there is an existing lateral drainage ditch or swale, a new drainage system must be designed. The cost of this system, along with a section identifying the basic design approach, should be included in the feasibility study. Also, the RWT paved surface will add to the local surface runoff, and should be included in the drainage calculations as appropriate.

The feasibility study should include a section on drainage, and especially how the existing railroad drainage system will be maintained. Prototype designs of any changes along with cost estimates should be included if the RWT will impact the existing drainage system in any way. The railroad company or agency should review plans, even if the proposed trail is adjacent to railroad property.

Lighting

Lighting an RWT is dependent on a variety of factors, including cost to install, maintain, and operate; whether the RWT will be used as a commuter facility in the winter and low light hours; and potential impact on neighbors. Most paved paths are not illuminated due to the expense to install and maintain the lighting and the potential impacts on nearby homes. Exceptions to this are at-grade crossings and undercrossings, where lighting is a matter of safety and visibility. Trail designers should take into account lighting impacts on train operation and visibility for any RWT crossing of or under a roadway and/or tracks.

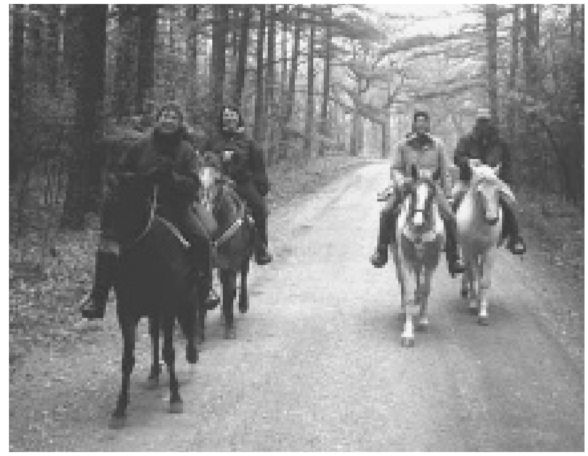
One innovative pathway lighting concept that may be considered is to have lighting activated by motion detectors, so that the trail is lighted while people approach and a few minutes after they pass, but not for the entire night.

Signing and Markings

Advisory and regulatory signs on RWTs related to transportation (stop, slow, curve ahead, etc.) should follow MUTCD standards, especially for signs that directly impact user safety. The size, frequency, location, and other aspects are clearly identified in the MUTCD or State highway design manual. Local agencies may use their own discretion for other signs, such as user protocol between pedestrians and bicyclists, speed limits, hours of use, and emergency contact information.

The feasibility study should present recommendations, designs, specifications, and costs on signing and striping that meet Federal and State standards, and the local agency needs. This may include entrance or gateway signs, natural or historic interpretation signs, or regulatory and etiquette signs.

Equestrian Considerations



Equestrian RWT users require special design consideration. *Bourbon, MO*

Lack of equestrian experience near railroads, horses' instinctual flight behavior, and equestrians' general wariness of new and potentially challenging situations require specific design considerations when planning for equestrian use on RWTs. All RWTs with potential equestrian use require site-specific analysis. Some equestrian users advocate fences of sufficient height to prevent horses jumping them when startled or frightened; however, this concern must be balanced with the need for visibility of trains for both horses and riders. Horses that cannot see an oncoming or approaching train will experience greater fear and confusion than if they are able to see and identify the source of noise. Equestrian use should not be promoted where barriers create a narrow trail environment.

Trail width is an overriding design issue when considering equestrian use on RWTs. RWTs designed to accommodate equestrian use should provide separate pathway treads for multiple users. Narrow railroad rights-of-way that afford width for only a single paved trail, or that provide inadequate shy distance for horses frightened by nearby or oncoming trains, are not appropriate candidates for accommodation of equestrian use.

Trestles and bridges require additional considerations. Many horses are frightened by bridges and other elevated environments, particularly lattice or perforated bridges and trestles that allow the animal a view of the ground surface substantially below the bridge deck. Most horses are not accustomed to this environment and will respond unpredictably with potentially negative consequences.

Considerations for Steam Locomotives

Several trails exist and/or are proposed within proximity to steam locomotives, for which special consideration is warranted. From time to time, depending on operations and the steam locomotive itself, it is necessary to blow condensation out of the steam cylinders while the locomotive is standing or moving. The outlets for this escaping steam and moisture are less than 300 mm (12 in) above the ground, and generally shoot out perpendicular to the locomotive. This may startle nearby trail users. Also, the reciprocating motion of valves and drive rods (attached to the large drive wheels) require additional lateral clearance for safety reasons. Thus, the feasibility study for RWTs proposed alongside steam locomotives should analyze the need for additional setback and other safety measures.