Guidelines

For Work Zone Designers

Pedestrian & Bicycle Accommodation

DEPARTMENT OF
Civil and
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UNIVERSITY OF WISCONSIN–MADISON

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15. Supplementary Notes This material is based on work supported by the Federal Highway Administration. This publication does not constitute a national standard, specification or regulation.			
16. Abstract Most State and many other transportation departments in the U.S. maintain roadway and/or work zone design manuals containing State specific regulations, policies, and design guidance for their designers and consultants to use. However, those manuals vary widely in the depth of coverage and the work zone design topics offered. National work zone design guidelines are lacking. This series of guidelines for work zone designers covers various work zone safety design topics for states, design manual decision makers, editors, and subject matter experts to develop or enhance their own guidance materials. "Guidelines for Work Zone Designers – Pedestrian and Bicycle Accommodation" provides guidance covering the topic of safely accommodating pedestrians and bicyclists in work zones and is not intended to be a stand-alone document for designing work zone traffic control plans. State, county, local, and tribal transportation agency subject matter experts, should use this material as reference material to augment their own work zone design policies and guidance. The material in this guide was gathered from existing State design manuals, considered as best state-of-the-practice by the authors and worthy of sharing with other states, and from state-of-the-art work zone safety and traffic management research documents developed by the Transportation Research Board, the FHWA and other institutions.			
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0. Foreword

This document is part of a series of prototypical work zone design guidelines developed at the University of Wisconsin-Madison Department of Civil and Environmental Engineering's Traffic Operations & Safety Laboratory through a grant provided by the Federal Highway Administration (FHWA). The documents in this series are intended to serve as templates for incorporation into Design Manuals prepared by state Departments of Transportation (DOTs) and other highway agencies such as tollway authorities and county, municipal, & tribal transportation departments.

Recommendations included in this document represent the authors' opinions of good practices as of the date of publication, but are not intended to serve as a standard, policy, or comprehensive reference guide. Instead, the intent is that the materials in this document will be adapted and augmented by highway agencies based on their own operational experiences, traffic conditions, topography, climate, organizational structures, risk management policies, legislation, case law, etc.

This document is intended to help highway agencies develop their own work zone pedestrian/bicyclist traffic management guidance, either as a section of an agency Design Manual (DM) or as a stand-alone document.

1. Introduction

Every year approximately 120 pedestrians and bicyclists are killed in work zones in the United States [1]; thousands more are injured. While some of these crashes would have occurred even without construction, many are in some way related to the presence of a work zone. Far too often, work zones are difficult for able-bodied pedestrians to navigate, and impassible (or nearly so) for pedestrians with disabilities. Work zone layouts not constructed following standards or best practices can sometimes provoke pedestrians and bicyclists to take risks that they would ordinarily avoid, resulting in preventable casualties. Highway designers are at the forefront of improving this situation. In this document, designers will find detailed information they can use to plan and design safer work zone pedestrian/bicyclist accommodations that are cost-effective, responsive to local site conditions, and consistent with the needs of a wide range of road users including people with disabilities.

In the past, many highway agencies in the United States left the layout of temporary pedestrian accommodations to the discretion of inspectors, field engineers, or other construction staff. This is problematic for a number of reasons:

- After a construction contract has been awarded, options for managing pedestrian and bicyclist traffic are generally quite limited. There are usually more options during the design phase.
- Maintaining accessible non-motorized routes during construction may be a legal duty in some jurisdictions.
- Field staff may or may not have the skills necessary to design safe, efficient interim pedestrian/bicyclist accommodations. Even when field personnel have appropriate expertise, designing the accommodations takes time away from their construction oversight and contract management duties, and therefore potential inconsistent application of pedestrian/bicyclist standards and guidelines.
- Temporary easements necessary for interim pedestrian/bicyclist facilities on private property require time for acquisition and is best done during the design process.
- The contract might not include the bid items necessary for constructing temporary or interim pedestrian/bicyclist facilities. This could result in substitution of contractual bid items intended for permanent use, resulting in unnecessary expense. In the extreme case, the contractually available materials may be too durable and additional costs may be incurred to demolish temporary facilities that were used for only a short time. For example, it rarely makes sense to lay a 6” thick concrete sidewalk that will be removed a few weeks later in a subsequent construction stage.
- The contractor might not be expecting to build temporary pedestrian/bicyclist facilities. Consequently, equipment and personnel appropriate to the task might not be readily available, resulting in costly change orders.
- Increased stress on communications between field staff on adjoining projects to assure pedestrian/bicyclist accommodation continuity.
- Communication with stakeholders and the public pertaining to pedestrian/bicyclists accommodations during construction are limited or non-existent.

The staging of pedestrian/bicyclist facility construction is often a significant consideration for projects where there is existing bicycle or pedestrian traffic. If the pedestrian/bicyclist construction staging is not clearly specified in the contractual documents, bidders will naturally make their own assumptions about how to build the project. In some cases, providing acceptable accommodations can conflict with the assumptions used to determine the winning bidder's price. This can result in safety issues, complaints from the public, or cost overruns.

1.1 The Safe System Approach

The Safe System Approach is a proven method for improving transportation safety. Fundamentally, it says that improving roadway safety is a responsibility all share as creators, managers, and users of the transportation system. To reduce casualties, safer roads, safer vehicles, safer speeds, and safer road user behavior are needed. In order to create a Safe System, it is necessary to recognize that all humans make errors and take risks—even road users who are well educated and law-abiding. Although it is probably not possible to prevent all crashes, the objective is to prevent death and serious injury caused by crashes.

The central idea of the Safe System is that when one part of the system fails, other parts of the system will be there to protect people and minimize the consequences of the failure. Much of the recent progress in improving motor vehicle safety can be attributed to safety features such as airbags, crumple zones, antilock brakes, and traction control. Pedestrians and bicyclists are vulnerable road users: their "vehicles" do not have the protective features that are now standard on passenger vehicles. As a result, the physical design of the work zone environment is doubly important for their safety.

Designers play a pivotal role in creating the Safe System. Designers select and specify a wide range of features that affect bicyclist and pedestrian safety in the work zone environment. These design decisions can affect the likelihood that a road user will be able to correct a mistake or misjudgment before it is too late.

Although designers do not directly control the behavior of pedestrians and bicyclists, designers influence the way people behave. For example, if pedestrians perceive a design to be unreasonably inconvenient (such as a long detour) they will be tempted to take risks to avoid the inconvenience (such as jumping a fence or making a mid-block crossing at a location with poor sight distance). Good design provides visual, tactile, and sometimes auditory clues that show the user which actions are desired and which are undesired. Great design makes it easy for people to do things the safe way.

1.2 Characteristics of Pedestrian/Bicyclist Crashes

According to 2003-2012 data from the National Highway Traffic Safety Administration (NHTSA), approximately 120 pedestrians and bicyclists were killed in work zones in the United States each year [1]. Approximately 2% of all pedestrian/bicyclist deaths occurred in work zones. Among work zone fatalities, the proportion of deaths involving bicyclists and pedestrians grew from 12% in 2002 to almost 17% in 2012. Of the non-motorized fatalities in work zones, approximately 93% involved pedestrians and the remaining 7% involved bicyclists.

Although not specific to work zones, a recent Canadian report found that 40% of fatally injured pedestrians had been drinking, 60% of pedestrian deaths occurred at night or in dim light, and 34% of fatally injured bicyclists were struck by a vehicle in darkness [2]. Therefore, these statistics foreshadow the importance of the information provided in this guide for designers to consider when designing TTC plans.

1.3 Accommodating All Road Users

Road users include the drivers and passengers of cars, buses, and heavy trucks along with public transit users, bicyclists, pedestrians, and (in some places) equestrians and horse-drawn vehicles. All road users (including people with disabilities) need to be safely accommodated during construction.

Although motor vehicle drivers are subject to age restrictions and testing of their vision and knowledge, there are no such limitations for other types of road users. As shown in Figure 1, even young children and people with severe physical or mental disabilities could be present in a work zone as pedestrians, bicyclists, or transit riders. In addition, over the past several years an increasing percentage of people with the means and ability to drive have been choosing to walk, bicycle, or use transit, especially in larger cities. As a result, it is more important than ever to accommodate road users safely during all highway construction projects:

1. Urban streets and suburban arterials often have large numbers of pedestrians and other non-motorized road users. In suburban environments, many trips involve a combination of bus and walking travel. For example, many retail, restaurant, and hotel employees commute by bus and then walk relatively long distances from the bus stop to their places of employment.

2. Pedestrian/bicyclist considerations are often overlooked on two-lane rural highway work zones. In rural non-resort areas, much of the pedestrian traffic may consist of people crossing the roadway to get to school bus stops, mailboxes, and neighboring residences. People walking and biking on the highway shoulder can be quite common in resort areas and near recreational facilities, schools, hotels, and other businesses. Where the shoulders are not well-defined, the presence of a beaten path parallel to the roadway is a good indicator of recurrent non-motorized traffic demand (although these paths may not be readily identifiable on aerial photos or during a project drive-through, they are often observable during a field visit on foot). In rural highway environments, the most frequently encountered pedestrians may also be some of the most vulnerable, such as school-age children and individuals unable to operate a vehicle due to physical or mental disability.

3. Although non-motorized traffic is typically prohibited on freeways or other high-speed limited access roadways, pedestrian/bicyclist access issues can still arise on projects when work on the limited-access facility impacts adjacent pedestrian/bicycle routes. For example:
   - Conflicts between bicyclists/pedestrians and highway traffic can occur at interchange ramp terminals.
   - Work on overpasses and underpasses may directly affect pedestrians, bicyclists, and transit users on the non-limited access roadway.
   - Temporary access points established to facilitate the ingress and egress of construction vehicles may conflict with existing walkways and bikeways.

Figure 1. Pedestrians without appropriate fencing from a work area.
Source: Wisconsin DOT

1.4 Temporary Pedestrian/bicyclist Design Principles

- **Accessibility** means the ability for everyone, including people with disabilities, to reach their destination safely with minimal inconvenience, as shown in **Error! Reference source not found.** . Driving detours delay arrival at the intended destination, but cyclists and pedestrians are even more reluctant to accept misdirection because biking and walking detours also require the expenditure of human energy. Another dimension of accessibility is the ability for first responders to reach workers or citizens in the event of an incident or mishap in or adjacent to the work zone.
- **Continuity** refers to a pedestrian/bicycle route that is free of physical interruptions. This includes both spatial continuity (the ability to walk or bicycle the entire project corridor) and temporal continuity (providing a pedestrian/bicyclist route throughout the duration of the project), also as shown in Figure 2.
- **Economic Feasibility** refers to developing a temporary accommodation plan that can be accomplished at reasonable cost. This includes not only the direct costs to the agency and the contractor, but also the indirect costs, such as extra travel time costs or transit fares, to pedestrians, bicyclists, and other road users. In most construction situations, the greatest indirect cost is the risk of a death or serious injury caused by inadequate temporary facilities. Another indirect cost is the extra time that it takes for detoured road users to reach their intended destination. For these computations, crash risks and delay can be converted to monetary values.
- **Separation** means using physical methods to reduce conflicts between motorized and non-motorized road users. Where there is sufficient space, separation can sometimes be accomplished using a lateral buffer space. Where width is limited, barriers are usually necessary. In some instances (especially where cycling speeds are high), it is also necessary to separate pedestrians from bicyclists to reduce risk of a pedestrian/bicyclist crash. As noted elsewhere in this document, it is necessary to keep pedestrians and all other bystanders away from construction equipment; this is usually accomplished with fencing or other physical barriers.

Figure 2. Temporary ADA pedestrian crossing
Source: UW-TOPS Lab

1.5 Trip Purpose

It is important to consider the needs of pedestrians and bicyclists making both through trips and those seeking local access to properties adjoining the work area. In urban and small-town business districts, often the majority of pedestrians are walking to business entrances. In residential areas, consideration must be given to assuring that residents are not forced to trespass across neighboring properties to reach their homes. Any impacts to sidewalks and bicycle paths affecting access to schools should be discussed with school administrators for assistance in developing mitigation strategies.

1.6 Workers as Pedestrians

Worker safety and pedestrian safety are often intertwined. Many tasks have workers move around the jobsite on foot. As they do so, they are likely to be focused on their work and not on traffic. While carrying heavy tools or materials it can be difficult for workers to act quickly if a hazardous situation develops. Workers can also be injured as they walk from their personal vehicles to the workstation or equipment. One of the most common crashes on construction sites is a worker on foot who is hit by a truck or other work vehicle that is backing up. Therefore, pedestrian safety deserves special attention when the facilities used by the public overlap with those used for internal circulation of workers-on-foot.

1.7 Legal and Regulatory Considerations

The Manual on Uniform Traffic Control Devices (MUTCD) defines the standards used by road managers nationwide to install and maintain traffic control devices on all public streets, highways, bikeways, and private roads open to public travel [3]. The MUTCD is published by the Federal Highway Administration (FHWA) under 23 Code of Federal Regulations (CFR), Part 655, Subpart F. Chapter 6 of the MUTCD includes a number of provisions related to safe pedestrian and bicycle accommodation in work zones. Mandatory requirements can be briefly summarized as follows:

- Alternate routes must be provided when pedestrian routes are closed.
- Adequate walkways must be provided to access properties adjoining the work.
- Pedestrians must be given notification upstream of sidewalk closures.
- Accessibility and detectability for pedestrians with disabilities must be maintained during construction if the existing facility is accessible or detectable*.

- If the project affects existing public transit stops, access for pedestrians and transit vehicles must be maintained or relocated.
- People involved in the project must be knowledgeable about the principles of the MUTCD and implement them using good engineering judgment.

*The MUTCD defines detectable in Section 1A.13 as having a continuous edge within 6 inches of the surface so that pedestrians who have visual disabilities can sense its presence and receive usable guidance information. However, MUTCD Section 6F.63 Channelizing Devices, provides further emphasis that devices used to channelize pedestrians shall be continuous detectable on the bottom and top, and the bottom surface shall be no higher than 2 inches above the ground and the top surface shall be no lower than 32 inches above the ground. The 2-inch dimension on the bottom supersedes the 6-inch dimension in the definition and is the controlling mandatory condition for the lower height. MUTCD Section 6F.74 Detectable Edging for Pedestrians provides examples of detectable edging products and methods, as well as colors that should be used. MUTCD Figure 6H-28 and 29, including their notes, provides typical detectable and accessibility applications for sidewalk detours and diversions.

The Americans with Disabilities Act (ADA) is a landmark civil rights law passed in 1990. The law is implemented through a series of standards issued by the United States Access Board. Facilities that are open to the public (except certain religious facilities and private clubs) are generally subject to ADA requirements. In general, *new* facilities must be designed in full compliance with ADA guidelines, while renovated facilities must be upgraded in proportion to the scope of the project.

Reasonable accommodation is a cornerstone of the ADA. This principle requires designers to exercise judgment and balance conflicting requirements. Examples of conflicts that can occur during street and highway construction include trade-offs between different categories of road users (e.g., pedestrians vs bicyclists), cost constraints, and scheduling, such as extending the construction duration to provide better temporary accommodations versus getting permanent accommodations in place quickly. In addition, individuals with different types of disabilities sometimes have differing needs.
Several different sets of ADA standards affect transportation projects to different degrees:

- **ADA Accessibility Guidelines (ADAAG).** Originally issued in 1991 and last updated in 2010, these standards primarily focus on architectural projects, i.e., the design and site planning of buildings such as apartments, offices, and shopping centers. The primary emphasis is on the indoor environment, though some elements of the guidance touch on exterior facilities such as ramps and walkways near building entrances.
- **ABA Standards.** A special version of the ADA guidance specific to facilities designed for the US General Services Administration, Department of Defense, and U.S. Postal Service.
- **ADA Standards for Transportation Facilities.** Published in 2006, this document focuses on the architectural design of airports, bus and train stations, ferry docks, and similar permanent facilities.

Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG) [4]. Issued in draft form in 2011 by the U.S. Access Board, PROWAG has not been finalized but serves as current accepted guidance regarding pedestrian design aspects of public streets and highways such as crosswalks, curb ramps, street furnishings, pedestrian signals, parking, and other components of the public right-of-way for temporary and permanent facilities. After completion of the Access Board's rulemaking, the U.S. Department of Transportation will need to adopt the guidelines into their ADA and Section 504 regulations before the guidelines can be considered enforceable standards by FHWA. Until the proposed guidelines are adopted as standards, FHWA considers the proposed guidelines to represent best practices for addressing accessibility issues in the public right-of-way [5]. All of the guidelines focus primarily on the construction-completed environment, and provide only limited guidance about temporary conditions. As a result, the designer needs to exercise judgment in determining how to maintain reasonable access for pedestrians and bicyclists during construction. In some cases, reasonable access can be addressed by providing alternate access, such as redirecting pedestrians to a side entrance while concrete is curing in front of a building or providing a temporary ramp structure over the curing concrete to provide access into a building. Tables 1 through 6 shows selected design criteria related to pedestrian/bicyclist accommodation from the draft PROWAG.

Table 1. Sidewalk and Pedestrian Access Route Dimensions and Clearances from Draft PROWAG Guidance

Design Element	Criteria	Notes	PROWAG Section
Width	Min 4.0'	Median/island: Min 5.0'	R302.3
Passing Spaces	Min 5.0’ by 5.0’ at max 200’ intervals	Necessary where the clear width is less than 5.0'	R302.4
Grade	Matching street grade	Where feasible, max 5%	R302.5
Cross Slope	Max 2%	See PROWAG for Exceptions	R302.6
Surface	Firm, stable, and slip resistant	-	R302.7
Vertical Discontinuities	Max 0.5"	Beveled with a slope less 50% (0.25' - 0.5')	R302.7.2
Horizontal Openings	Max 0.5"	-	R302.7.3
Flangeway Gaps	Max 2.5"	Non-freight rail track	R302.7.4
Flangeway Gaps	Max 3.0"	Freight rail track	R302.7.4

Source: US Access Board

Table 2. Perpendicular Curb Ramp Dimensions and Clearances from Draft PROWAG Guidance

Design Element	Criteria	Notes	PROWAG Section
Width	Min 4.0'	-	R304.5.1
Rise	Max 2.5'	-	R407.5
Grade Breaks	Perpendicular to the direction of the ramp	Not permitted on the ramp runs, turning spaces	R304.5.2
Cross Slope	Max 2%	See PROWAG for exceptions	R304.5.3
Counter Slope	Max 5%	-	R304.5.4
Turning Space	Min (4.0' by 4.0')	Top of the curb ramp	R304.2.1
Running Slope	Min 5%, Max 8.3%	Max ramp length: 15.0'	R304.2.2
Turning Space Running Slope	Max 2%	-	R304.2.2
Flared Sides Slope	Max 10%	-	R304.2.3

Table 3. Parallel Curb Ramp Dimensions and Clearances from Draft PROWAG Guidance

Design Element	Criteria	Notes	PROWAG Section
Width	Min 4.0'	-	R304.5.1
Grade Breaks	Perpendicular to the direction of the ramp	Not permitted on the ramp runs, turning spaces	R304.5.2
Cross Slope	Max 2%	See PROWAG for exceptions	R304.5.3
Counter Slope	Max 5%		R304.5.4
Turning Space	Min 4.0' by 4.0'	At the bottom of the curb ramp	R304.3.1
Running Slope	Min 5%, Max 8.3%	Max ramp length: 15.0'	R304.3.2
Turning Space Running Slope	Max 2%	-	R304.3.2

Source: US Access Board

Table 4. Blended Transition Curb Ramp Dimensions and Clearances from Draft PROWAG Guidance

Design Element	Criteria	Notes	PROWAG Section
Width	Min 4.0'	-	R304.5.1
Grade Breaks	Perpendicular to the direction of the ramp	Not permitted on the ramp runs, turning spaces	R304.5.2
Cross Slope	Max 2%	See PROWAG for exceptions	R304.5.3
Counter Slope	Max 5%	-	R304.5.4
Running Slope	Max 5%	-	R304.4.1

Source: US Access Board

Table 5. Transit Stops Dimensions and Clearances from Draft PROWAG Guidance

Design Element	Criteria	Notes	PROWAG Section
Clear Length	Min 8.0'	Perpendicular to the street	R308.1.1.1
Clear Width	Min 5.0'	Parallel to the street	R308.1.1.1
Grade (Parallel Street)	Same as the street	-	R308.1.1.2
Grade (Perpendicular Street)	Max 2%	-	R308.1.1.2
Surface	Firm, stable, slip resistant	-	R308.1.3.1 (R302.7)

Source: US Access Board

Table 6. Ramps Not Contained Within the Street or Highway Dimensions and Clearances from Draft PROWAG Guidance (Not Controlled by Street Grade)

Design Element	Criteria	Notes	PROWAG Section
Slope	Min 5%, Max 8.3%	Stairways along with ramps is desirable but not required	R407.2
Rise	Max 2.5’	-	R407.5
Width	Min 3.0’ between handrails	-	R407.6.2
Length	Min 5.0'	-	R407.6.3
Landing	Min 5.0’ by width of ramp run	-	R407.6
Landing Direction Change	Min 5.0' by 5.0'	-	R407.6.4 (R302.7)
Surface	Firm, stable, and slip resistant	-	R407.7
Handrails	Required if rise greater than 6”	-	R407.8
Edge Protection	Required 1.0’ extended ramp surface beyond face of handrail on each side	Curb or barrier required on each side of ramp if greater than 4” opening at bottom	R407.9.1 and R407.9.2

Source: US Access Board

1.8 Design Flexibility Issues

Section R201.2 of the proposed PROWAG guidance states that the document is intended to apply to both permanent and temporary facilities in the public right-of-way [4]. The guidance recognizes the importance of field constraints. Specifically, PROWAG section R202.3.1 discusses the need for flexibility in cases of facility alteration. It states that compliance is required to the extent practicable within the scope of the project where existing physical constraints make alterations impractical. Notable phrases are “**within the scope of the project”** and “**extent practicable**.” As a result, clarity of the project scope is important to the determination of compliance. The draft language also includes recognition that partial compliance may be necessary due to existing physical constraints such as terrain, underground structures, adjacent developed facilities, and natural/historic features. The duration of a temporary condition is not directly mentioned in the PROWAG guidance.

Situations requiring judgment in the application of PROWAG are likely to be encountered often on highway construction projects. For example, consider the case of an existing bridge that is 56 feet wide and carries a four-lane undivided state highway through the central business district of a small town. Under normal conditions, this would provide four 12-foot travel lanes (two in each direction) and a 4-foot wide sidewalk on each side. A typical construction method would be to repair the bridge deck in halves, split down the centerline, thus allocating 28 feet of width for work activity and 28 feet for traffic. A 2-foot-wide concrete barrier would be typically provided to separate traffic from the work zone, along with a 2-foot clearance or "shy distance" between the barrier and the traffic lanes. This could be allocated as two 10-foot lanes, one for each travel direction, and a single 4-foot sidewalk, which is the minimum required under the proposed PROWAG guidance.

2. General Design Considerations

The MUTCD establishes three guiding principles for pedestrian traffic control in work zones. These guiding principles should also apply equally to bicyclists:

- Pedestrians should not be led into conflicts with vehicles, equipment, and operations.
- Pedestrians should not be led into conflicts with vehicles moving through or around the worksite.
- Pedestrians should be provided with a convenient and accessible path that replicates as nearly as practical the most desirable characteristics of the existing sidewalk(s) or footpath(s).

2.1 Separation of Pedestrians from Work Activities

For the safety of workers and the public, pedestrians and bicyclists shall be separated from work activities and directed to safe, stable paths. Children and other unauthorized people shall be deterred from entering the work site, especially when heavy equipment is in operation (Figure 3). In addition to improving safety, separating pedestrian traffic from work operations can increase productivity by reducing the amount of time workers need to spend waiting for pedestrians to get out of their way.

Just as cones, drums, barricades, and temporary barriers are used to delineate the boundaries between traffic space and workspace for motor vehicle work zones, continuous fencing, temporary barriers, and longitudinal channelizing devices shall be used to delineate the boundaries of areas that remain open to pedestrian/bicyclist traffic and the work activity area, as shown in Figure 4. Standards, guidance, and support for pedestrian fencing, positive protection, and longitudinal channelizing devices are provided in the MUTCD sections 6F.63, 6F.70, 6F.71, and 6F.74.

Figure 3. Children bicycling in active work area.
Source: Wisconsin DOT

Figure 4. Work area with controlled pedestrian access.
Source: Photo reproduced with the permission of the American Traffic Safety Services Association (ATSSA)

Yellow tape is incapable of providing detectable path guidance and only used for emergencies for very-short duration until detectable temporary perimeter fencing can be put in place. Tape may also be used in situations where the work activity poses no significant hazard, for example to discourage pedestrians from stepping on freshly seeded grass. Tape shall never be used as the sole means of preventing pedestrians or bicyclists from entering an area with live traffic, an open trench or similar hazard.

If the site constraints are such that there is no alternative to allowing pedestrians to go through the work area to access adjoining properties, special attention should be given to assuring operational alternatives are available in lieu of physical accommodations. See Section 2.16 for a discussion on operational alternatives for accommodating pedestrians and bicyclists.

2.2 Selection of Techniques and Materials

The selection of techniques and materials for temporary pedestrian/bicyclist facilities require a clear understanding of the project context, work duration, and expected service life. For example, a municipal Department of Public Works (DPW) or state highway maintenance department may wish to build a set of reusable portable pedestrian/bicyclist accommodation devices that can be deployed on numerous projects over a period of several years. This is quite different from a contractor who is supplying pedestrian/bicyclist accommodation devices that will only be used for the duration of the construction period and then discarded. Even if the basic layout of the pedestrian/bicyclist accommodations was similar, different materials might be appropriate. For example, the DPW's reusable pedestrian/bicyclist platforms might be built from treated lumber surfaced with 3/4" treated plywood carefully assembled with polyurethane adhesive and screws, while the contractor's platforms might appropriately be built from untreated lumber and 1/2" oriented strand board quickly assembled with nails.

2.3 Pathway Widths

For temporary pedestrian pathways, the PROWAG recommended minimum width is 4 feet, with a MUTCD preferred width of 5 feet. Sections narrower than 4 feet should be an exception and kept as short as possible, preferably limited to squeezing around single obstacles such as a tree or light pole. This exception should only be used where the width restriction is the result of a physical obstruction, and cannot be justified solely based on providing more space for contractor work operations. Where sidewalks are less than 5 feet wide, passing sections with a width of 5 feet or more should be provided at regular intervals, with at least one 5-foot x 5-foot passing space approximately every 200 linear feet.

Preferred one-way bikeway widths are 5 feet, with 4 feet an acceptable minimum width. There currently are no research results on the feasibility for reducing bikeway width standards for temporary work zone situations. However, in 2014, NCHRP Report 766, "Recommended Bicycle Lane Widths for Various Roadway Characteristics", suggests it may be feasible to safely reduce permanently marked bicyclist lanes to as low as 3.5 feet, on streets with travel lanes between 10 feet to 12 feet wide. The Report 766 conclusions are most applicable to urban and suburban roadways with level grade and a posted speed limit of 30 mph and should be used cautiously for the design of roadways with motor vehicle speeds outside of the range of 25 to 35 mph, and in particular for higher-speed roadways. Therefore, it appears reasonable marked bicyclist lanes may be narrowed to 3.5 feet in work zones on facilities meeting the parameters in NCHRP 766. On projects outside the parameters in NCHRP 766, maintaining existing bicycle facility widths in work zones is recommended. If maintaining existing bicycle facilities is not possible, consider other alternatives including establishing a signed bicycle route detour or create a shared travel lane, which is referred to as a sharrow. If bicyclist facilities still cannot be physically accommodated, consider operational alternatives (See Section 2.16).

2.4 Slopes and Cross-Slopes

Under the proposed PROWAG guidance the slope of a sidewalk or other exterior walkway is permitted to match the slope of the adjoining street or highway. Where pedestrian access routes are not contained within a street or highway right-of-way, the maximum grade should not exceed 5 percent.

Some situations require the construction of temporary pedestrian ramps (Figure 5). In permanent construction the ADA standard for such ramps is not to exceed an 8.3% (1:12) slope, excepting that a 10% (1:10) slope is permitted for a rise of up to 6 inches and a 12.5% slope (1:8) is permitted for a rise of up to 3 inches. A reduction of these criteria may be necessary in temporary situations, for example a 1:10 slope with a rise of approximately 9 inches could be required to maintain access to a business on an urban street construction project, and this would typically be preferable to complete loss of access to the property. Skid-resistant surfaces are essential in outdoor environments with slopes steeper than 1:12; this can be acomplished through grooving, anti-skid tape, surface coatings, or the use of materials such as broom-finish concrete or steel diamond plate.

Figure 5. Temporary Pedestrian Ramp.
Source: Oregon DOT

Under the proposed PROWAG guidance the cross-slope for permanent outdoor walkways should be less than 2%, but may be 5% in street crossings without yield, stop, or traffic signal control. A cross-slope matching the street or highway grade is permitted on mid-block crosswalks (PROWAG R302.6). Anti-skid treatments are strongly recommended at sites with severe cross-slopes.

Careful attention should be given to drainage when temporary facilities involve the construction of surfaces that are completely flat (no slope or cross slope). For example, grooves or drain holes can be provided to prevent rainwater from ponding on the temporary surface.

2.5 Crosswalk Detectability

Tactile warning plates surfaced with truncated domes were originally developed to warn blind and visually impaired pedestrians approaching subway platform edges. As shown in Figure 6, detectable edge treatments are also used to warn pedestrians approaching points of conflict with faster traffic such as bicycles or motor vehicles. While an abrupt drop-off such as a curb can usually be detected by a blind pedestrian using a cane, it is difficult for blind pedestrians to distinguish curb ramps from other gradual slopes. ADA requires the color of tactile treatments to contrast with the ordinary walkway surface; this is primarily intended to provide a visual cue to pedestrians with low vision but benefits all sighted pedestrians. If the existing facility is detectable, the MUTCD requires detectability to be maintained during construction, including on temporary facilities and pedestrian detours.

Figure 6. Tactile warning with contrasting color at temporary curb ramp in work zone.
Source: UW-TOPS Lab

Detectable treatments should be used whenever a ramp or slope leads to a crosswalk or other situation where visually impaired pedestrians need to be alerted to the presence of cross-traffic. Temporary driveways used by construction vehicles are one such situation.

Tactile warning surfaces are produced in several materials (listed in approximate order of initial installation cost):

- Rubber or vinyl tiles
- Ceramic tiles
- Concrete paving blocks and bricks
- Cast iron plates
- Stainless steel plates

All materials are appropriate for permanent facilities in warm climates. In cold climates, cast iron or stainless steel plates are generally preferred for permanent installations because they are resistant to delamination and chipping caused by freeze-thaw cycles, de-icing chemicals, and snow removal. When specifying temporary tactile treatments, designers should generally use the least expensive material that is compatible with the temporary surface treatment and provides a service life sufficient for the duration of the temporary condition. For example, thin rubber tiles securely glued to a plywood or oriented strand board (OSB) ramp surface could be expected to perform satisfactorily for a few months if they are not subject to abuse.

Suggested Agency Policy. Detectable treatments should be provided on crosswalks and similar situations when a temporary pedestrian condition has an expected duration of 48 hours or more, regardless of the detectability of the existing route. Detectable treatments must be provided when the work duration exceeds 48 hours and the existing route is detectable.

For mobile operations, emergency repairs, and other situations with an expected duration of less than 48 hours, the use of portable temporary ramps with anti-skid surfaces is recommended. The use of detectable treatments should be considered for situations lasting less than 48 hours if the pedestrian volume exceeds 300 pedestrians during any one hour of the day (an average of 5 pedestrians per minute). Tactile warning is strongly recommended at all sites close to facilities that accommodate blind or visually-impaired pedestrians.

2.6 Vertical Alignment (Vertical Surface Discontinuities)

Excessively high vertical "lips" or thresholds are an obstacle to wheeled pedestrian traffic and a tripping hazard for foot traffic. As shown in Figure 7**Error! Reference source not found.**, the ADA optimum proposed PROWAG guidance establish that the maximum vertical dimension for an abrupt grade change is 1/4 inch. A second case, illustrated in Figure 8 allows a beveled configuration with a total rise of 1/2 inch with a slope no steeper than 1:2. Unfortunately, these configurations are often unachievable for temporary construction due to the physical characteristics of commonly-used materials such as timber, asphalt, and concrete.

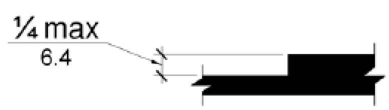


Figure 7. Flush vertical level change per PROWAG R302.7.2
Source: US Access Board

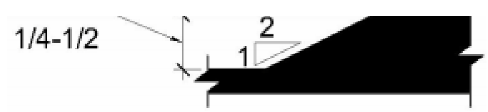


Figure 8. Beveled vertical change per PROWAG R302.7.2
Source: US Access Board

- **Wood Construction.** The most commonly-used materials for surfacing of temporary wood walkways are 3/4-inch (nominal) plywood and 3/4-inch Oriented Strand Board (OSB). Consequently, this results in a 3/4-inch vertical rise change. The most practical way to accomplish this with commercially-available materials is to use lap siding boards (also called bevel siding.) The thin end of lap siding is typically 3/8 inch. Although this thickness is slightly more than the 1/4-inch contemplated in the ADA indoor construction guidance, it is a practical minimum for temporary pedestrian/bicyclist facility construction because wood boards thinner than 3/8 inch are very likely to crack or split in outdoor environments.

- **Asphalt Construction**. As shown in Figure 9, the thin end of asphalt wedges tends to ravel or chip if a wedge is installed directly over existing pavement. The minimum thickness of asphalt is related to the size of the stone aggregate used in the asphaltic mixture. Asphalt less than 1/2-inch thick has little strength. Therefore, as illustrated in Figure 10 it is typically necessary to mill out some of the existing pavement before placing an asphalt wedge.

Figure 9. Raveling on thin edge of asphaltic wedge constructed without pavement milling.
Source: UW-TOPS LAB

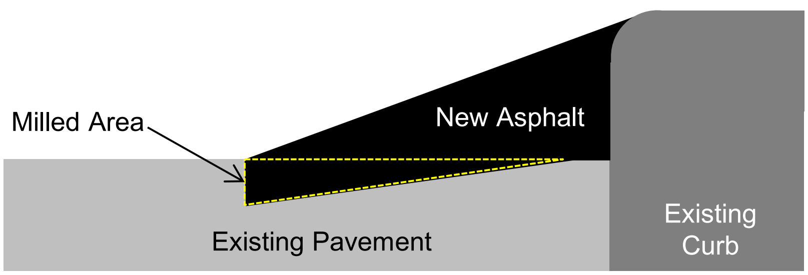


Figure 10. Milling detail for asphalt wedges used as curb ramps.
Source: UW-TOPS Lab

- **Concrete Construction.** As with asphalt, the size of the aggregate used in concrete affects the ability to construct a wedge. The most economical solution is generally to specify small aggregate and add acrylic resin admixture (also called acrylic fortifier) to make the thin edge of the wedge more resistant to chipping. Alternatively, the existing surface could be milled as shown for the asphalt case in Figure 10.

Figure 11. Existing sidewalk with vertical faulting.
Source: Wikimedia Commons

- **Existing Walkways.** As shown in Figure 11, many existing sidewalks have slab faults far exceeding 1/4 inch. In hilly areas, vertical differentials between adjacent older slabs are sometimes as much as 3 inches. The most common causes are differential settlement and tree roots. When an existing walkway is expected to have a significant increase in pedestrian traffic volume resulting from its use as a designated pedestrian detour, the designer should consider requiring milling, grinding, or filling of any severe faults or other vertical imperfections. Slab replacement may be necessary in some instances.

2.7 Gratings and Slotted Covers

Facilities that will be used as a detoured route for bicycle and pedestrian traffic should be reviewed to assure that covers are in place and in safe condition. As shown in Figure 12, inlets with wide openings placed parallel to the dominant direction of travel can be quite hazardous for bicyclists and pedestrians. Inlets with narrow openings oriented perpendicular or diagonal to traffic (Figure 13) are safer. Locking or tack-welded covers may be needed in potentially high-theft areas. Proposed PROWAG guidance would limit the width of drainage openings to 1/2 inch on new installations. PROWAG also notes the importance of orienting the openings perpendicular to traffic. Geotextile fabric is used for silt control and should be cut to avoid pedestrian tripping hazards.

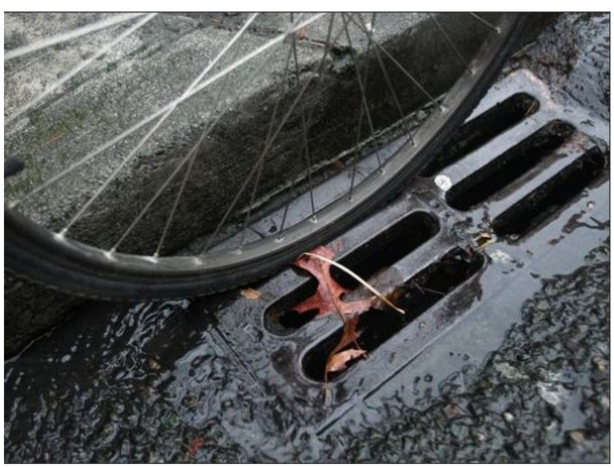


Figure 12. Some inlets are hazardous for bicycles.
Source: seattlepi.com/local/transportation/article/Cyclists-want-action-on-dangerous-storm-drains-1261495.

Figure 13. Bicycle-safe drain grate.
Source: Wikimedia Commons/Berlin gully deckle lagois-seibert

2.8 Surface Condition

The surfaces of temporary pedestrian/bicyclist facilities must be firm, stable, and slip resistant at all times. Section 5 of this document provides more information about options for surfacing materials.

2.9 Materials Storage

Salvaged materials, items awaiting installation, concrete forms, tools, and similar items should not be left in locations where they pose a tripping hazard for pedestrians. Children are often attracted to stockpiled materials and construction equipment, especially if the work zone is within walking distance of a residential area. Although these are sometimes seen as "construction" issues rather than "design" issues, good design can help prevent the problem. When laying out the work zone, consider designating locations where materials and supplies can be stored safely away from pedestrians and not affecting a safe travel path for bicyclists, preferably in an area that can be fenced to restrict unauthorized access.

In many cases, space within the work zone is limited, and consideration should be given to designating near-site location(s) for material storage. It is often preferable to have several small storage sites close to the work area, rather than a single large yard a considerable distance away. If suitable storage sites are not available within the public right-of-way, consider using nearby off-street public parking lots. Alternatively, contractual provisions should call out the need for the contractor to identify and lease suitable privately owned spaces for storage. In all cases, the contractual documents should clearly state that the contractor will not be permitted to leave tripping hazards in the pedestrian area and tire hazards in the bicyclists' path.

2.10 Vertical Obstructions

As shown in Figure 14, overhead obstructions can be a serious hazard for pedestrians, especially visually impaired pedestrians in pedestrian areas and walkways. The proposed PROWAG guidance stipulates that a height of at least 80 inches should be clear of any obstacle, including signs. This is commonly referred to as the pedestrian "box". No intrusion, such as the corner of signs, greater than 4 inches shall occur into the box. In addition, as shown in Figure 15, no protrusions are allowed in the lower 27 inches of the box.

Figure 14. Pedestrian hazard due to low sign.
Note: Non-MUTCD compliant uniform font on sign.
Source: ADA in the Work Zone: A Legal Perspective Presentation Janine C. Ashe, FHWA

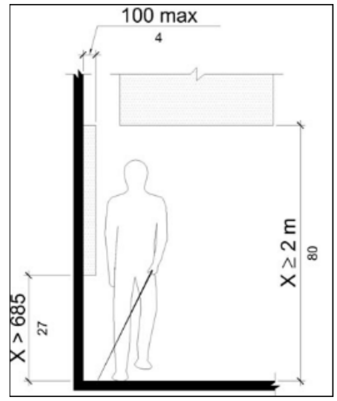


Figure 15. Draft PROWAG protrusion limits.
(Larger text: millimeters. Smaller text: inches.)
Source: US Access Board

2.11 Sign Mounting

As shown in Figure 16, the draft PROWAG guidance is very specific regarding the acceptable methods for mounting signs in pedestrian areas. A minimum post width of 2.5 inches is stipulated in the guidance. In effect, the guidance requires any sign that is more than 10.5 inches wide to be mounted on two posts, unless the bottom of the sign is at least 80 inches above the walkway.

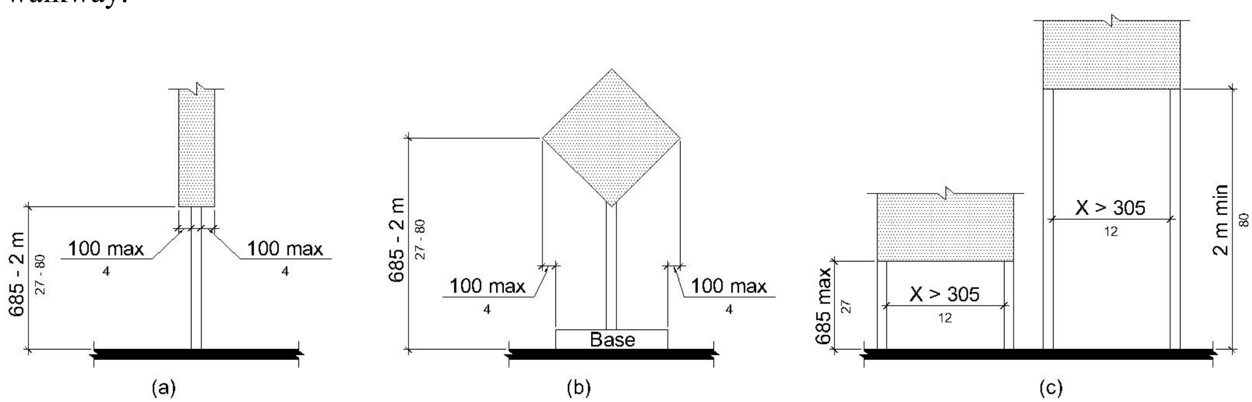


Figure 16. Acceptable sign mounting details from the draft PROWAG guidance.
(Larger text: millimeters. Smaller text: inches.)
Source: US Access Board

2.12 Pedestrian Refuges

As shown in Figure 17, temporary curb bulb-outs or median refuges can simplify crossing movements and reduce crossing distances, facilitating a safer pedestrian environment during construction.

Figure 17. Temporary traffic island allowing two-stage bicyclist crossing of a busy roadway (Dutch example).
Source: David Hembrow

2.13 Traffic Signal Timing

Temporary redirection of bicyclist and pedestrian traffic can increase pedestrian/bicyclist volumes at the intersections and crossings that remain open. Changes in pedestrian/bicyclist volume should be considered when establishing traffic signal timing.

2.14 Temporary Pedestrian Signals

Keeping permanent traffic signal systems in operation during construction can be complicated. As shown in **Error! Reference source not found.**, temporary traffic signal systems can be used to control motor vehicles and pedestrian traffic. Some products can be equipped with solar power and wireless communications. The temporary pedestrian signals can be configured for actuation by a pedestrian pushbutton, or operated as an automatic phase of the overall signal system.

2.15 Pedestrian/Bicycle Detection

Manual pushbuttons activated by pedestrians or bicyclists are the most frequently-used method for detecting pedestrian/bicyclist presence. While this is often sufficient for the purposes of actuating signals, in some work zone situations it is necessary to automatically warn drivers or construction personnel about pedestrian presence. An example would be a haul road where truck drivers entering the work area cannot see approaching bicyclists. Passive detector technologies include infrared, ultrasonic, and radar which can be used to activate warning signs or lights automatically in such situations.

Figure 18. Temporary traffic signal with pedestrian signal indications.
Source: Horizon Signal (IRF webinar)

Automatic pedestrian detection at signalized pedestrian crossings can be used to extend the pedestrian phase if the crossing is occupied for an unusually long time. Examples of this include; a person who moves very slowly due to age or disabilities, or a peloton of bicyclists crossing the roadway. This can help optimize signal capacity at sites where some of the turn lanes have been temporarily taken out of service.

2.16 Operational Alternatives to Physical Accommodations

In some cases, it is not feasible to provide temporary pedestrian/bicyclist facilities due to site constraints, work duration, or the length of the pedestrian/bicyclist detour that would be needed. An example would be a sidewalk closure on railroad crossing where there is not enough space for a temporary crossing and the next crossing is several miles away.

In some cases, the most practical and cost-effective option is to arrange for the local public transit system to ferry pedestrians and bicyclists around the closure. A similar option is to provide a shuttle bus, on-call van, or taxi service funded predominantly by the project.

Another potential operational alternative is to provide a flagger who closes the roadway to vehicular traffic when pedestrians and bicyclists need to cross. When operational alternatives are used in lieu of physical accommodations, significant coordination with stakeholders could be necessary to assure that the operating hours and quality of service meet the needs of the affected road users. Lift-equipped specialty vehicles could be necessary to provide accommodations for people with disabilities.

3. Common Work Zone Hazards and Solutions

3.1 Introduction

The next several sections of this document provide visual examples of common work zone hazards and potential solutions. Since most of the photos speak for themselves, commentary has been limited to short captions.

3.2 No Alternative Route

Problem

Figure 19. Complete removal of all pedestrian pathways.
Source: Wisconsin DOT

Solution

Figure 20. Pedestrians temporarily rerouted around work area.
Source: IRF Webinar Pedestrian Safety in Work Zones April 29, 2015

3.3 Unmarked or Poorly Marked Closure

Problem

Figure 21. Pedestrians lead into closed area and inappropriate use of yellow tape.
Source:www.pedbikeimages.org/ Dan Burden

Solution

Figure 22. Sidewalk closure with audible information device. Note: Sidewalk closure signs are non-MUTCD compliant.
Source: Photo reproduced with the permission of the American Traffic Safety Services Association (ATSSA)

Problem

Figure 23. Pedestrians routed into live traffic lanes and non-compliant MUTCD sign.
Source: IRF Webinar

Solution

Figure 24. Pedestrians routed around closed sidewalk at intersection work area with ADA compliant temporary crosswalk. Note: detectable barrier needed at end of sidewalk instead of Type III barricade.
Source: UW-TOPS Lab

Problem

Figure 25. Non-detectable termination of sidewalk.
Source: Wisconsin DOT

Solution

Figure 26. Sidewalk terminus fully barricaded.
Source: PSS (Plastic Safety Systems)

3.4 Separation of Bystanders from Work Area

Problem

Figure 27. Children playing in work activity area.
Source: Wisconsin DOT

Solution

Figure 28. Well-delineated work activity area.
Source: Wikimedia Commons

3.5 Open Manholes and Similar Hazards

Problem

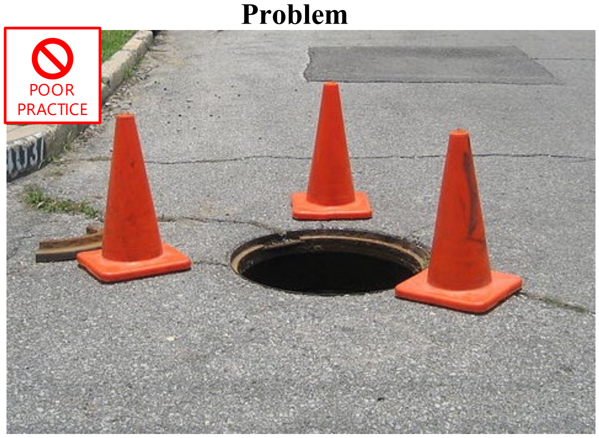


Figure 29. Open manhole (short duration). Not MUTCD compliant. Source: Wikimedia Commons

Solution

Figure 30. Barricade with ADA detectable bottom edge. Note: vertical stripes are non-MUTCD compliant. Stripes should slant toward the center.
Source: www.pedbikeimages.org/Dan Burden

3.6 Trenches

Problem

Figure 31. Trench delineated only by tape (Czech example).
Source: Wikimedia Commons

Solution

Figure 32. Trench protected by temporary fence.
Source: Oxford Plastics LLC

3.7 Tripping Hazards

Problem

Figure 33. Concrete pump hose blocking sidewalk causing a tripping hazard.
Source: John Shaw

Figure 35. Water hose protected by double ramp allowing pedestrians to safely cross hose.
Source: UW-TOPS Lab

Figure 34. Potential tripping hazard from fence legs.
Source: Wikimedia Commons

Figure 36. Pedestrian-friendly fencing supports.
Source: Oxford Plastics LLC

4. Design Elements

4.1 Portable Ramps and Temporary Ramps

Portable ramps and temporary ramps can assist the designer in maintaining access for all road users during construction. Prefabricated ramps are available in plastic, rubber, aluminum, and steel. Ramps can also be site-fabricated using lumber. Asphalt and concrete can be used to construct temporary ramps, but it is difficult to achieve a smooth taper at the bottom of the ramp unless the size of the paving aggregate is quite small.

Portable ramps such as the proprietary product shown in Figure 37 are intended primarily for short-duration applications. For longer duration the ramps should be anchored for improved stability and security. These products are typically designed to accommodate a range of curb heights. For example, according to its manufacturer the product shown in Figure 37 can be used for curb heights ranging from 2.4 inches to 6.3 inches.

Some proprietary products can be attached to the existing curb using masonry anchors. Anchoring the ramp deters theft and helps assure that it remains in the correct position, but generally means drilling anchor holes into the existing concrete. Design considerations for deciding whether to anchor the ramp include the work duration, whether the curb will be replaced during a later project stage, and the physical condition of the existing curb (spalled concrete may not hold an anchor securely).

Temporary ramps such as the one shown in Figure 38 are intended for locations with longer work durations. Although perpendicular-to-curb configurations (Figure 41) are the most frequently used, parallel-to-curb ramps (Figure 40) are useful in some situations.

When lightweight materials are used to construct temporary ramps that will remain in place for 72 hours or more, they should be securely anchored to the existing curb or pavement. Depending on the ramp material and work duration, appropriate anchoring methods could include masonry anchors, masonry screws, or polyurethane/acrylic construction adhesives. Conversely, burlap or heavy paper may be necessary to prevent poured-in-place concrete or asphalt ramps from permanently bonding to the existing pavement.

Figure 37. Portable curb ramp (proprietary).
Source: Oxford Plastics LLC

Figure 38. Temporary curb ramp (concrete).
Source: Photo reproduced with the permission of the American Traffic Safety Services Association (ATSSA)

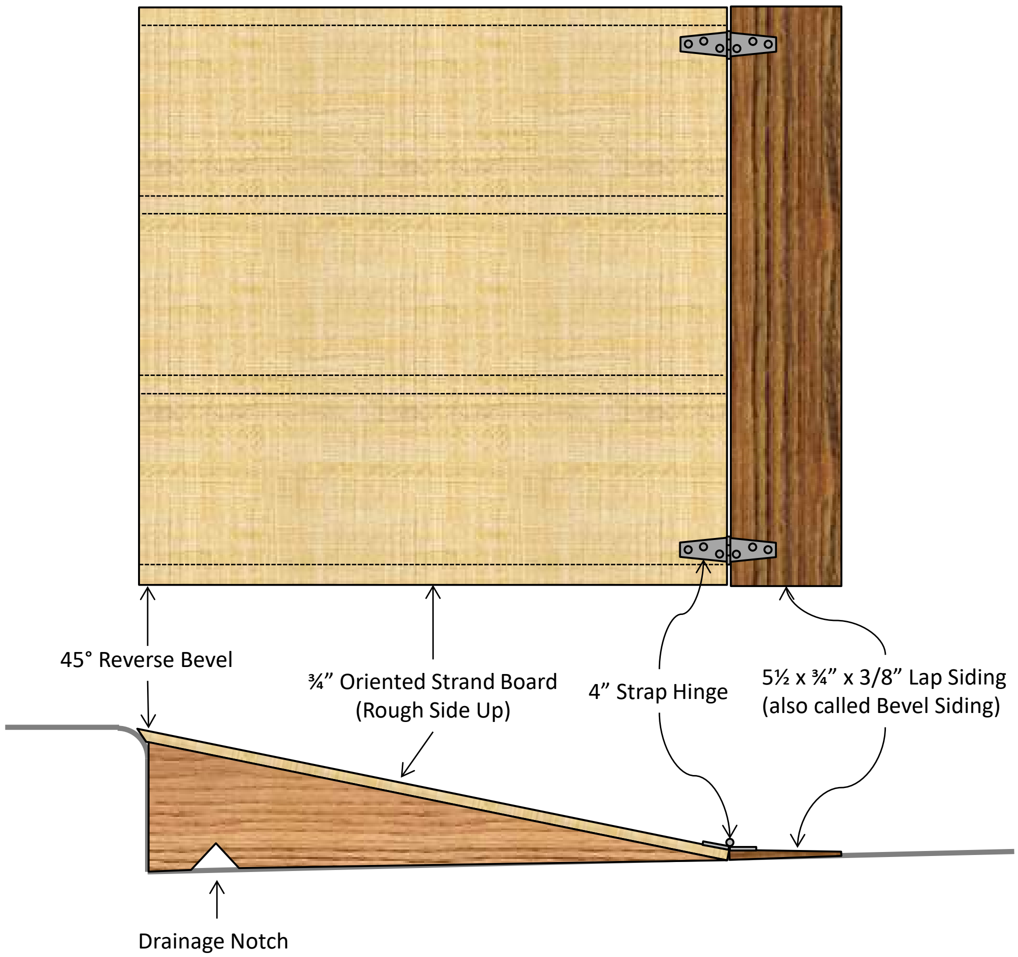


Figure 39. Temporary curb ramp fabricated from standard lumber.
Source: UW-TOPS Lab

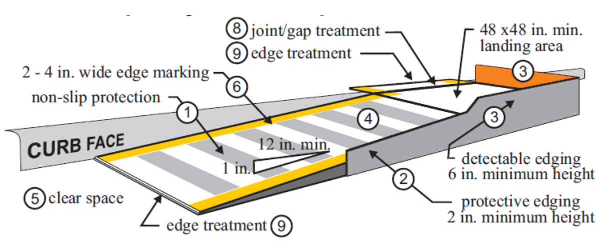


Figure 40. Temporary ramp parallel to curb
Source: Minnesota DOT

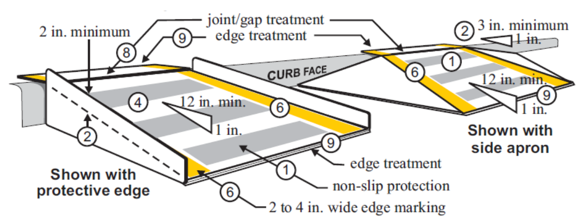


Figure 41. Ramps perpendicular to curb
Source: Minnesota DOT

Ramp Placement. Portable or temporary ramps should be placed at locations that are as smooth and level as possible, and where horizontal curvature is minimal. Locations should be selected to minimize conflicts with motorized traffic and construction vehicles. Where traffic conflicts are unavoidable, the designer should take care to assure that ramp users and other vehicles can see one another easily. Signage warning of the unusual condition may be appropriate for both ramp users and the roadway or construction traffic. In cases where visibility is extremely limited, it may be desirable to specify the installation of electronic warning signs oriented toward the motorized traffic and activated by a passive pedestrian detector as described in Section 2.15.

Dimensions, Slopes and Other Details. The proposed PROWAG guidelines are limited or silent on dimensions for temporary curb ramps and only discuss permanent construction dimensions. Information for temporary installations, only provides reference to MUTCD Part VI for guidance. Therefore, the permanent guideline dimensions should be followed, included during construction, wherever possible. The proposed PROWAG guidelines dimensions for different type of curb ramp design elements are shown in Table 1 in Section 1.7.

For parallel-to-curb applications, the minimum length of the landing at the top of the ramp should be 48 inches with a desirable length of 60 inches. The top of the landing should be flush with the top of the curb. If the back of curb is rounded at the curb face, the surface of the landing should be chamfered, or a filler strip should be used to minimize gaps and tripping hazards.

For a typical curb rise of approximately 6 inches, the slope of the ramp generally should not be steeper than 1:10 (10%). A slope of 1:12 (8.3%) or flatter is desirable. Slopes as steep as 1:8 (12.5%) may be used if it is necessary to shorten the ramp to avoid creating a hazardous condition (i.e., if a longer ramp would extend too far into the roadway). If the ramp has flared sides, the side flares should also have a slope of 1:10 or flatter. To reduce tripping hazards, the maximum height of any threshold or vertical lip should not exceed 3/8 inch.

All portable and temporary ramps should have a skid-resistant surface such as broom-finish concrete, diamond plate, or T1-11 plywood installed with the grooves perpendicular to the traffic direction. The ramp should be designed to support a safe working load of at least 450 pounds. Depending on the ramp design, material, and location it may be necessary to include a pipe or other means of carrying stormwater under the ramp.

It is desirable for the color of the ramp to contrast with adjoining pavements and walkways. Delineation of the sides of the ramp using 2-inch- wide skid-resistant pavement marking paint (or tape) in a color that contrasts with the rest of the ramp is desirable if the ramp will remain in place for an extended duration (i.e., 2 weeks or more). Contrasting paint or tape may also be used in other situations where it is necessary to draw attention to the ramp. Designers should pay particular attention to ramp visibility in situations where there is pedestrian traffic both parallel and perpendicular to the ramp, and where there is a high probability of visually impaired or intoxicated pedestrians.

Edge Rails. Edge rails (Figure 40 and Figure 41) are intended to help prevent wheelchairs from running off the ramp (especially if the ramp is narrow) and serve as a guide for blind pedestrians using canes to identify the ramp edge. The PROWAG has separate guidance for curb ramps and other ramps, and edge protection is only required and used for other ramps. For work zone applications, temporary ramps have more attributes like permanent ramps than curb cut ramps. These types of temporary ramps are appropriate for this application since they do not disturb curbs or sidewalks.

Although some proprietary products incorporate shallow edge rails as a stiffener, the Minnesota DOT guidance, excerpted in Figure 40 and Figure 41, uses edge rails in a situation where there is no handrail. The 2" minimum height may present potential tripping and snagging hazards, especially for people wearing longer skirted garments. Sharp corners and roughly sawn wood could exacerbate the hazard. While addition of edge rails is relatively straightforward if the ramp is fabricated from wood or metal, it is difficult when concrete or asphalt is used. The benefits of edge rails on temporary ramp appears to out-weigh the potential negative tripping attribute.

Material and Equipment Selection. Prefabricated portable ramps are useful for short-duration projects or brief stages of larger projects. Portable ramps are available for rental in some markets. The use of site-fabricated concrete or asphalt ramps is likely to be a cost-effective option when the ramp will remain in place for an extended duration. Site-fabricated or pre-fabricated wood ramps are useful when it is necessary to orient the ramp parallel to the curb, and for unusually high or low curbs. They may also be a good choice if prefabricated ramps are not readily available, especially if local crews have suitable carpentry skills.

There are several possible methods for specifying prefabricated ramps in procurement documents. These include:

- Functional specifications for the length, width, curb height range, anti-skid surface, minimum load capacity, maximum unit weight, and perhaps color.
- State approved proprietary products list.
- Contractor developed shop drawings or product information sheet, subject to approval of the resident engineer.

4.2 Double Ramps for Bridging Over Pipes, Cables, Etc.

It is sometimes necessary for pedestrians or bicyclists to cross over various types of tubes such as hoses, pipes, cables, or conduits. While ordinary electrical extension cords and very small tubes (3/8-inch diameter or less) can sometimes be secured directly to the pavement surface using mastic tape, larger tubes, and unsecured tubes of any diameter are a potential tripping hazard for pedestrians and a falling hazard for bicyclists. Depending on rigidity and diameter, it could also be necessary to protect the tube from being cut or crushed by foot or wheeled traffic. Double-ramps are a straightforward solution to this situation.

Dimensions, Slopes and Other Details. This device is a ramp in which the upward, horizontal, and downward sections are continuous. As shown in Figure 42, prefabricated double-ramps are produced in steel, aluminum, and polyurethane. Double ramps can also be site-fabricated using standard lumber, i.e., a doubled version of the design shown in Figure 39.

The minimum height of the double-ramp is dictated by the diameter of the tubes to be crossed. The width and slope design criteria are the same as for the single curb ramps described in Section 4.1. The ramp surface should be skid-resistant. Color contrast with the adjoining walkway pavement is desirable.

In some situations, it is necessary for several tubes to cross the walkway or bikeway in a relatively short distance. In this case, it may be desirable to use a pair of single ramps and an extended elevated platform.

Figure 42. Examples of double ramps for tube crossings.
Source: Handiramp.com (Left) TOPS Lab (Right)

4.3 Temporary Covers and Footplates

Many work operations need trenching and/or removal of street iron such as manhole covers, catch basin lids, and utility vault lids. Temporary covers such as those shown in Figure 43 and Figure 44 can help prevent serious pedestrian and worker injuries. Foot plates such as those shown in Figure 45 and Figure 46 help protect bicyclist, pedestrian, and improve worker safety at trenches. The cover should be slip-resistant (even when wet) with a textured surface treatment or non-slip coating. If the cover will remain in place for more than a few hours (e.g., overnight with workers not present), and subject to parallel vehicular traffic, anchoring to the pavement is recommended. The trench stability should be assessed prior to the foot or road plate being installed to assure the ground conditions are structurally sound.

Figure 43. Modular road and sidewalk trench cover system with self-pinning anchors and sloping edges.
Source: Oxford Plastics LLC

Figure 44. Modular trench cover system to accommodate varying length of open trench.
Source: Oxford Plastics LLC

Figure 45. Temporary manhole or trench cover with sloping edge system for pedestrian safety
Source: Oxford Plastics LLC

Figure 46. Safety edging and pinning for steel plates.
Source: Platelocks.com

4.4 Manhole Safety

When the top of an open manhole is at approximately the same elevation as the adjacent road surface, temporary covers discussed in Section 4.3 can help protect pedestrian, bicyclist and worker safety. As shown in Figure 47, and Figure 48, other devices are available to provide trip/fall protection and deter unauthorized access in situations such as the following:

- Exposed utilities significantly higher or lower than the surrounding terrain
- Uneven or unstable surfaces
- Workers and/or equipment inside the chamber

Figure 47. Open manhole guard.
Source: Oxford Plastics LLC

Figure 48. Temporary fencing around utility vault.
Source: portlandoregon.gov

4.5 Temporary Pedestrian/Bicycle Bridges

Temporary bridges help assure the continuity of pedestrian/bicycle accommodations by allowing users to cross trenches, missing or broken sidewalks, and other areas with uneven or unstable footing. Commercially prefabricated bridges are available in steel, aluminum, and plastic. Bridges can also be site-fabricated using standard lumber, typically for low depth or short-term use.

In contrast to trench covers and footplates, temporary bridges channelize users onto a relatively narrow area and handrails should be provided on both sides to minimize falling hazards. The bridge surface should be skid-resistant. To provide firm support the bridge span may need to be considerably longer than the trench width; ground condition should be checked prior to installation. Signs, fences, and lighting can also help guide users to the bridge and prevent falls into adjoining areas.

Dimensions and other details. Bridge width should be selected based on the anticipated volume and speed of bicycle and pedestrian traffic. For temporary pedestrian bridge applications, a minimum width of 48 inches should be provided but a width of 60 inches or more is desirable. For one-way bicycle applications, a minimum width of 48 inches is also desirable; for two-way bicycle traffic under very low volumes a width of 60 inches can be considered, but this should be increased to 72 to 96 inches for moderate to heavy bicycle traffic. The PROWAG Sections R204.4 and R302.5 directs pedestrian facilities not to exceed the general grade established for the adjacent street or highway. Where the pedestrian access route is not contained within the street or highway right-of-way, the PROWAG guidance recommends a maximum 5% grade. PROWAG also recommends where pedestrian overpasses are provided prior to the construction project, an alternative pedestrian circulation path should be provided, including during the construction project. Separate lanes for bicyclists and pedestrians is desirable for high-volume situations, and for sites where bicyclists are likely to be moving at significantly higher speeds. The bridge surface should be level or gently sloped.

4.6 Benches

On projects requiring re-routing bicyclists and pedestrians to a longer path, temporary sitting benches serve as resting places that help offset the increased walking or cycling distance. Resting places are particularly important for older pedestrians and child cyclists, especially on routes with steep grades. Temporary, low cost benches can be either constructed on-site with lumber or specifying low cost commercially available benches for the duration of the project.

4.7 Temporary Mid-Block Crossings

Depending on site conditions, the designer has a number of options for separating pedestrian/bicycle movement from work site activity and adjacent traffic. When the selected design involves full closure of the sidewalk on one side of the roadway, pedestrians are often directed to cross to the opposite side. In some cases, pedestrians perceive the detour to be excessively long, resulting in jaywalking, pedestrian traffic in the work activity area, or other behaviors that are unsafe and/or disruptive to work operations. Such behavior can be particularly common when the detour means doubling-back to reach a popular mid-block destination such as a large retail store, office building, or cinema. The use of temporary mid-block crossings can help reduce this problem, but it then becomes necessary to mark the temporary crossing very clearly so that drivers do not encounter a confusing or unexpected situation.

As shown in Figure 49, Figure 50, and Figure 51, temporary mid-block crossings are usually composed of crosswalk marking, signage directing bicyclists and pedestrians where to cross, and signage providing motorists with advance warning of the crossing and directing motor vehicles to stop. On high-volume roadways, temporary islands can improve safety and reduce traffic delays by allowing pedestrians to make a two-stage mid-block crossing (Figure 17).

In situations with a heavy volume of pedestrians or bicyclists, the use of a human flagger, temporary HAWK signal, or Rectangular Rapid Flash Beacon (RRFB) should be considered.

Temporary ramps may be necessary to avoid abrupt grade changes (Figure 49). Temporary lighting may also be used (see Section 4.11).

Figure 49. Temporary mid-block crosswalk with ramp. Note: non-compliant MUTCD sign on barricade.
Source: myedmondsnews.com

Figure 50. Pedestrian signage for temporary crossing. Note: Work area requires full pedestrian closure and compliant MUTCD regulatory pedestrian sign, i.e. MUTCD R9-11a.
Source: http://baystateroads.tumblr.com/post/99051072465/tech-note-68-pedestrian-barracades- guidance

Figure 51. Vehicular signage for temporary crossing. Note: non-MUTCD compliant sign legend.
Source: edenprairieweblogs.org/policedepartment/posts

4.8 Pedestrian/Bicycle Longitudinal Channelizing Barricades and Fencing Systems

Longitudinal channelizing barricades and fences, as shown in Figure 52, are useful for several purposes:

- Serve as a visual deterrent to motorists from entering the area preserved for pedestrian/bicycle use.
- Deter bicyclists and pedestrians from entering the travel way and/or work activity area.

Figure 52. Orange and white longitudinal channelizing device/barricade used to separate pedestrians from motorized traffic.
Source: Yodock (A Trinity Industries Inc. Company)

While some channelizing barricades and fences may have the same visual appearance as a "barrier" system, the barricades and fences are not designed to reduce the penetration caused by motor vehicles that strike the barricade or fence. In this document the term "barrier" refers only to devices/systems that have successfully passed crash testing protocols and are used to minimize the distance an errant motor vehicle leaves the traveled way, such as intruding into a bicycle or pedestrian area and are discussed in Section 4.9.

There are many types of fencing systems. They range from low cost options that serve primarily as a visual demarcation between areas (e.g., a short snow fence) to high cost options designed to keep unauthorized personnel out of dangerous work areas (e.g., a tall chain link fence topped with barbed wire). The appropriate treatment depends on how hazardous the work area is, how close it is to the pedestrian/bicyclist facilities, and (to a lesser extent) the anticipated age and number of pedestrians, bicyclists and other bystanders. Deep drops, steep slopes, exposed high voltage wiring, and blasting are some examples of site conditions that are likely to use highly secure fencing.

A wide range of materials are used for work zone fences. The most popular are polyethylene plastic and steel products that are available in numerous patterns and thicknesses, but may also be constructed on-site with lumber. Regardless of the material specified, adherence to MUTCD and PROWAG guidance for ADA detectability and prevention of protrusions that can obstruct or injure a pedestrian. As shown in Figure 53, plywood walls are used to keep pedestrians out of work areas and provide additional visual and noise screening of the work area. Fence visibility can be increased by adding signage or color.

Figure 53. Temporary plywood walls.
Source: Wikimedia Commons/Work_On_Darby_Street,_Auckland

In work zone environments there are important trade-offs between the portability of the fencing system and the level of security it provides. For example, some portable systems are supported solely by their own weight and perhaps with a ballast material, while other temporary systems use large feet weighted down with sandbags. Semi-permanent fences are often built on posts pounded into the ground. The greatest security is offered by permanent fences with posts set in concrete. Short fences are easier to transport and less likely to fall over, but taller height fences can prevent trespassing.

While contractors can reasonably be expected to identify the type of fencing that is needed to deter theft or vandalism of their own equipment, specifying the *type, height,* and *location* of work zone fencing sufficient to protect the safety of the public is appropriately an agency design decision.

Site-specific factors to consider when specifying fencing design details include:

- Degree of hazards in the area to be fenced off
- Work duration
- Work pace (e.g., fast vs slow-moving operations)
- Pedestrian/bicyclist traffic volume
- Available width
- Availability of alternate routes
- Resistance to vandalism and theft
- Access to adjoining properties
- Around-the-fence and through-the-fence access to the work zone

Longitudinal Channelizing Barricade Devices are frequently used as an effective method for defining pedestrian and/or bicyclist paths through work zones, as shown in Figure 54. Some proprietary channelizer barricades are designed so they may serve as a support system for perimeter fences and traffic signs. These channelizers are often filled with water ballast to support the weight of the fencing material, as shown in Figure 55.

The channelizer devices are defined by the MUTCD as “lightweight, deformable devices that are highly visible and have good target value.” When the channelizers are interlocked together they can prevent pedestrians from straying from a channelized path, which greatly aid sight impaired pedestrians. Longitudinal channelizer devices come in different shapes, sizes, and colors are commonly made of polyethylene plastic.

Channelizer plastic shells often have the same visual appearance as a barrier, but unless the devices have been successfully crash tested, and are designed and installed per the manufacturer’s instructions, the devices are classified as barricades. Channelizer devices should not be designed to provide positive protection for pedestrians or workers.

Figure 54. Longitudinal channelizer barricade system defines effective unobstructed pathway for pedestrians.
Source: Yodock (A Trinity Industries Inc. Company)

Figure 55. Water filled longitudinal channelizer barricade system used to support visual screening fence next to a work site.
Source: Yodock (A Trinity Industries Inc. Company)

Portable Fences are freestanding devices that can be used to identify the boundaries of a work area, and to channelize pedestrian/bicyclist traffic (Figure 56 to Figure 57) Typically, they are 32 to 40 inches tall and consist of lightweight prefabricated panels or sections that can be transported in a van or pick-up and set up by one or two workers. These systems are best suited to temporary conditions such as maintenance projects, short duration work zones, and situations that occur for up to a few days incidental to larger projects, for example keeping pedestrians away from concrete that is curing. Many of the products in this category feature interlocking or folding designs to expedite setup and increase the number of panels that can be carried on a truck.

The height of the top surface of the portable fence should be at least 32 inches. The bottom surface shall be no higher than 2 inches above the ground to facilitate detection by users of long canes. Pedestrians with disabilities benefit from a continuous gripping surface along the top of the fence, but currently only a few proprietary products offer this design.

The support leg or foot should not impede the passage of pedestrian/bicycles. Some systems can be ballasted with sandbags to increase wind resistance. Stability can also be increased by using a zigzag pattern if there is sufficient space (Figure 57). Specifications should consider site conditions, for example, are the systems suitable for use on paved surfaces, or also suitable for use on uneven ground.

Figure 56. Portable plastic fence with anti-trip feet.
Source: Oxford Plastics LLC

Figure 57. ADA compliant longitudinal pedestrian barricade for channelizing pedestrians away from traffic and work areas.
Source: Plastic Safety Systems (PSS)

Temporary fences are larger and heavier than the portable fencing systems described in the previous section (Figure 58 and Figure 59). Typically, they are medium height (48 to 72 inches tall) and typically need two or more workers to move. Because of the greater height, a larger base is typically used. Bases are generally not troublesome when pedestrians are approaching from a direction perpendicular to the fence, but they can become a tripping hazard when the fence runs parallel to a pedestrian/bicyclist pathway.

Figure 58. Portable mesh panel fence with ADA detectable bottom rail.
Source: Oxford Plastics LLC

Figure 59. Orange plastic work zone fence used for closure. Note: Non-compliant barricade and sign on barricade.
Source: Stuart Macdonald for AmericanTrails.org

Semi-permanent fencing systems (Figure 60) can be distinguished from temporary fences by the fact that the posts are pounded into the ground. As a result, the fence cannot easily be moved, though it may be possible to gain access by removing a section of the fence fabric. A variety of fence heights is used depending on the nature of the work zone and the severity of hazards.

Figure 60. Semi-permanent chain link fence. Note: Need ADA detectable bottom rail on chain link fence.
Source: pedbikesafe.org/PEDSAFE/casestudies/James M. Ercolano

Permanent fencing systems can be distinguished from semi-permanent fences by virtue of the fact that some or all of the fence posts are set in concrete (sometimes this is done only for corner posts). Another distinguishing feature is the design of the top rail, which is sometimes a pipe rather than a wire. This type of fence is quite difficult to move, though it may be possible to gain access by removing a section of the fence fabric. A wide range of heights is available; the 96 inches height provides considerable resistance to climbing. In high-security applications, one or more strands of barbed wire or razor wire can be added to the top rail.

4.9 Barrier Systems for Pedestrian/Bicycle Applications

Barrier systems can be used to create temporary pedestrians and bicyclist pathways in work zones. In contrast to barricades and fences which only serve as a visual deterrent, properly selected barriers can deflect vehicles and minimize an errant vehicle from entering the pedestrian/bicyclist pathway by redirecting the vehicle back into the general traffic lanes, as shown in Figure 61. The companion guide to this document entitled, "Guidelines for Work Zone Designers – Positive Protection", provides detailed information about various barrier systems including concrete, steel, and ballast filled plastic barriers.

The anticipated speed of motor vehicle traffic in the work zone is usually the starting design consideration in choosing the appropriate Test Level barrier system for a project. Barrier systems are currently classified according to the Crash Test Level criteria in which they have been successfully crash tested [6].

- Test Level 1 is done at 31 mph using a 2420-pound car and a 5000-pound pickup truck.
- Test Level 2 is done at 43 mph using a 2420-pound car and a 5000-pound pickup truck.
- Test Level 3 is done at 62 mph using a 2420-pound car and a 5000-pound pickup truck.
- Test Level 4 is done at 56 mph using a 22,000-pound single unit truck.

Another important design consideration when selecting a barrier system is the deflection that occurs in the event the barrier is struck by a motor vehicle. In many cases, some deflection into the pedestrian/bicyclist area may be an acceptable risk in event of a barrier strike on relatively low pedestrian volume pathways. A rigid (minimally deflecting) barrier system may need to be specified in situations where deflection space is limited, such as bridge decks, or on high pedestrian volume corridors where a higher risk intrusion distance is unacceptable. Please see the AASHTO Roadside Design Guide for more information on crash testing criteria [7].

Figure 61. Separating pedestrians from urban street traffic using TL-1 crash tested plastic barrier system. Note: Non-compliant MUTCD color used for regulatory pedestrian sign.
Source: Wikimedia Commons

Figure 62. Longitudinal space is needed for barrier end treatments.
Source: Wikimedia Commons

In pedestrian/bicyclist applications, concrete and water-filled plastic barriers are the most frequently used types. Concrete barrier is readily available in most locations, and is potentially easy to specify if it is being used elsewhere on the project. Water-filled plastic barriers are easier to move and deploy, and their shorter sections can readily conform to the tighter curves often found in urban situations. However, these barrier systems have a greater deflection distance than concrete barrier systems.

End treatments are an important aspect of barrier design (Figure 62). The blunt ends of concrete barriers are a crash hazard; they must be protected using an impact attenuator or other crashworthy end treatment, unless they can be tapered back to a point beyond the clear zone or tied into an existing permanent barrier. Some plastic barrier systems are certified as their own end treatments, and this feature can be attractive in urban situations where it is necessary to end and restart the barrier at intersections.

4.10 Falling Debris Protection

Construction of bridges, buildings, and other tall structures can create a falling debris hazard for adjacent pedestrian/bicyclist facilities. As shown in Figure 63, a cover should be used to protect the walkway/bikeway from falling debris, even when debris netting is used.

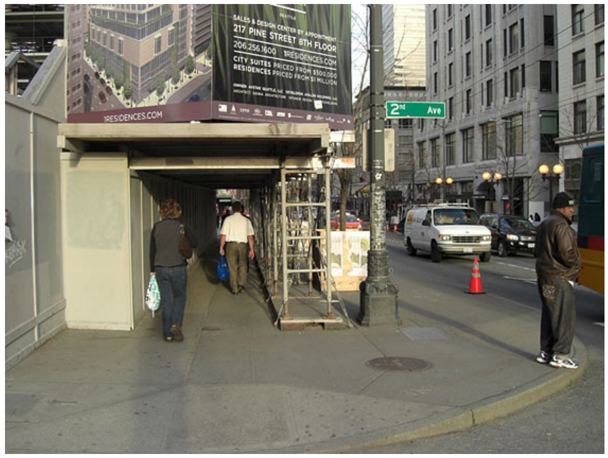


Figure 63. Falling debris protection at a building construction site.
Source: City of Seattle

Details. Covered walkways should have clear unobstructed ceiling heights of not less than 8 feet. For *walkways,* a minimum width of 4 feet is recommended (5 to 6 feet preferred). At locations with high pedestrian volumes a greater width is typically used. For *bikeways,* a minimum width of 5 feet is typically used unless it is a one-way bikeway or the bicyclist volume is extremely low. Width should be measured from wall to wall (not from handrail to wall or handrail to handrail). Lighting for night safety is usually necessary, especially if the walkway is long or ambient light sources are obstructed (see Section 4.11 for recommended illuminance levels).

Figure 64 illustrates a typical specification drawing for covered walkways. The associated specifications are as follows:

> Roofs of covered walkways should consist of planking no less than the industry standard nominal thickness of 2 inch, closely laid, made watertight, and covered with exterior grade fire resistant plywood. All sill plates and posts should be ground contact rated pressure-preservative treated material. All fasteners shall be galvanized steel. The roof should be designed to carry a live load of at least 200 pounds per square foot. For covered walkways adjacent to buildings 100 feet or less in height, the roof should be designed to carry a live load at least 150 pounds per square foot. Steel or other materials having equivalent strength and suitability may be used in lieu of wood to construct covered walkways.

White or light-colored paint on the wall and ceiling will aid in achieving recommended lighting levels in the temporary walkway. White panels of thin, textured fiberglass-reinforced-plastic may be specified in graffiti-prone areas, since the surface resists adhesion of most inks and paints.

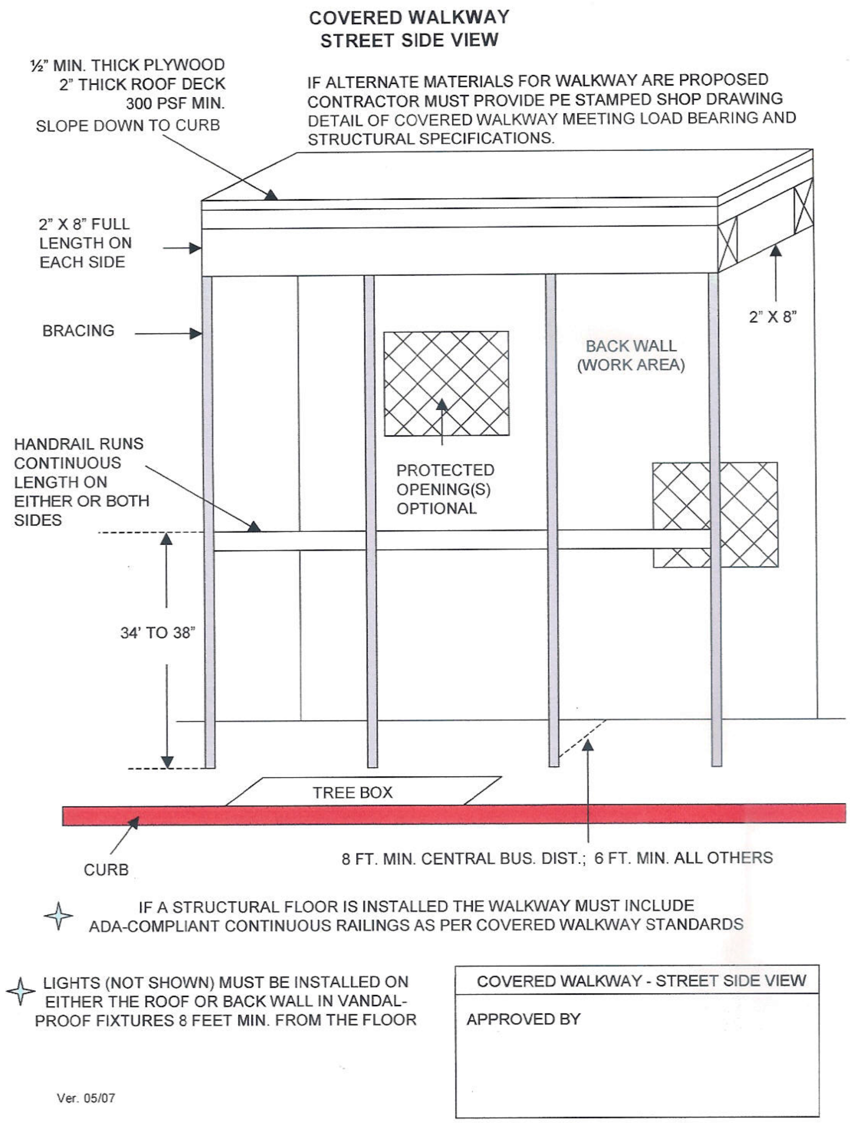


Figure 64. Typical details for covered walkway.
Source: DC Department of Transportation Pedestrian Safety and Work Zone Standards

4.11 Temporary Lighting

Temporary pedestrian/bicycle lighting in work zones serves three main functions:

- Deterring collisions between motor vehicles, bicyclists, and pedestrians.
- Assuring that cyclists and pedestrians are able to see tripping hazards such as uneven pavement, drop-offs, and steps.
- Enhancing personal security.

A recent Canadian study found that 34% of fatally injured bicyclists were struck by a vehicle in darkness and 60% of pedestrian deaths occurred at night or during dim light conditions [2]. Although the proportion of these deaths that occurred in work zones is unknown, it is reasonable to assume that the hazards of walking or riding a bicycle at night are amplified by work zone conditions. Night work zones near sporting venues, concert venues, and night entertainment districts are likely to have heavy pedestrian night activity and prone to potential pedestrian crashes.

The provision of temporary lighting devices uses engineering judgment to balance the benefits of lighting against installation and energy costs. In recent years, the availability of low voltage battery-solar LED lights has made these decisions easier. In some cases, inexpensive consumer-grade devices are used; although these mass-market products lack the durability of permanent street lighting systems, they are often sufficient for the limited duration of a construction project.

Several situations are reasonably categorized as high-risk and should be illuminated at all times. Examples include signalized intersections, roundabouts, and bus stops. General or spot lighting should also be provided to mark tripping hazards, uneven surfaces, drop-offs, closures, and similar situations.

The Illumination Engineering Society provides detailed guidance for illumination levels for roadways, including walkways and bikeways [8]. A more thorough discussion on illumination design is provided in the companion guide to this document entitled "Guidelines for Work Zone Designers – Illumination for Night Construction." [9]

The amount of light falling on a surface is called **illuminance** (E) and is measured in lux (metric units) or foot-candles (US customary units) (1 fc = 10.76 lux). Illuminance can be measured with a light meter; as a quick reference on a clear night the full moon produces about 1 lux (0.1 fc), and office interiors are usually illuminated to about 500 lux (50 fc). There is no direct relationship between the number of lumens a lamp (bulb) produces and the resulting illuminance—it depends on how focused the light is and the distance between the lamp and the viewing surface. Similarly, illuminance is only indirectly related to lamp wattage (power consumption)—some types of lamps are more efficient than others. Brighter lighting (above the IES minimum levels) can draw attention to crosswalks, improve visibility, and enhance pedestrian walkway safety.

Figure 65. Light fixture mounted on temporary signal arm provides some crosswalk illumination, but glare partially obscures the signal indication.
Source: IRF Webinar: Pedestrian Safety in Work Zones

Excessive contrast between two areas is called **glare**. While some glare may cause discomfort, most drivers can still adequately perform their driving task. However, as glare increases in intensity, it may provoke people to cover their eyes or look away. In extreme glare, viewers are temporarily blinded. Temporary fixtures mounted relatively low are a common source of glare in work zones (Figure 65). For example, in Figure 66 most of the light produced by the temporary walkway lighting shines into the eyes of oncoming drivers, and relatively little shines onto the footway itself. This situation could potentially be remedied by using reflector lamps to direct the light downward.

Figure 66. Reflector lamps instead of incandescent lamp bulbs could have been used to only direct light downward at this covered walkway.

Source: Photo reproduced with the permission of the American Traffic Safety Services Association (ATSSA)

Installation. Permanent highway lighting systems are generally installed at a height of approximately 40 feet to minimize glare. In some cases, these luminaires (lighting fixtures) can be utilized during construction, perhaps with temporary overhead wiring. In other cases, illumination can be provided using temporary pole-mounted luminaires or luminaires attached to permanent or temporary structures such as pedestrian walkways or scaffolding.

Another solution is to mount temporary pedestrian/bicyclist lighting on barricades, drums, or fences. In these cases, it is sometimes possible to minimize glare by positioning the lights well below eye level (Figure 67 and Figure 68). The lighting system should be continuous along the pedestrian/bicyclist pathway throughout the work area.

Figure 67. Temporary lighting mounted on barricades.

Source: flickr.com/photos/aeschylus18917/3204156550

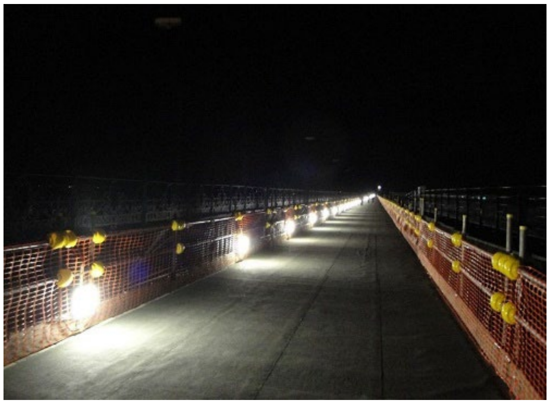


Figure 68. Temporary lighting mounted on fences. Note: ADA detection rail correctly used on right side fence.

Source: Wikimedia Commons

Energy. The designer should carefully consider the available energy sources for the lighting system. The choice will depend largely on the site conditions and work duration. In some cases, temporary lights can be connected to an electrical main or powered by portable generators, but finding safe and convenient ways to route temporary wires or cables can be an ongoing challenge as work progresses. Batteries recharged by solar panels are an increasingly popular solution. The use of low voltage lighting systems (typically 6, 12, or 24 volts) can reduce electrical hazards, simplify compliance with the electrical code, and reduce the consequences if a wire is accidentally cut by work operations.

Light Source. A wide range of illumination technologies can be used to provide temporary pedestrian/bicyclist lighting, including incandescent, halogen, LED, and metal halide. When contractor-supplied lighting is loosely specified, contractors often select string lights and equip them with bare Type A incandescent lamps (the round bulbs ordinarily used in residential fixtures). Although the up-front cost is low, they are easily vandalized. Most string lights are intended for semi-protected use on building construction sites and are rated for use in "damp locations". The designer should specify devices rated for use in "wet locations" unless they will be protected by a covered walkway or other structure, in which case damp-rated devices might suffice.

In many cases, it is desirable to specify the specific type of reflector lamps (Figure 69), which creates the desired cone of light. This will more effectively light the desired surface, reduce glare, and limit spillover into residences or other adjacent areas. Type PAR (Parabolic Aluminized Reflector) lamps are available in spotlight (narrow cone) and flood light (wide cone) configurations. Another way to reduce glare is to specify diffusers to spread the light more uniformly.

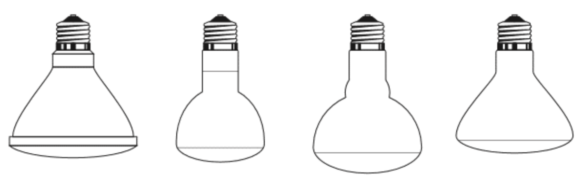


Figure 69. Incandescent reflector lamps. From left to right, types PAR, ER, BR, and R.
Source: Wikimedia Commons

4.12 Transit Stops

Road construction can have a significant impact on public transit operations such as intercity bus, urban bus, light rail, subway, commuter rail, and ferries. The MUTCD requires accommodations when public transit operations are affected by construction. Finding appropriate ADA compatible solutions typically requires coordination with the transit agencies and/or private transportation operating companies serving the site. Depending on site conditions, options could include:

- Providing temporary surfacing and temporary shelters to maintain service at existing locations.
- Relocating stops.
- Re-routing transit operations to a less-affected road or street.
- Rearranging pedestrian access to fixed facilities such as rail stations.

Passengers should not be discharged into closed areas or onto unstable surfaces (Figure 70). Nearly all modern transit buses are equipped with retractable wheelchair ramps at the front door. To provide space for deployment of the ramp, the proposed PROWAG guidance requires permanent stops to have a 5 x 8 foot boarding and alighting pad, with the long dimension oriented perpendicular to the roadway as shown in Figure 71. In consultation with transit operators, these dimensions could be relaxed to some a degree for temporary situations where space is limited. Rear-door pads might be necessary at some stops, such as higher-volume bus stops where passengers typically board at the front and step off at the back. The spacing between bus doors is usually about 20 feet, but this dimension can vary by make and model and should be affirmed with local bus operators and designed to accommodate the length of buses in use at that location. Motorcoaches used for long-distance services are generally 45 feet long; single-deck motorcoaches generally have only a front door, while double-deckers usually have two doors.

Figure 70. Passengers discharged into sidewalk closure.
Source: Wisconsin DOT

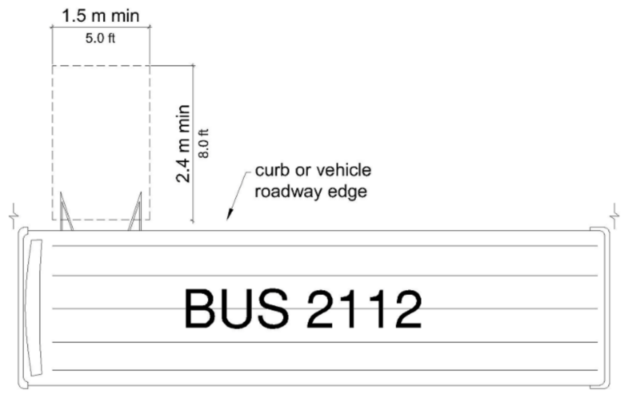


Figure 71. Proposed PROWAG dimensions for permanent bus stops.
Source: US Access Board

Temporary shelters can be assembled from a variety of materials (Figure 72 and Figure 73), and temporary bus stop pads can be surfaced with any of the materials discussed in Section 5.


Figure 72. A temporary bus shelter constructed with lumber and plywood.
Source: flickr.com


Figure 73. Temporary bus shelter constructed mainly from scaffolding materials. Note: ADA ramp used, but ADA detectable edge needed at end of platform.
Source: photobucket.com

Appropriate signage is necessary to alert passengers about service changes. This includes not only signs showing the temporary stop location, but also signs alerting passengers that the usual stop is temporarily out of service.

4.13 Railroad Crossings

When public railroad crossings that accommodate pedestrian movement are within a work zone (or a crossing is being repaired or replaced), the designer should initiate early coordination with the railroad company. In some states, there is a specific state agency with jurisdictional authority over public crossings, and this agency should be treated as a stakeholder. In nearly all cases, any modifications to crossing signals, bells, or other warning devices will need to be completed by the railroad's signal maintenance department and not the roadway contractor.

In most cases, the temporary facilities will need the same level of pedestrian protection that is provided in the permanent situation. For example, if the project involves reconstructing a railroad overpass, a temporary pedestrian structure will probably be necessary. Conversely, if the existing crossing is at-grade, a temporary pedestrian grade crossing could be an acceptable solution. Proper directional and railroad warning signing, temporary fencing to prevent pedestrian crossing movements at unacceptable locations, temporary surfacing, and tactile warning devices should be incorporated into the work zone design (Figure 74).

Figure 74. Temporary pedestrian rail line crossing. (UK example, non-MUTCD compliant RR x-buck)
Source: Wikimedia/Level_Crossing_At_Kingdon_Street_West

4.14 Bridges and Tunnels

If an existing bridge or tunnel has pedestrian/bicyclist accommodations, a similar level of accommodation should be provided during work operations. Special effort is typically appropriate if the available width is insufficient to maintain the pedestrian/bicyclist pathway during construction, since detours are often too long to be practical for non-motorized road users.

If there is high pedestrian/bicyclist demand, constructing temporary bridges can sometimes be justified. In general, the cost of building a temporary pedestrian/bicyclist bridge will be lower than a comparable bridge for motor vehicles, due to the narrower width and lighter design load. In some cases, operational alternatives such as a temporary shuttle service are the most feasible alternative (see Section 2.16).

5. Temporary Surfacing Options

The selection of appropriate surfacing materials is an important consideration in the design of temporary pedestrian/bicyclist facilities. The surface should be firm, stable, and continuous. Many different construction materials can meet this need. The selection should take into consideration the type of traffic (bicyclists, pedestrians, or both) and the duration of the temporary condition. In general, wheelchair users need a firmer surface than bicyclists do.

Although asphalt and concrete are the materials most frequently used for permanent pedestrian/bicyclist facility surfacing, due to cost and other factors these materials are not always the right choice for temporary facilities, especially if the temporary facility is only needed for a short time.

Another design consideration is the amount of effort needed to remove the temporary surface and restore the space to its previous use. Materials such as Controlled Low Strength Material (CLSM) and soil-cement can be repositioned using shovels (or in some cases left in place), while stronger materials might need to be broken up and hauled away. A related design issue is the vertical staging of the project, i.e., whether the temporary pedestrian/bicyclist surfacing can be re-used as a base for permanent paving.

Consideration should be given to the desired surface finish for the temporary facility. In some cases, a somewhat rough finish is desirable to increase skid resistance and compensate for the less-than-ideal grades, cross-slopes, and drainage, which could exist during construction.

5.1 Asphalt

Hot mix asphalt is often used for surfacing temporary pedestrian facilities that have a service life of two weeks or more. In some cases, the asphalt is placed directly on uncompacted soil; this solution can be acceptable for short project stages, though it is easily damaged if run over by motor vehicles or construction equipment. Depending on the characteristics of the native soil, a compacted base may be more appropriate to assure adequate durability. Temporary asphalt pathway design specifications should be included in the bid package to assure acceptable performance. Feedback from construction engineers indicates that contractors generally prefer to use the same asphalt that is specified elsewhere on the project, since it is seldom cost-effective to produce a special mix for a relatively small amount of the temporary pedestrian/bicyclist paving.

5.2 Controlled Low Strength Material (CLSM)

CLSM is also called flowable fill, lean-mix backfill, backfill control - low strength, controlled density fill, flowable plastic soil-cement, or soil-cement slurry. It is a self-leveling concrete-like material, currently most often used as backfill for utility trenches. Most ready-mix concrete suppliers can also provide CLSM because it is produced using the same ingredients: water, aggregate, Portland cement, and fly ash (admixtures are sometimes included, for example to accelerate or delay hardening as necessary). The water/cement ratio is much higher than structural concrete, resulting in compressive strength of roughly 100 to 200 psi (the strength of concrete is usually 3000 to 5000 psi or more). When discharged from ready-mix concrete trucks CLSM has approximately the same consistency as a slurry (Figure 75). After hardening, the surface should be smooth and firm enough to walk or bicycle on (Figure 76).

CLSM mixes can be formulated to a wide range of flow, strength, and weight characteristics. The target strength for CLSM in temporary pedestrian/bicyclist path applications is approximately 150 psi; this is the *upper limit* for subsequent excavation using a hand shovel or backhoe. Stronger mixes can be used as a base or for permanent facilities. Although compressive strength is not the only factor affecting the ease of CLSM removal, mixes with strength exceeding 150 psi typically need a jackhammer or pavement breaker to remove the slab. Curing time typically ranges from 1 to 8 hours depending on the ambient temperature and mix design.

Figure 75. Controlled Low Strength Material (CLSM) discharging from mixer truck.
Source: FHWA /pavement/recycling

Figure 76. Construction of an apron using CLSM.
Source: North Dakota State University

In work zone bicyclist and pedestrian applications, CLSM can potentially serve as a base for permanent pedestrian/bicyclist pavement, or as a relatively low-cost temporary surfacing, that could be removed during subsequent stages of the project. Since CLSM is self-consolidating, it generally requires little or no surface finishing. As with any project, workmanship should be inspected to assure that there are no tripping hazards at grade changes, joints between pours, interfaces with existing manholes, valve boxes, and similar items.

Where existing grades and slopes are relatively flat, construction of a bicycle or pedestrian pathway using CLSM is generally straightforward. Existing turf, topsoil or other material is first milled or excavated to a depth of approximately 3 inches. Next, the CLSM is discharged into this shallow trench from ready-mix concrete trucks. Basic hand tools such as flat shovels and squeegees are used to spread the CLSM as it is discharged from the truck. In many cases, the sides of a shallow trench can serve as "formwork" for the CLSM-surfaced pathway. Ordinary formwork will be needed to control the movement of unhardened CLSM at vertical interfaces such as the end of a run (in many instances it will be cost-effective and expeditious to use pressure-treated softwood lumber as leave-in-place formwork).

More information about CLSM can be found in NCHRP Report 597, "Development of a Recommended Practice for Use of Controlled Low-Strength Material in Highway Construction". While CLSM has been applied most often as a backfill, void fill, utility bedding, and bridge approach fill material in the past, more applications such as temporary sidewalks and pads are expected as the highway construction industry becomes more familiar with this material.

5.3 Stabilized Soil (Soil-Cement and Soil-Polymer)

Stabilized soil has been used as a construction material for approximately 100 years. Currently it is most often used to build or improve low-volume rural roads. In this technique, the existing soil is tilled to the desired depth, mixed with Portland cement and/or fly ash, and a small amount of water, compacted, and misted with water periodically for approximately 3 to 5 days to activate the cement properties. The result is a smooth, hard surface that can withstand a considerable amount of weather and traffic. A modern update on this technique is the use of proprietary acrylic polymer blends in place of the cement. Soil-polymer hardens more quickly than soil-cement and does not need misting, which is advantageous in hot, dry environments.

Various types of equipment can be used to build a stabilized soil pathway. For small areas such as a temporary pedestrian ramp, till the native soil and blend in the Portland cement using hand tools or a gardener's rototiller and compaction done using a vibratory plate compactor. For medium areas such as a temporary pathway several hundred feet long, a tractor-mounted rotary tiller and a small pavement roller would be appropriate. For a half mile or longer pathway, specialty equipment typically used for full-depth pavement reclamation (Figure 77) would be an efficient option.

Figure 77. Full-depth stabilized soil reclamation equipment.
Source:roadrecycling.org/FDR-Process

The tilling depth and cement/polymer dosage depend upon the existing soil type. Organic top soils will need greater tilling depth and more cement/polymer, compared to inorganic soils, such as sand. The effort to blend in clay soils will also be greater. If the existing vertical grade is too shallow, clean local sand or gravel fill materials can be added prior to stabilization. For a semi-permanent pathway, the surface can be coated with a thin bituminous layer, such as a chip seal or slurry seal, to increase water resistance and durability.

5.4 Compacted Gravel

Gravels can be broadly classified as rounded or angular, and open-graded or closed-graded. The choice of material greatly influences its suitability for temporary bicyclist path construction:

- Gravels with **rounded** particles, such as pea gravel or river gravel, cannot be compacted satisfactorily. Rounded gravel will move under foot traffic and can bog down wheeled traffic. Therefore, rounded gravels are unsuitable for surfacing pedestrian/bicyclist facilities unless they are mixed with a binder material such as Portland cement.
- Gravels with **angular** particles, such as crushed stone are more suitable for pathway construction because the particles interlock and form a solid mass when properly compacted.

- **Open-graded** materials have relatively uniform particle sizes; when compacted there are openings, which provide drainage. As a result, open-graded materials are generally suitable for subgrade but not for surfacing.
- **Close-graded** materials, also called well graded materials, include a wide range of particle sizes; when fully compacted the smaller particles will fill the gaps between larger stones, creating a solid surface.
- **Dense-graded aggregate** (also called breaker run, crusher run, quarry process gravel, or shoulder stone) is generally the most suitable material for temporary bicyclist path surfacing. It is the result of mechanically crushing quarried stone and includes a full range of particle sizes, from large stones to powder. Some park systems and other trail operators use well-compacted dense-graded aggregate as an inexpensive material for permanent bicyclist path surfacing. It is also frequently used as a base for asphalt paving.

Another consideration is the type of stone available near the site. Where available at reasonable cost, dense-graded limestone is advantageous for bikeway construction. Limestone is moderately soluble in water, and over time, well-compacted dense-graded limestone will consolidate to form a concrete-like surface after exposure to rainwater or water spray.

The designer should specify the gravel size based on the thickness of the temporary surface. For example, 3/4-inch close-graded base is comprised of particles 3/4 inch and smaller, and would be a reasonable choice for a 1½-inch thick temporary bicyclist path.

Gravel surfacing must be well compacted to support wheeled or pedestrian traffic. A minimum compaction of 90% is a good target for a short-term facility. Higher compaction rates should be specified if the temporary pathway would remain in place as a base for permanent surfacing.

5.5 Proprietary Matting Systems

A number of vendors offer proprietary pedestrian matting systems. The lightweight and portability of these systems is advantageous for shorter-duration project stages, such as redirecting pedestrians while a permanent concrete surface is curing. Some products feature an open mesh design to reduce damage to existing grass. Panel connections and friction surfacing are important details of these systems (Figure 78). Project specifications should assure that there are no uneven joints. Otherwise, the joints can be tripping hazards and can be troublesome for wheelchair users. Typically, the panels are supplied as 4-foot x 8-foot sheets that can be cut to size if necessary. The mats are available for rental in some markets.

Figure 78. Pedestrian matting application
Source: Oxford Plastics LLC

5.6 Plywood

Plywood is a readily available building material product that may be appropriate for many temporary pedestrian and bicyclist facilities. Specifying the appropriate plywood grade and thickness is necessary.

Plywood is manufactured in thicknesses from 1/8 inch to 1¼ inches, but panels thicker than 3/4 inch are not readily available in all markets. Plywood thinner than ½ inch is prone to rapid deterioration and may not support the load. Therefore, ¾ inch nominal thickness is commonly specified as a practicable thickness specification for work zone applications.

Letter grading systems for plywood panels are based on the appearance of the outer plies. The most common grades are A through D. Knots, splits, and other surface imperfections result in a lower grade mark. Panels can also be sanded or unsanded. For work zone pedestrian/bicyclist surfacing applications, smoother is certainly **not** better, since a smooth surface can be slippery under wet or snow-covered conditions. In order to improve the slip resistance, specifying an anti-slip surface is important for walkways, especially ramps. There are commercial products that can be applied, as well as adding grit to paint to improve the texture and friction of the surface.

Figure 79. Detail of the "C" side of a sheet of CD plywood.
Source: Wikimedia/KouzouyouGouhan_Stamp_01.jpg

Another distinguishing feature of plywood products is the type of adhesive used to laminate the plies [5]:

- INTERIOR grade is intended for indoor use only.
- EXPOSURE 2 grade is intended for interior use but can withstand brief exposure to rain.
- EXPOSURE 1 grade can withstand some intermittent rain exposure.
- EXTERIOR grade is suitable for applications that experience repeated wetting and drying, long-term exposure to weather, and similar conditions.

CDX Plywood. The most widely available plywood grade is C-D EXPOSURE 1 (commonly called CDX). CDX is often manufactured with exterior grade adhesive but specifying simply as CDX does **not** assure that exterior-rated product will be supplied. As shown in Figure 79, CDX has a somewhat rough surface. Knotholes on the C side and small splits on the D side are typical. Significant imperfections are likely also to be present in the inner plies. CDX plywood is typically produced in 4-foot x 8-foot sheets; in some markets 4-foot x 9-foot and 4-foot x 10-foot sheets are also available.

When used as a surfacing treatment that is not directly in contact with the ground, CDX plywood panels can be expected to provide reasonable performance for temporary pedestrian/bicyclist surfacing under typical summer work zone site conditions (including occasional rain) for about four months. EXPOSURE 1 rated CDX is not recommended for locations that have continuous moisture exposure, nor for situations where the temporary pedestrian/bicyclist surface will be subject to several months of frequent rain, snow, or ice.

Rough-Sawn Plywood Siding is well suited to the surfacing of temporary wood pedestrian/bicyclist pathways. An EXTERIOR grade product is often used as a vertical siding material for sheds and other wood structures. In horizontal applications, its rough face can contribute to foot traction. Typical thicknesses are 11/32 inch (3/8 inch nominal) and 19/32 inch (5/8 inch nominal) and typical sheet sizes are 4-foot x 8-foot and 4-foot x 10-foot.

Plywood siding is produced with grooved and ungrooved finishes. “No groove” sheets are desirable for pedestrian/bicyclist surfacing applications but are not be available in all markets (contact a full-service lumberyard in the project area to determine availability). If ungrooved stock cannot be obtained locally, material with a 4-inch or 8-inch on-center T1-11 shallow groove pattern is recommended. As shown in Figure 80 the grooves in T1-11 are 3/8-inch wide and slightly less than 1 ply deep. It is preferable to orient the groves perpendicular to the direction of travel (which usually means cutting the sheets in half).

Plywood with 12-inch on center grooves is not recommended for pedestrian/bicyclist applications because the surface usually has the “reverse board and batten” (RB&B) pattern with wide grooves that could adversely impact wheelchair users and other wheeled traffic.

Figure 80. Plywood siding with T1-11 groove pattern at 4 inches on center.
Source: Wikimedia/putnamlumber.com/Images/products/plywood/T1-11_Deco_4

Rough-sawn plywood siding can reasonably be expected to have a durability of 1 year for pedestrian/bicyclist surfacing applications, including locations that have continuous moisture exposure and frequent rain, snow, or ice.

Preservative Treated Plywood has a surface finish similar to CDX. It is typically produced using EXTERIOR grade adhesives is then impregnated with wood preservatives, which impart a greenish color. It is generally available only in 15/32 inch (1/2 inch nominal) and 23/32 inch (3/4 inch nominal) thicknesses in 4-foot x 8-foot sheets. Although the material typically costs about 50% more than CDX, it is very resistant to decay. As a result, it is a good choice for temporary pedestrian/bicyclist surfaces that will remain in place for more than 1 year, or for building reusable pedestrian/bicyclist pathway panels.

Marine Plywood is 'exterior" grade plywood with a smooth surface finish, typically A-B grade. The smooth surface reduces pedestrian traction, resulting in greater risk of slips or falls under wet conditions. Marine plywood does *not* contain wood preservatives; it has the same weathering properties as other untreated exterior grade plywood products. The material typically costs 3 times as much as CDX.

5.7 Oriented Strand Board (OSB)

When used as a temporary pedestrian/bicyclist surfacing treatment that is not directly in contact with the ground, EXPOSURE 1 graded OSB panels can be expected to have a useful service life of 3 months or more under typical summer work zone site conditions (including occasional rain). OSB is not recommended for locations that have continuous moisture exposure, nor for situations where the temporary pedestrian/bicyclist surface will be subject to several months of frequent rain, snow, or ice.

OSB is an engineered wood product manufactured from wood shreds bonded with adhesive resin [9]. As shown in Figure 81, "oriented" refers to the fact that the direction of the shreds is not random: similar to plywood, they are placed at right angles in alternating directions using an odd number of layers (usually 3 or 5).

A useful characteristic of OSB is that one side of the panel has a skid-resistant texture. For pedestrian/bicyclist applications, the designer should specify that OSB is installed with the rough side up. The smooth side of OSB panels can be slippery and should not be used for walkway surfaces.

OSB has about the same fastener-holding power as plywood, but is less expensive. Depending on the manufacturer and product grade, it may be more or less rigid than plywood of the same thickness [10]. Like plywood, uncut OSB panels are usually stronger and more rigid in the long dimension. In contrast to plywood, OSB is uniform and does not have knots or weak spots [11].

Figure 81. Oriented Strand Board (OSB)
Source: Wikimedia Commons/Elke Wetzig

OSB panels are typically produced in "sheathing" and "subfloor" designations. The "sheathing" grade (ordinarily used for roof and wall applications) is preferable for temporary pedestrian/bicyclist accommodations. Typical thicknesses are 1/2 inch, 5/8 inch and 23/32 inch (nominally 3/4 inch). The most common panel size is 4-foot x 8-foot but 4-foot x 9-foot and 4-foot x 10-foot panels are available in some markets. Panels marked *STRUCTURAL 1* are stronger than panels without this certification.

The water resistance of OSB panels depends on the type of adhesive used to manufacture the panel and, to a lesser extent, the type of wood. As of 2015, *EXTERIOR* grade OSB panels were not available in the United States, but several manufacturers offer *EXPOSURE 1* grade panels, which are produced using a moisture-resistant adhesive. Several brands have a water-resistant clear or colored edge coating to deter edge swell.

Since OSB is produced in a number of proprietary grades, a call to a full-service lumberyard in the project area may be helpful in identifying the most suitable OSB panels that are available near the project site [10], [12]. These can potentially be specified in the project documents using "a '(brand name and product trademark) or approved equal' approach."

5.8 Timber

Wood boards or timber serves several purposes in the construction of temporary pedestrian/bicyclist facilities:

- **Dimension lumber** (such as 2x4s) is often used to support plywood or OSB surfaces.
- **Rollout boardwalks** assembled from timber with rope or nylon webbing can be useful to maintain foot traffic during short-duration work activities. These types of boardwalks can be prefabricated off-site or obtained commercially. The spacing between boards should be approximately 1/2 inch.
- **Timber puncheons** (also called bog bridges) allow a temporarily pathway to be built over soft or wet ground (Figure 82).

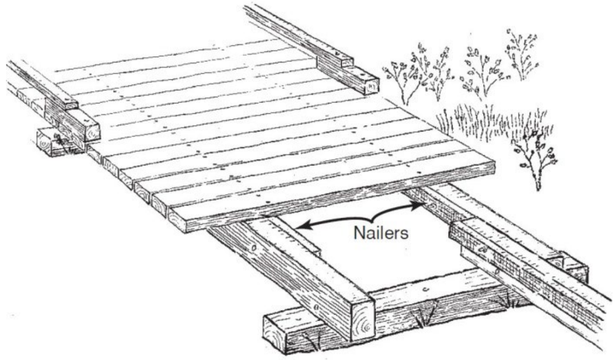


Figure 82. Timber puncheon.
Source: FHWA.dot.gov/environment/recreational_trails/publications

Standard softwood timber (known by the industry designation SPF or Spruce-Pine-Fir) is generally suitable for shorter-duration projects, especially in applications where it is not in direct contact with the ground. Treated timber can be used in applications that need greater durability; when new it usually has a greenish color imparted by the copper-based wood preservative. Due to cost, specialty wood products such as cedar or redwood are generally not appropriate for temporary facilities.

Fasteners. The fasteners specified for timber construction are as important as the wood itself. While nails can be used for facilities with a short service life, they generally begin working loose after a few months. Painted or galvanized steel screws or bolts are less likely to loosen. Due to cost, stainless steel fasteners are generally not appropriate for temporary facilities. Although resistant to rust, stainless steel fasteners are not as strong as carbon steel; they tend to break or strip when mechanically driven. The use of polyurethane or acrylic construction adhesives can greatly increase the durability of wood pedestrian/bicyclist facilities, but will also make them more difficult do disassemble when no longer needed.

5.9 Concrete

Concrete is a higher-cost surfacing option. Nevertheless, it can be useful for facilities that will have a long service life, such as project stages that will carry over winter, or a temporary facility installed at the beginning of a multi-year project that will be used for the entire project duration. The cost of removal should be considered if the concrete will not become part of the permanent facility.

5.10 Steel Plates

Steel plates, similar to the plates as used in roadways for trench covers, can also be used on sidewalks to bridge trenches, and are occasionally used as ramps. For the safety of pedestrians and bicyclists, they must be skid-resistant. This means applying an anti-skid coating or (for longer service life) micro texturing the surface. Diamond plate, also known as “checker plate”, is not an acceptable anti-skid surface texture for outdoor wet environments. Lifting loops should be recessed or kept away from the walking area. For ADA compliance, plate edges should be beveled or the plates should be installed using safety edging (Figure 46).

6. Work Zone Pedestrian/Bicycle Design Process

The development of pedestrian/bicyclist accommodations is an integral part of the work zone design process. There is considerable interaction between pedestrian/bicyclist design and other elements of overall work zone design, so the two should not be done in isolation. By the time the development of the Transportation Management Plan (TMP) begins, the designer should develop a clear idea of how bicyclists and pedestrians will fit into the overall design. As part of the TMP process, the designer should carefully review the existing bicycle and pedestrian facilities in and adjacent to the project limits. This review of bicyclist and pedestrian facilities should be done concurrently with all of the other reconnaissance data collection needed to develop a good traffic control plan.

6.1 On-Site Reconnaissance

On-site designer reconnaissance is recommended for beginning the design process to determine the appropriate type of temporary pedestrian and bicyclist facilities needed. Photographs, aerial images, and computer accessible street-view applications can provide general impressions of the site and are valuable memory aids, but field visits to observe pedestrian and bicyclist travel patterns are recommended. The purpose of the on-site visits allows the designer to more fully understand not only what the pedestrian and bicyclist facilities look like, but also provides information and impressions on the facility users and their capabilities, how they interact with the facility, and overall pedestrian and bicycle travel patterns. It is also useful for designers to walk or bicycle the route in order to visualize how construction will affect the non-motorized users.

It can be extremely helpful to visit the site more than once: pedestrian/bicyclist use patterns can vary considerably depending on the time of day, day of week, etc. For example, commercial areas that appear relatively quiet during the day may have considerably more pedestrian traffic in the evening, especially if they include restaurants, cinemas, or other entertainment destinations. At some sites, abrupt fluctuations in pedestrian volume occur with the arrival of aircraft, buses, ferries, or trains. Other sites have distinct patterns tied to the schedules for schools, universities, or major employers. Tourist/recreational destinations, resort towns, and areas near sports venues may have completely different pedestrian traffic patterns depending upon the season and day of week. The observer should also be alert for time-related variations in the composition of the pedestrian/bicyclist traffic; for example, at certain times there may be an influx of children, people with disabilities or older pedestrians. Evidence of pedestrian activity outside of designated pathways can be an indicator of high demand pedestrian activity that is worthy of consideration.

Designer night observations are particularly important near night entertainment establishments and districts, sporting venues, and restaurants: defects in existing bicycle and pedestrian facilities that appear to be relatively minor by day may be quite hazardous under dim illumination or in the veiling glare of advertising signs or flashing lights.

Recommended reconnaissance procedures include:

- Divide project area into logical segments or zones based on the land use, terrain, and configuration of existing pedestrian facilities.
- Observe and record the level of pedestrian traffic in each zone at various relevant times. If a pedestrian/bicyclist traffic count is not feasible, rate the pedestrian/bicyclist traffic level using an ordinal scale, such as none, light, medium, heavy, very heavy.
- Take note of the presence of pedestrians with special needs, such as schoolchildren, people with disabilities, and older pedestrians. Sometimes commercial deliveries using carts or hand trucks are also a consideration.
- Note the location, volume, and frequency of pedestrian traffic at bus stops, taxi stands, and other potential pedestrian drop-off zones.
- Note the location of any informal pathways, cut-throughs, shortcuts, temporary paths. A beaten path is often a good indicator of pedestrian demand that is not well served by the existing configuration.
- Conduct a walk-through of the existing pedestrian accommodations and a bicycle tour on the existing bicycle accommodations, including making photographs and video tapes for future reference in the office. Ideally, this should cover all directions, both by day and by night.
- Observe pedestrian/bicyclist traffic at existing intersections and crosswalks, making particular note of any recurrent illegal or dangerous actions such as jaywalking.
- Note any significant defects or hazards in the existing pedestrian/bicyclist facilities, as these could influence the sequencing and staging of the pedestrian/bicyclist facilities construction. Also, look at the condition of possible detour routes.
- Review the site for potential alternative pedestrian/bicyclist access that could be used during construction, such as access from side streets or alleys.
- Do not attempt to evaluate pedestrian/bicyclist facilities based solely on a driving tour of the site. From within a vehicle, it is easy to overlook relevant features of the pedestrian/bicyclist facility.

6.2 Coordination with Local Stakeholders

Pedestrian/bicyclist stakeholder coordination includes both formal and informal efforts to gather information about the needs of bicyclists and pedestrians in the project area, and gathering feedback on proposed temporary pedestrian/bicyclist accommodations. Relevant stakeholders include adjacent property owners (both business and residential) and local officials. Representatives of public transit systems should be contacted to begin dialogue about possible adjustment of bus routes, stops, or schedules. Major generators of pedestrian/bicyclist traffic, notably schools, should also be consulted. Special consideration should be given to obtaining information about the needs of people with disabilities in the project area, either by talking to those individuals directly or in coordination with relevant organizations. Local bicycle clubs can also be a useful source of information, though the designer needs to bear in mind that such groups are usually comprised of avid cyclists with relatively high skill levels.

Coordination of work zone pedestrian/bicyclist accommodations can generally be done in conjunction with other information gathering and public outreach efforts that are traditionally completed as part of the project development process. Pedestrian/bicyclist issues should be addressed specifically as part of the information gathering effort. For example, an informational

board illustrating proposed pedestrian/bicyclist detours during construction could be presented at the public outreach meeting to solicit public comment.
When gathering information from stakeholders, be sure to inquire about any events that affect pedestrian/bicyclist volumes. Examples include school schedules, local festivals, bicyclist races, and other special events.

7. Construction Staging

Construction staging refers to the major sequencing of construction activities. If staging is not carefully planned, it can become quite difficult for people to access residences, businesses, public buildings, and other facilities in and around the work zone. Inadequate staging is a frequent source of public complaints and potentially violates the civil rights of people with disabilities. Inadequate staging can also diminish site safety. To avoid these issues, the sequencing of pedestrian/bicyclist facility construction should be developed as an integral part of the overall construction-staging plan for the entire project:

- Bid documents should describe the staging in enough detail that each bidder can understand at least one way to construct the facilities in a sequence that safely meets the needs of all road users at reasonable cost.
- In some cases, more than one staging sequence is feasible. The bid documents do not need to show all possibilities, but should reflect the designer's vision of the best option.
- Occasionally the successful bidder may wish to propose an alternate arrangement. This would be negotiated after the project has been let in accordance with the agency's usual policies.

Staging plan development should involve coordination between the community leaders, businesses, and other major pedestrian and bicycle traffic generators. Also recommended during project development are conducting community outreach meetings and opportunities for pedestrians and bicyclists users to express their views and concerns.

As shown in Figure 83, the construction methods that are most expeditious for the contractor often conflict with pedestrian/bicyclist safety and mobility. Temporary loss of access can also have adverse financial impacts on adjoining businesses, so it is important for public agencies to avoid the perception that they are putting the contractor's profitability above that of other businesses.

Figure 83. Concurrent construction of all four pedestrian crosswalks makes business access difficult (Canadian example). Note: Non-MUTCD compliant drums and improper closure of work site.
Source : Charles Akben-Marchand, Images of Centretown (http://centretown.blogspot.ca)

Figure 84. Thoughtful staging provides safe pedestrian and bicycle access during construction (Australian example).
Source: Wikimedia Commons

The amount of staging flexibility that the designer has depends to a large degree on what kind of pedestrian/bicyclist facilities already exist. For example, if the site currently has no pedestrian/bicyclist facilities, adding sidewalks and/or bikeways can probably be done at any stage of the project (often as the last stage). If there are existing pedestrian facilities the designer will need to develop a staging sequence that accommodates pedestrian movements at all times (e.g., Figure 84). Accommodation of bicyclists is slightly more discretionary, in the sense that bicyclists can sometimes be relocated to a parallel facility, redirected into mixed traffic, or need to walk their bicycles for a short distance. The feasibility of each of these options is site-specific and will depend on the bicycle traffic volume and the age and skill level of the cyclists present on the site. The condition of the existing infrastructure is also a consideration.

Often the biggest challenge is the relatively short time when the pedestrian/bicyclist facility itself is under construction. For example, if an existing sidewalk is being removed and replaced there will be a time when there is no pavement and a time when the new concrete has not yet hardened. The conventional solution to this problem is to redirect pedestrians to the opposite side of the street (if it has a sidewalk), but this can result in loss of access to properties on the side that is being reconstructed. Another potential solution is to provide a temporary walking surface such as plastic matting (Figure 78) or a rollout boardwalk (Figure 82) on the adjoining terrace area. In other cases, access could be temporarily moved to the back or side of the affected properties.

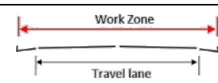
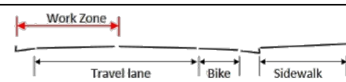
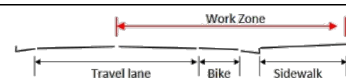
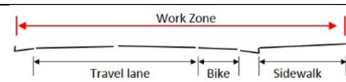
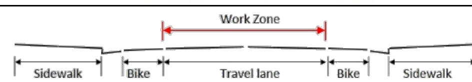
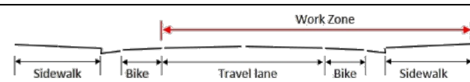
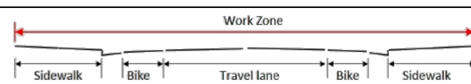
The selection of materials for temporary pedestrian/bicyclist facilities is an integral part of designing the construction staging. The durability of the materials needs to be proportionate to the duration of the project stage. Assuming that they are adequate in terms of safety and stability, materials that will be used for only a short time should be easy to remove. Special provisions can be inserted into the contract documents to assure that materials intended for short-term use do not remain in place too long. For example, a surface made of untreated plywood should be removed or replaced before the wood becomes rotted or splintered.

Staging plan alternatives should be developed based on the pedestrian/bicyclist site reconnaissance information, the condition of existing infrastructure, and other site conditions such as motor vehicle traffic management and the extent of underground utility work. Consideration should be given to changes in vertical grade and horizontal alignment.

7.1 Situations Appropriate for Pedestrian/Bicycle Staging Plan

Table 7 provides general guidance on situations where a pedestrian/bicycle staging plan are appropriate as part of the bid document package.

Table 7. Guide to Situations Requiring a Pedestrian/Bicycle Staging Plan

Existing Pedestrian/ Bicyclist Facilities	**Type of Work**	**Diagram**	**Pedestrian Staging Plan Needed?**
None	Within Travelled Way		No
One Side	In travelled way on opposite side from pedestrian/bicyclist facility		No
One Side	In travelled way on same side as pedestrian/bicyclist facility		Yes
One Side	In travelled way on both sides		Yes
Both Sides	Within Travelled Way Only		No
Both Sides	Motor vehicle lanes and pedestrian/bicyclist facility on one side		Usually
Both Sides	Motor vehicle lanes and pedestrian/bicyclist facilities on both sides.		Yes

7.2 Typical Staging Methods

Although every pedestrian/bicyclist staging plan needs to be customized for the site and the combination of improvements that is being designed, there are several commonly used pedestrian/bicyclist construction staging methods. For simplicity, this section only describes situations without separate bicyclist facilities, but the same principles can be applied to bikeways.

Method 1: Inside-Out. This method usually involves three stages:

1. Existing pedestrian accommodations on the "outside" of the right-of-way are left in place while the street or highway on the "inside" of the right-of-way is built.
2. When the new street is completed, the sidewalks on one side of the roadway are torn out and replaced while pedestrians are detoured to the opposite side.
3. When the first new sidewalk is completed, it is re-opened to pedestrian traffic. Pedestrians from the opposite side are then detoured onto the newly constructed sidewalk while the second sidewalk is built.

Though commonly used, a fundamental problem of the inside-out method is that it is very difficult to maintain access to properties on the side of the street where sidewalk construction is taking place. As a result, the method is best suited for sites where most of the pedestrian traffic is passing through the site rather than going to destinations in or adjacent to the work zone.

Method 2: Outside-In. This flips the sequence of the Inside-Out method:

1. The sidewalks on one side of the roadway are torn out and replaced while pedestrians are detoured to the opposite side.
2. When the first new sidewalk is completed, it is re-opened to pedestrian traffic. Pedestrians from the opposite side are then are detoured onto the newly constructed sidewalk while the second sidewalk is built.
3. With the new pedestrian accommodations on the "outside" of the right-of-way completed, work then begins on the roadway "inside" of the right-of-way.

As with the inside-out method, it is very difficult to maintain access to properties on the side of the roadway where sidewalk construction is taking place. As a result, the outside-in method is best suited for sites where the sidewalk is being permanently relocated, or where most of the pedestrian traffic is passing through the site rather than going to destinations adjacent to the work zone.

Method 3: Inside-Out with Lane Closures. This modification of the inside-out method provides temporary access to properties adjoining the work zone by means of a closed traffic lane or (more often) a closed parking lane:

1. Existing pedestrian accommodations on the "outside" of the right-of-way are left in place while the street or highway on the "inside" of the right-of-way is built.
2. A newly reconstructed traffic lane or parking lane is temporarily reallocated to pedestrian use while the adjoining sidewalk is torn out and replaced. (Barriers such as those shown in **Error! Reference source not found.** are generally used to separate pedestrians from motorized traffic). Depending on the available workspace, this could be done concurrently on both sides of the street, or each side could be done separately.

In general, this method is not suitable for situations where the roadway is being widened.

Method 4: Outside-In with Traffic or Parking Lane Closures. This modification of the outside-in method provides temporary access to properties adjoining the work zone by means of a closed traffic lane or closed parking lane:

1. A traffic lane or parking lane is temporarily reallocated to pedestrian use while the adjoining sidewalk is torn out and replaced. (Barriers such as those shown in **Error! Reference source not found.** are generally used to separate pedestrians from motorized traffic). Depending on the available workspace, this could be done concurrently on both sides of the street, or each side could be done separately.
2. With the new pedestrian accommodations completed on the "outside" of the right-of-way, work then begins on the roadway "inside" of the right-of-way.

In general, this method is amenable to roadway widening projects because the new sidewalks can be built in their final location at the outset. This method can also be useful when there is a significant grade change on the new construction.

Method 5: Temporary Pedestrian Pathways. If there is enough space, temporary pedestrian pathway(s) can be constructed to provide access while the permanent walkways are rebuilt. This is often the most effective way to provide full access to adjacent properties while minimizing overall disruption and inconvenience. In many cases, Temporary Limited Easements (TLEs) can be obtained so that the temporary pathway can be located on private property.

1. Pedestrians are routed onto a temporary pathway. Depending on the available workspace, this could be done concurrently on both sides of the street, or each side could be done separately.
2. The new roadway and permanent sidewalks are constructed.
3. The temporary pathways are removed and the landscaping is restored.

Method 6: Complete Pedestrian Detour. Detouring pedestrians can reduce construction time, but detours are usually inconvenient for pedestrians. In addition, pedestrian detours can result in loss of access to adjoining properties.

1. Pedestrians are detoured to an alternate route such as a parallel street or alley.
2. The entire roadway is reconstructed.

Method 7: Accelerated Construction with Full Closure. Occasionally, work occurs in a location where pedestrians are present only at limited, predictable times. Work at such sites can sometimes be completed as a "blitz" when pedestrians are absent. For example, a complete pedestrian closure might be feasible near a stadium that only has pedestrian activity during events, in a financial district that only has pedestrian activity during daytime weekday business hours, or in a resort area during the off-season. In some cases, prefabricated components are specified or contractual incentives are put in place to assure that work is completed quickly.

1. All pedestrian facilities are closed and any remaining pedestrians are redirected to alternate routes.
2. All work is completed as quickly as possible so that the pedestrian facilities can re-open before the start of the next wave of pedestrian activity.

7.3 Vertical Staging

Most of the effort in developing a staging plan is likely to focus on the allocation of the horizontal space available within the right-of-way (and the way this allocation changes as work progresses). In some cases, there is also a vertical aspect to the staging plan. This is especially likely if there are significant grade changes or deep excavations on the project. For example, in some cases it could be desirable to build a temporary pedestrian/bicyclist facility that becomes the pavement base for a permanent pedestrian/bicyclist facility or roadway. In such cases, the use of materials such as soil cement or CLSM could be desirable. A similar possibility is a temporary pedestrian/bicyclist path (also possibly built using soil cement or CLSM) that is left in place, covered with topsoil, and seeded when it is no longer needed. Occasionally such options can reduce construction cost by avoiding the need to move material twice. Development of the vertical staging should also consider grades, cross-slopes, and the need for temporary walls or pilings.

7.4 Alternating Side Construction

Alternating side construction is frequently used for urban and suburban street construction projects. This technique usually reduces the number of stage changes and is relatively simple to integrate with motorized vehicle traffic staging patterns. Underground utility work is often the deciding factor in which side to close first. If utility work is not an overriding consideration, construction should begin on the side that will cause the least inconvenience to bicyclists and pedestrians. This will often allow bicyclists and pedestrians to take advantage of newly constructed permanent facilities during later stages.

7.5 Alleys as Temporary Pedestrian/Bicyclist Access

Providing property access during construction can be difficult, especially if the right-of-way is narrow. Traditional and neo-traditional commercial districts with narrow setbacks can be particularly challenging, especially if the sidewalk fills the entire space between the back-of-curb and the building face.

As shown in Figure 85, this problem can sometimes be resolved by using existing alleys for back-door access. Typically, pedestrians continue to use front entrances while the alley is improved. When the alley is ready for pedestrians, front-door access is restricted to allow the contractor to use the majority of the available roadway width (from building face to building face) for work operations.

Figure 85. Concept of using an older commercial areas alley for pedestrian access during construction.
Source: Wikimedia Commons/ Baty Arnaud & Alex Hartunian & Mock-up drawing by UW-TOPS Lab

In some cases, it is appropriate to prohibit motor vehicle traffic in the alley during construction. This could consist of complete (temporary) pedestrian-only use of the alley, or it could be used by pedestrians-only when stores are open for business, with deliveries made during non-store hours. In other situations, low-volume vehicular traffic might need to be maintained during some or all hours of the day. Since most alleys are quite narrow, pavement marking could be used to designate separate spaces for pedestrians and a single lane of one-way traffic (eight or nine-foot lane width is not unusual in alleys). Traffic calming techniques such as round-top speed humps could be used to minimize cut-through traffic and reduce the likelihood and severity of vehicle-pedestrian collisions.

Alley improvements are often necessary to provide a safe walking environment. Items, which could legitimately be considered as mitigation expenses for the highway project, include:

- Manhole and inlet repairs such as replacement of defective covers and obsolete grates.
- Resurfacing of alley pavement.
- Installation of pavement marking and signage to regulate the use of alley space during construction.
- Installation of signage and pavement markings to regulate or prohibit parking in the alley during construction.
- Minor walkways that are essential to provide a firm walking surface from the alley to one entrance for each private property.
- Installation of small (e.g., 12" x 24") uniform back door signs for *business* properties. (Signage for residential properties, if provided, should be limited to address numbers).
- Temporarily relocating trash dumpsters and recycling containers to free up space for bicyclists, pedestrians, and vehicles.
- Temporary alley lighting during construction.

Expenses, which would typically be the responsibility of individual property or business owners, include:

- Repair or replacement of building components such as back doors, steps, etc.
- Painting and graffiti removal, if appropriate.
- Landscaping and decorations.
- Rearranging merchandise, furnishings, and equipment.

Permanent upgrades to the alley that are not essential to its temporary use as the pedestrian/bicyclist access may require a local government cost share in accordance with agency policies. Some examples include decorative pavement, landscaping, and permanent lighting.

7.6 Pedestrian/Bicycle Detours

Short-term pedestrian/bicyclist detours are sometimes necessary to protect the public from falling debris or similar hazards during work operations such as bridge deck demolition, girder placement, or installation of overhead electrical equipment. The use of long-term pedestrian/bicycle detours should be limited to situations where there is no other reasonable alternative. Factors to be considered when selecting a detour route include:

- Route length and associated indirection and inconvenience.
- Grades and cross-slopes (especially in hilly or mountainous areas).
- Traffic hazards such as skewed intersections, railroad crossings, and situations requiring bicyclists to ride in heavy mixed traffic.
- Alternative access for properties normally served by the pedestrian/bicyclist facility.
- Overall quality of the alternative route compared to the usual route.

7.7 Intersection Construction

The methods used for intersection construction can strongly influence the construction-staging plan. In some cases, it is possible to build intersections in halves (or even quarters) to minimize pedestrian/bicyclist disruption. Nevertheless, such methods can increase the overall project duration (with resulting impacts on cost) and sometimes result in construction joints in unfavorable locations. Building in halves or quarters is often infeasible on projects that have a significant grade change.

When it is not feasible to build an intersection in halves or quarters, it is usually desirable to do the intersection work in a checkerboard pattern so that every other intersection retains nearly normal traffic pattern. This can help reduce disruption to pedestrians and (especially) transit operations. In some cases, temporary mid-block crossings are necessary to maintain access to properties.

7.8 Roundabout Construction

There are several ways to build a roundabout. As shown in Figure 86, one option is to construct it in halves or quarters, similar to the method described above for conventional intersections. This allows motor vehicle traffic to be maintained in part(s) of the intersection during construction, but can result in significant conflicts between pedestrians, bicyclists, and motorized traffic. For safety reasons, it is often preferable to close the construction site to pedestrian/bicyclist traffic when this method is used.

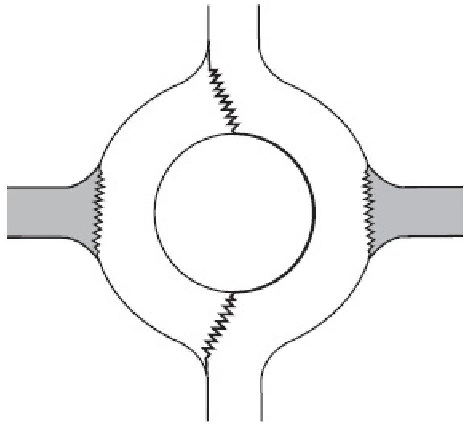


Figure 86. Construction of roundabout in halves.
Source: Centre d'Information sur le Ciment et ces Applications CTC-T63.

Figure 87. Slipform paving of a large roundabout.
Source: Centre d'Information sur le Ciment et ces Applications CTC-T63.

As shown in Figure 87, often the most expeditious way to build a roundabout is to construct the circulatory roadway as a ring, and then add the approaches. This method usually means closing the intersection to motor vehicle traffic, but pedestrian/bicyclist traffic can sometimes be maintained around the periphery (at times pedestrians and bicyclists may need to travel 270° to complete certain movements). For ease of construction equipment access, one possible sequencing option is as follows:

a. Build the permanent sidewalk as an outer ring. Install fences to prevent pedestrians from entering the inner area where the roadway will be built.
b. Build a "C"-shaped portion of the circulatory roadway.
c. Complete the rest of the circulatory roadway and the first roundabout approach in a single pour.
d. Complete the remaining three approaches.

7.9 Pedestrian Staging Example

As part of major freeway project in northeastern Wisconsin, the ramp terminals at the interchange of US 10/WIS 441 and Appleton Road (WIS 47) were reconstructed. US 10/WIS 441 is a freeway and Appleton Road is a multilane suburban arterial. Properties near the interchange include several restaurants and big-box retail stores. As shown in Figure 88, the existing interchange had sidewalks along the west side of Appleton Road (north is to the right in the figure) and partial pedestrian accommodations on the east side. Upon completion, the design called for sidewalks on both sides of Appleton Road. The area has moderate pedestrian volumes, including some people with disabilities employed at the Goodwill Community Center in the northwest quadrant of the interchange.

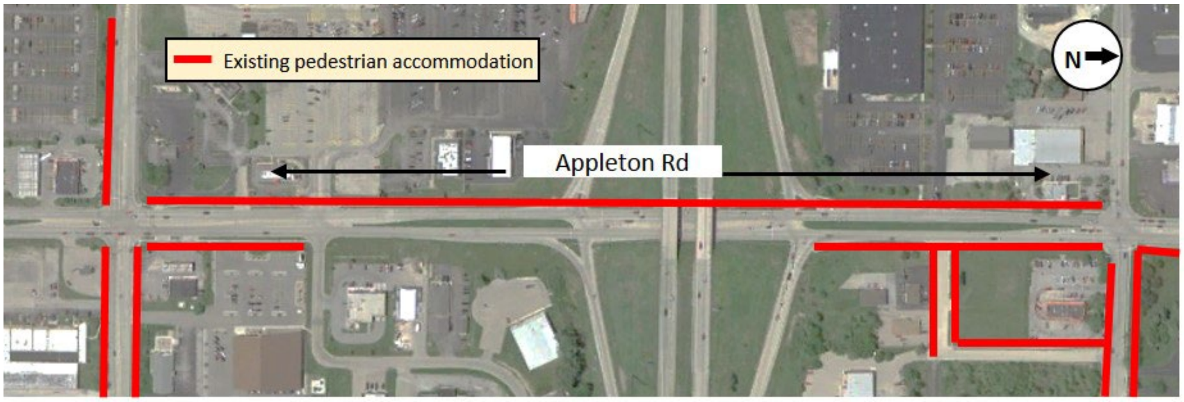


Figure 88. Existing (pre-construction) pedestrian accommodations at Appleton Road interchange.
Source: UW-TOPS Lab

As shown in Figure 89, a construction-staging plan was developed to maintain pedestrian access while the roundabouts were constructed. During the first stage, temporary asphalt walkways were installed on the west side of Appleton Road to replace the sidewalk sections that had to be removed for roundabout construction. In the second stage, permanent walkways were installed along the east side of Appleton Road. Finally, the temporary asphalt walkways on the west side were removed and replaced with permanent concrete sidewalks. This work was integrated with staged construction of the roundabouts and related highway infrastructure.

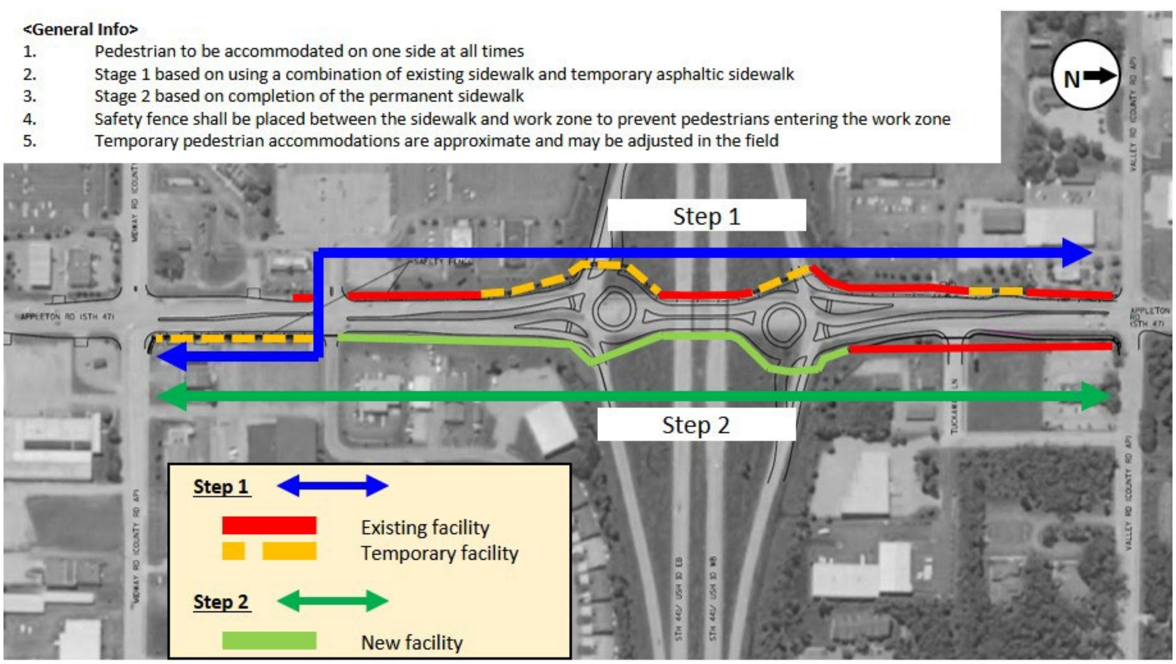


Figure 89. Pedestrian staging plan for Appleton Road interchange.
Source: UW-TOPS Lab

8. Maintaining Pedestrian/Bicycle Facilities During Construction

Contractual provisions should be put in place to assure that temporary pedestrian/bicyclist accommodations are kept in satisfactory condition throughout the duration of the project. The inspection frequency and timelines to correct identified problems should be specified. Defects on temporary pedestrian and bicycle facilities should be corrected with the same priority that is given to motorized traffic, including urgent correction of any issues that pose a clear and present danger to public safety.

At minimum, the contractual language should address the following considerations:

- Pedestrian and bicyclist signage, signals, and pavement markings should remain in acceptable condition. Sign legends and colors should remain consistent with the MUTCD. Any signs that are stolen, damaged, or vandalized should be replaced promptly. Signs, signals, and markings that are no longer needed should be removed or covered promptly.
- Pedestrian and bicyclist fences, channelizing devices, and barriers should be kept in satisfactory condition. Water-filled barriers should be topped up periodically to compensate for evaporative loss. Devices that are no longer needed should be removed promptly.
- Walking and cycling surfaces should remain firm, stable, and slip resistant. Mud, debris, and rubbish should be removed from surfaces promptly. Surfaces that are open to public use should be kept clear of tools, equipment, and construction materials.
- Lighting systems needed for public safety should remain functional during hours of darkness. Luminaires, lamps, and batteries in temporary lighting systems should be replaced promptly in the event of equipment failure, theft, vandalism, or damage.
- Public trash receptacles should be emptied on a regular basis.

9. Appendix A

Appendix A is a 2023 revision made to this document.

Information presented in the Appendix applications is offered as support material to the national MUTCD. The illustrations included in this Appendix expand upon situations presented in the MUTCD Chapter 6H.01 for a variety of temporary traffic control plans specifically for accommodating pedestrian and bicycle situations. The information illustrated can be adapted to a broad range of conditions, combined with other MUTCD typical applications or other illustrations in this Appendix, and/or added to other user guidance materials to achieve an appropriate temporary traffic control plan. Other devices may be added to supplement the devices and device spacing may be adjusted to provide additional reaction time or improved delineation, as well as to meet field conditions. Fewer devices may also be used based on field conditions. Sign spacing and other dimensions for various area and roadway types are found throughout Part 6 in the MUTCD.

Each of the illustrations in the Appendix is accompanied by a Notes page with headings for Standards, Guidance, Option, or Support material shown on the illustrations, based on compliance with the MUTCD. A legend with the symbols used for the illustrations is also provided as Table A-1 and the meaning of letter codes used on the illustrations is shown on Table A-2. Table A-3 has the formulas for determining taper lengths which comes from the MUTCD Table 6C-4. Some of the illustrations show temporary traffic control devices for only one direction of travel.

Figure A1. Work Beyond the Shoulder and Affecting Sidewalk (I-1)

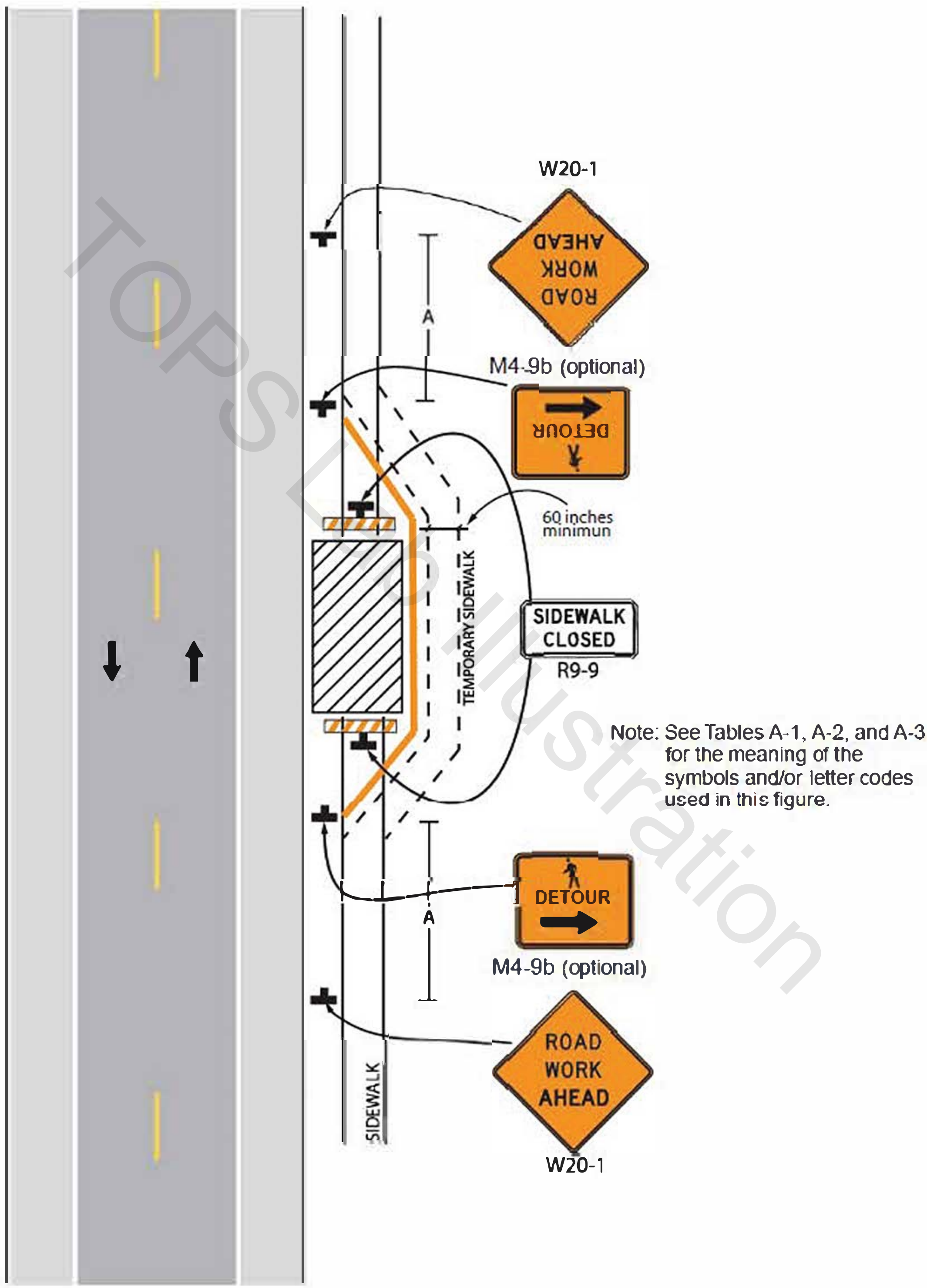


Illustration I-1

Notes for Figure A1—Illustration I-1
Work Beyond the Shoulder and Affecting Sidewalk

Standard:

1. **A temporary sidewalk route or diversion shall be provided if the work area blocks an existing sidewalk. Sidewalk continuous longitudinal channelizing devices shall be provided. The SIDEWALK CLOSED sign shall be placed on a ADA barricade where the sidewalk is closed. The temporary sidewalk or detour shall comply with latest ADA requirements.**
2. **Vehicle hazard warning signals shall not be used instead of the vehicle's high-intensity rotating, flashing, oscillating, or strobe lights.**

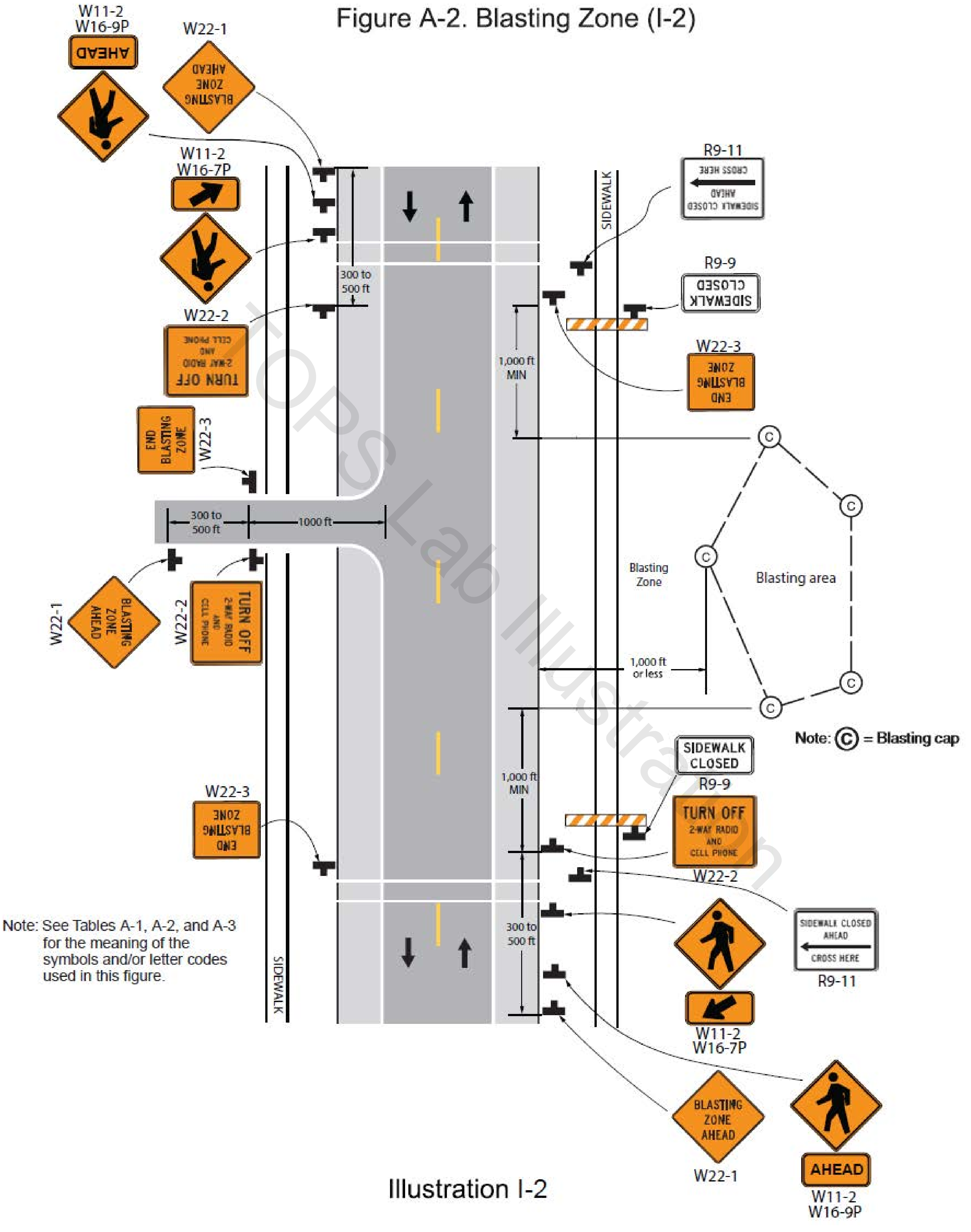
Guidance:

3. *If the work space is in the median of a divided highway, an advance warning sign should also be placed on the left side of the directional roadway.*
4. *The protective requirements of a diverted sidewalk should be based on engineering judgement.*

Option:

5. The ROAD WORK AHEAD sign may be replaced with other appropriate signs such as the SHOULDER WORK sign. The SHOULDER WORK sign may be used for work adjacent to the shoulder.
6. The ROAD WORK AHEAD sign may be omitted where the work space is behind a barrier, more than 24 inches behind the curb, or 15 feet or more from the edge of any roadway.
7. For short-term, short duration or mobile operation, all signs and channelizing devices may be eliminated if a vehicle with activated high-intensity rotating, flashing, oscillating, or strobe lights is used.
8. Vehicle hazard warning signals may be used to supplement high-intensity rotating, flashing, oscillating, or strobe lights.
9. The width of the alternative pedestrian route may be 48 inches with a passing area of 60 inches every 200 feet.

Figure A-2. Blasting Zone (I-2)



Note: See Tables A-1, A-2, and A-3 for the meaning of the symbols and/or letter codes used in this figure.

Illustration I-2

Notes for Figure A2—Illustration I-2
Blasting Zone

Support:

1. **When blasting in the vicinity of roadways and sidewalks is required, consideration on whether to use detours or diversions is a design decision to provide appropriate safety for users. Existing alternative roadways and sidewalks in the area can be examined. Factors such as amount of blasting required and whether alternative routes are available can be examined in making the decision on how to treat roadway users when blasting will occur.**
2. **Alternative sidewalks and diversions are prefered instead of adding temporary crossings.**

Option:

1. **Existing roadways, sidewalks, and permanent sidewalk crossings in advance of the blasting area may be used to detour or divert users.**
2. **Temporary pedestrian crossing pavement markings may be used if temporary pedestrian crossing(s) are used in advance of the blasting area.**
3. **A permanent pedestrian crossing may be used in advance of the blasting area.**

Standard:

1. **Whenever blasting caps are used within 1,000 feet of a roadway, the signing shown shall be used.**
2. **The signs shall be covered or removed when there are no explosives in the area or the area is otherwise secure.**
3. **Whenever a side road intersects the roadway between the BLASTING ZONE AHEAD sign and the END BLASTING ZONE sign, or a side road is within 1,000 feet of any blasting cap, similar signing, as on the mainline, shall be installed on the side road.**
4. **Whenever a sidewalk is within 1,000 feet from a blasting area, a SIDEWALK CLOSED sign and barricade shall be used to restrict access to the blasting area. A temporary pedestrian crossing(s) shall be provided ahead of the blasting area. Pedestrian crossing sign(s) and SIDEWALK CLOSED AHEAD CROSS HERE sign(s) shall be used. The temporary pedestrian crossing(s) shall comply with ADA requirements.**
5. **Prior to blasting, the blaster in charge shall determine whether road users in the blasting zone will be endangered by the blasting operation. If there is danger, road users shall not be permitted to pass through the blasting zone during blasting operations.**

Guidance:

1. *On a divided highway, the signs should be mounted on both sides of the directional roadways.*

Figure A3. Work on the Shoulders (I-3)

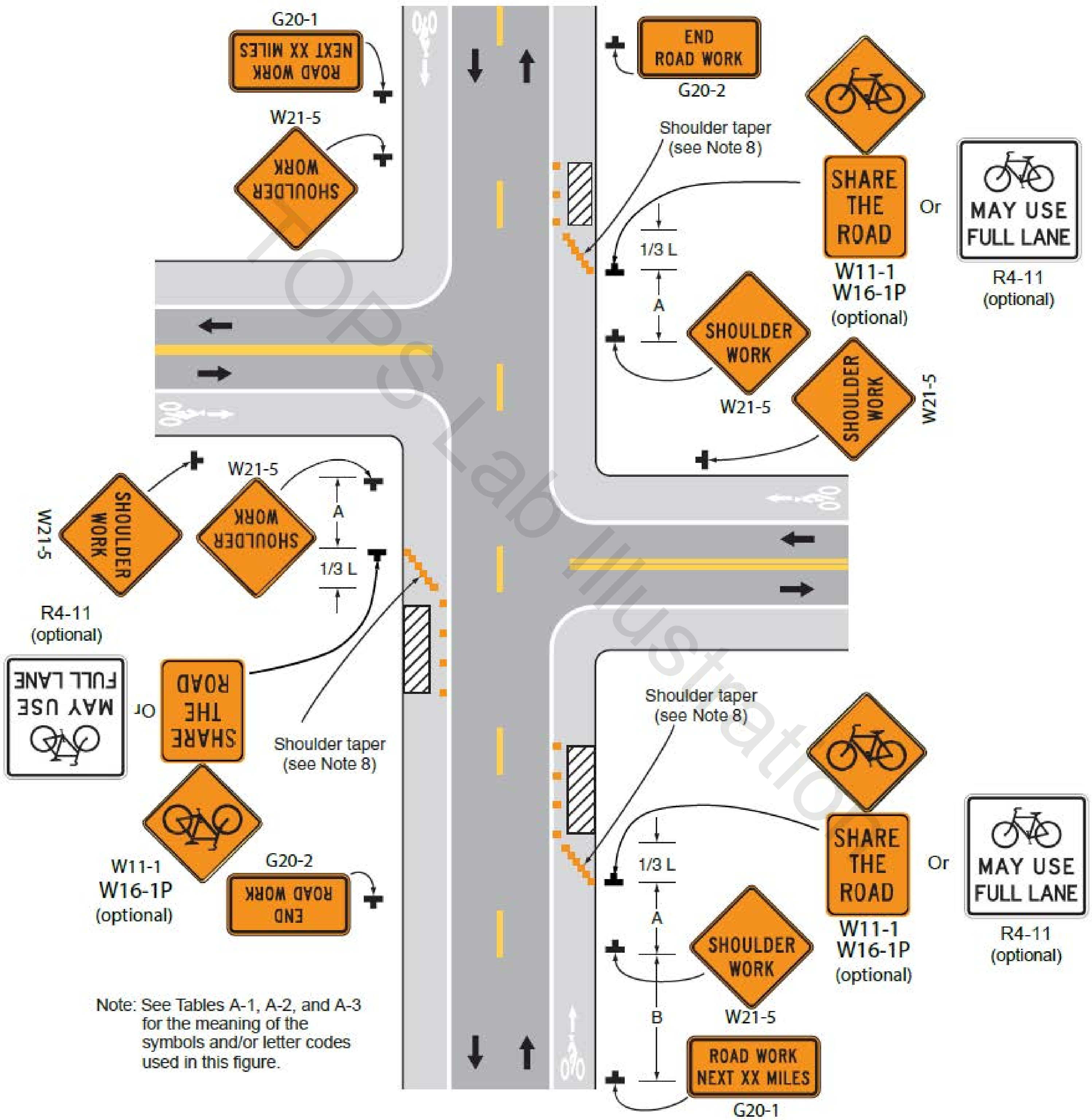


Illustration I-3

Notes for Figure A3—Illustration I-3
Work on the Shoulders

Guidance:

1. *A SHOULDER WORK sign should be placed on the left side of the roadway for a divided or one-way street only if the left shoulder is affected.*

Option:

2. The Workers symbol signs may be used instead of SHOULDER WORK signs.
3. The SHOULDER WORK AHEAD sign on an intersecting roadway may be omitted where drivers emerging from that roadway will encounter another advance warning sign prior to this activity area.
4. Bicycle symbol and SHARE THE ROAD or MAY USE FULL LANE signs may be used in locations where bicyclists are normally permitted to ride on the shoulder.
5. For short duration operations of 60 minutes or less, all signs and channelizing devices may be eliminated if a vehicle with activated high-intensity rotating, flashing, oscillating, or strobe lights is used.
6. Vehicle hazard warning signals may be used to supplement high-intensity rotating, flashing, oscillating, or strobe lights.

Standard:

7. **Vehicle hazard warning signals shall not be used instead of the vehicle's high-intensity rotating, flashing, oscillating, or strobe lights.**
8. **When paved shoulders having a width of 8 feet or more are closed, at least one advance warning sign shall be used. In addition, channelizing devices shall be used to close the shoulder in advance to delineate the beginning of the work space and direct vehicular traffic to remain within the traveled way.**

Figure A4. Short-Duration or Mobile Operation on a Shoulder (I-4)

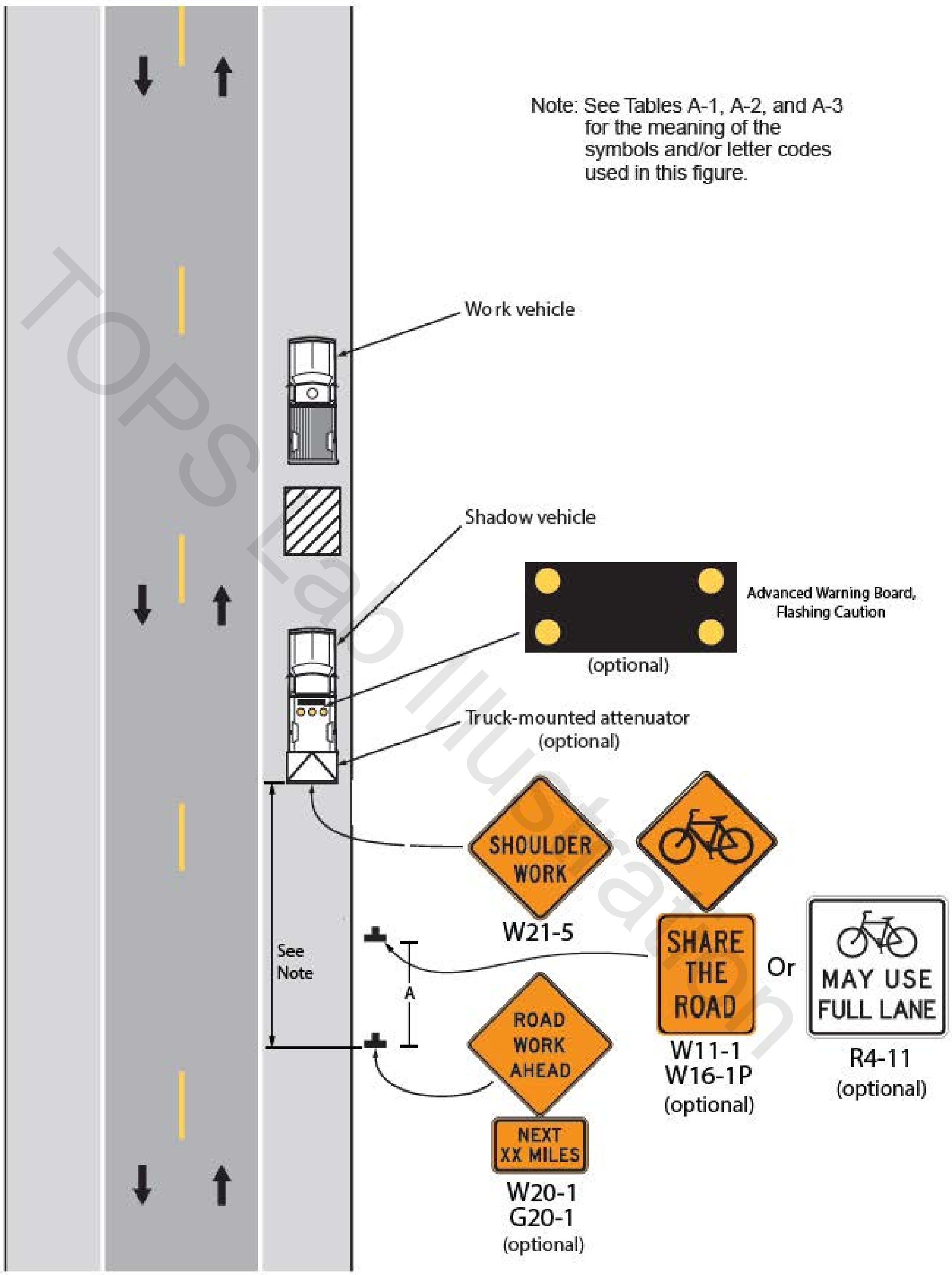


Illustration I-4

Notes for Figure A4—Illustration I-4
Short Duration or Mobile Operation on a Shoulder

Guidance:

1. *In those situations where multiple work locations within a limited distance make it practical to place stationary signs, the distance between the advance warning sign and the work should not exceed 5 miles.*
2. *In those situations where the distance between the advance signs and the work is 2 miles to 5 miles, a Supplemental Distance plaque should be used with the ROAD WORK AHEAD sign.*

Option:

1. The ROAD WORK NEXT XX MILES sign may be used instead of the ROAD WORK AHEAD sign if the work locations occur over a distance of more than 2 miles.
2. Stationary warning signs may be omitted for short duration or mobile operations if the work vehicle displays high-intensity rotating, flashing, oscillating, or strobe lights.
3. Vehicle hazard warning signals may be used to supplement high-tensity rotating, flashing, oscillating, or strobe lights.
4. Bicycle symbol and SHARE THE ROAD or MAY USE FULL LANE signs may be used in locations where bicyclists are normally permitted to ride on the shoulder.

Standard:

1. **Vehicle hazard warning signals shall not be used instead of the vehicle's high-intensity rotating, flashing, oscillating, or strobe lights.**
2. **If an arrow board is used for an operation on the shoulder, the caution mode shall be used.**
3. **Vehicle-mounted signs shall be mounted in a manner such that they are not obscured by equipment or supplies. Sign legends on vehicle-mounted signs shall be covered or turned from view when work is not in progress.**

Figure A5. Shoulder Work with Minor Encroachment (I-5)

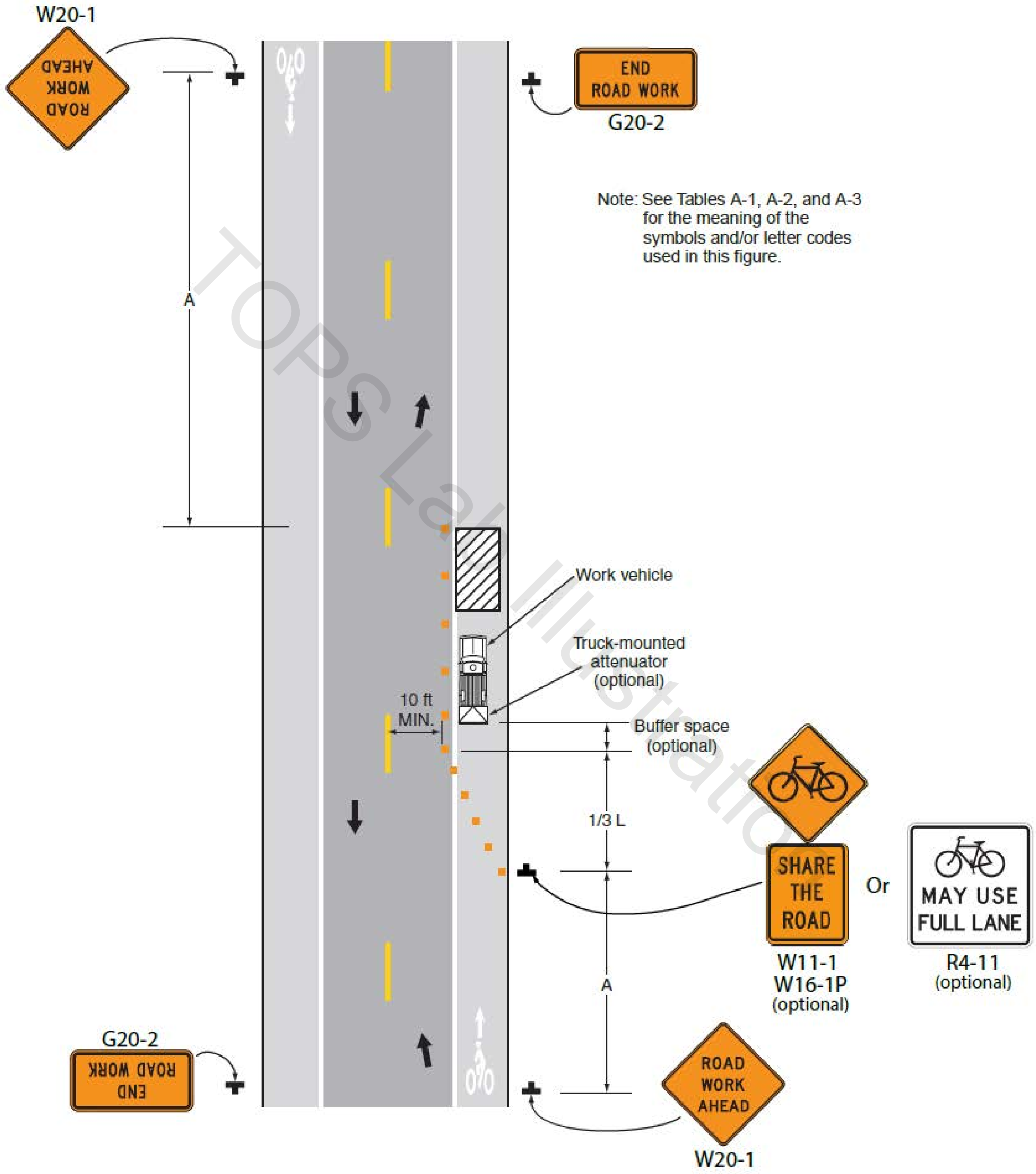


Illustration I-5

Notes for Figure A5—Illustration I-5
Shoulder Work with Minor Encroachment

Guidance:

1. *All lanes should be a minimum of 10 feet in width as measured to the near face of the channelizing devices.*
2. *The treatment shown should be used on a minor road having low speeds. For higher-speed traffic conditions, a lane closure should be used.*

Option:

3. For short-term use on low-volume, low-speed roadways with vehicular traffic that does not include longer and wider heavy commercial vehicles, a minimum lane width of 9 feet may be used.
4. Prior to the activity area, bicycle symbol and SHARE THE ROAD or MAY USE FULL LANE signs may be used in locations where bicyclists are normally permitted to ride on the shoulder.
5. Where the opposite shoulder is suitable for carrying vehicular traffic and of adequate width, lanes may be shifted by use of closely-spaced channelizing devices, provided that the minimum lane width of 10 feet is maintained.
6. Additional advance warning may be appropriate, such as a ROAD NARROWS sign.
7. Temporary traffic barriers may be used along the work space.
8. The shadow vehicle may be omitted if a taper and channelizing devices are used.
9. A truck-mounted attenuator may be used on the shadow vehicle.
10. For short-duration work, the taper and channelizing devices may be omitted if a shadow vehicle with activated high-intensity rotating, flashing, oscillating, or strobe lights is used.
11. Vehicle hazard warning signals may be used to supplement high-intensity rotating, flashing, oscillating, or strobe lights.

Standard:

12. **Vehicle-mounted signs shall be mounted in a manner such that they are not obscured by equipment or supplies. Sign legends on vehicle-mounted signs shall be covered or turned from view when work is not in progress.**
13. **Shadow and work vehicles shall display high-intensity rotating, flashing, oscillating, or strobe lights.**
14. **Vehicle hazard warning signals shall not be used instead of the vehicle's high-intensity rotating, flashing, oscillating, or strobe lights.**

Figure A6. Road Closures with a Diversion (I-6)

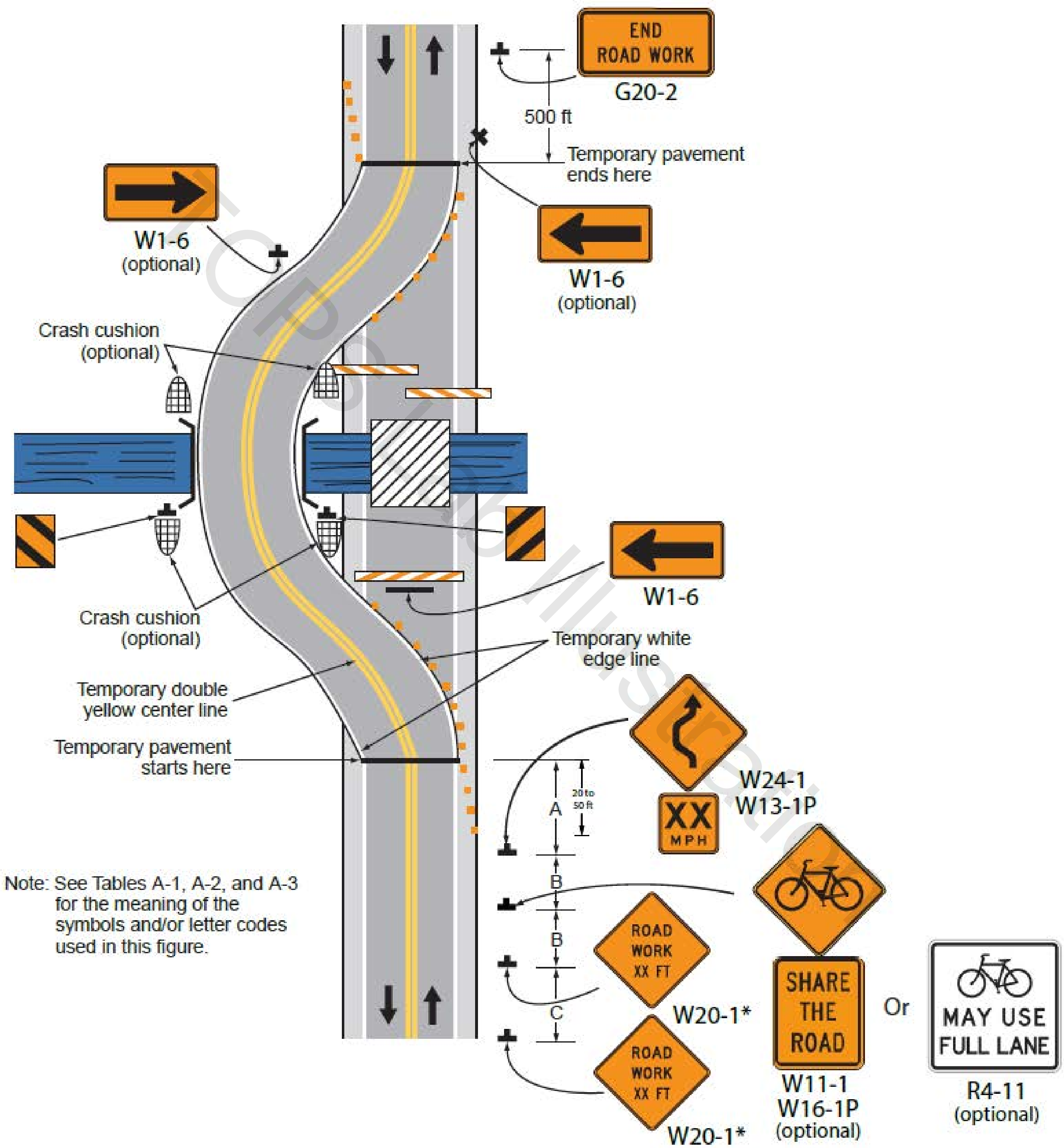


Illustration I-6

Notes for Figure A6—Illustration I-6
Road Closures with a Diversion

Support:

1. Signs and object markers are shown for one direction of travel only.

Standard:

2. **Devices similar to those depicted shall be placed for the opposite direction of travel.**
3. **Pavement markings no longer applicable to the traffic pattern of the roadway shall be removed or obliterated before any new traffic patterns are open to traffic.**
4. **Temporary barriers and end treatments shall be crashworthy.**

Guidance:

5. *If the tangent distance along the temporary diversion is more than 600 feet, a Reverse Curve sign, left first, should be used instead of the Double Reverse Curve sign, and a second Reverse Curve sign, right first, should be placed in advance of the second reverse curve back to the original alignment.*
6. *When the tangent section of the diversion is more than 600 feet, and the diversion has sharp curves with recommended speeds of 30 mph or less, Reverse Turn signs should be used.*
7. *Where the temporary pavement and old pavement are different colors, the temporary pavement should start on the tangent of the existing pavement and end on the tangent of the existing pavement.*

Option:

8. Flashing warning lights and/or flags may be used to call attention to the warning signs.
9. On sharp curves, large arrow signs may be used in addition to other advance warning signs.
10. Delineators or channelizing devices may be used along the diversion.
11. In advance of the work space, bicycle symbol and SHARE THE ROAD or MAY USE FULL LANE signs may be used in locations where bicyclists are normally permitted to ride on the shoulder.

Figure A7. Parking Lane, Bike Lane, and One Travel Lane Closure at Multi-Lane Roadway (I-7)

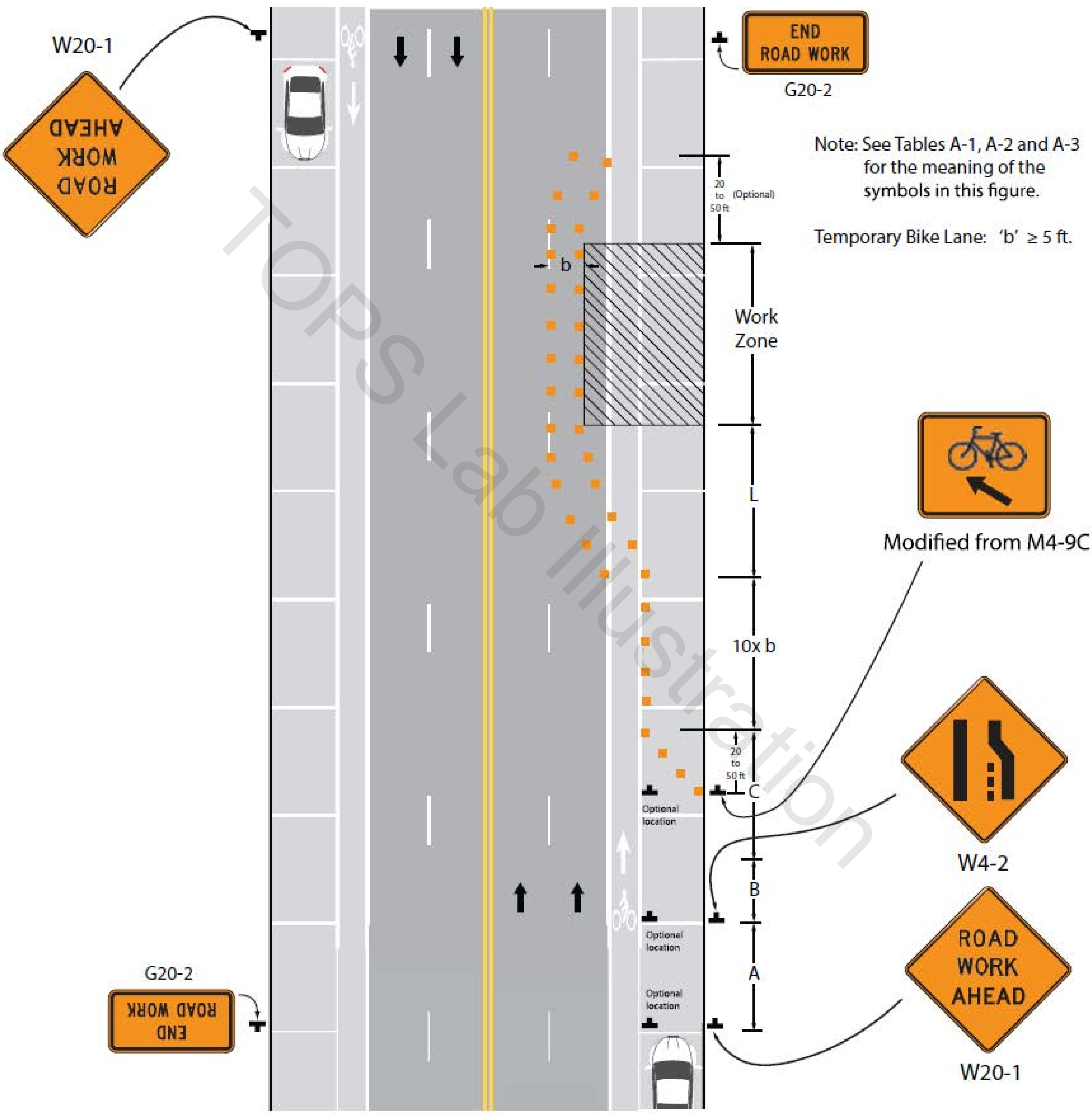


Illustration I-7

Notes for Figure A7—Illustration I-7
Parking Lane, Bike Lane, and One Travel Lane Closure at Multi Lane Roadway

Guidance:

1. *A ROAD WORK AHEAD sign should be placed on the right side of the roadway.*
2. *The LANE ENDS sign should be used to warn of the reduction in the number of traffic lanes in the direction of travel on a multi-lane highway.*

Option:

3. Bike lanes may not be closed for construction activities unless the closure is documented and approved.
4. Work zones that include bike lane closures may post construction zone speed limits of 25 mph or less.
5. All bicycle-related wayfinding signage may be permanent as other signage in the construction zone.
6. Other pavement marking such as roadway striping, temporary bike lanes and/or sharrows may be installed on long term projects.

Standard:

7. **Active bike lanes shall remain clear (5' minimum). Signage, channelizing devices, barriers, and other equipment shall not be placed in active bike lanes or in locations that would block bicyclists' path of travel.**

Figure A8. Parking and Bike Lane Closure (I-8)

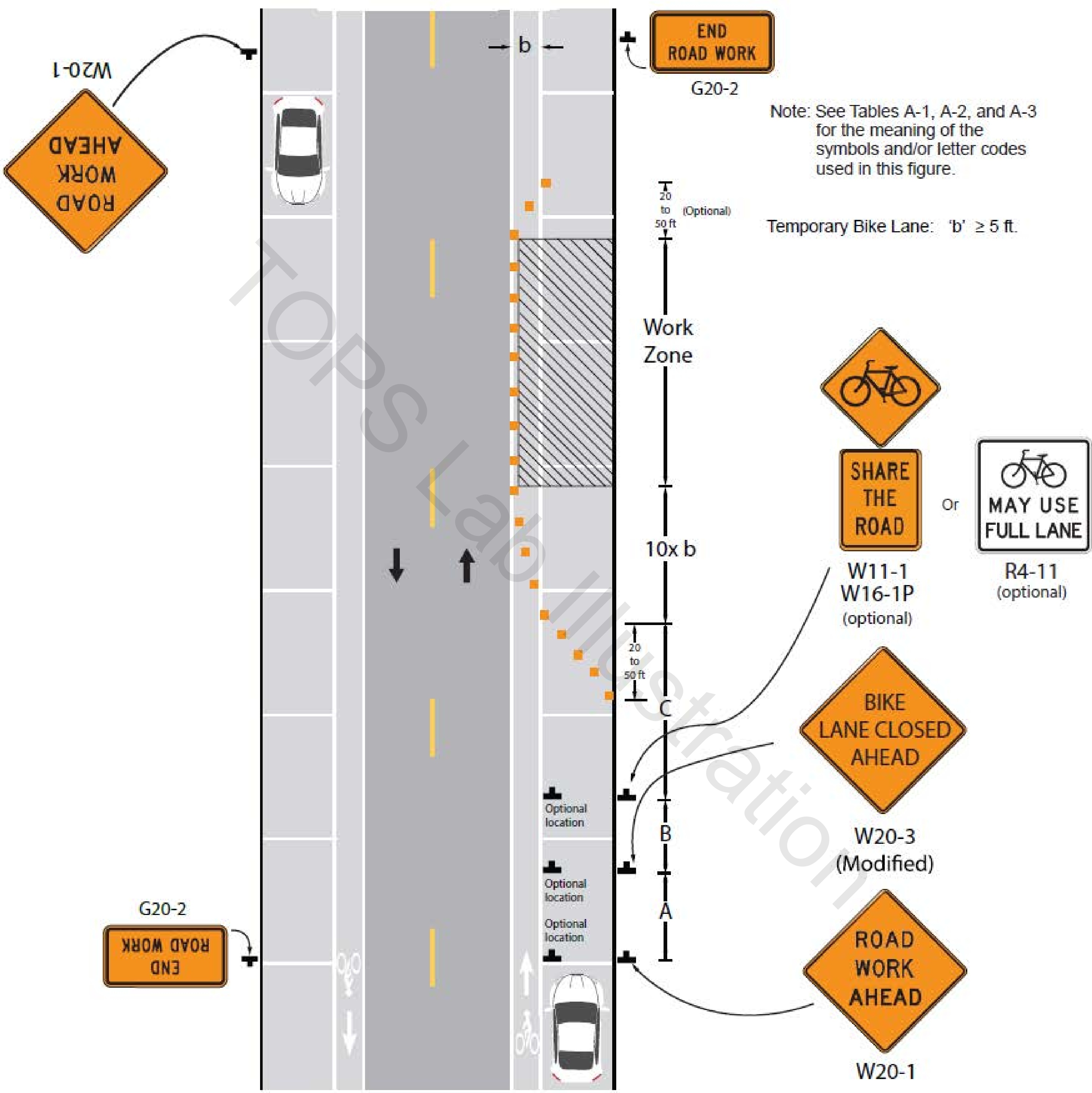


Illustration I-8

Notes for Figure A8—Illustration I-8
Parking Lane and Bike Lane Closure

Guidance:

1. *A ROAD WORK AHEAD sign should be placed on the right side of the roadway.*
2. *The BIKE LANE CLOSED AHEAD sign should be used to warn of the bike lane closure in the direction of travel on a two lane undivided roadway.*

Option:

3. Bike lanes may not be closed for construction activities unless the closure is documented and approved.
4. Work zones that include bike lane closures may post construction zone speed limits of 25 mph or less.
5. All bicycle-related signage may be permanent as other signage in the construction zone.
6. Other pavement marking such as roadway striping, temporary bike lanes and/or sharrows may be installed on long term projects.
7. Bicycle symbol and SHARE THE ROAD or MAY USE FULL LANE signs may me used in locations where bicyclists are normally permitted to ride on the shoulder.

Standard:

8. **Active bike lanes shall remain clear (5' minimum). Signage, channelizing devices, barriers, and other equipment shall not be placed in active bike lanes or in locations that would block bicyclists' path of travel.**

Figure A9. Lane Closure on a Two-Lane Road or Street with Low Traffic Volumes (I-9)

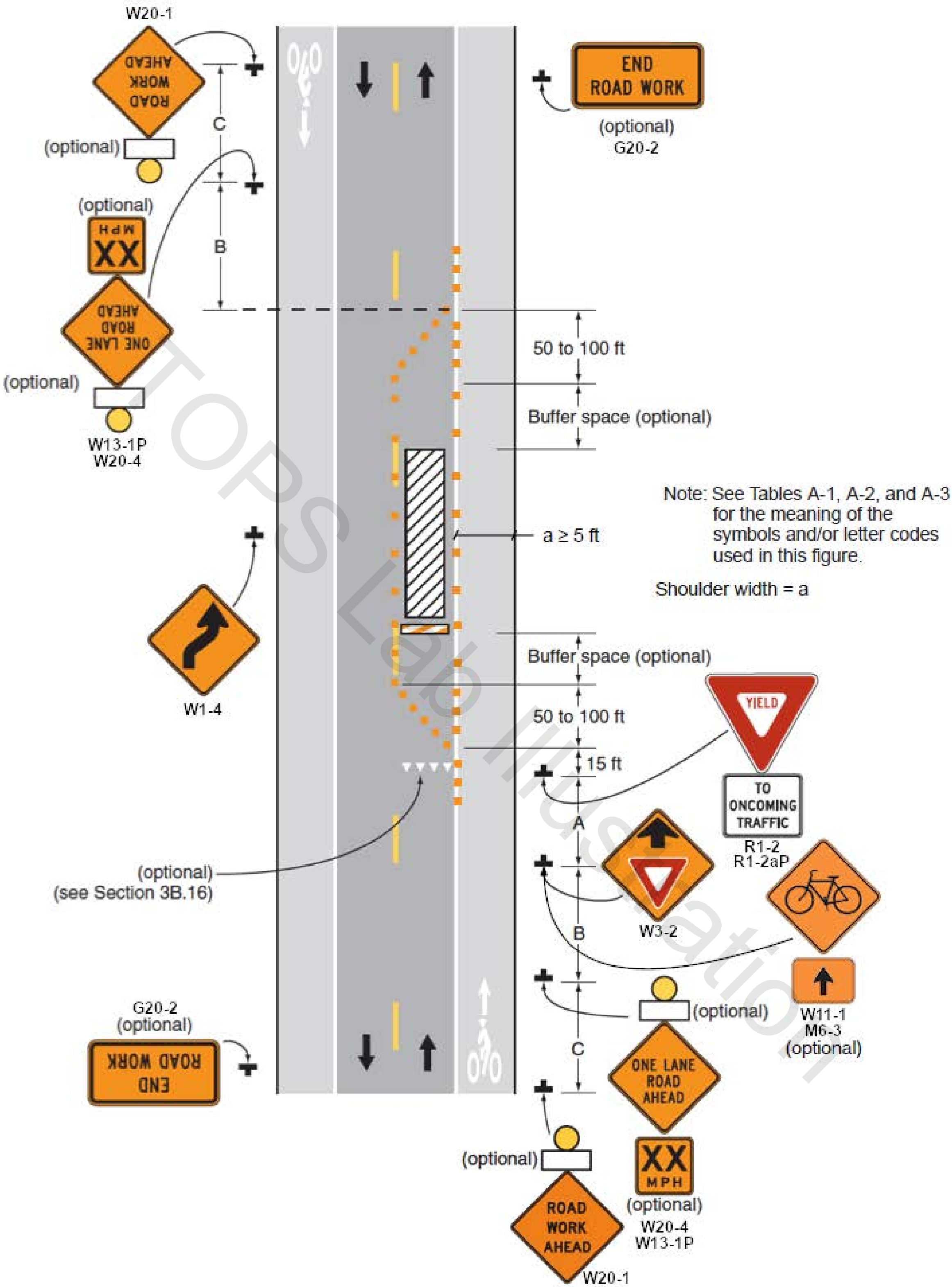


Illustration I-9

Notes for Figure A9—Illustration I-9
Lane Closure on a Two-Lane Road or Street with Low Traffic Volumes

Option:

1. This TTC zone application may be used as an alternate to the TTC application shown in Figure 6H-10 (using flaggers) when the following conditions exist:
    a. Vehicular traffic volume is such that sufficient gaps exist for vehicular traffic that must yield.
    b. Road users from both directions are able to see approaching vehicular traffic through and beyond the worksite and have sufficient visibility of approaching vehicles.
2. The Type B flashing warning lights may be placed on the ROAD WORK AHEAD and theONE LANE ROAD AHEAD signs whenever a night lane closure is necessary.
3. In advance of the work space, bicycle symbol signs and bicycle lane pavement marking may be used in locations where bicyclists are normally permitted to ride on the shoulder.

Standard:

1. **Work area shall only be limited to the travel lane and no construction equipment or obstructions shall be placed on the adjacent shoulder. A minimum shoulder width of 5' or greater to accommodate bicyclists shall be provided.**

Figure A10. Lane Closure on a Two-Lane Road or Street Using Traffic Control Signals (I-10)

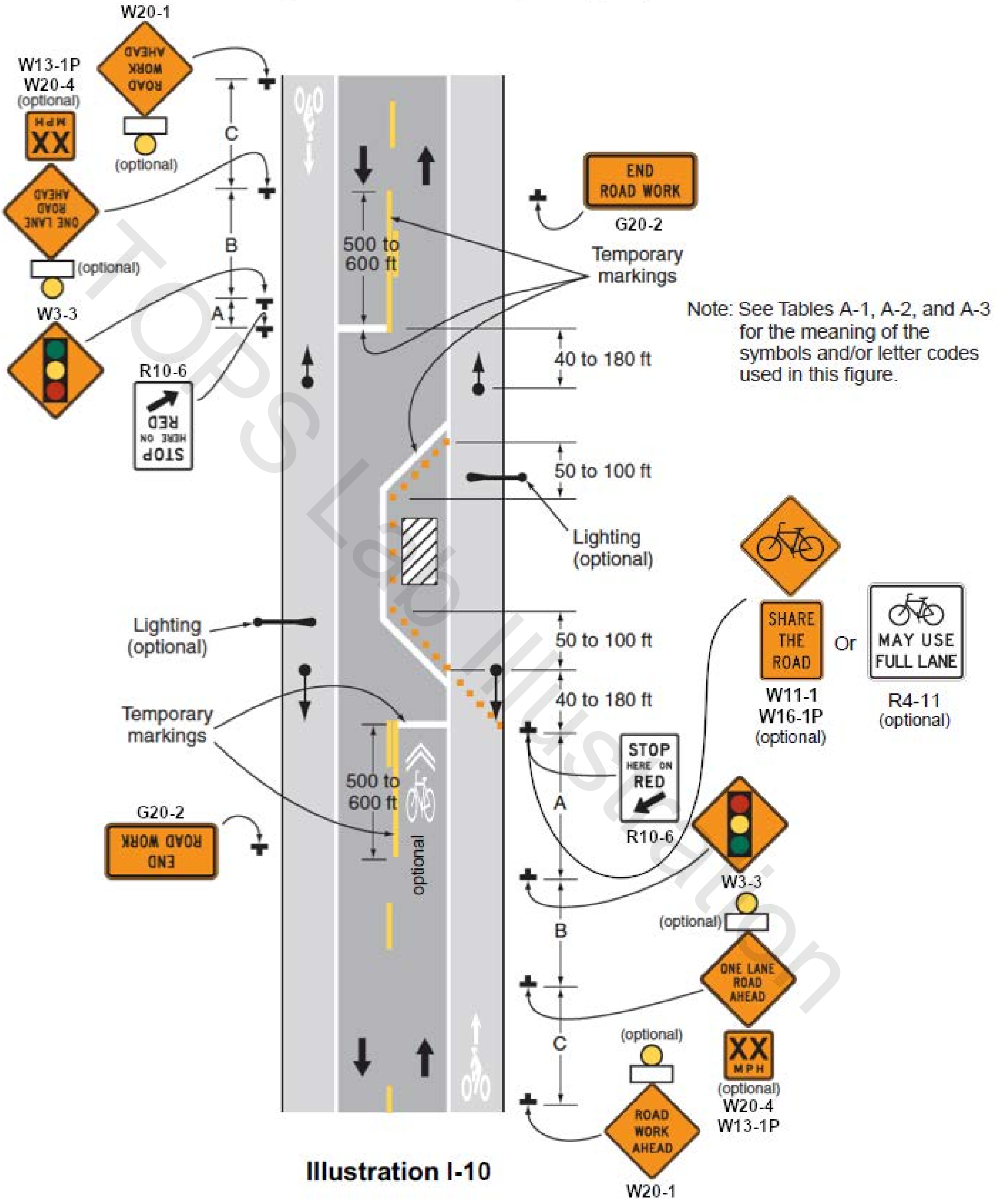


Illustration I-10

Notes for Figure A10—Illustration I-10
Lane Closure on a Two-Lane Road or Street Using Traffic Control Signals

Standard:

1. **Temporary traffic control signals shall be installed and operated in accordance with the provisions of Part 4. Temporary traffic control signals shall meet the physical display and operational requirements of conventional traffic control signals.**
2. **Temporary traffic control signal timing shall be established by authorized officials. Durations of red clearance intervals shall be adequate to clear the one-lane section of conflicting vehicles.**
3. **When the temporary traffic control signal is changed to the flashing mode, either manually or automatically, red signal indications shall be flashed to both approaches.**
4. **Stop lines shall be installed with temporary traffic control signals for intermediate and long-term closures. Existing conflicting pavement markings and raised pavement marker reflectors between the activity area and the stop line shall be removed. After the temporary traffic control signal is removed, the stop lines and other temporary pavement markings shall be removed and the permanent pavement markings restored.**
5. **Safeguards shall be incorporated to avoid the possibility of conflicting signal indications at each end of the TTC zone.**

Guidance:

6. *Where no-passing lines are not already in place, they should be added.*
7. *Adjustments in the location of the advance warning signs should be made as needed to accommodate the horizontal or vertical alignment of the roadway, recognizing that the distances shown for sign spacings are minimums. Adjustments in the height of the signal heads should be made as needed to conform to the vertical alignment.*

Option:

8. Flashing warning lights shown on the ROAD WORK AHEAD and the ONE LANE ROAD AHEAD signs may be used.
9. Ahead of the work space, bicycle symbol sign and SHARE THE ROAD sign may be used.
10. The Shared Lane Marking may be used in locations where bicyclists need to share the road with motor vehicles for long-term projects.
11. Removable pavement markings may be used.

Support:

12. Temporary traffic control signals are preferable to flaggers for long-term projects and other activities that would require flagging at night.
13. The maximum length of activity area for one-way operation under temporary traffic control signal control is determined by the capacity required to handle the peak demand.

Figure A11. Work in the Center of a Road or Street with Low Traffic Volumes (I-11)

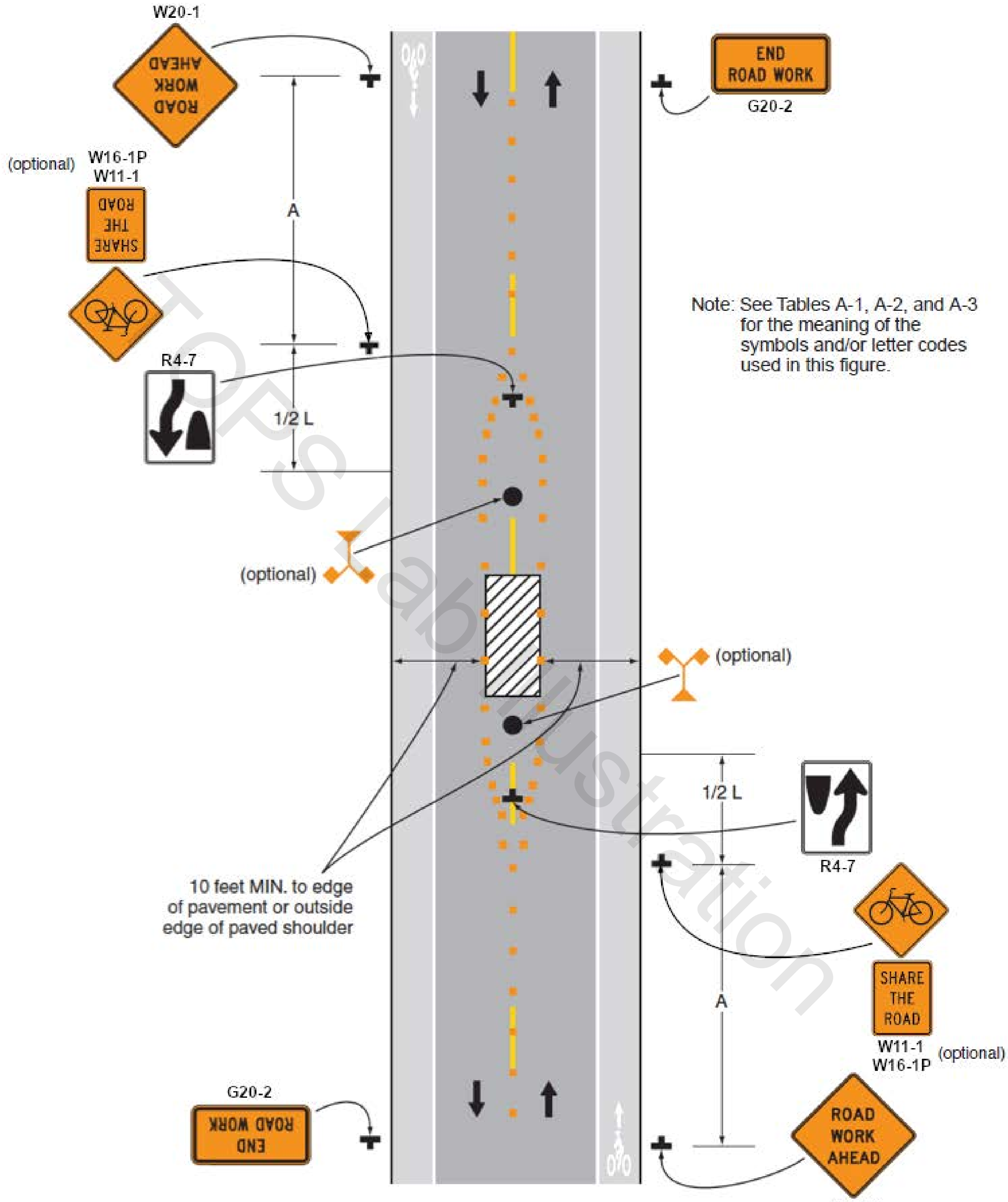


Illustration I-11

Notes for Figure A11—Illustration I-11
Work in the Center of a Road or Street with Low Traffic Volumes

Guidance:

1. *The lanes on either side of the center work space should have a minimum width of 10 feet as measured from the near edge of the channelizing devices to the edge of the pavement or the outside edge of the paved shoulder.*

Option:

2. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
3. If the closure continues overnight, warning lights may be used on the channelizing devices.
4. A lane width of 9 feet may be used for short-term stationary work on low-volume, low-speed roadways when motor vehicle traffic does not include longer and wider heavy commercial vehicles.
5. A work vehicle displaying high-intensity rotating, flashing, oscillating, or strobe lights may be used instead of the channelizing devices forming the tapers or the high-level warning devices.
6. Vehicle hazard warning signals may be used to supplement high-intensity rotating, flashing, oscillating, or strobe lights.
7. In advance of the work space, bicycle symbol and SHARE THE ROAD signs may be used in locations where bicyclists are normally permitted to ride on the shoulder.

Standard:

8. **Vehicle hazard warning signals shall not be used instead of the vehicle's high-intensity rotating, flashing, oscillating, or strobe lights.**

Figure A12. Surveying Along the Center Line of a Road or Street with Low Traffic Volumes (I-12)

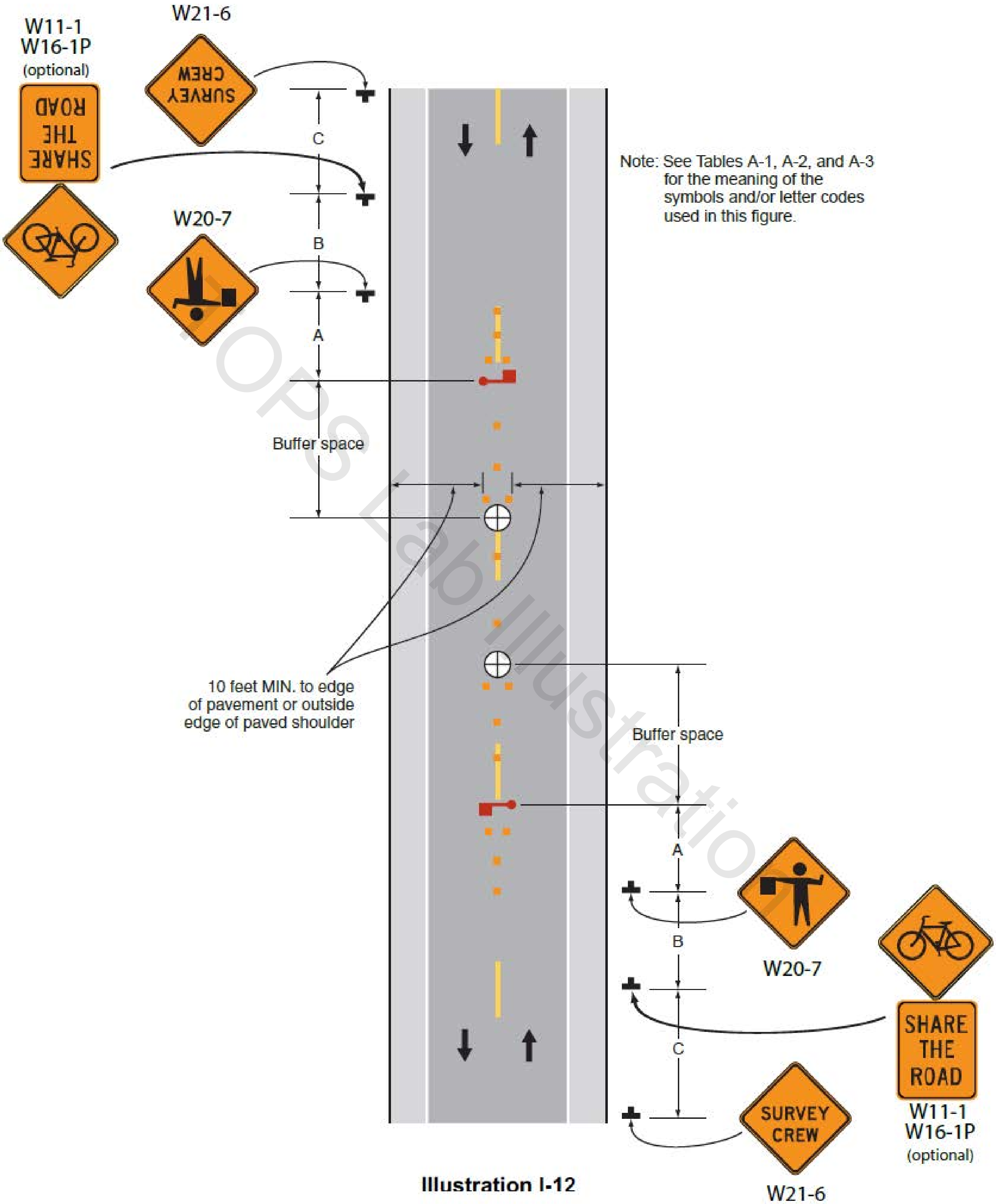


Illustration I-12

Notes for Figure A12—Illustration I-12
Surveying Along the Center Line of a Road or Street with Low Traffic Volumes

Guidance:

1. *The lanes on either side of the center work space should have a minimum width of 10 feet as measured from the near edge of the channelizing devices to the edge of the pavement or the outside edge of the paved shoulder.*
2. *Cones should be placed 6 to 12 inches on either side of the center line.*
3. *A flagger should be used to warn workers who cannot watch road users.*

Standard:

4. **For surveying on the center line of a high-volume road, one lane shall be closed using the information illustrated in Figure 6H-10.**

Option:

5. A high-level warning device may be used to protect a surveying device, such as a target on a tripod.
6. Cones may be omitted for a cross-section survey.
7. ROAD WORK AHEAD signs may be used in place of the SURVEY CREW AHEAD signs.
8. Flags may be used to call attention to the advance warning signs.
9. If the work is along the shoulder, the flagger may be omitted.
10. For a survey along the edge of the road or along the shoulder, cones may be placed along the edge line.
11. A BE PREPARED TO STOP sign may be added to the sign series.
12. In advance of the work space, bicycle symbol and SHARE THE ROAD signs may be used where bicyclists are normally permitted to ride on the shoulder.

Guidance:

13. *When used, the BE PREPARED TO STOP sign should be located before the Flagger symbol sign.*

Figure A13. Lane Closure on a Minor Street (I-13)

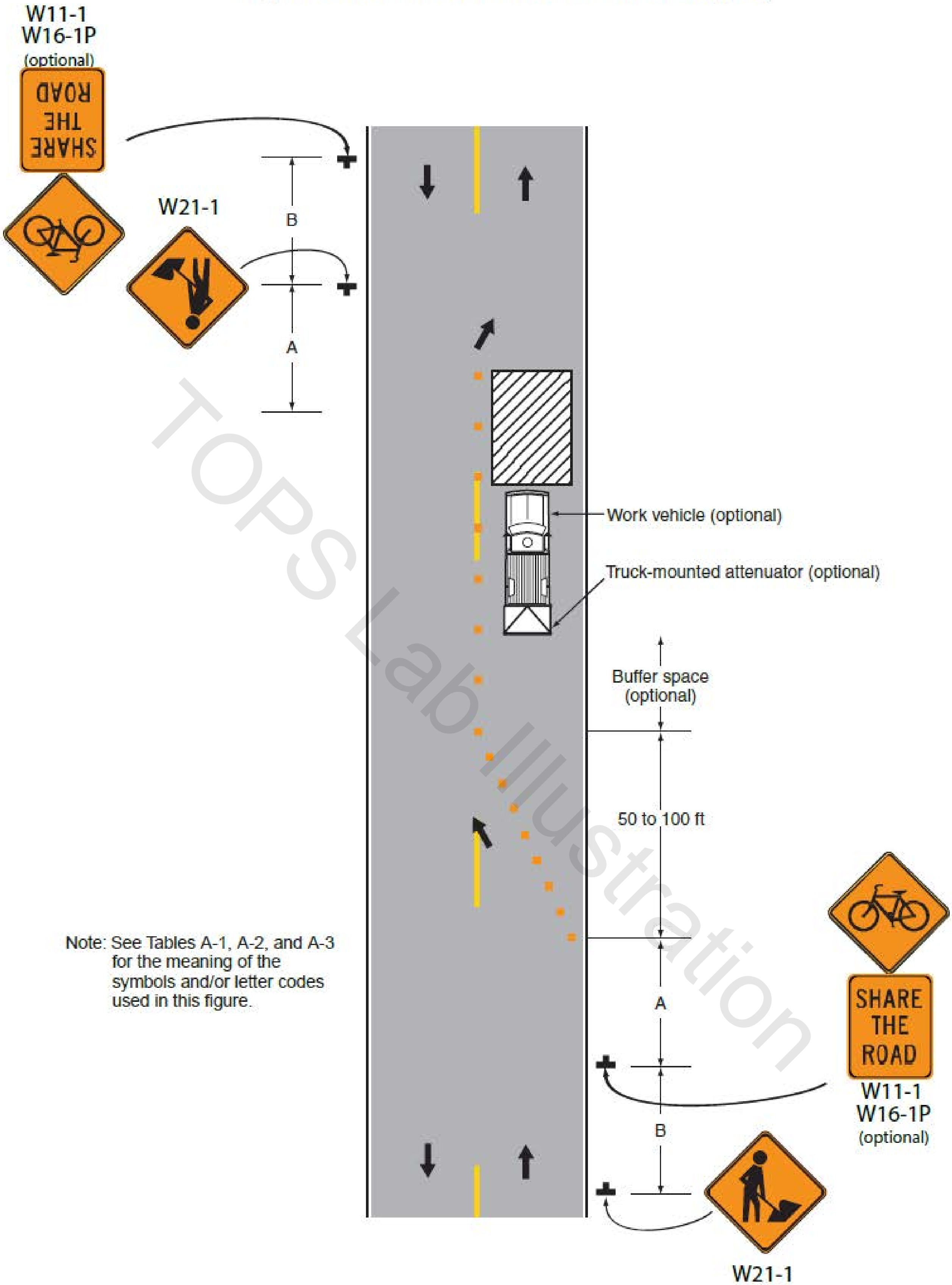


Illustration I-13

Notes for Figure A13—Illustration I-13
Lane Closure on a Minor Street

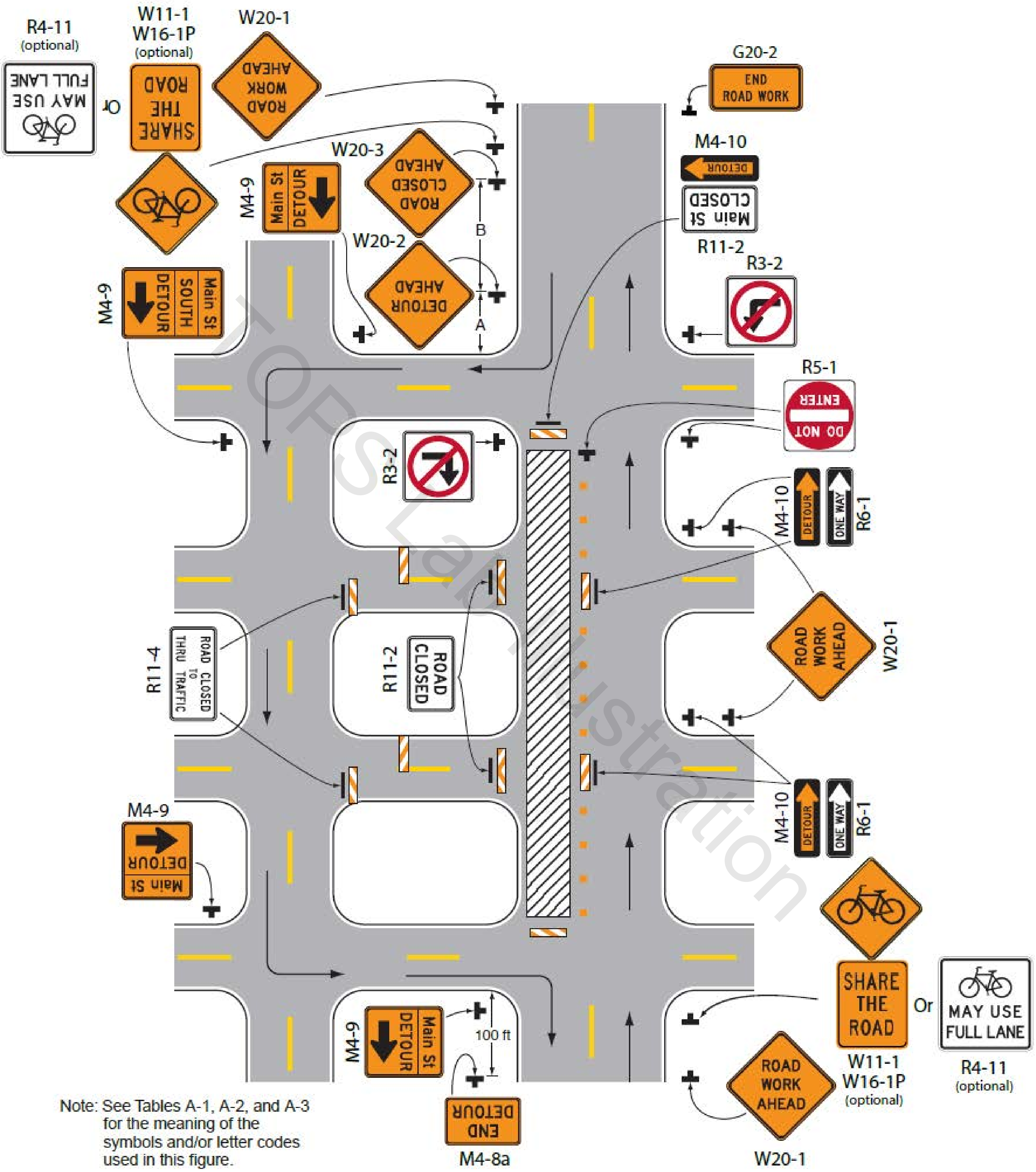
Standard:

1. **Where vehicular traffic cannot effectively self-regulate, one or two flaggers shall be used as illustrated in Figure 6H-10.**
2. **This illustration shall be used only for low-speed facilities having low traffic volumes.**

Option:

1. Where the work space is short, where road users can see the roadway beyond, and where volume is low, vehicular traffic may be self-regulating.
2. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
3. A truck-mounted attenuator may be used on the work vehicle and the shadow vehicle.
4. In advance of the work space, bicycle symbol and SHARE THE ROAD signs may be used.

Figure A14. Detour for One Travel Direction (I-14)



Note: See Tables A-1, A-2, and A-3 for the meaning of the symbols and/or letter codes used in this figure.

Illustration I-14

Notes for Figure A14—Illustration I-14
Detour for One Travel Direction

Guidance:

1. *This plan should be used for streets without posted route numbers.*
2. *On multi-lane streets, Detour signs with an Advance Turn Arrow should be used in advance of a turn.*

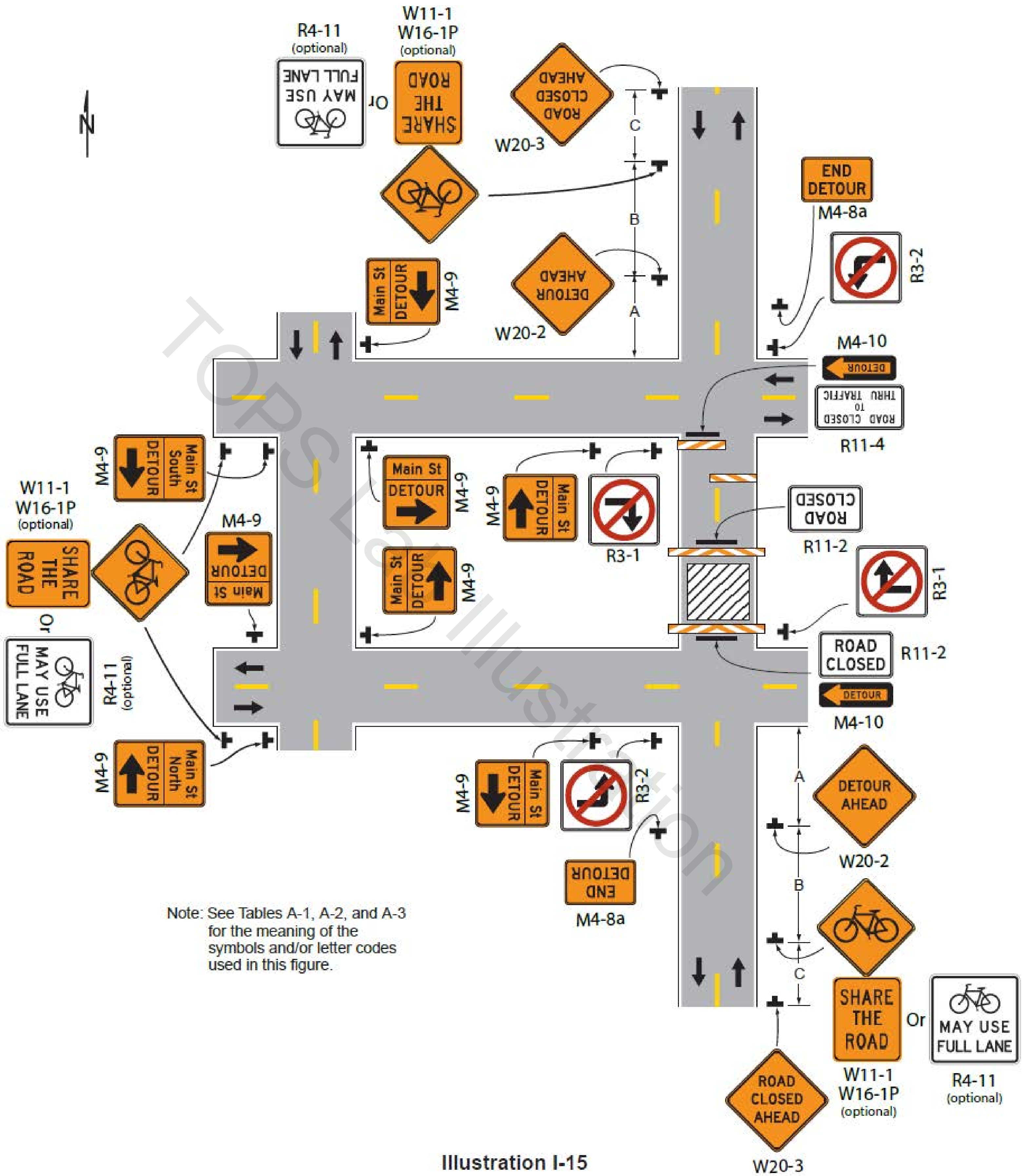
Option:

3. The STREET CLOSED legend may be used in place of ROAD CLOSED.
4. Additional DO NOT ENTER signs may be used at intersections with intervening streets.
5. Warning lights may be used on Type 3 Barricades.
6. Detour signs may be located on the far side of intersections.
7. A Street Name sign may be mounted with the Detour sign. The Street Name sign may be either white on green or black on orange.
8. In advance of the work space, bicycle symbol and SHARE THE ROAD or MAY USE FULL LANE signs may be used.

Standard:

9. **When used, the Street Name sign shall be placed above the Detour sign.**

Figure A15. Detour for a Closed Street (I-15)



Note: See Tables A-1, A-2, and A-3 for the meaning of the symbols and/or letter codes used in this figure.

Illustration I-15

Notes for Figure A15—Illustration I-15
Detour for a Closed Street

Guidance:

1. *This plan should be used for streets without posted route numbers.*
2. *On multi-lane streets, Detour signs with an Advance Turn Arrow should be used in advance of a turn.*

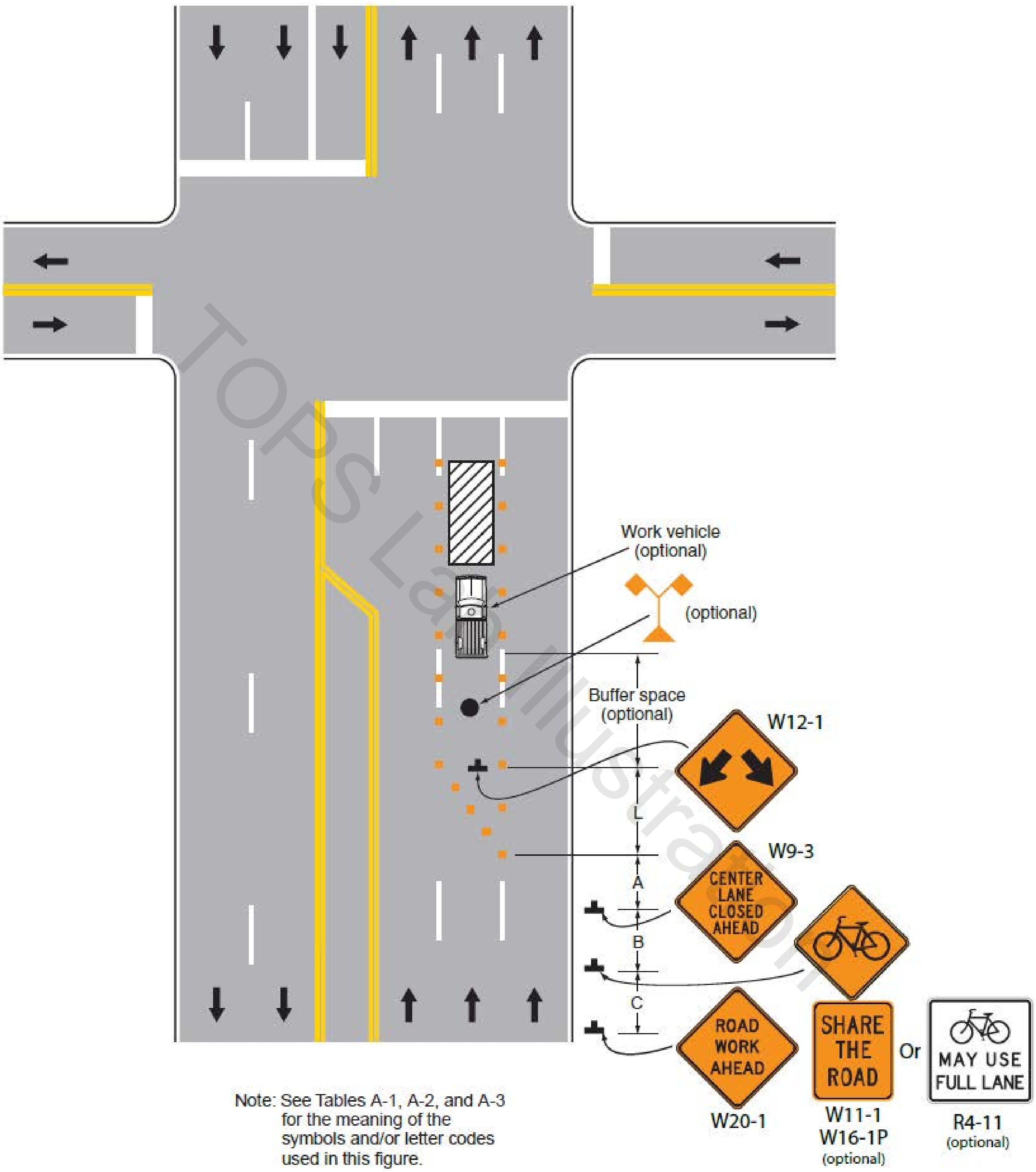
Option:

3. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
4. Flashing warning lights may be used on Type 3 Barricades.
5. Detour signs may be located on the far side of intersections. A Detour sign with an advance arrow may be used in advance of a turn.
6. A Street Name sign may be mounted with the Detour sign. The Street Name sign may be either white on green or black on orange.
7. In advance of the work space, bicycle symbol and SHARE THE ROAD or MAY USE FULL LANE signs may be used.

Standard:

8. **When used, the Street Name sign shall be placed above the Detour sign.**

Figure A16. Lane Closure on the Near Side of an Intersection (I-16)



Note: See Tables A-1, A-2, and A-3 for the meaning of the symbols and/or letter codes used in this figure.

Illustration I-16

Notes for Figure A16—Illustration I-16
Lane Closure on the Near Side of an Intersection

Standard:

1. **The merging taper shall direct vehicular traffic into either the right-hand or left-hand lane, but not both.**

Guidance:

2. *In this typical application, a left taper should be used so that right-turn movements will not impede through motor vehicle traffic. However, the reverse should be true for left-turn movements.*
3. *If the work space extends across a crosswalk, the crosswalk should be closed using the information and devices shown in Figure 6H-29.*

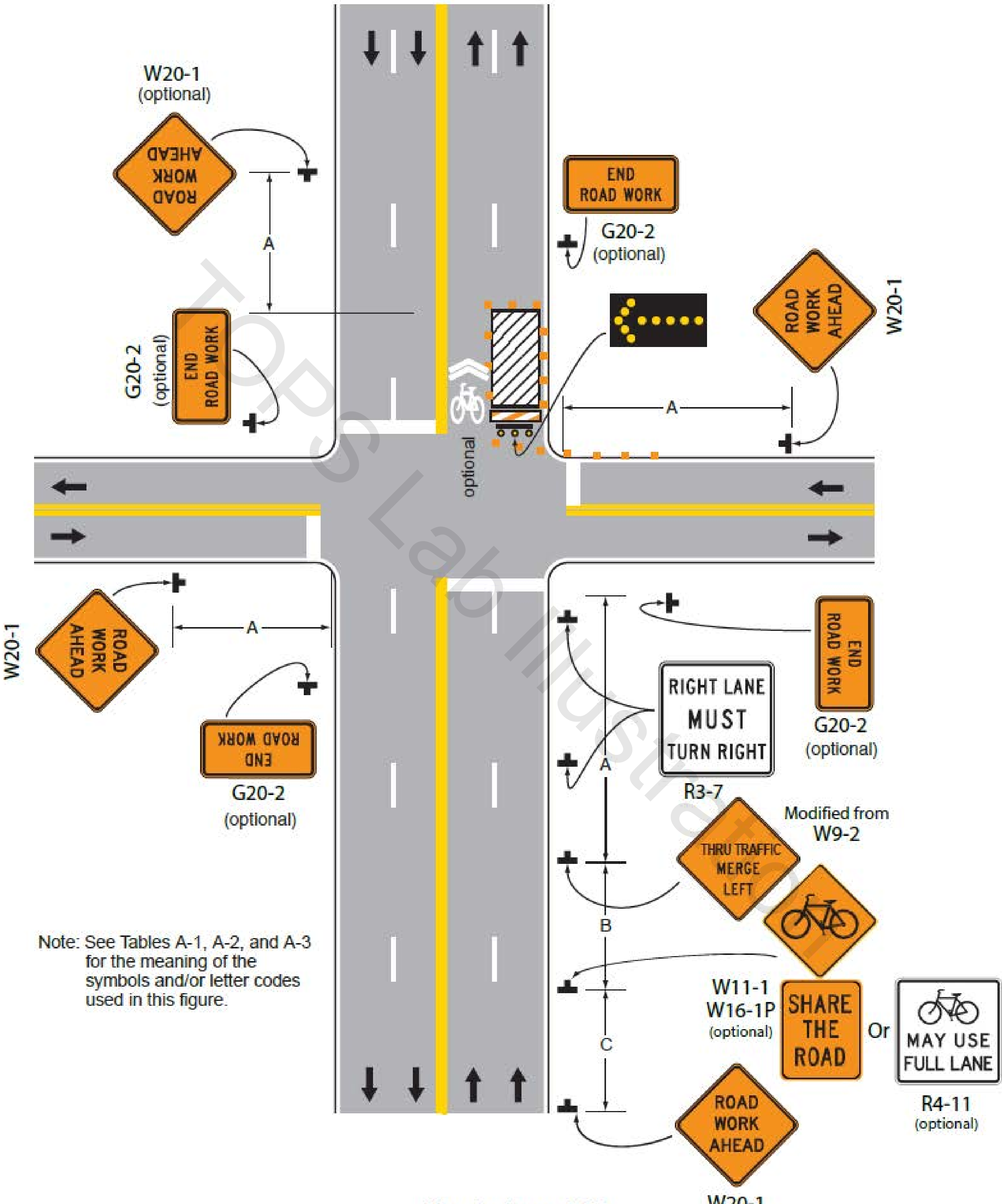
Option:

4. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
5. A shadow vehicle with a truck-mounted attenuator may be used.
6. A work vehicle with high-intensity rotating, flashing, oscillating, or strobe lights may be used with the high-level warning device.
7. Vehicle hazard warning signals may be used to supplement high-intensity rotating, flashing, oscillating, or strobe lights.
8. In advance of the work space, bicycle symbol and SHARE THE ROAD or MAY USE FULL LANE signs may be used.

Standard:

9. **Vehicle hazard warning signals shall not be used instead of the vehicle's high-intensity rotating, flashing, oscillating, or strobe lights.**

Figure A17. Right Hand Lane Closure on the Far Side of an Intersection (I-17)



Notes for Figure A17—Illustration I-17
Right-Hand Lane Closure on the Far Side of an Intersection

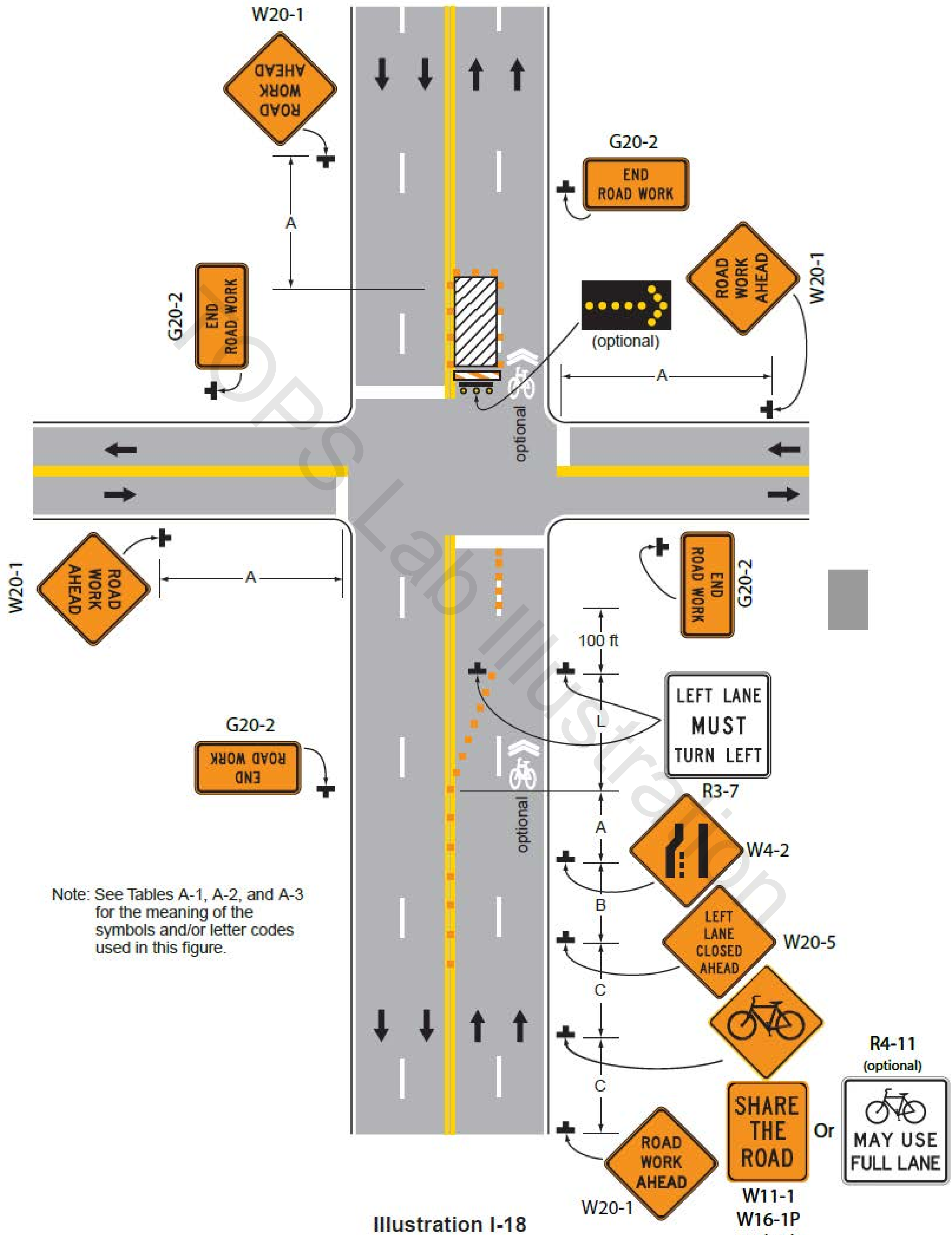
Guidance:

1. *If the work space extends across a crosswalk, the crosswalk should be closed using the information and devices shown in Figure 6H-29.*

Option:

2. The normal procedure is to close on the near side of the intersection any lane that is not carried through the intersection. However, when this results in the closure of a right-hand lane having significant right turning movements, then the right-hand lane may be restricted to right turns only, as shown. This procedure increases the through capacity by eliminating right turns from the open through lane.
3. For intersection approaches reduced to a single lane, left-turning movements may be prohibited to maintain capacity for through vehicular traffic.
4. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
5. In advance of the work space, bicycle symbol and SHARE THE ROAD or MAY USE FULL LANE signs may be used. For long term projects, a share lane marking may be used in the lane next to the work space where bicyclists need to share a lane with motor vehicles.
6. Where the turning radius is large, it may be possible to create a right-turn island using channelizing devices or pavement markings.

Figure A18. Left-Hand Lane Closure on the Far Side of an Intersection (I-18)



Note: See Tables A-1, A-2, and A-3 for the meaning of the symbols and/or letter codes used in this figure.

Illustration I-18

Notes for Figure A18—Illustration I-18
Left-Hand Lane Closure on the Far Side of an Intersection

Guidance:

1. *If the work space extends across a crosswalk, the crosswalk should be closed using the information and devices shown in Figure 6H-29.*

Option:

2. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
3. In advance of the work space, bicycle symbol and SHARE THE ROAD or MAY USE FULL LANE signs may be used. For long term projects, Share Lane Markings may be used, as shown.
4. The normal procedure is to close on the near side of the intersection any lane that is not carried through the intersection. However, when this results in the closure of a left lane having significant left-turning movements, then the left lane may be reopened as a turn bay for left turns only, as shown.

Support:

5. By first closing off the left lane and then reopening it as a turn bay, the left-turn bay allows storage of turning vehicles so that the movement of through traffic is not impeded. A left-turn bay that is long enough to accommodate all turning vehicles during a traffic signal cycle will provide the maximum benefit for through traffic. Also, an island is created with channelizing devices that allows the LEFT LANE MUST TURN LEFT sign to be repeated on the left adjacent to the lane that it controls.

Figure A19. Half Road Closure on the Far Side of an Intersection (I-19)

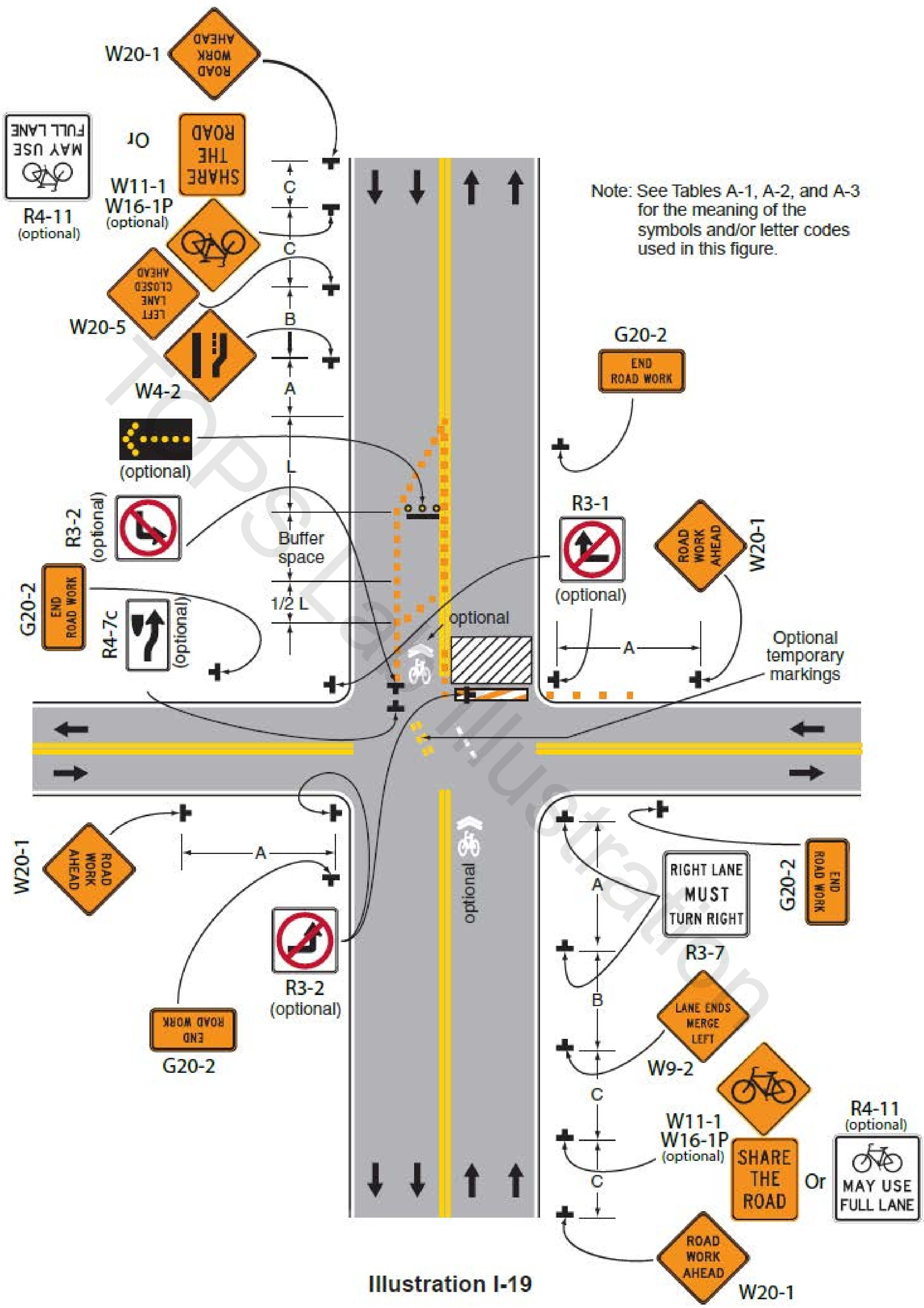


Illustration I-19

Notes for Figure A19—Illustration I-19
Half Road Closure on the Far Side of an Intersection

Guidance:

1. *If the work space extends across a crosswalk, the crosswalk should be closed using the information and devices shown in Figure 6H-29.*
2. *When turn prohibitions are implemented, two turn prohibition signs should be used, one on the near side and, space permitting, one on the far side of the intersection.*

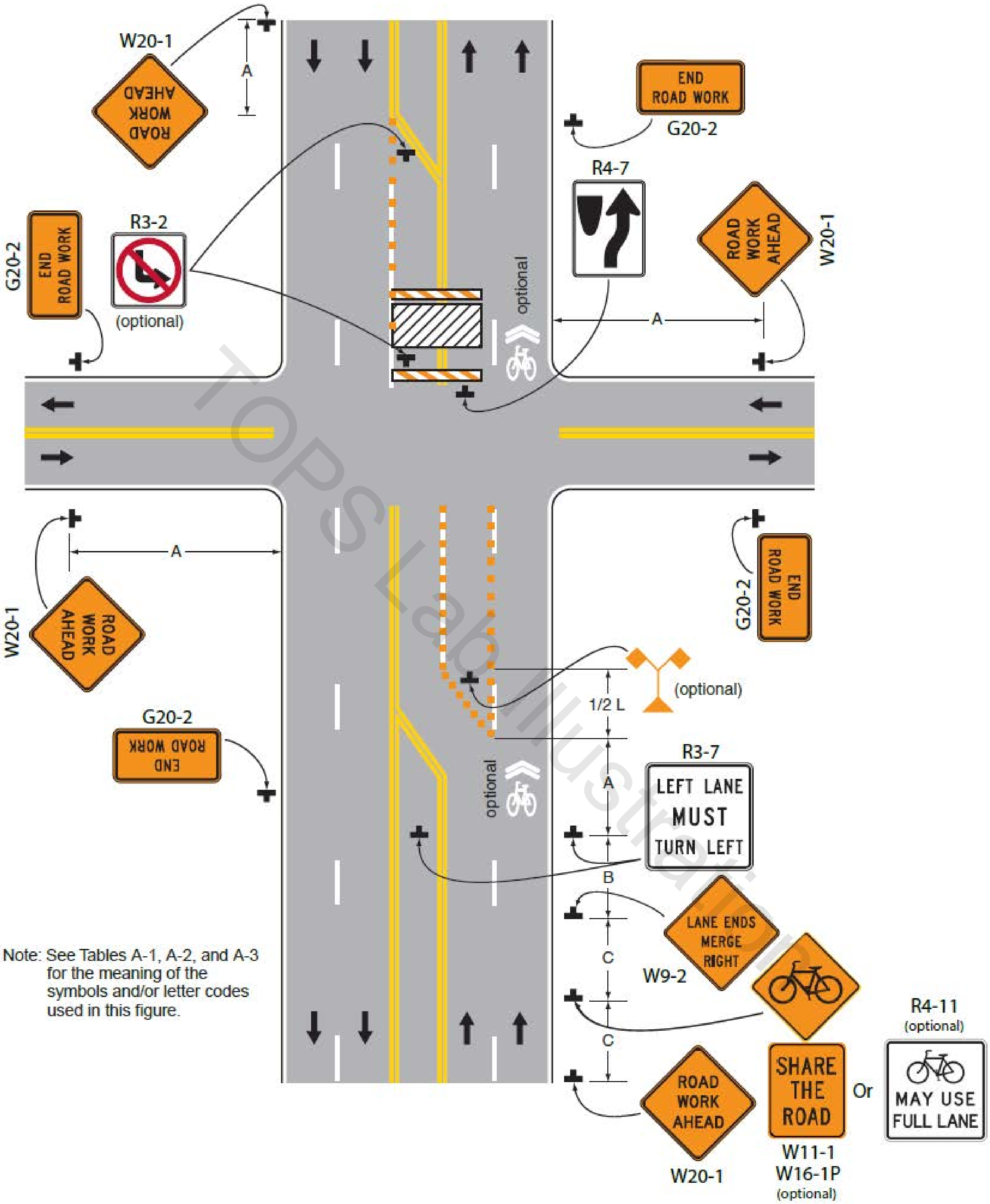
Option:

3. A buffer space may be used between opposing directions of vehicular traffic as shown in this application.
4. The normal procedure is to close on the near side of the intersection any lane that is not carried through the intersection. However, if there is a significant right-turning movement, then the right-hand lane may be restricted to right turns only, as shown.
5. Where the turning radius is large, a right-turn island using channelizing devices or pavement markings may be used.
6. There may be insufficient space to place the back-to-back Keep Right sign and No Left Turn symbol signs at the end of the row of channelizing devices separating opposing vehicular traffic flows. In this situation, the No Left Turn symbol sign may be placed on the right and the Keep Right sign may be omitted.
7. For intersection approaches reduced to a single lane, left-turning movements may be prohibited to maintain capacity for through vehicular traffic.
8. Flashing warning lights and/or flags may be used to call attention to advance warning signs.
9. In advance of the work space, bicycle symbol and SHARE THE ROAD or MAY USE FULL LANE signs may be used. For long term projects, Share Lane Markings may be used, as shown.
10. Temporary pavement markings may be used to delineate the travel path through the intersection.

Support:

11. Keeping the right-hand lane open increases the through capacity by eliminating right turns from the open through lane.
12. A temporary turn island reinforces the nature of the temporary exclusive right-turn lane and enables a second RIGHT LANE MUST TURN RIGHT sign to be placed in the island.

Figure A20. Multiple Lane Closure at an Intersection (I-20)



Note: See Tables A-1, A-2, and A-3 for the meaning of the symbols and/or letter codes used in this figure.

Illustration I-20

Notes for Figure A20—Illustration I-20
Multiple Lane Closures at an Intersection

Guidance:

1. *If the work space extends across a crosswalk, the crosswalk should be closed using the information and devices shown in Figure 6H-29.*
2. *If the left through lane is closed on the near-side approach, the LEFT LANE MUST TURN LEFT sign should be placed in the median to discourage through vehicular traffic from entering the left-turn bay.*

Support:

3. The normal procedure is to close on the near side of the intersection any lane that is not carried through the intersection.

Option:

4. If the left-turning movement that normally uses the closed turn bay is small and/or the gaps in opposing vehicular traffic are frequent, left turns may be permitted on that approach.
5. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
6. In advance of the work space, bicycle symbol sign and SHARE THE ROAD or MAY USE FULL LANE signs may used. For long term projects, Shared Lane Markings may be used, as shown.

Figure A21. Closure in the Center of an Intersection (I-21)

Note: See Tables A-1, A-2, and A-3 for the meaning of the symbols and/or letter codes used in this figure.

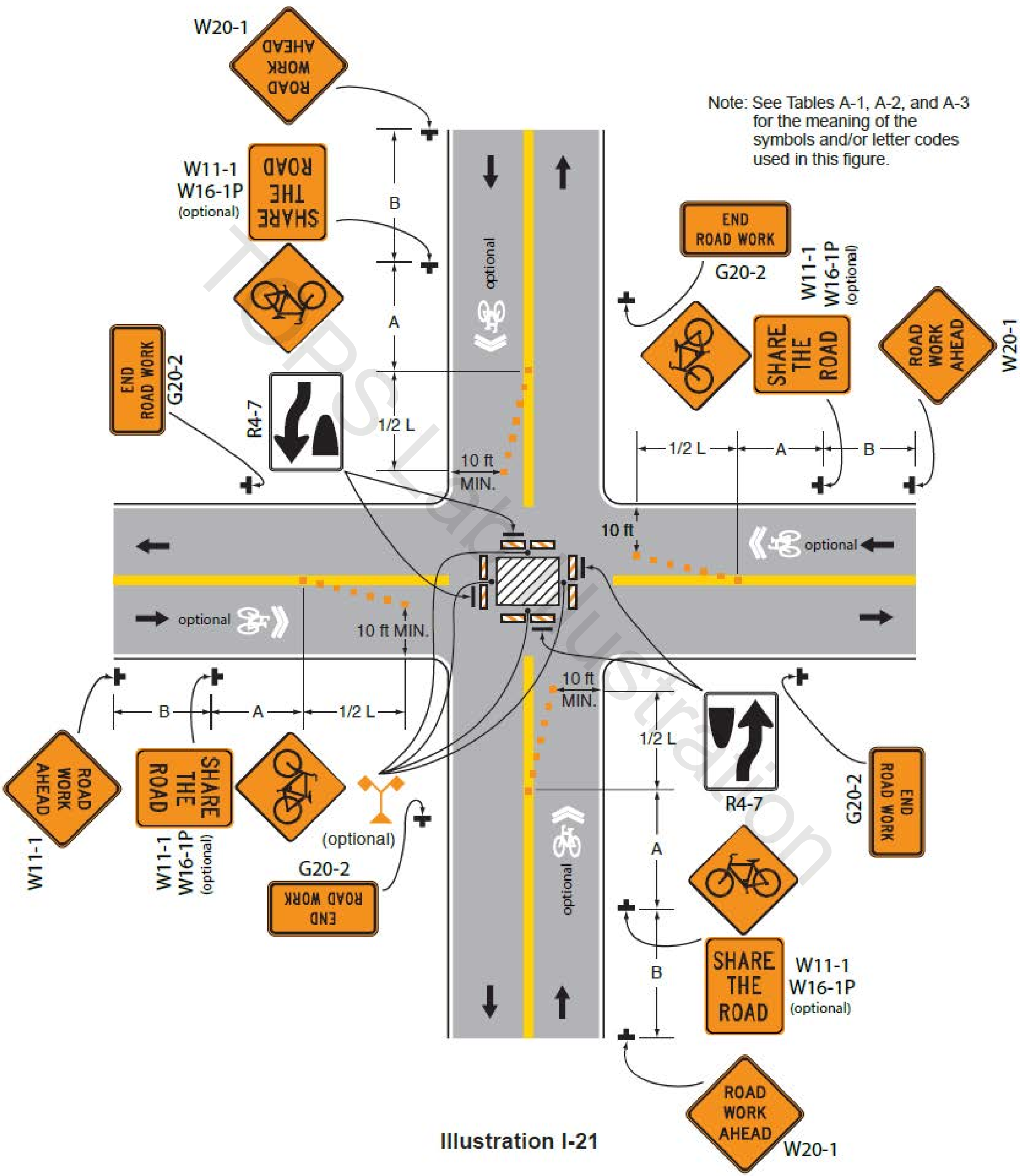


Illustration I-21

Notes for Figure A21—Illustration I-21
Closure in the Center of an Intersection

Guidance:

1. *All lanes should be a minimum of 10 feet in width as measured to the near face of the channelizing devices.*

Option:

2. A high-level warning device may be placed in the work space, if there is sufficient room.
3. For short-term use on low-volume, low-speed roadways with vehicular traffic that does not include longer and wider heavy commercial vehicles, a minimum lane width of 9 feet may be used.
4. Flashing warning lights and/or flags may be used to call attention to advance warning signs.
5. In advance of the work space, bicycle symbol sign and SHARE THE ROAD signs may used. For long term projects, Shared Lane Markings may be used, as shown.
6. Unless the streets are wide, it may be physically impossible to turn left, especially for large vehicles. Left turns may be prohibited as required by geometric conditions.
7. For short-duration work operations, the channelizing devices may be eliminated if a vehicle displaying high-intensity rotating, flashing, oscillating, or strobe lights is positioned in the work space.
8. Vehicle hazard warning signals may be used to supplement high-intensity rotating, flashing, oscillating, or strobe lights.

Standard:

9. **Vehicle hazard warning signals shall not be used instead of the vehicle's high-intensity rotating, flashing, oscillating, or strobe lights.**

Figure A22. Closure at the Side of an Intersection (I-22)

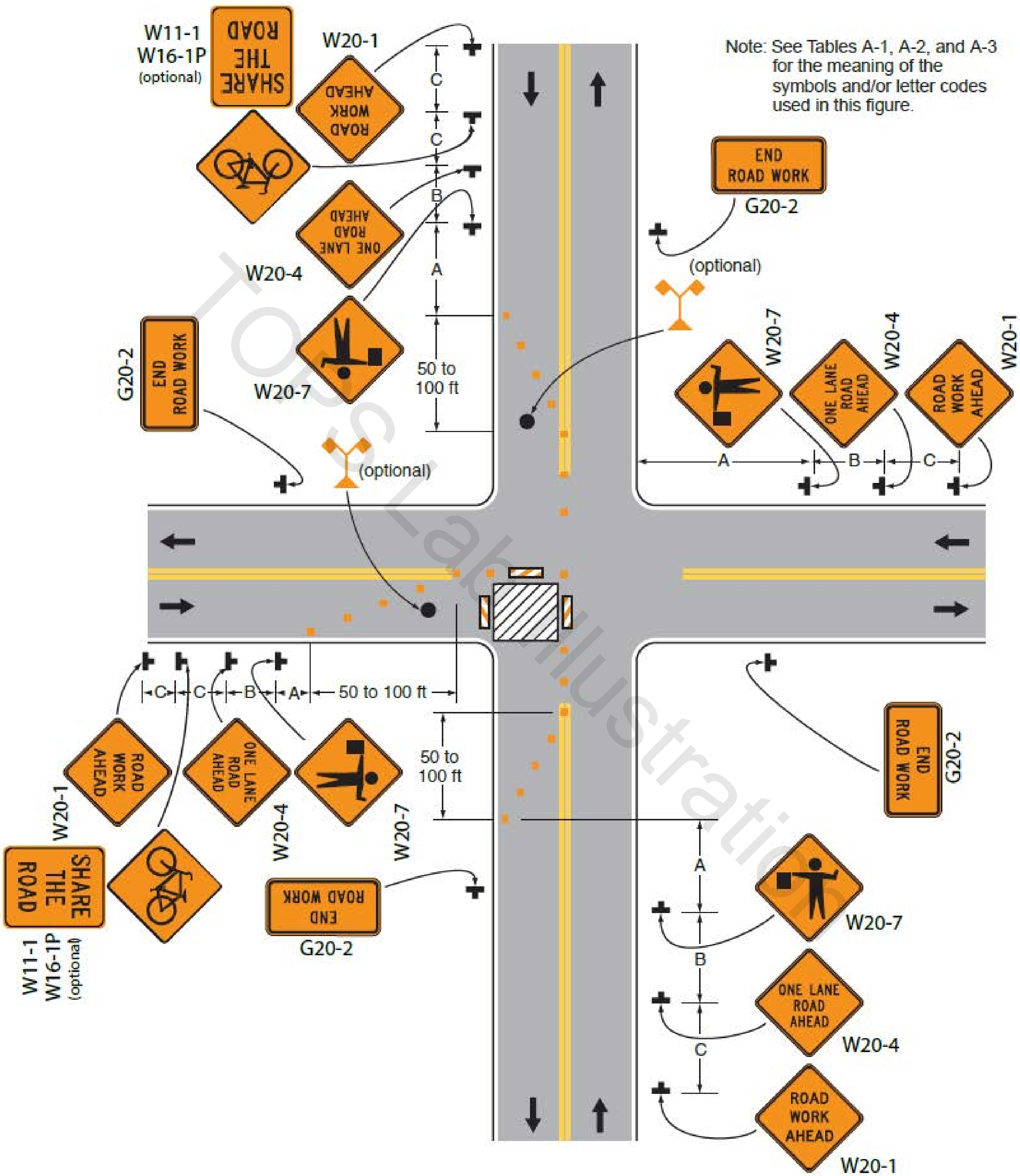


Illustration I-22

Notes for Figure A22—Illustration I-22
Closure at the Side of an Intersection

Guidance:

1. *The situation depicted can be simplified by closing one or more of the intersection approaches. If this cannot be done, and/or when capacity is a problem, through vehicular traffic should be directed to other roads or streets.*
2. *Depending on road user conditions, flagger(s) or uniformed law enforcement officer(s) should be used to direct road users within the intersection.*

Standard:

3. **At night, flagger stations shall be illuminated, except in emergencies.**

Option:

4. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
5. In advance of the work space, bicycle symbol and SHARE THE ROAD signs may used.
6. For short-duration work operations, the channelizing devices may be eliminated if a vehicle displaying high-intensity rotating, flashing, oscillating, or strobe lights is positioned in the work space.
7. A BE PREPARED TO STOP sign may be added to the sign series.

Guidance:

8. *When used, the BE PREPARED TO STOP sign should be located before the Flagger symbol sign.*
9. *ONE LANE ROAD AHEAD signs should also be used to provide adequate advance warning.*

Support:

10. Turns can be prohibited as required by vehicular traffic conditions. Unless the streets are wide, it might be physically impossible to make certain turns, especially for large vehicles.

Option:

11. Vehicle hazard warning signals may be used to supplement high-intensity rotating, flashing, oscillating, or strobe lights.

Standard:

12. **Vehicle hazard warning signals shall not be used instead of the vehicle's high-intensity rotating, flashing, oscillating, or strobe lights.**

Figure A23. Interior Lane Closure on a Multi-Lane Street (I-23)

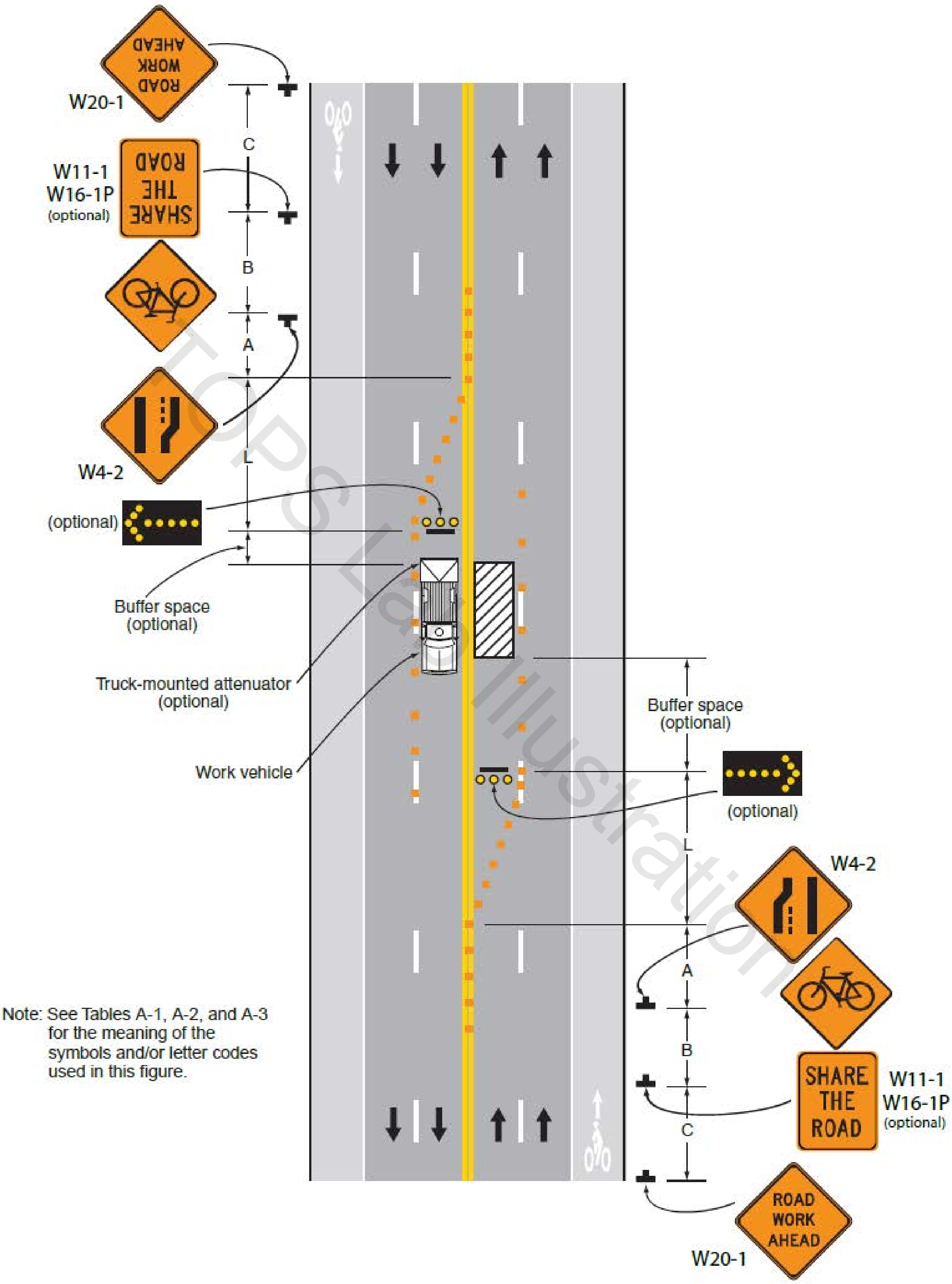


Illustration I-23

Notes for Figure A23—Illustration I-23
Interior Lane Closure on a Multi-Lane Street

Guidance:

1. *This information applies to low-speed, low-volume urban streets. Where speed or volume is higher, additional signing such as LEFT LANE CLOSED XX FT should be used between the signs shown.*

Option:

2. The closure of the adjacent interior lane in the opposing direction may not be necessary, depending upon the activity being performed and the work space needed for the operation.
3. Shadow vehicles with a truck-mounted attenuator may be used.
4. In advance of the work space, bicycle symbol and SHARE THE ROAD signs may used.

Figure A24. Lane Closure on a Street with Uneven Directional Volumes (I-24)

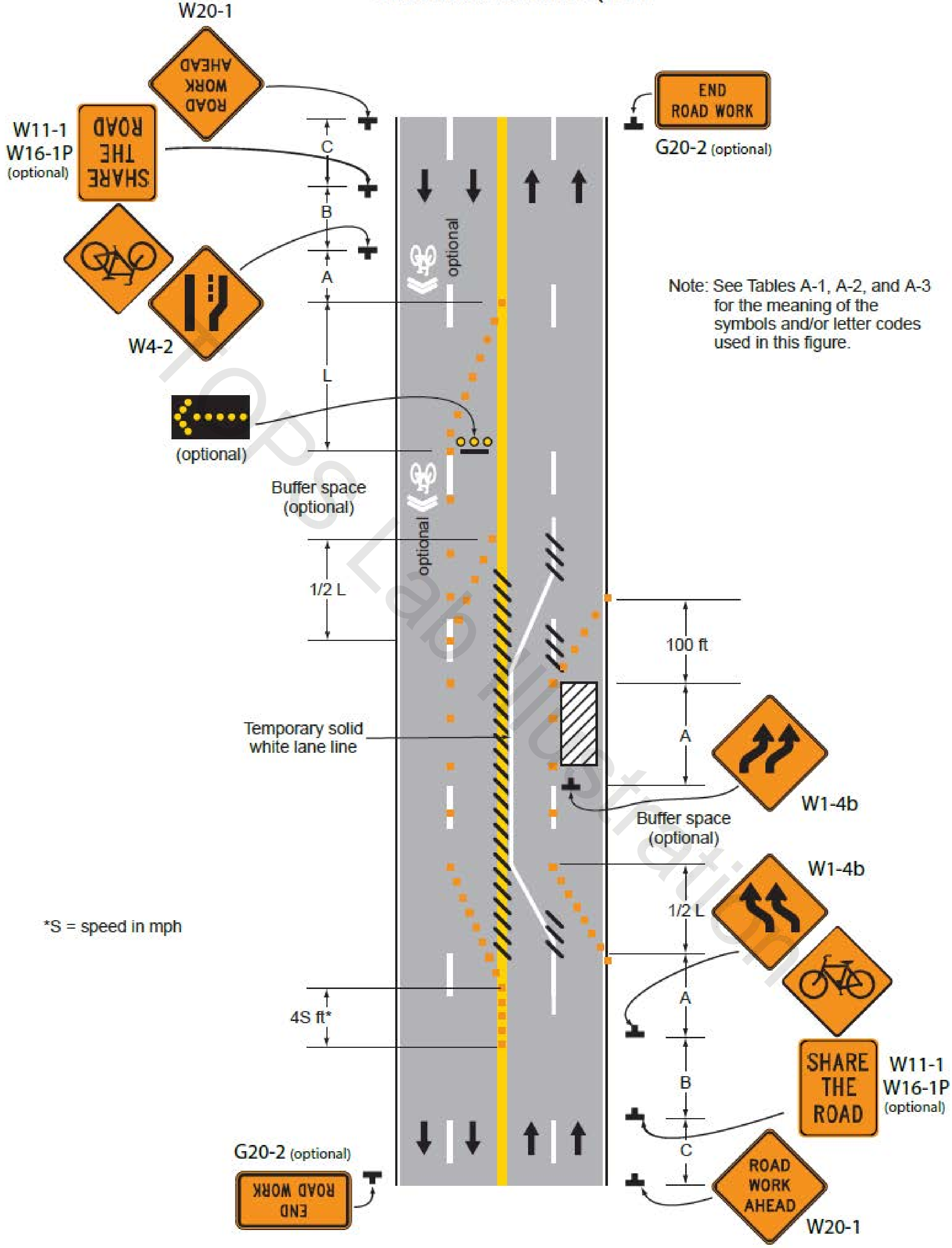


Illustration I-24

Notes for Figure A24—Illustration I-24
Lane Closure on a Street with Uneven Directional Volumes

Standard:

1. **The illustrated information shall be used only when the vehicular traffic volume indicates that two lanes of vehicular traffic shall be maintained in the direction of travel for which one lane is closed.**

Option:

2. The procedure may be used during a peak period of vehicular traffic and then changed to provide two lanes in the other direction for the other peak.

Guidance:

3. *For high speeds, a LEFT LANE CLOSED XX FT sign should be added for vehicular traffic approaching the lane closure, as shown in Figure 6H-32.*
4. *Conflicting pavement markings should be removed for long-term projects. For short-term and intermediate-term projects where this is not practical, the channelizing devices in the area where the pavement markings conflict should be placed at a maximum spacing of 1/2 S feet where S is the speed in mph. Temporary markings should be installed where needed.*
5. *If the lane shift has curves with recommended speeds of 30 mph or less, Reverse Turn signs should be used.*
6. *Where the shifted section is long, a Reverse Curve sign should be used to show the initial shift and a second sign should be used to show the return to the normal alignment.*
7. *If the tangent distance along the temporary diversion is less than 600 feet, the Double Reverse Curve sign should be used at the location of the first Two Lane Reverse Curve sign. The second Two Lane Reverse Curve sign should be omitted.*

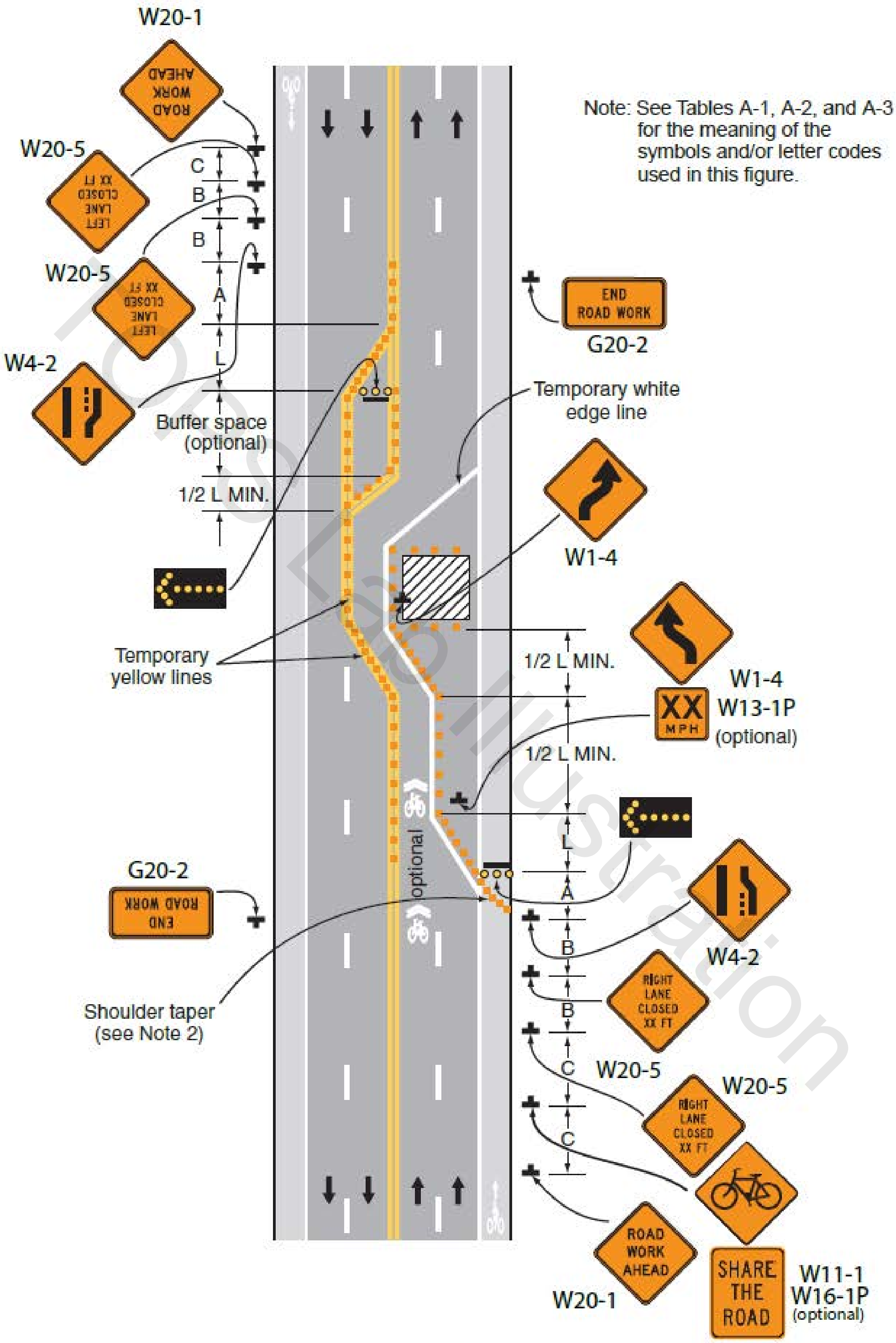
Standard:

8. **The number of lanes illustrated on the Reverse Curve or Double Reverse Curve signs shall be the same as the number of through lanes available to road users, and the direction of the reverse curves shall be appropriately illustrated.**

Option:

9. A longitudinal buffer space may be used in the activity area to separate opposing vehicular traffic.
10. Where two or more lanes are being shifted, a W1-4 (or W1-3) sign with an ALL LANES (W24-1cP) plaque (see Figure 6F-4) may be used instead of a sign that illustrates the number of lanes.
11. Where more than three lanes are being shifted, the Reverse Curve (or Turn) sign may be rectangular.
12. A work vehicle or a shadow vehicle may be equipped with a truck-mounted attenuator.
13. In advance of the work space, bicycle symbol and SHARE THE ROAD signs may used.
14. For long term projects, a Shared Lane Marking may be used in open lanes where bicyclists need to share the road with motor vehicles and speed limit is 35 mph or less.

Figure A25. Half Road Closure on a Multi-Lane, Street or Highway (I-25)



Note: See Tables A-1, A-2, and A-3 for the meaning of the symbols and/or letter codes used in this figure.

Illustration I-25

Notes for Figure A25—Illustration I-25
Half Road Closure on a Multi-Lane, Street or Highway

Standard:

1. **Pavement markings no longer applicable shall be removed or obliterated as soon as practical. Except for intermediate-term and short-term situations, temporary markings shall be provided to clearly delineate the temporary travel path. For short-term and intermediate-term situations where it is not feasible to remove and restore pavement markings, channelization shall be made dominant by using a very close device spacing.**

Guidance:

2. *When paved shoulders having a width of 8 feet or more are closed, channelizing devices should be used to close the shoulder in advance of the merging taper to direct vehicular traffic to remain within the traveled way.*
3. *Where channelizing devices are used instead of pavement markings, the maximum spacing should be 1/2 S feet where S is the speed in mph.*
4. *If the tangent distance along the temporary diversion is less than 600 feet, a Double Reverse Curve sign should be used instead of the first Reverse Curve sign, and the second Reverse Curve sign should be omitted.*

Option:

5. Warning lights may be used to supplement channelizing devices at night.
6. Prior to the activity area, bicycle symbol sign, SHARE THE ROAD sign, and bicycle lane pavement marking may be used in locations where bicyclists are normally permitted to ride on the shoulder.
7. The Shared Lane Marking may be used in locations where cyclists need to share the road with motor vehicles and speed limit is 35 mph or less.
8. A truck-mounted attenuator may be used on the work vehicle and/or the shadow vehicle.

Figure A26. Work in the Vicinity of a Grade Crossing (I-26)

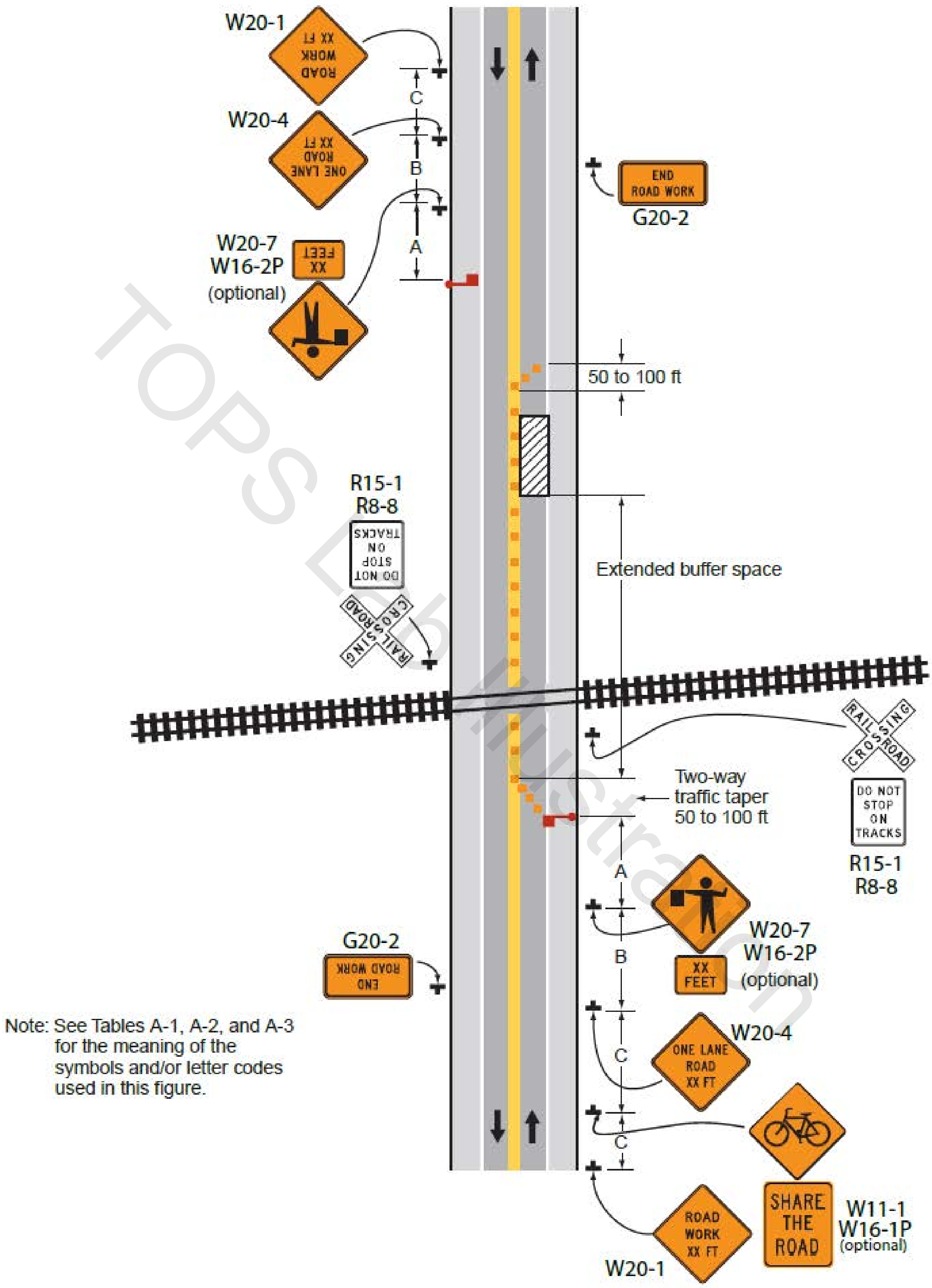


Illustration I-26

Notes for Figure A26—Illustration I-26
Work in the Vicinity of a Grade Crossing

Guidance:

1. *When grade crossings exist either within or in the vicinity of roadway work activities, extra care should be taken to minimize the probability of conditions being created, by lane restrictions, flagging, or other operations, where vehicles might be stopped within the grade crossing, considered as being 15 feet on either side of the closest and farthest rail.*

Standard:

2. **If the queuing of vehicles across active rail tracks cannot be avoided, a uniformed law enforcement officer or flagger shall be provided at the grade crossing to prevent vehicles from stopping within the grade crossing (as described in Note 1), even if automatic warning devices are in place.**

Guidance:

3. *Early coordination with the railroad company or light rail transit agency should occur before work starts.*
4. *In the example depicted, the buffer space of the activity area should be extended upstream of the grade crossing (as shown) so that a queue created by the flagging operation will not extend across the grade crossing.*
5. *The DO NOT STOP ON TRACKS sign should be used on all approaches to a grade crossing within the limits of a TTC zone.*

Option:

6. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
7. A BE PREPARED TO STOP sign may be added to the sign series.
8. In advance of the lane closure, bicycle symbol and SHARE THE ROAD signs may used.

Guidance:

9. *When used, the BE PREPARED TO STOP sign should be located before the Flagger symbol sign.*

Standard:

10. **At night, flagger stations shall be illuminated, except in emergencies.**

Table A-1. Meaning of Symbols on Illustrations

Arrow board	Shadow vehicle
Arrow board support or trailer (shown facing down)	Sign (shown facing left)
Changeable message sign or support trailer	Surveyor
Channelizing device	Temporary barrier
Crash cushion	Temporary barrier with warning light
Direction of temporary traffic detour	Traffic or pedestrian signal
Direction of traffic	Truck-mounted attenuator
Flagger	Barricade
High-level warning device (Flag tree)	Warning light
Longitudinal channelizing device	Work space
Luminaire	Work vehicle
Pavement markings that should be removed for a long-term project	
Bicycle lane symbol and arrow marking Figure 9C-3 A	Bicycle share lane marking Figure 9C-9

Table A-2. Meaning of Letter Codes on Illustrations

Road Type	Distance Between Signs[2]		
	A	B	C
Urban (low speed)[1]	100 feet	100 feet	100 feet
Urban (high speed)[1]	350 feet	350 feet	350 feet
Rural	500 feet	500 feet	500 feet
Expressway / Freeway	1,000 feet	1,500 feet	2,640 feet

1. Speed category to be determined by highway agency
2. The column headings A, B, and C are the dimensions shown in Figures 6H-1 through 6H-46. The A dimension is the distance from the transition or point of restriction to the first sign. The B dimension is the distance between the first and second signs. The C dimension is the distance between the second and third signs. (The "first sign" is the sign in a three-sign series that is closest to the TTC zone. The "third sign" is the sign that is furthest upstream from the TTC zone.)

Table A-3. Formulas for Determining Taper Length

Speed (S)	Taper Length (L) in feet
40 mph or less	$L = \frac{WS^2}{60}$
45 mph or more	$L = WS$

Where: L = taper length in feet
W = width of offset in feet
S = posted speed limit, or off-peak 85th-percentile speed prior to work starting, or the anticipated operating speed in mph

10. References

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