PDHonline Course C725 (5 PDH)

Traffic Control for Work Zones

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Traffic Control for Work Zones

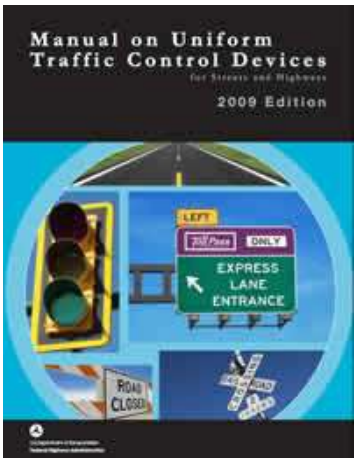
Gregory J. Taylor, P.E.

INTRODUCTION

This course shows how to effectively plan and design temporary traffic controls for work zone locations. The contents of this course are intended to serve as guidance and not as an absolute standard or rule. Its purpose is to help you to use the **Manual on Uniform Traffic Control Devices (MUTCD) Part 6 – Temporary Traffic Control** more effectively and not replace it. Should there be any discrepancies between the contents of this course and the MUTCD - always follow the MUTCD.

Upon course completion, you should be familiar with the general design guidelines for work zone traffic control. The course objective is to give engineers and designers an in-depth look at the principles to be considered when selecting and designing temporary traffic control for work zones.

For this course, the *Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) 2009 Edition* will serve as a reference for fundamental design principles. The MUTCD is recognized as the **national standard** for all traffic control devices installed on any street, highway, bikeway, or private road open to public travel. Any traffic control device design or application contained within it is considered to be in the public domain and available for use.



http://mutcd.fhwa.dot.gov/pdfs/2009/mutcd2009edition.pdf **MUTCD 2009**

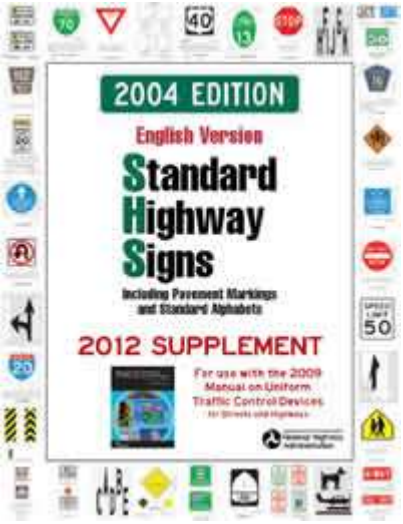
http://mutcd.fhwa.dot.gov/pdfs/2009/part6.pdf **Part 6**

Traffic signs and pavement markings are typically used for conveying laws and regulations, traffic and roadway conditions, and guidance and other information. These critical tools provide important information for safe travel on any U.S. roadway system.

Road users process different types of visual and non-visual information differently: speed, roadway conditions, traffic, legal enforcement, noise levels, etc. Signs and markings serve as reminders of important information, so road users do not have to memorize everything.

The goal is to provide drivers with relevant information when they need it - resulting in safer, more efficient roadways with reduced liability risks. However, poor sign management can greatly reduce safety, contribute to roadway incidents, and increase liability exposure.

The *Standard Highway Signs and Markings* book contains detailed specifications for all adopted standard signs and pavement markings. All traffic control devices have to be similar to or mirror images of those this manual. Any symbols or colors cannot be modified unless otherwise stated.



http://mutcd.fhwa.dot.gov/SHSe/shs_2004_2012_sup.pdf

MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD)

By law (23 CFR 655, Subpart F), the *Manual on Uniform Traffic Control Devices* (MUTCD) is recognized as "the national standard for all traffic control devices installed on any street, highway, bikeway, or private road open to public travel". It is the definitive authority for traffic signs and pavement markings.

Nationwide consistency is the goal of the MUTCD by requiring uniform, understandable, and effective traffic control devices on all facilities open to public travel. It defines the nationwide standards for the installation and maintenance of the devices on all streets and highways. The MUTCD allows us to drive anywhere in the U.S. using the same basic signs with the same meanings. Drivers who see a particular sign should expect it to mean the same thing regardless of location.

The MUTCD has nine chapters ("Parts"):

General

Signs

Marking

Highway Traffic Signals

Low-Volume Roads

Temporary Traffic Control

School Areas

Highway-Rail Grade Crossings

Bicycle Facilities

Since this course concentrates primarily on the subject of temporary traffic control, we will focus mainly on **Part 6 - Temporary Traffic Control**.

SHALL, SHOULD, and MAY

The terms "shall," "should," and "may" have specific meanings when used in the MUTCD.

> **SHALL** – Required, mandatory or specifically prohibitive practice.
> Any statements with "shall" conditions are typically used as a STANDARD in the MUTCD. These items cannot be modified or compromised. There is no allowance for discretion and they must be followed.
>
> **SHOULD** – Advisory or recommended practice in typical situations.
> Deviation is appropriate if justified by engineering judgment or study. Statements marked as "should" are used for GUIDANCE in the MUTCD.
>
> **MAY** – Permissive or optional practice without requirement or recommendation.
> Items marked as "may" are typically used in OPTION statements in the MUTCD and can contain allowable modifications.

SUPPORT statements do not contain the verbs "shall", "should", or "may". These statements are for informational purposes only (without any mandate, recommendation, or enforcement).

Road User

The MUTCD defines a road user as *"a vehicle operator, bicyclist, or pedestrian, including persons with disabilities, within the highway or on a private road open to public travel"*. This group includes users of various skill levels and ages, pedestrians, wheelchairs, runners, rollerbladers, bicyclists, truck drivers, and motorcyclists. By meeting user needs, engineers can minimize any problems that the average road user may encounter.

Temporary Traffic Control

A temporary traffic control (TTC) zone is a roadway location with changing user conditions due to road work, incidents, or special events. The main function of temporary traffic control is *"to provide for the reasonably safe and effective movement of road users through or around TTC zones while reasonably protecting road users, workers, responders to traffic incidents, and equipment".* Any TTC plan should include all phases of project development – planning, design, construction, and restoration.

FUNDAMENTAL PRINCIPLES OF TEMPORARY TRAFFIC CONTROL

- General plans/guidelines should be developed to provide safety for all users' equipment.
- Road user movement should be obstructed as little as possible.
- Motorists, bicyclists, and pedestrians should be guided in a clear and positive fashion through TTC zones and incident sites.
- Routine day/night inspections should be performed to provide acceptable levels of operations.
- Attention should be given to roadside safety maintenance during the life of the TTC zone.
- Each person (from upper-level management to field workers) whose actions affect TTC zone safety, should receive appropriate training for job decisions each individual is required to make.
- Good public relations should be maintained.

Definitions

The following terms may help determine the appropriate traffic control for existing street or highway conditions.

Low Speed – roadways with posted speed limits of 40 mile per hour (mph) or less.

High Speed – locations with posted speed limits of 45 mph or greater

Low Volume – sites with the average daily traffic volumes (ADT) less than 400 vehicles per day.

Special attention should be paid to nearby facilities (schools, manufacturing plants, etc.) that impact special traffic generation, and work zone locations subject to peak-hour traffic increases (typically 7-9 a.m. and 4-6 p.m).

Urban Street Conditions – routes with relatively low speeds, pedestrian activity, intersections, business entrances, and/or residential driveways. Work zones do not have to be within a municipality's corporate limits to qualify as an urban condition.

PARTS OF A TRAFFIC CONTROL ZONE

A traffic control zone is located between the first warning device and the where traffic resumes normal operations. Typical types of traffic control devices used in work zone traffic control include:

Signs
Channelizing Devices
Lighting Devices
Pavement Markings

Most temporary traffic control (TTC) zones are divided into the following four areas:

Advance warning area
Informs road users about an upcoming work zone or incident area and may vary from a single device to a series of advance signs.

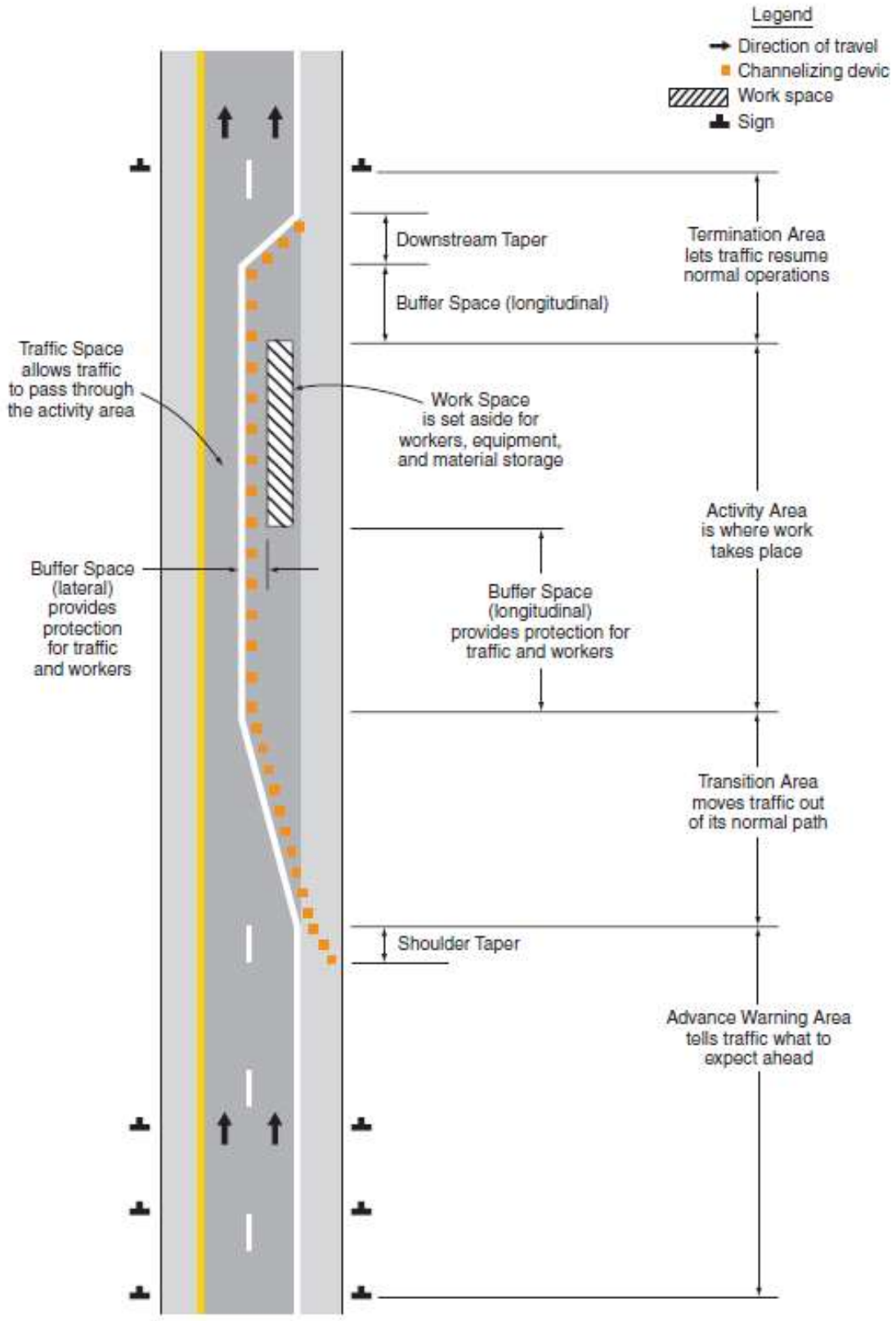
Transition area
Redirects vehicles away from their normal path and through the work area. This route should be conspicuous regardless of time or weather. These areas usually involve the use of tapers.

Activity area
Where work actually occurs.
This site is closed to traffic and set aside for workers, equipment, and construction materials. Activity areas may be broken down into three subareas:

Work Space – workers, equipment, and material storage
Traffic Space – passing traffic through the activity area
Buffer Space – traffic and worker protection

Termination area
Contains adequate distance for users to clear the work area and return to their normal driving route. This area extends from the downstream end of the work area to the last traffic control device.

Figure 6C-1. Component Parts of a Temporary Traffic Control Zone



Taper Length Criteria for Work Zones

Tapers are typically used for moving traffic laterally from one travel path to another in the transition and termination areas. They are created by using a combination of channelizing devices and/or pavement markings. The taper lengths in close proximity to curves, ramps, crossroads, interchanges, etc. may be adjusted for the specific location. *The maximum device spacing (feet) in a taper should be equal to the speed limit (mph).*

Merging taper - moves traffic laterally from one lane to merge into another.
- requires the longest distance since drivers must merge into common road space

Shifting taper - used to move traffic into a different path for locations where merge is not required.
- should be lengthened where possible to increase effectiveness
- horizontal curves may also be used for changing the alignment

Shoulder taper - used on high-speed roadways with shoulders that are part of the activity area and are closed, or in locations where improved shoulders might be mistakenly used as a driving lane
- typical (but shortened) closure procedures may be used.

Downstream taper - useful in termination areas to reassure drivers that they have passed the work area and can move back into the lane that was closed.
- should have a minimum length of 50 feet and a maximum length of 100 feet with a spacing of approximately 20 feet

One-lane, two-way taper - used in advance of an activity area which occupies part of a two-way roadway where part of the road is used alternately by traffic in each direction.

Figure 6C-2. Types of Tapers and Buffer Spaces

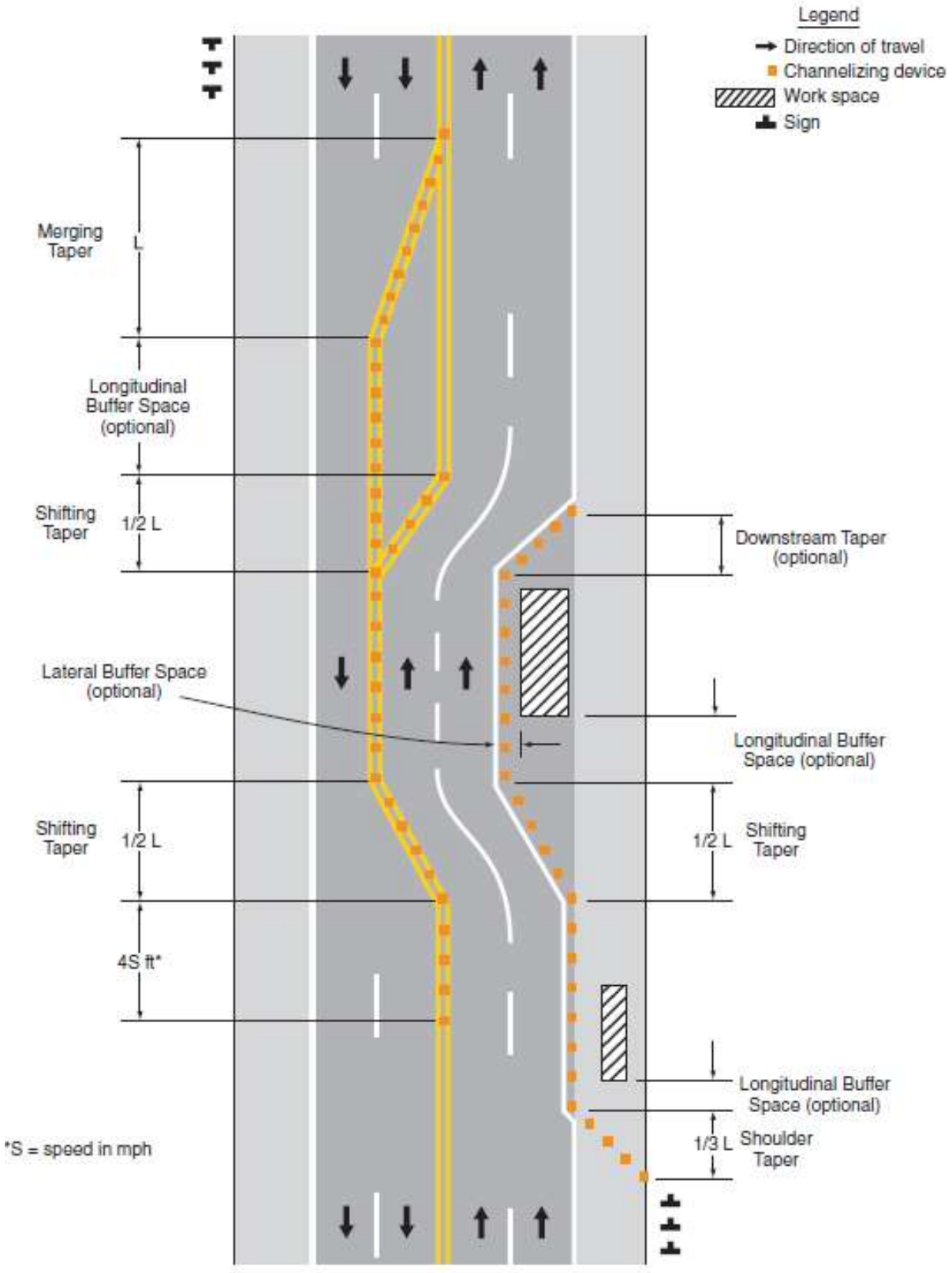


Table 6C-3. Taper Length Criteria for Temporary Traffic Control Zones

Type of Taper	Taper Length
Merging Taper	at least L
Shifting Taper	at least 0.5 L
Shoulder Taper	at least 0.33 L
One-Lane, Two-Way Traffic Taper	50 feet minimum, 100 feet maximum
Downstream Taper	50 feet minimum, 100 feet maximum

Note: Use Table 6C-4 to calculate L

Table 6C-4. 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

Buffer Lengths

Optional buffer areas are open or unoccupied spaces that separate roadway traffic from work areas or potentially hazards. Their function is to provide a margin of safety for both traffic and workers. Any work activity, equipment storage, materials, etc. should not be allowed in this area.

Lateral Buffer Space - separates traffic from the work area
- use and width based on conditions at the work site.

Longitudinal Buffer Space - length based on Stopping Sight Distance

Table 6E-1. Stopping Sight Distance as a Function of Speed

Speed*	Distance
20 mph	115 feet
25 mph	155 feet
30 mph	200 feet
35 mph	250 feet
40 mph	305 feet
45 mph	360 feet
50 mph	425 feet
55 mph	495 feet
60 mph	570 feet
65 mph	645 feet
70 mph	730 feet
75 mph	820 feet

* Posted speed, off-peak 85th-percentile speed prior to work starting, or the anticipated operating speed

PEDESTRIAN AND WORKER SAFETY

Pedestrian Safety

Temporary traffic control zones can impact a wide range of pedestrians (young, elderly, and disabled). Pedestrians need protection from potential injuries and a clearly defined travel path. Pedestrian traffic control (signs, channelizing devices, flags, suitable fencing, etc.) need to be used where travel paths are affected by construction, maintenance, or utility operations. The temporary facilities should be detectable, include accessibility features, and direct pedestrian flow through or around the work zone.

Major Considerations in Planning for Pedestrian Safety

- Avoid pedestrian conflicts with work site vehicles, equipment, or operations
- Avoid any direct conflicts with traffic moving through or around the work area
- Provide a safe, convenient travel path that mimics the most desirable characteristics of sidewalks or footpaths.

Worker Safety

The safety of workers in a work zone is equally as important as the traveling public. Temporary traffic control zones present challenges which create a high degree of vulnerability for roadway workers. The best protection for all is effective work zone traffic control.

Key Elements to Consider for Improving Worker Safety

Training

All workers should be trained to minimize their vulnerability when working adjacent to traffic. All workers with specific traffic control responsibilities should be appropriately trained in TTC techniques, placement, and usage.

Temporary Traffic Barriers

Barriers should be placed along the work space based on lateral clearance of workers from adjacent roadway traffic, vehicle speed, work duration, type of operations, time of day, and traffic volume.

Speed Reduction

Traffic speed may be reduced by regulatory speed zoning, funneling, lane reduction, uniformed law enforcement officers or flaggers.

Activity Area

Internal work activities should be coordinated to prevent backing-up maneuvers of construction vehicles and reduce the exposure to risk.

Worker Safety Planning

A worksite basic hazard assessment should be conducted and job classifications determined by trained personnel. Protection measures should be determined and implemented by a safety professional.

FLAGGING

Flaggers stop or slow traffic at jobsites to help protect the workers. They need to be clearly visible from an adequate distance to permit proper driver reaction prior to entering the work site. Since flaggers are responsible for public safety and are constantly in contact with the public, they should have appropriate training in traffic control and public contact.

Flagger Responsibilities

- Receive and communicate specific instructions
- Move and maneuver quickly
- Control signaling devices (such as paddles and flags)
- Understand and apply safe traffic control practices
- Recognize dangerous traffic situations and warn workers in sufficient time

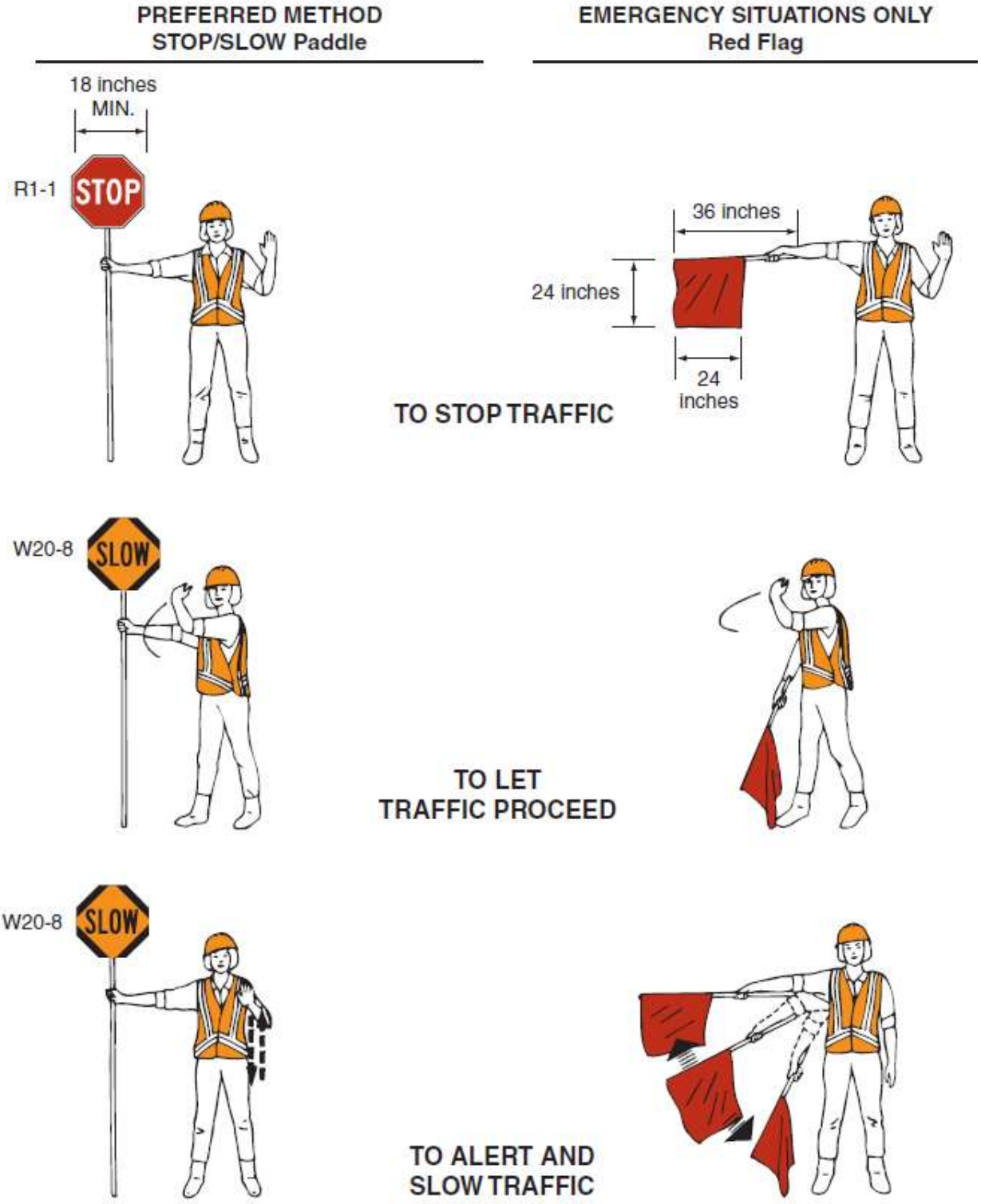
Flaggers need to wear appropriate high-visibility safety apparel with fluorescent orange-red and/or fluorescent yellow-green outer material identifying the wearer as a person. Retroreflective materials should be orange, yellow, white, silver, or yellow-green *(minimum visibility of 1,000 feet).*

Automated Flagger Assistance Devices

Automated Flagger Assistance Devices (AFADs) are remote-controlled devices operated by a single flagger or by separate flaggers near each work site. These help control drivers through temporary traffic control zones and allow flaggers further distance away from traffic.

Mounting – Post-mounted signs (in rural areas) need to be installed a minimum height of *5 feet* above the traveled way (measured from the bottom of the sign), and *7 feet* for urban locations. Signs on barricades and other portable supports can be installed at lower heights with the bottom of the sign *a minimum of one foot* above the traveled way. All sign supports and barricades must meet crashworthy requirements.

Figure 6E-3. Use of Hand-Signaling Devices by Flaggers



TRAFFIC SIGNS

Drivers must be able to read a sign from a reasonable distance and have adequate reaction time to safely travel the roadway. As the national population gets older, the average driver gets older, and people continue driving at older ages. Improving nighttime visibility of signs and pavement markings becomes more important as the traveling public gets older. As we age, our eyes gradually become less light sensitive.

Retroreflectivity is the ability of a traffic control device to reflect light from its surface back to its original source. Retroflective traffic signs can be used for increasing nighttime visibility. Maintaining retroreflectivity is a crucial element of traffic safety since fatal night crashes occur approximately three (3) times as often as daytime traffic fatalities.

Retroreflectivity Elements

Light source (vehicle headlights)
Target (traffic control device)
Receptor (driver's eyes)

Technologies involving glass beads or prismatic reflectors are more visible and bright since more light is reflected directly back to the original source.

All signs (regulatory, warning, and guide) and object markers need to be retroreflective or illuminated to display the same shape and color regardless of time and day. New materials or methods can be used as long as the traffic control devices meet the standard color requirements. Sign design should be uniform without any decrease in: **visibility, legibility,** or **driver comprehension during day or night conditions.**

Sign Type and Designation

Over the years, traffic signs have been responsible for providing messages of increasing complexity. To meet this challenge, the MUTCD specifies standard design features to encourage adequate perception-reaction time for the road user. These features (size, shape, and color) are specific to the functional category of each traffic sign.

WORK ZONE TRAFFIC CONTROL SIGN CATEGORIES AND USE

CATEGORY	USE
Regulatory	Requires or prohibits actions by the road user
Warning	Warns user of conditions that may require an action to avoid a hazardous situation
Guide & Information	Helps user find their way, informs user of traveler services, etc.

Sign Color and Shape

A sign's color and shape is important in conveying traffic control information. These specific combinations inform drivers of the type of sign. The colors and shapes are designed to command attention and convey a clear simple message. Signs usually have one color (typically black or white) for the legend, which includes symbols, text and border. Some signs (such as prohibition signs) have two-color legends containing a red circle and slash over a black symbol. The Federal Highway Administration (FHWA) established a color code of appropriate colors for traffic control devices.

COLOR CODE FOR TRAFFIC CONTROL DEVICES

COLOR	MEANING
Black	Regulation
Blue	Road user services guidance, tourist information, evacuation route
Brown	Recreational and cultural interest area guidance
Coral	Unassigned
Fluorescent Pink	Incident management
Fluorescent Yellow-Green	Pedestrian, bicycle warning, playground warning, school bus and school warning
Green	Indicated movements permitted, direction guidance
Light Blue	Unassigned
Orange	Temporary traffic control
Purple	Lanes restricted to use only by vehicles with registered electronic toll collection (ETC) accounts
Red	Stop or prohibition

White Regulation

Yellow Warning

Table 2A-4. Use of Sign Shapes

Shape	Signs
Octagon	Stop*
Equilateral Triangle (1 point down)	Yield*
Circle	Grade Crossing Advance Warning*
Pennant Shape/Isosceles Triangle (longer axis horizontal)	No Passing*
Pentagon (pointed up)	School Advance Warning Sign (squared bottom corners)* County Route Sign (tapered bottom corners)*
Crossbuck (two rectangles in an "X" configuration)	Grade Crossing*
Diamond	Warning Series
Rectangle (including square)	Regulatory Series Guide Series** Warning Series
Trapezoid	Recreational and Cultural Interest Area Series National Forest Route Sign

* This sign shall be exclusively the shape shown.

** Guide series includes general service, specific service, tourist-oriented directional, general information, recreational and cultural interest area, and emergency management signs.

Sign Size

Standard sign sizes should be used unless engineering judgment indicates otherwise. Sign sizes should not be smaller than the minimum sizes contained in the MUTCD. However, larger sizes may be used where deemed appropriate. Shapes and colors as close to the standard proportions should also be used.

Sign Location

Signs requiring different user decisions need to be spaced sufficiently far apart to allow for reasonable reaction time. Multiple signs should be compatible and provide a logical sequence of communication. The road user needs to have adequate time to adjust speed, avoid any potential hazard, and continue on their desired route. These signs should be placed on the right side of the roadway where they can be easily recognized and understood. Signs in other locations should be considered supplementary to signs in the normal locations.

Potential sign locations should:

Be outside the clear zone unless placed on a breakaway or yielding support
Not be hidden from view
Optimize nighttime visibility
Minimize the effects of mud splatter and debris
Not obscure each other – Avoid clutter

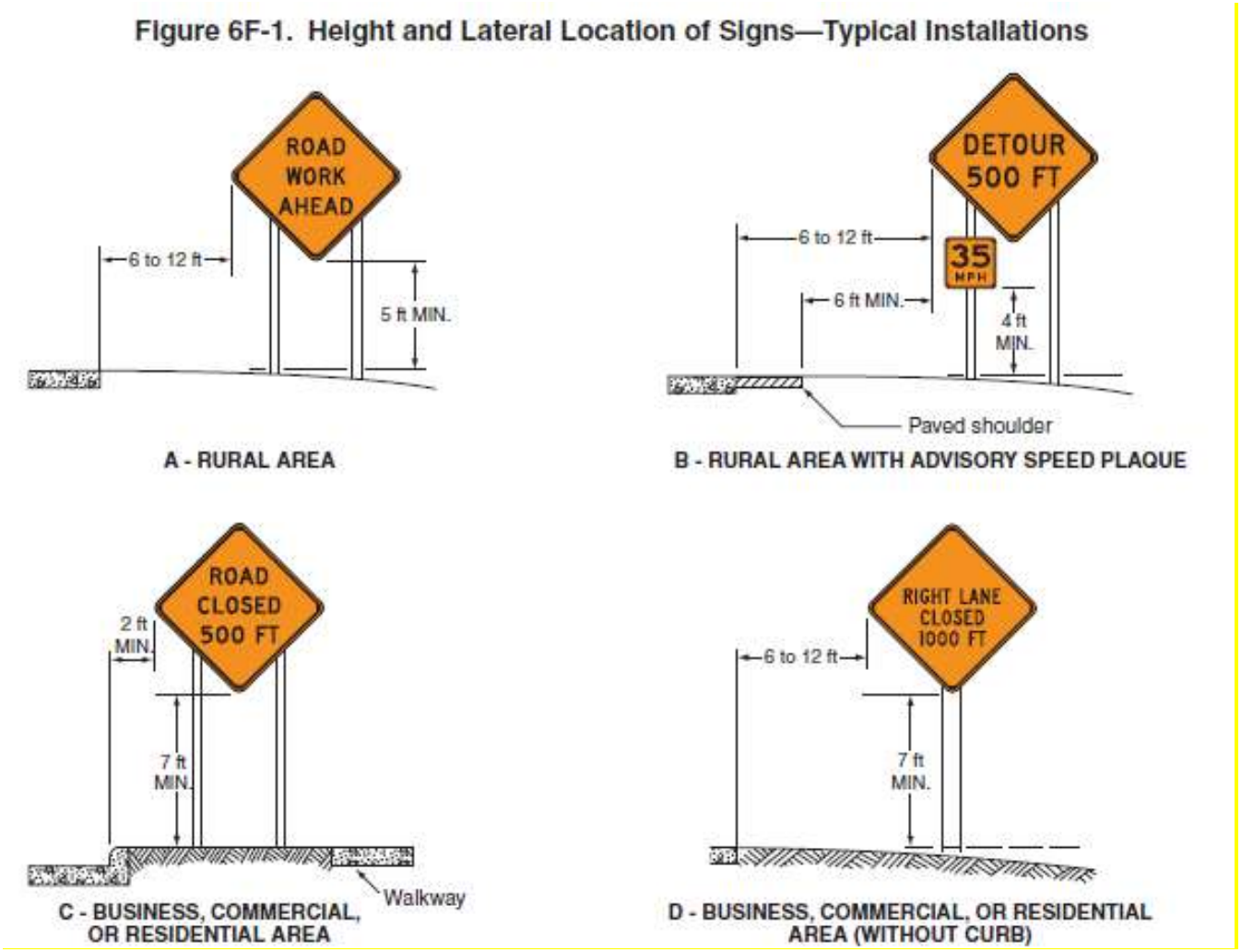
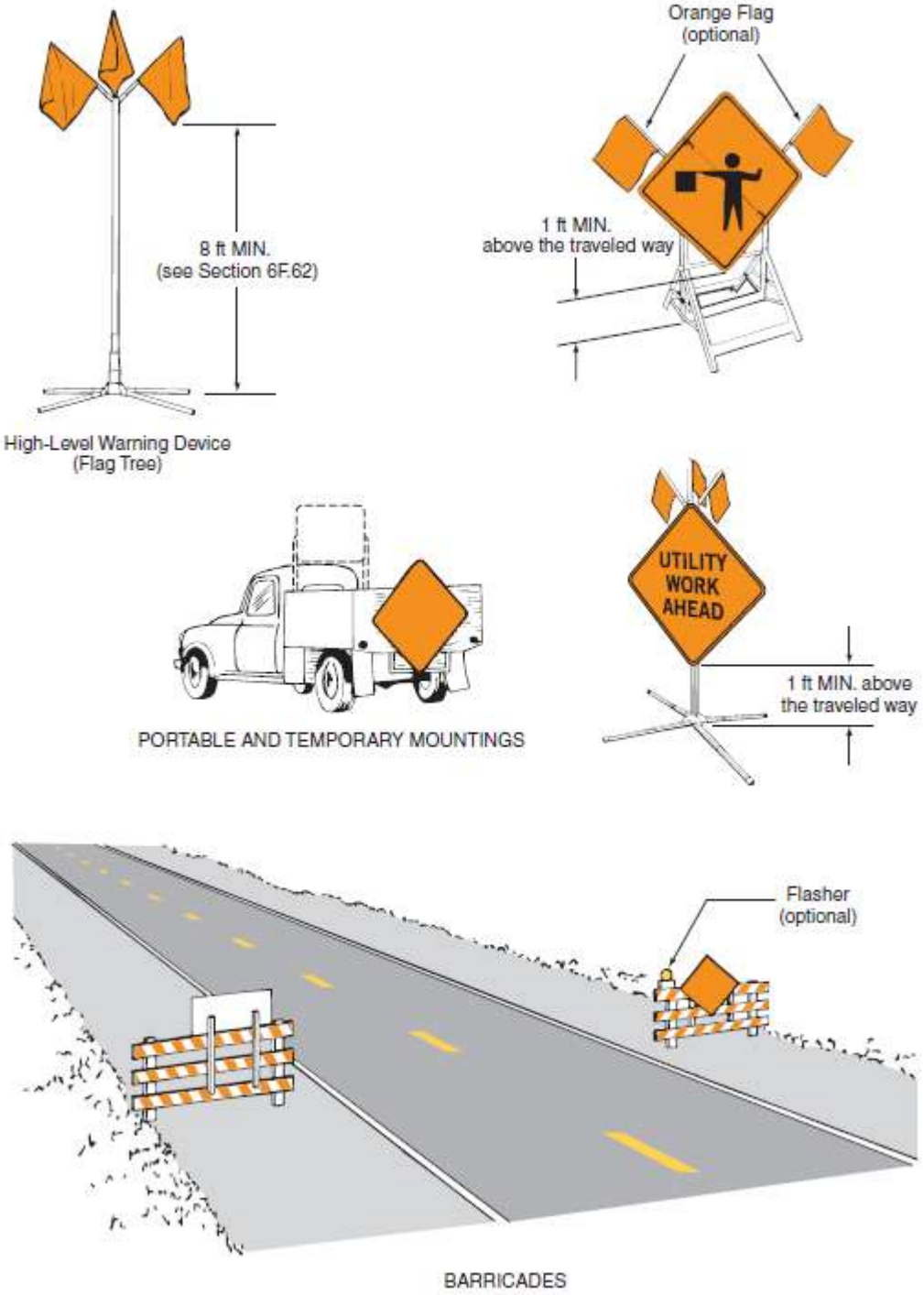


Figure 6F-2. Methods of Mounting Signs Other Than on Posts



Lateral Distance

A sign's proximity to the road directly impacts visibility. Close placement enhances readability but also increases the likelihood of damage by traffic. Signs installed further away from the roadway are less vulnerable to damage but harder to read.

Post-mounted signs should have a *minimum lateral clearance of 12 feet* from the edge of the travel way to the near edge of the sign. For shoulder widths over 6 feet, the *minimum offset should be 6 feet* from the shoulder's edge. Potential sites should be located as far as practical from the edge of shoulder with minimum traffic exposure to sign supports.

For curbed roadways with parking or pedestrians, the edge of the sign should be a *minimum offset of two feet* from the face of curb which allows for adequate vehicle door clearance. Increasing this lateral offset distance minimizes chances of sign damage by vehicles but caution needs to be exercised to prevent sidewalk blockage.

Height Above the Roadway

The height of a sign can impact sign visibility, roadway safety, and pedestrian access. The minimum height for signs installed in rural areas is *5 feet* (measured from the edge of pavement elevation to the bottom of the sign). For urban areas with parking, pedestrian, or sight distance challenges, the *minimum height requirement is 7 feet*. At curb locations, this distance is measured from the top of curb to the bottom of sign. The minimum height for roadways without curb is measured from the edge of traveled way elevation to the bottom of the sign. For areas with sidewalks, the *minimum height is 7 feet* (measured from the top of sidewalk to the bottom of the sign).

The MUTCD specifies only *minimum heights* for sign assemblies. For hillcrests, it may be useful to place the sign higher than normal for better visibility.

MINIMUM SIGN HEIGHT

5 ft	**Rural**
7 ft	**Parking or pedestrian movements (non-rural)**
7 ft	**Directional signs on expressways and freeways**
8 ft	**Height of sign if secondary sign present**
5 ft	**Secondary sign above the level of the pavement edge**
7 ft	**All route signs, warning signs, and regulatory signs on expressways and freeways**

Signs mounted on barricades or other portable supports may be installed at lower heights with the bottom of the sign *a minimum of one foot* above the traveled way. All sign supports and barricades must meet crashworthy standards.

REGULATORY SIGNS

Regulatory signs inform motorists of traffic regulations, laws, and applicable legal requirements. These signs require or prohibit the movement of vehicles, pedestrians, and other road users. Their function is to encourage the safe, orderly flow of traffic. All signs should clearly communicate its message and provide adequate visibility (retroreflective or illumination).

Unless specifically designated otherwise, all regulatory signs must be rectangular (exceptions include stop signs, yield signs and railroad crossing signs). The colors for regulatory signs are white, black, and red.

Regulatory signs are used to fulfill a need. Drivers tend to disregard a regulation perceived as unneeded. However, other road users may expect them to obey the sign, and act accordingly which may result in crashes (example: Yield sign). Regulatory signs can be used to remind road users of statutory traffic laws (no parking, one way, etc.). However, some laws may not need signs to be enforceable.

Table 2B-1. Regulatory Sign and Plaque Sizes

Sign or Plaque	Sign Designation	Section	Conventional Road		Expressway	Freeway	Minimum	Oversized
			Single Lane	Multi-Lane				
Stop	R1-1	2B.05	30 x 30*	36 x 36	36 x 36	—	30 x 30*	48 x 48
Yield	R1-2	2B.08	36x36x36*	48x48x48	48x48x48	60x60x60	30x30x30*	—
To Oncoming Traffic (plaque)	R1-2aP	2B.10	24 x 18	24 x 18	36 x 30	48 x 36	24 x 18	—
All Way (plaque)	R1-3P	2B.05	18 x 6	18 x 6	—	—	—	30 x 12
Yield Here to Peds	R1-5	2B.11	—	36 x 36	—	—	—	36 x 36
Yield Here to Pedestrians	R1-5a	2B.11	—	36 x 48	—	—	—	36 x 48
Stop Here for Peds	R1-5b	2B.11	—	36 x 36	—	—	—	36 x 36
Stop Here for Pedestrians	R1-5c	2B.11	—	36 x 48	—	—	—	36 x 48
In-Street Ped Crossing	R1-6,6a	2B.12	12 x 36	12 x 36	—	—	—	—
Overhead Ped Crossing	R1-9,9a	2B.12	90 x 24	90 x 24	—	—	—	—
Except Right Turn (plaque)	R1-10P	2B.05	24 x 18	24 x 18	—	—	—	—
Speed Limit	R2-1	2B.13	24 x 30*	30 x 36	36 x 48	48 x 60	18 x 24*	30 x 36

WARNING SIGNS

Warning signs are typically used in roadway work zones for construction and maintenance activities. They alert road users to unexpected/unapparent conditions on or near the roadway. These signs may require actions by the driver to ensure safe traffic operations. The majority of warning signs are diamond-shaped with a black legend/border on an orange background, and located on the right-hand side of the roadway.

Background colors for warning signs depend on their use. Signs regarding pedestrians, bicyclists and playgrounds may have a black legend/border and yellow or fluorescent yellow-green background. For buses, schools and supplemental plaques, the signs have a black legend/border with a fluorescent yellow-green background.

School signs
Pentagon-shaped

Railroad warning signs
Circular

No passing signs
Triangular

Size – The standard size for advance warning signs in higher-speed work zones is typically **48 inches by 48 inches**. For work zones with moderately low speeds and traffic volumes, a minimum size of 36 inches by 36 inches may be used. Secondary roads or city streets with very low speeds may use warning signs (having short word messages or symbols) that are smaller than standard sizes with a minimum size of 24 inches by 24 inches.

Properly located warning signs can reduce incidents by improving driver Perception-Response Times (PRT). A standard value for PRT is typically **2.5 seconds**, with 2.5 to 3.0 seconds for older drivers, and longer times for unexpected events.

SPEED-TIME-DISTANCE RELATIONSHIPS

SPEED (mph)	TIME (sec)					
	1	1.5	2	2.5	3	3.5
20	29	44	59	73	88	103
25	37	55	73	92	110	128
30	44	66	88	110	132	154
35	51	77	103	128	154	180
40	59	88	117	147	176	205
45	66	99	132	165	198	231
50	73	110	147	183	220	257
55	81	121	161	202	242	282
60	88	132	176	220	264	308
65	95	143	191	238	286	334
70	103	154	205	257	308	359

Distance (feet)

Example – Perception Response Time
Speed: 45 mph

Perception Response Time	Distance Traveled
2.5 seconds	165 feet
3.0 seconds	198 feet

Table 6C-1. Recommended Advance Warning Sign Minimum Spacing

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

* Speed category to be determined by the highway agency
** 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.)

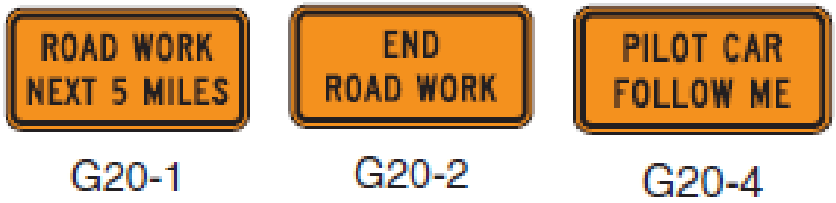
Although some warning signs may be more effective than others, their use should produce a significant reduction in related incidents. But like all traffic signs, improper use usually causes disrespect for all warning signs, and minimizes their effectiveness. All signs that are no longer appropriate should be removed or covered if work is suspended for short periods.

When considering the use of a warning sign:

Determine if the hazard can be removed.
If it will take time to remove the hazard, use a temporary sign to warn traffic.
If the hazard is impossible or too expensive to remove, install a warning sign.
Any temporary signage should be removed as soon as it is no longer needed.

GUIDE AND INFORMATION SIGNS

Guide and information signs are intended to guide road users through temporary traffic control zones to their destination in the most simple, direct manner possible. These signs that direct drivers through work zones or detours are black with an orange background. All guide and information signs (message, border, legend and background) should be retroreflective or illuminated.



G20-1 G20-2 G20-4

Accurate and timely navigation information is crucial for traffic safety. Guide and information signs can help prevent erratic maneuvers, and minimize potential crashes.

Guide Signs Used in TTC Zones

- Standard route markings
- Directional signs and street name signs
- Special guide signs

INCIDENT MANAGEMENT SIGNS

A traffic incident management area is a TTC zone containing temporary traffic controls authorized by a public authority in response to an incident. The MUTCD defines a traffic incident as "an emergency road user occurrence, a natural disaster, or other unplanned event that affects or impedes the normal flow of traffic". Examples include: vehicles blocking a traffic lane; hazardous material spills; and natural disasters (floods and severe storm damage). Incident management zones extend from the first warning device to the last temporary traffic control device - or to where vehicles clear the incident and return to the original travel lanes.

Classes of Traffic Incidents

Major - more than 2 hours
Intermediate - 30 minutes to 2 hours
Minor - under 30 minutes

Incident management signs have a black legend/border with a fluorescent pink background.

W3-4


W4-2

W9-3

E5-2a

The major function of TTC at a traffic incident management area is to temporarily guide road users safely past the incident, and prevent any secondary traffic incidents. In the event of an emergency incident, temporary traffic control devices that are readily available may be used for the initial response if they do not create unnecessary additional hazards.

Benefits of Traffic Incident Management Area TTC

- Protects workers and incident responders
- Aids in moving road users past incident
- Reduces potential secondary crashes
- Prevents unnecessary use of surrounding roadways

Local municipalities need to coordinate any incident responses with appropriate local safety, emergency, enforcement, towing and recovery authorities to minimize additional risk to other road users.

PAVEMENT MARKINGS

Pavement marking is more than just roadway striping. It is a guidance system that relays regulatory and vehicle-path information to the user without requiring them to divert their attention from the road. These markings should encourage safe, efficient traffic flow while optimizing roadway capacity. In order to be effective, pavement markings need to be easily recognized and understood. A uniform system of marking color, shape, and application has been developed to convey the same message for a specific situation.

All pavement markings need to be properly maintained to assure good daytime and nighttime visibility. It is the municipality's responsibility to maintain the marking once the decision has been made to install it. If the municipality decides that the marking is no longer needed, documentation of the decision process should be recorded. Pavement markings deemed non-applicable or confusing should be removed as soon as possible.

Temporary markings within TTC zones provide a clearly defined path through the work zone. These markings are typically needed during roadway reconstruction while open to traffic (resurfacing, lane shifts, etc.).

MATERIALS

Pavement markings typically include paints and thermoplastics but they may also use other marking materials (colored paving, raised pavement markers, etc.). Highly visible delineators and channelizing devices can also be placed vertically above the roadway.

Paint is the easiest, cheapest, and most commonly used pavement marking material. However, it is also the least durable. To combat poor nighttime visibility, retroreflectivity can be improved by adding glass beads into the wet paint.

Thermoplastic pavement markings use a heated temperature-setting plastic material for use on asphalt pavements. Due to temperature-related expansion and contraction differentials between plastic and concrete (which may result in thermoplastic separation) thermoplastic is prohibited from use on concrete.

Marking color, pattern, and orientation provide crucial information to roadway users. Complying with these standards provide positive guidance and should be maintained throughout the product's life. Materials that minimize tripping or maintain traction for users (pedestrians, bicyclists, motorcycles, etc.) should also be considered when choosing pavement markings.

RAISED PAVEMENT MARKERS (RPM)

Raised pavement markers may be substituted for other types of markings in TTC zones. These are normally used for detours, temporary roadways, and/or new travel lane alignments. The color of raised pavement markers under both daylight and nighttime conditions should match the color of the marking for which they serve, supplement or substitute.

Retroreflective or internally illuminated raised pavement markers can be used in the roadway bordering curbed approach ends or on top of raised medians and curbs of islands. These markers are available in mono-directional and bidirectional types (capable of displaying the applicable color for each direction of travel). Internally illuminated markers must be steadily illuminated and not flash when used.

Non-retroreflective raised pavement markers should not be used as a lone substitute for other types of pavement markings without supplemental retroreflective or internally illuminated markers.

Directional configurations should maximize correct information and minimize confusing information from other markers that do not apply to the road user.

The spacing of RPMs should correspond with the pattern of broken lines for which the markers serve, supplement or substitute. For additional emphasis, retroreflective raised pavement markers may be spaced closer than described in the MUTCD if determined appropriate by engineering judgment/study.

For further information, the *"Traffic Control Devices Handbook"* contains spacing details for raised pavement markers on longitudinal markings.

DELINEATORS

Delineators should supplement or act in combination with other temporary traffic control devices to indicate the roadway's alignment and to outline the vehicle path through the TTC zone. Delineators are useful for roadway locations with long continuous sections or short stretches where the alignment might be confusing or unexpected (lane-reduction transitions, horizontal curves, etc.). These are effective *guidance* devices (rather than warning devices) at night and during adverse weather due to their visibility when the roadway may be wet or snow covered.

Delineator Design

Delineators consist of retroreflective devices (3-inch minimum) that normally retroreflect light from a distance of 1,000 feet when illuminated by standard automobile high beam headlights.

Single delineators: One retroreflective element for a given direction of travel at a specific location. May be installed on the left-hand side where needed

Double delineator: Two identical retroreflective elements mounted together for a direction. An appropriately sized vertically elongated delineator may be substituted for a double delineator.

Delineator Application

A series of single delineators should be located on the right side of freeways and expressways and on one side of interchange ramps, except when either of the following conditions is met:

- On tangent sections of freeways and expressways when both of the following conditions are met:
    1. Continuous raised pavement markers are used to supplement pavement markings on lane lines throughout all curves and on all tangents,
    2. Roadside delineators are used to direct traffic into all curves.

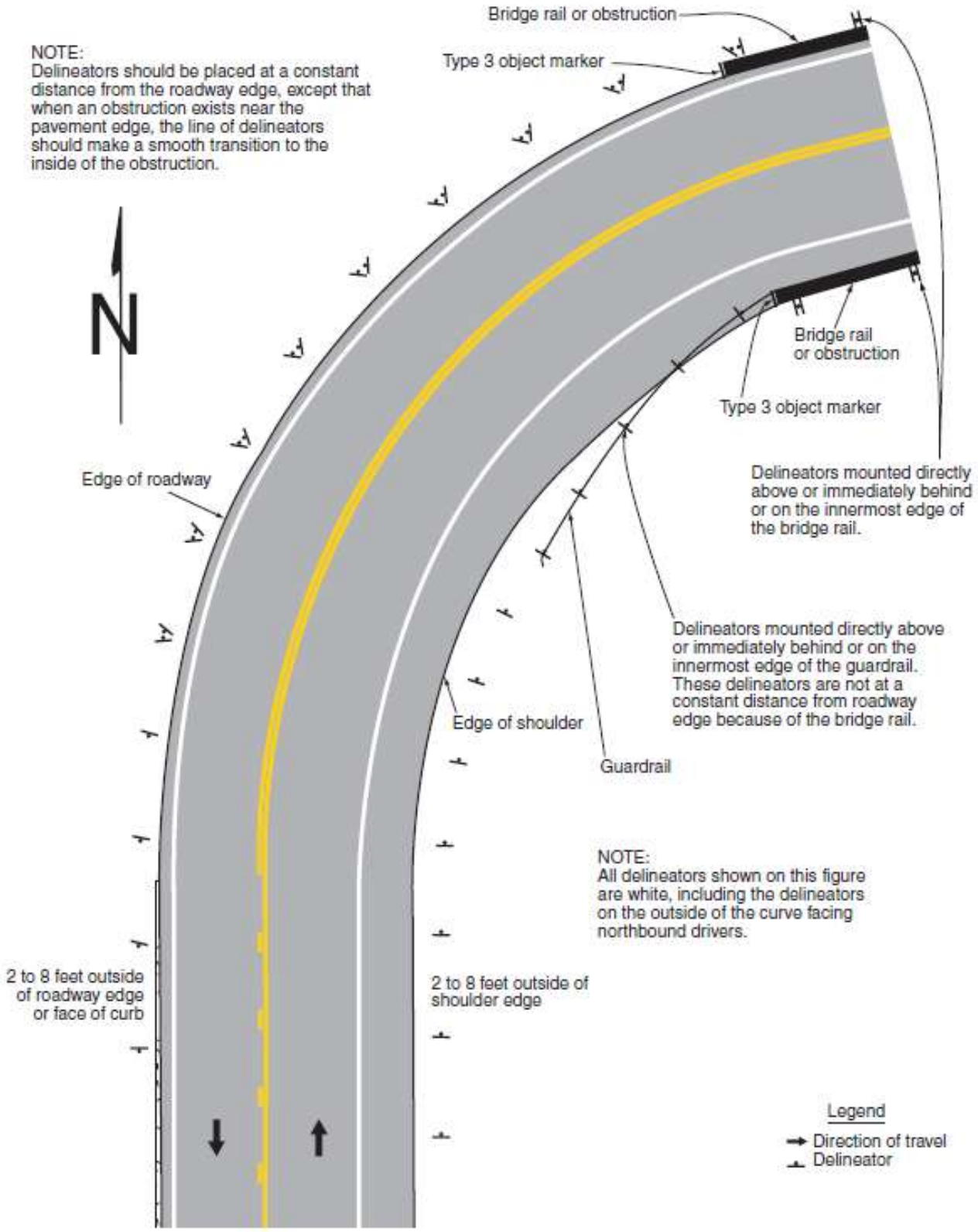
- On sections of roadways with continuous lighting between interchanges.

Delineators may also be used on other classes of roadways and their colors should comply with the edge line color.

TTC Delineator Colors

White	Both sides of a two-way roadway Right-hand side of a one-way roadway
Yellow	Left-hand side of a one-way roadway

Figure 3F-1. Examples of Delineator Placement



Appropriate colors can indicate where either an outside or inside traffic lane merges into an adjacent lane. Delineators should be installed adjacent to the lane reduced for the full transition length and show the reduction.

Red delineators may be used on the reverse side of any delineator where it would warn a road user traveling in the wrong direction on that particular ramp or roadway. These delineators should also be used on both sides of truck escape ramps (spaced at 50-foot intervals) to identify the ramp entrance. Spacing beyond the entrance should be adequate for the escape ramp's length and design.

Delineator Placement and Spacing

The mounting height of delineators should be approximately *4 feet* (measured vertically from the bottom of the device to the elevation of the edge of the pavement). They may be mounted at a lower elevation on the face or top of guardrails or other barriers.

Delineators should be installed at a constant distance from the edge of roadway *2 to 8 feet* outside the outer edge of the shoulder; or in line with roadside barriers (maximum distance of 8 feet outside the outer edge of the shoulder). For locations with obstructions between the pavement edge and the line of the delineators, the delineators should be transitioned to the innermost edge of the obstruction. For guardrail or other longitudinal barriers, the delineators should be transitioned just behind, directly above, or on the barrier's innermost edge.

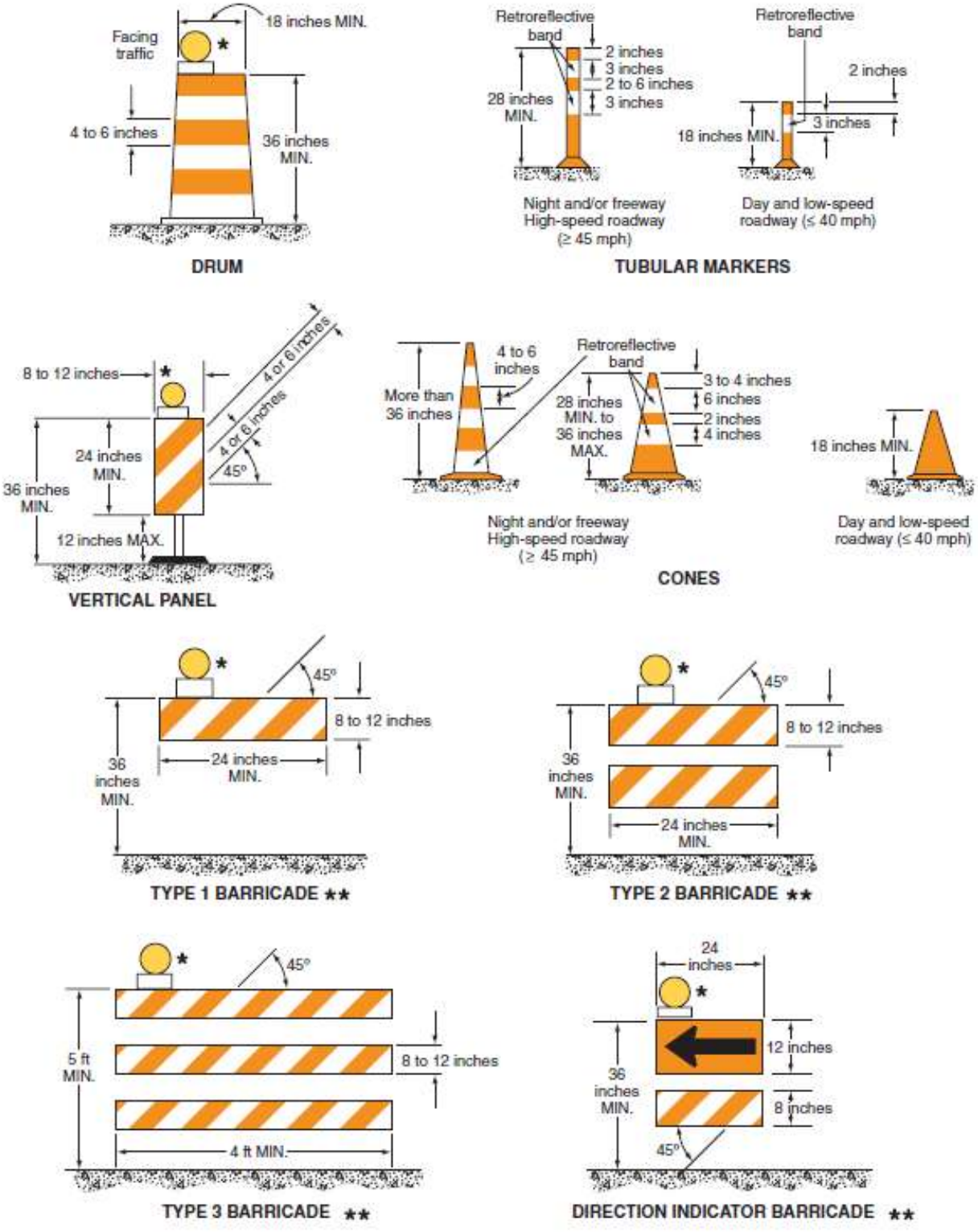
Delineators should be spaced so several delineators are always visible to the road user.

CHANNELIZING DEVICES

Channelization devices (cones, tubular markers, vertical panels, drums, lane separators, raised islands, etc.) are used to emphasize traffic control sites (road closures, islands, reversible lane delineation, and channelizing lines).

Colors for channelizing devices are typically orange or the same color as the pavement marking that they supplement/substitute. Channelizing devices must be retroreflective or internally illuminated for nighttime use. *White* retroreflective material should be used for devices that separate traffic in the same direction. If the channelization separates flows in the opposite direction or are located on the left side edge line of a one-way roadway, the sheeting or bands should be *yellow*. These devices should be kept clean and bright to maximize target value.

Figure 6F-7. Channelizing Devices



* Warning lights (optional)
** Rail stripe widths shall be 6 inches, except that 4-inch wide stripes may be used if rail lengths are less than 36 inches. The sides of barricades facing traffic shall have retroreflective rail faces.

Guidelines for Spacing Channelizing Devices

- The maximum spacing (feet) between devices in a taper should be equal to the speed limit (mph).
- All tapers should have a minimum of 6 channelizing devices.
- The maximum spacing (feet) between devices in a buffer or work area should be twice the speed limit (mph).
- For urban areas shorter spacing between devices in the buffer and work areas may be more appropriate (ex: spacing used in tapers).

TEMPORARY RAISED ISLANDS

A temporary raised island may be combined with pavement markings and other suitable channelizing devices to separate traffic for two-lane, two-way operations or freeways. These islands may also be used where the physical separation of traffic from the work zone is not required.

Temporary Raised Island Guidelines

Roadway	ADT
Two-Lane Two-Way	4000 to 15,000
Freeway	22,000 to 60,000

Temporary raised islands should not be designed that may cause a motorist to lose control if their vehicle inadvertently strikes the island. In the event that the island is struck, island fragments should not be able to penetrate the vehicle or involve other motorists.

Basic Temporary Raised Island Dimensions

Height	4 inches
Width	12 inches
Corners	Rounded or camfered

LIGHTING DEVICES

Lighting devices (warning lights, vehicle rotating or strobe lights, and arrow panels) for short-term work zones are designed to supplement signs and channelizing devices.

Warning lights (Type A, Type B, Type C, and Type D 360-degree) are portable, powered, yellow, lens-directed, enclosed lights with a maximum spacing equal to channelizing device spacing requirements. **Type A, Type C, and Type D** warning lights need to be capable of visibility on a clear night from a distance of *3,000 feet*. **Type B** warning lights should be visible on a sunny day without the sun directly on or behind the device from a distance of *1,000 feet*. The minimum mounting height for warning lights is *30 inches* to the bottom of the lens.

Principal Types of Warning Lights

Low-Intensity Flashing Lights (Type A)

- used at night to warn drivers of a potentially hazardous area
- may be mounted on channelizing devices

High-Intensity Flashing Lights (Type B)

- used during both daylight and nighttime hours to warn motorists of a hazard or to draw attention to advance warning signs
- operates 24 hours per day
- may be mounted on supports or warning signs

Low-Intensity Steady-Burn Lights (Type C & Type D 360 degree warning lights)

- used at night in a series to delineate the edge of the travel way
- may be placed on the outside of a curve to delineate the curve

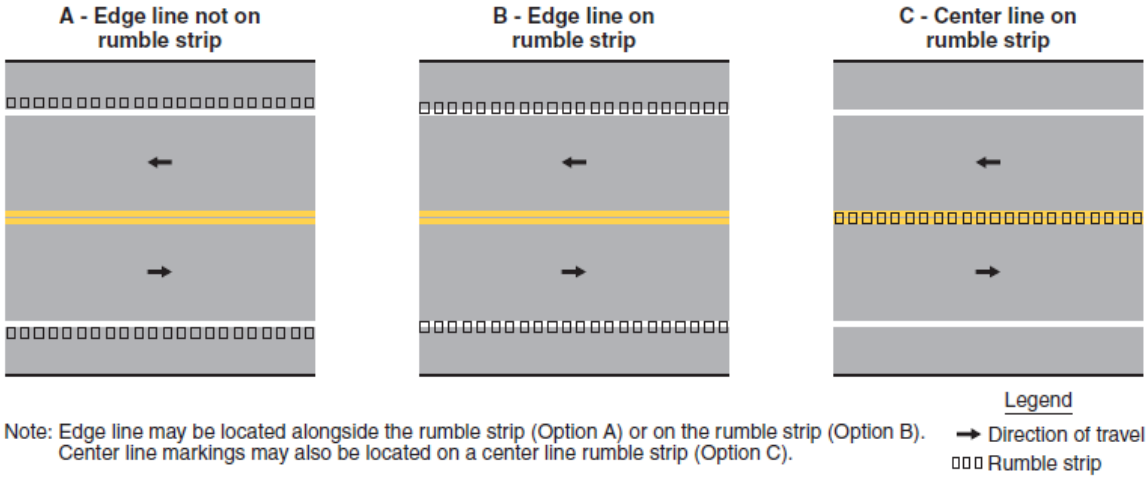
RUMBLE STRIP MARKINGS

Longitudinal rumble strips are either a series of rough-textured, slightly raised, or depressed road surfaces that warn drivers through vibration and sound of the edges of the travel lane.

Possible Longitudinal Rumble Strip Locations

Shoulder	Roadway shoulder near travel lane
Divided Highway	Median side (left) and/or outside shoulder (right)
Two-way Roadways	Along center line

Figure 3J-1. Examples of Longitudinal Rumble Strip Markings



Note: Edge line may be located alongside the rumble strip (Option A) or on the rumble strip (Option B). Center line markings may also be located on a center line rumble strip (Option C).

An edge line or center line may be installed over a longitudinal rumble strip to create a *rumble stripe.* However, edge lines should not be placed in addition to shoulder rumble stripes.

Transverse rumble strips consist of intermittent narrow, transverse areas of roughly textured, slightly raised, or depressed road surface that extend across the travel lanes. Through noise and vibration, these alert drivers to unusual vehicular traffic conditions, such as unexpected changes in road alignment or conditions that require stops or speed reductions.

For locations where a transverse rumble strip color within a travel lane does not match the color of the pavement, the color of the strip should be either *black or white*. White transverse rumble strips should not be installed where they may be confused with other transverse markings (stop lines, crosswalks, etc.).

Transverse rumble strips should not be placed on sharp horizontal/vertical curves, or on roadways used by bicyclists unless a minimum clear path of *4 feet* is provided at each roadway edge or each paved shoulder.

DURATION OF WORK

The work duration of a temporary traffic control zone determines the number and types of devices to be used. Typically, the number of traffic control devices is directly proportional to the operation's length.

Long-Term Stationary – More than 3 days.

Intermediate- Term Stationary - More than 1 daylight period to 3 days, or night work lasting more than 1 hour..

Short-Term Stationary – Daytime work for more than 1 hour within a single daylight period.

Short Duration – Up to 1 hour.

Mobile – Intermittently or continuously.

LOCATION OF WORK

A work zone's location determines the types of traffic control chosen. Usually, the closer the work is to traffic, the more traffic control devices will be required.

Advance warning should convey that work is taking place within the traveled way and should supply information about roadway conditions (exceptions include short-duration and mobile operations). These traffic control devices indicate how traffic can move through the work zone.

MOBILE OPERATIONS

Mobile operations are typically either *intermittent* or *continuously moving* work activities. Safety should never be compromised by using fewer devices than needed due to frequently changing locations. For successful mobile operations, the advance warning area must move with the work area or be moved periodically to warn motorists.

Portable devices should be used whenever possible. Vehicles with appropriate colors, markings, lights, signs, arrow panels, or changeable message signs may be substituted for channelizing devices. Shadow vehicles with truck-mounted attenuators (TMS's) are typically used for these operations.

Intermittent Mobile Operations

These operations (litter cleanup, utility operations, roadway maintenance, etc.) involve frequent short stops but are similar to stationary operations. Slow moving operations (less than 3 mph) may require stationary signage to be periodically retrieved and repositioned in the advance warning area. If flaggers are used, caution must be used to prevent unnecessary exposure to hazards.

Continuously Mobile Operations

These are mobile work operations where workers and equipment move along at slow speeds without stopping (mowing, pavement striping, street sweeping, or herbicide spraying). For locations with low traffic volumes and good visibility, a well-marked well-signed vehicle may be sufficient. For high traffic volumes and/or speeds, a shadow vehicle must be used to ensure the advance area moves with the work area.

Figure 6H-4. Short-Duration or Mobile Operation on a Shoulder (TA-4)

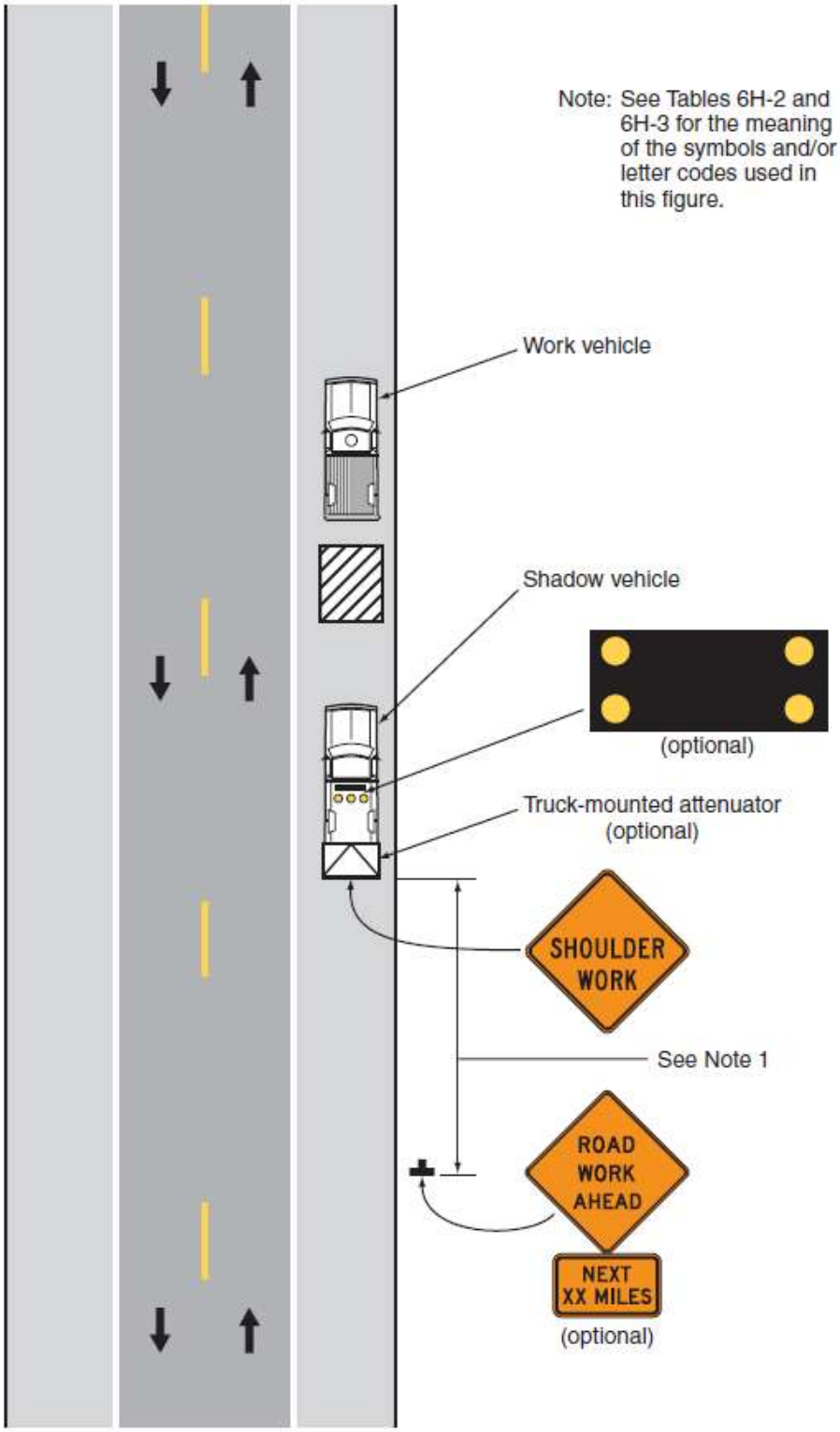


Figure 6H-17. Mobile Operations on a Two-Lane Road (TA-17)

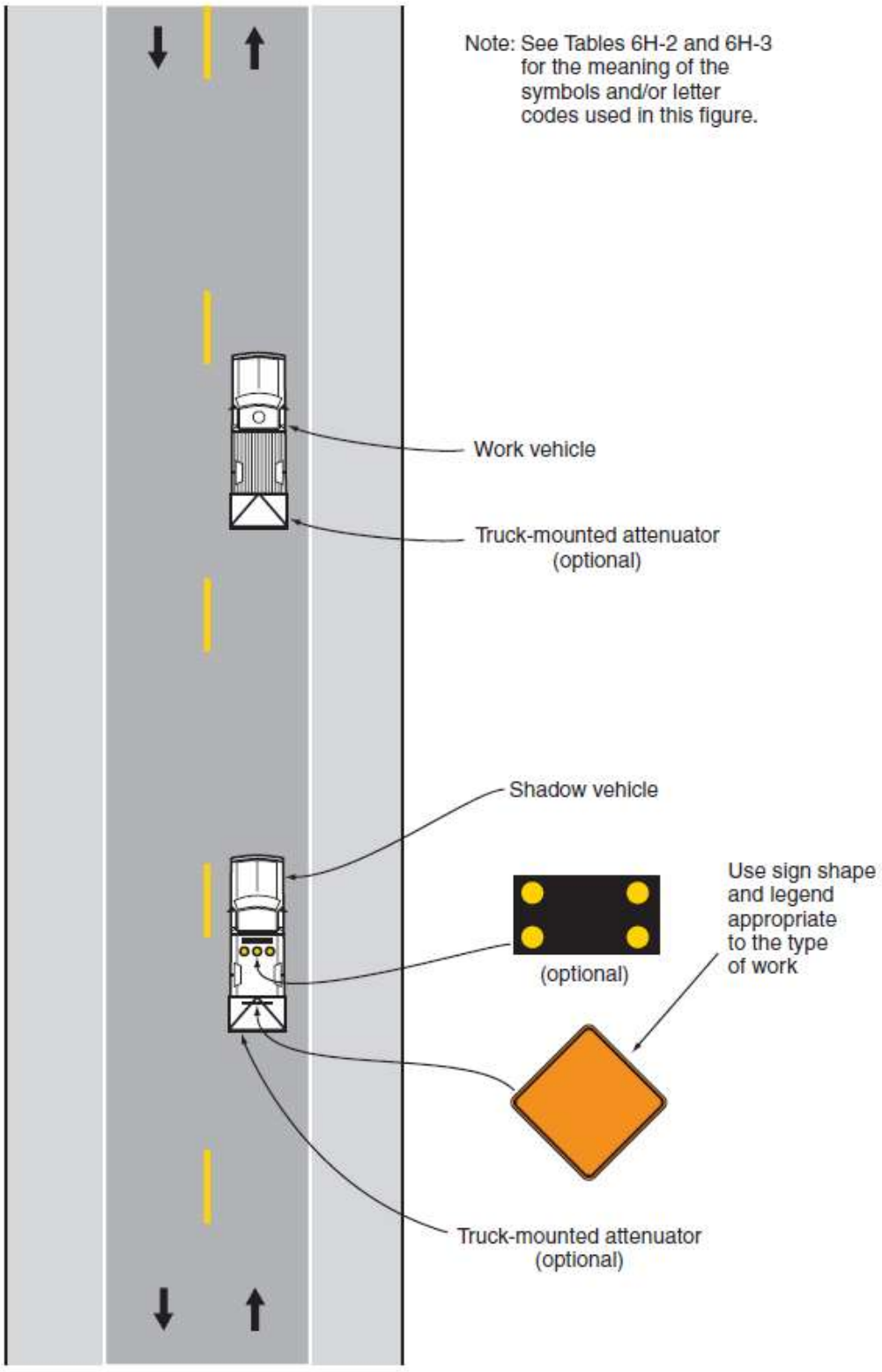
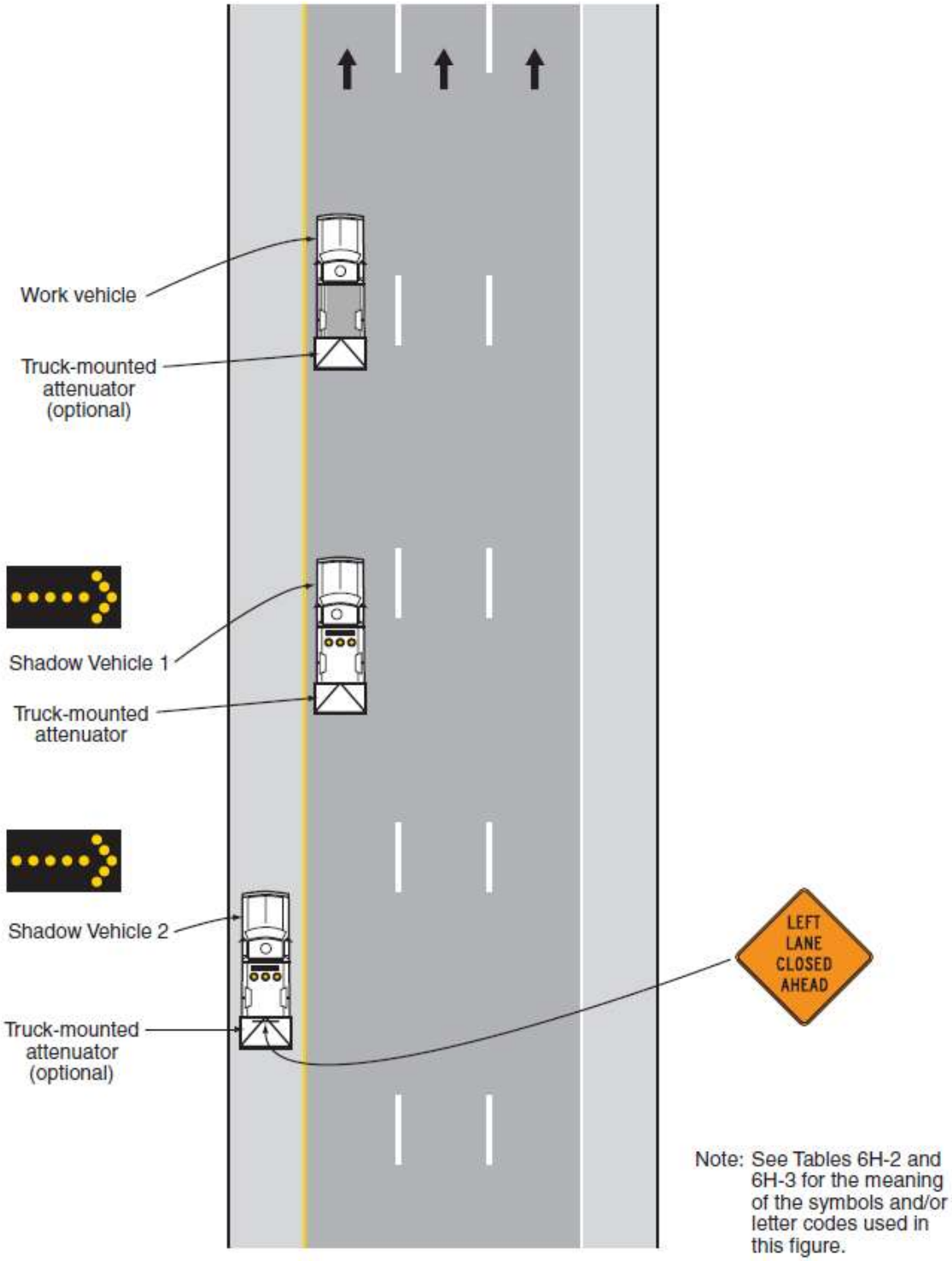


Figure 6H-35. Mobile Operation on a Multi-Lane Road (TA-35)



Note: See Tables 6H-2 and 6H-3 for the meaning of the symbols and/or letter codes used in this figure.

MAINTENANCE ISSUES

Traffic control devices require periodic inspection to ensure that they are serviceable for their intended purpose. Pavement markings that are no longer applicable need to be scarified or obliterated to be unidentifiable. These markings need to be retroreflective unless there is sufficient ambient light. Any interstate or highway device should also be retroreflective.

Pavement markings (thermoplastic, epoxy, or tape) should be replaced as required or recommended by the manufacturer. Painted markings have shorter life spans and should be repainted annually or when necessary.

An up-to-date inventory is essential for proper maintenance by providing a record of existing devices, and estimating replacement quantities.

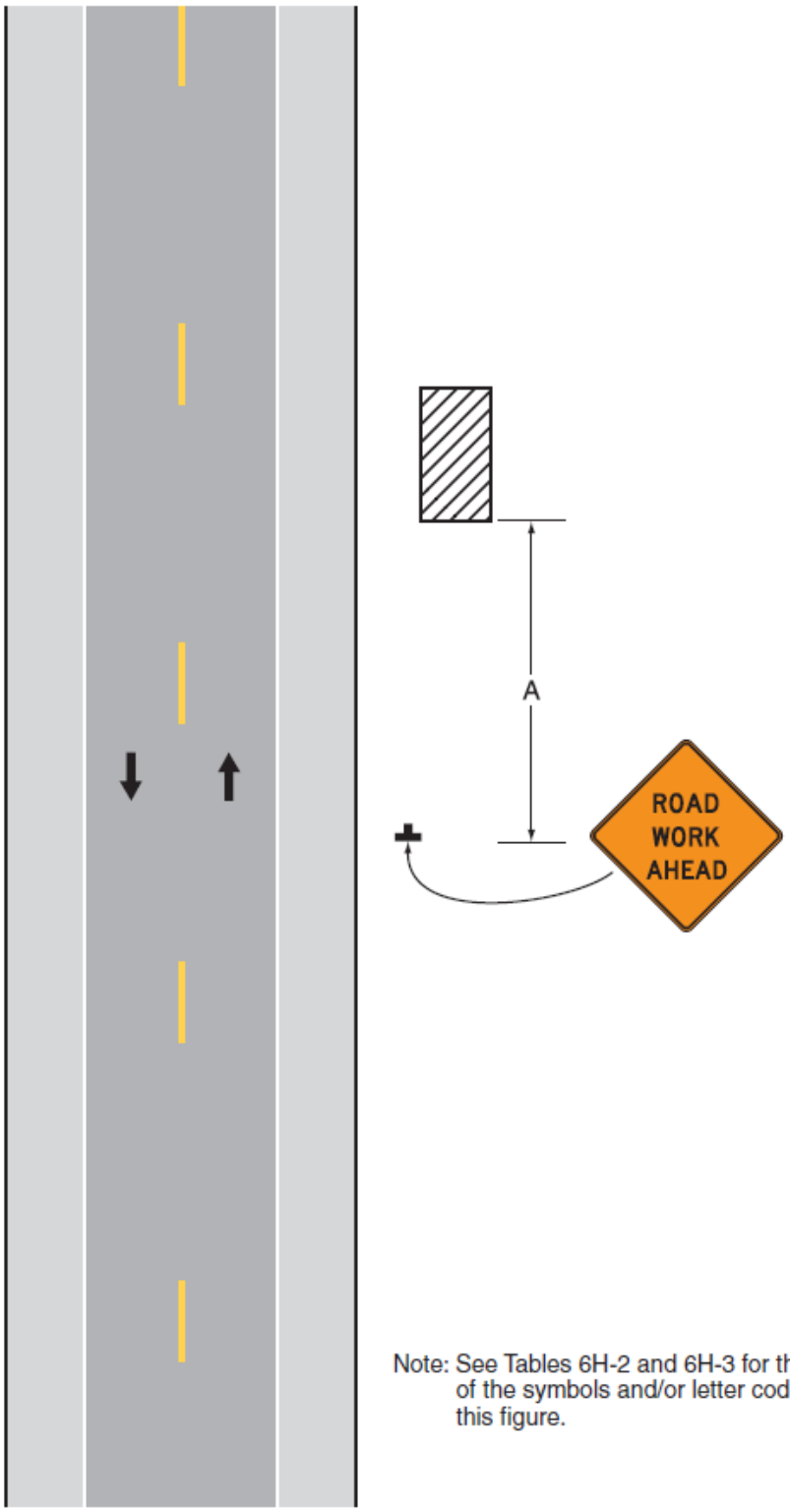
Inspections should be conducted during daylight and night hours (as well as under wet road conditions) to evaluate marking visibility and retroreflectivity. Any water can severely affect retroreflectivity with tarred joints and sealed cracks appearing more dominant than the striping. Bright sunlight at low angles (sunrise and sunset) can also produce this effect.

TYPICAL APPLICATIONS OF TEMPORARY TRAFFIC CONTROL

The following diagrams are typical examples of effective work zone traffic control. These layouts do not cover every situation requiring work area protection and may be tailored to fit the conditions of a particular location.

Figure 6H-1	Work Beyond the Shoulder	TA-1
Figure 6H-4	Short-Duration or Mobile Operation on a Shoulder	TA-4
Figure 6H-6	Shoulder Work with Minor Encroachment	TA-6
Figure 6H-10	Lane Closure on a Two-Lane Road Using Flaggers	TA-10
Figure 6H-11	Lane Closure on a Two-Lane Road - Low Traffic	TA-11
Figure 6H-13	Temporary Road Closure	TA-13
Figure 6H-15	Work in the Center of a Road with Low Traffic Volumes	TA-15
Figure 6H-26	Closure in the Center of an Intersection	TA-26
Figure 6H-33	Stationary Lane Closure on a Divided Highway	TA-33

Figure 6H-1. Work Beyond the Shoulder (TA-1)



Note: See Tables 6H-2 and 6H-3 for the meaning of the symbols and/or letter codes used in this figure.

Figure 6H-4. Short-Duration or Mobile Operation on a Shoulder (TA-4)

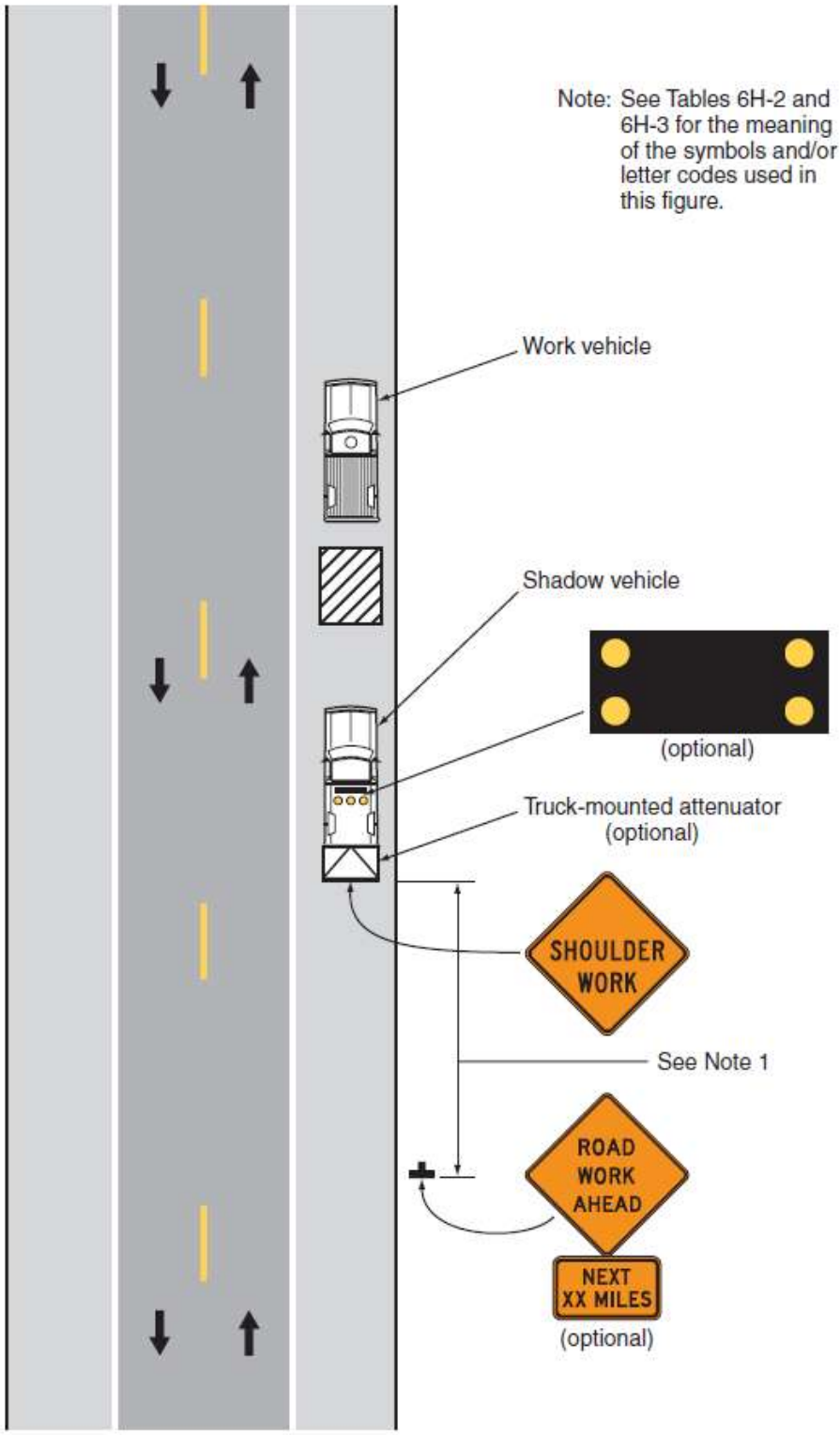
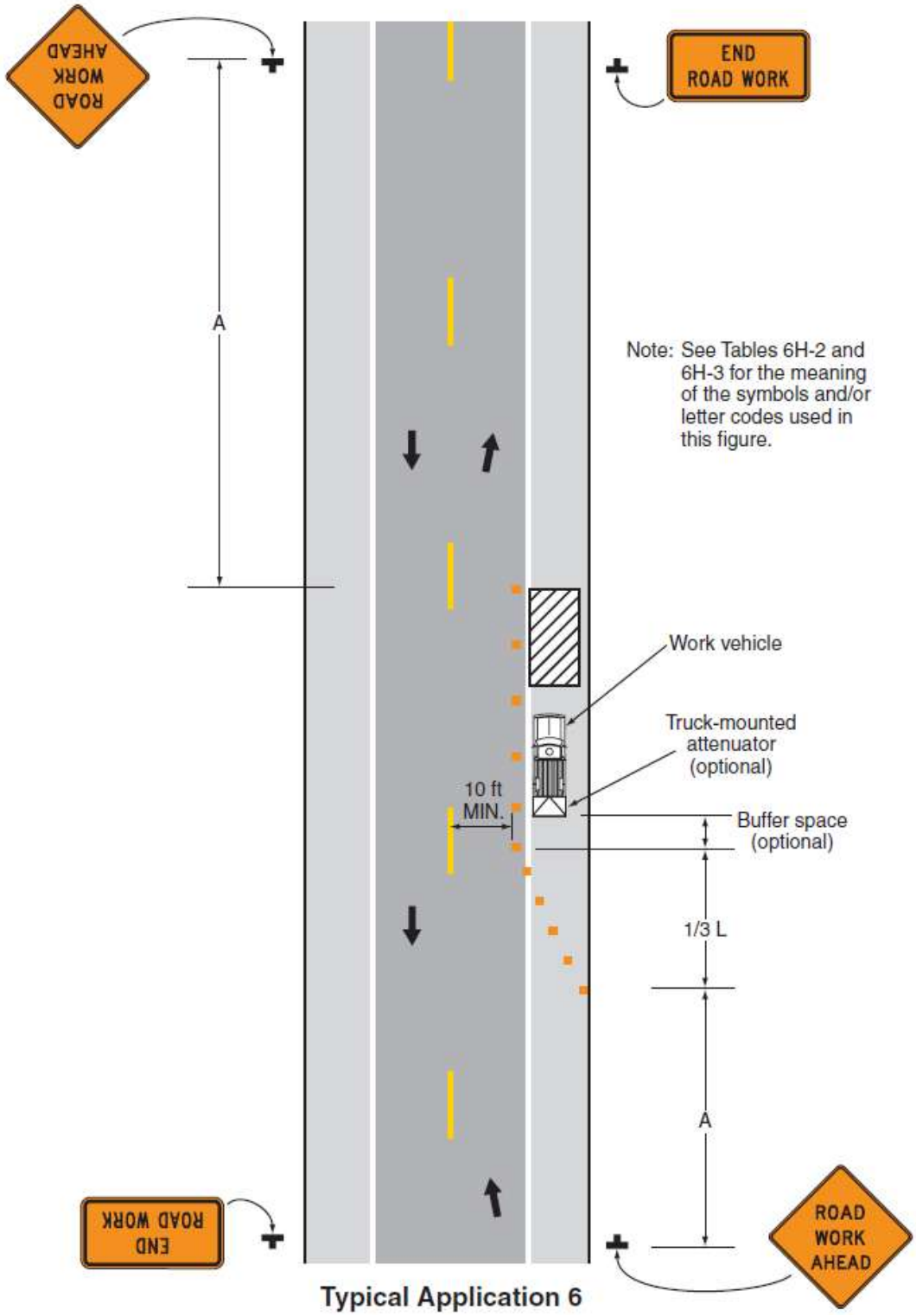


Figure 6H-6. Shoulder Work with Minor Encroachment (TA-6)



Typical Application 6

Figure 6H-10. Lane Closure on a Two-Lane Road Using Flaggers (TA-10)

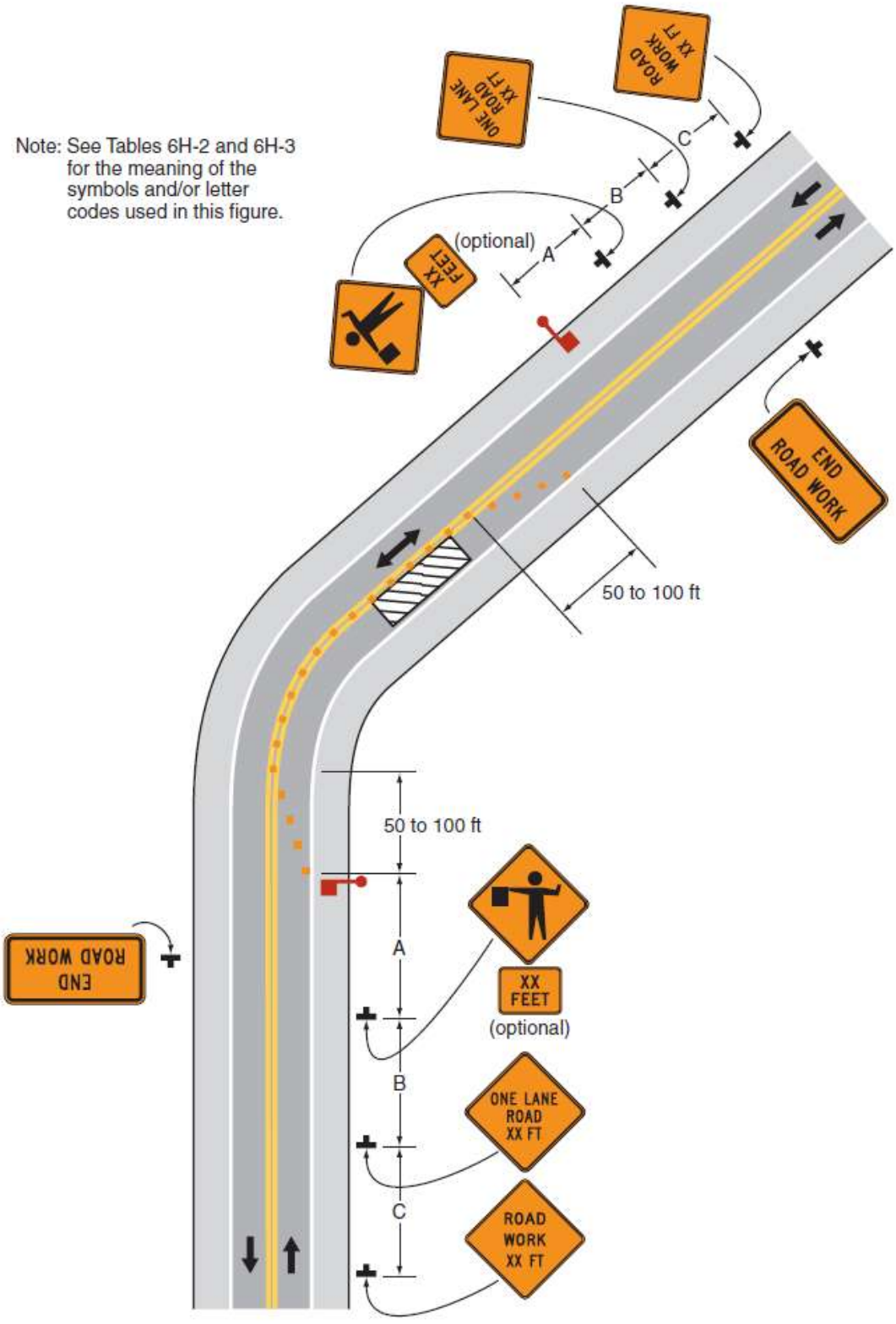


Figure 6H-11. Lane Closure on a Two-Lane Road with Low Traffic Volumes (TA-11)

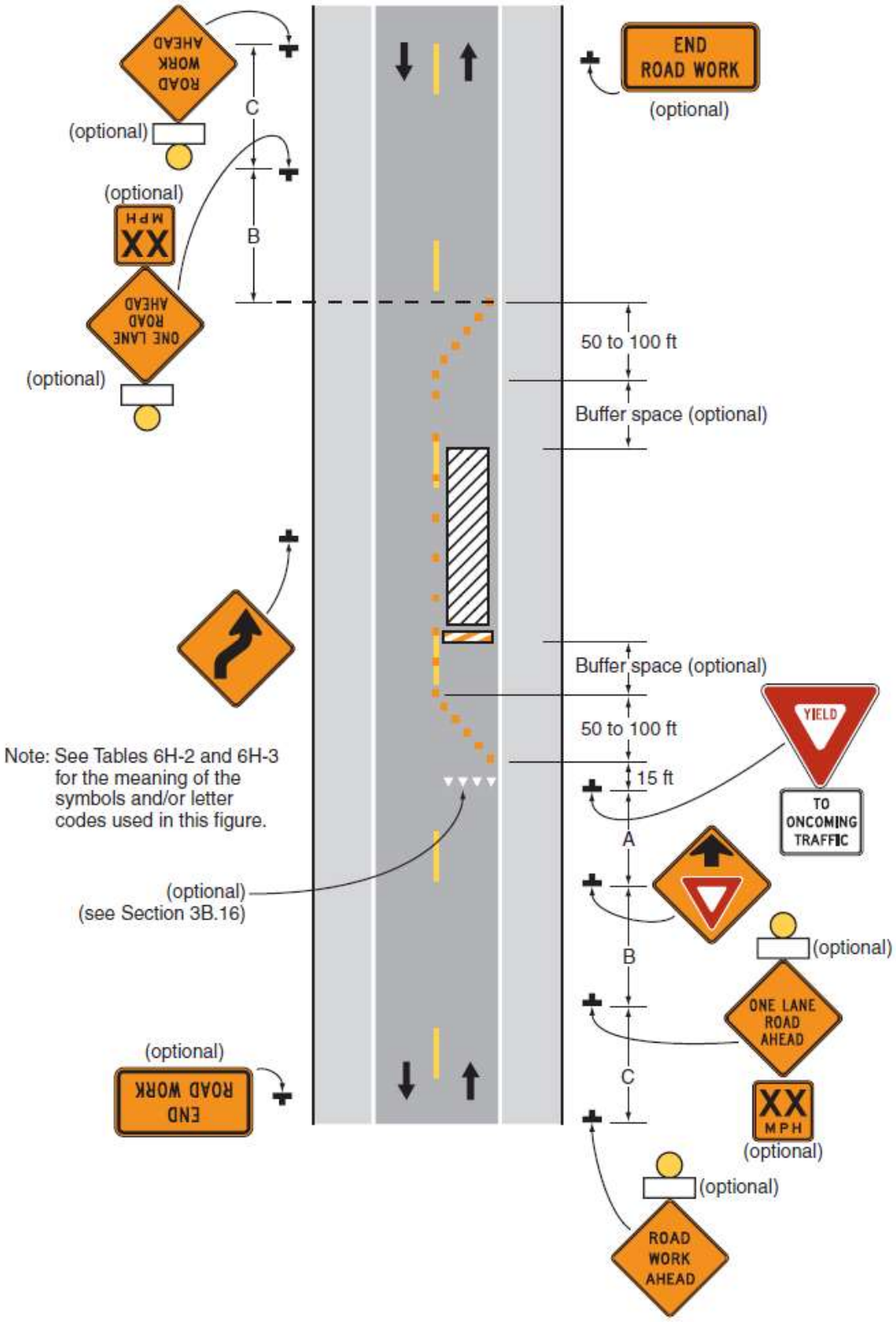
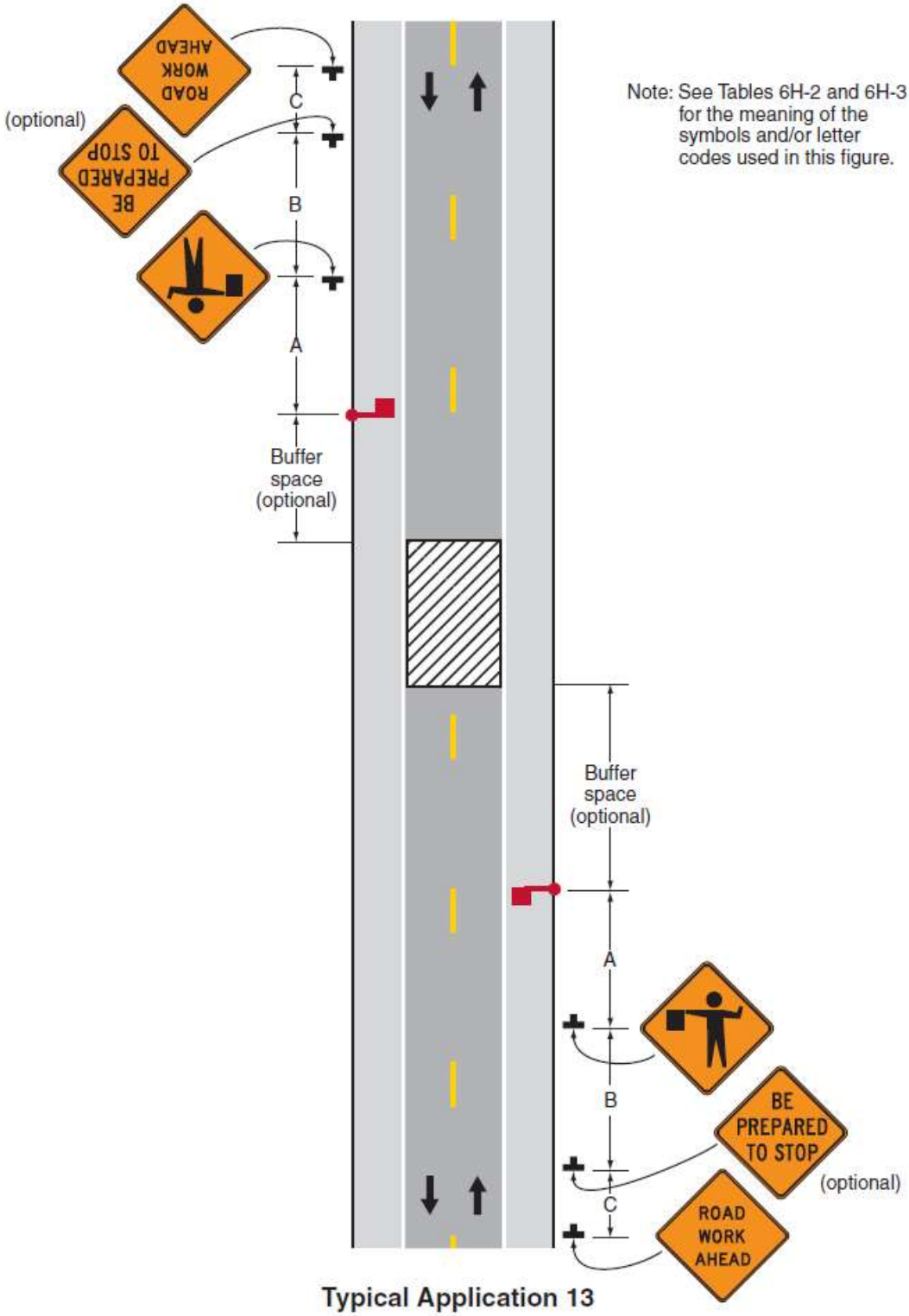


Figure 6H-13. Temporary Road Closure (TA-13)



Typical Application 13

Figure 6H-15. Work in the Center of a Road with Low Traffic Volumes (TA-15)

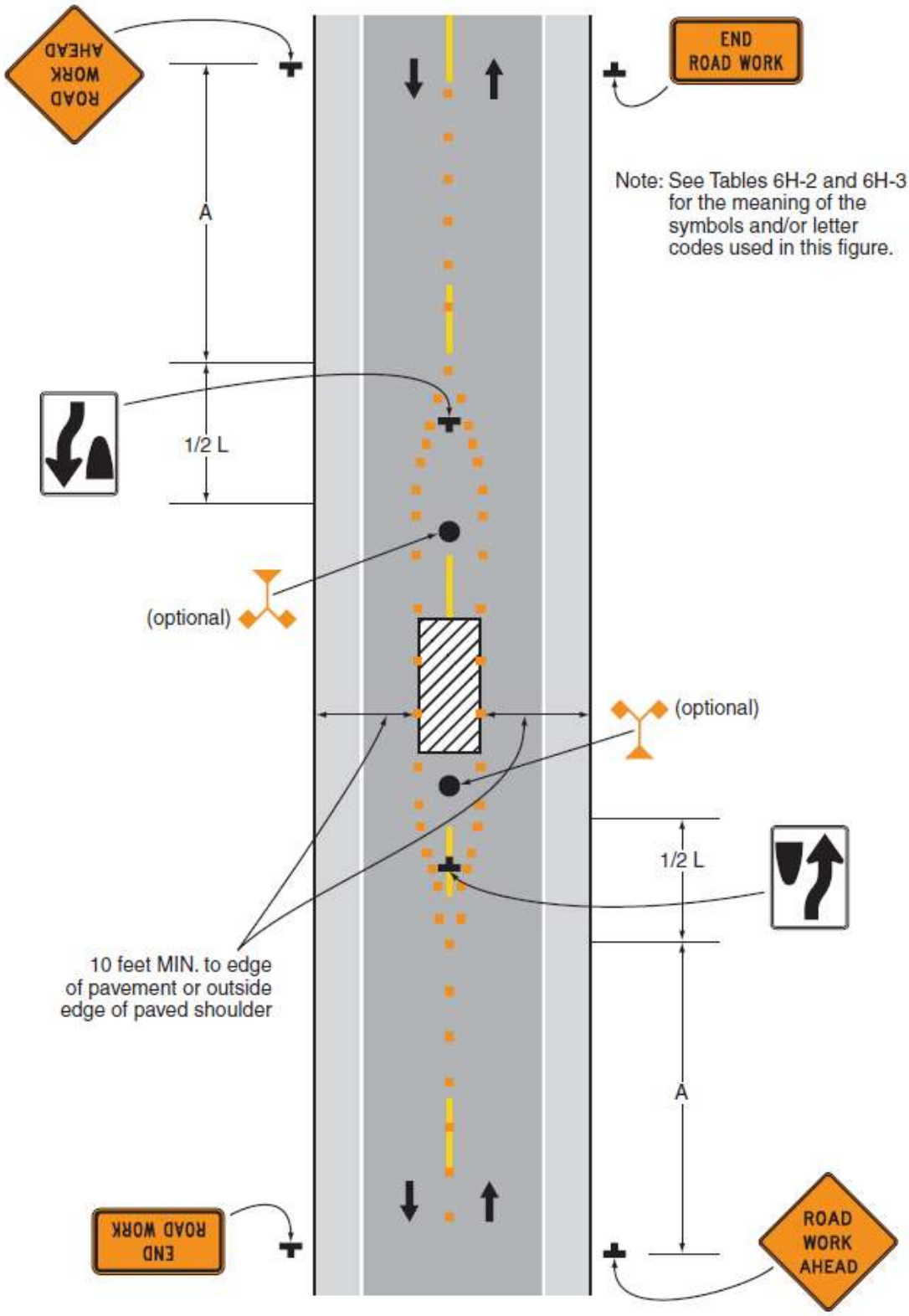
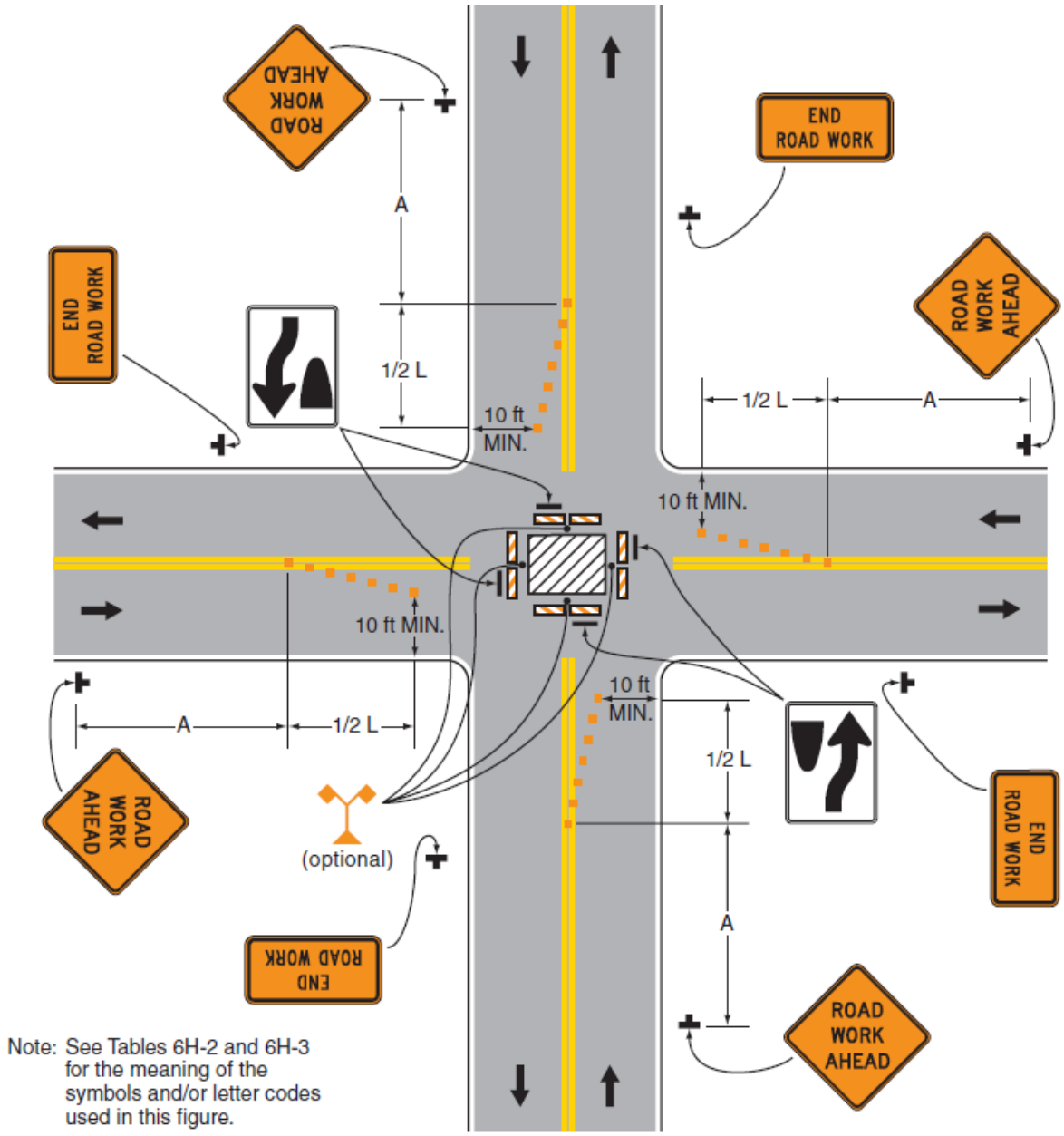
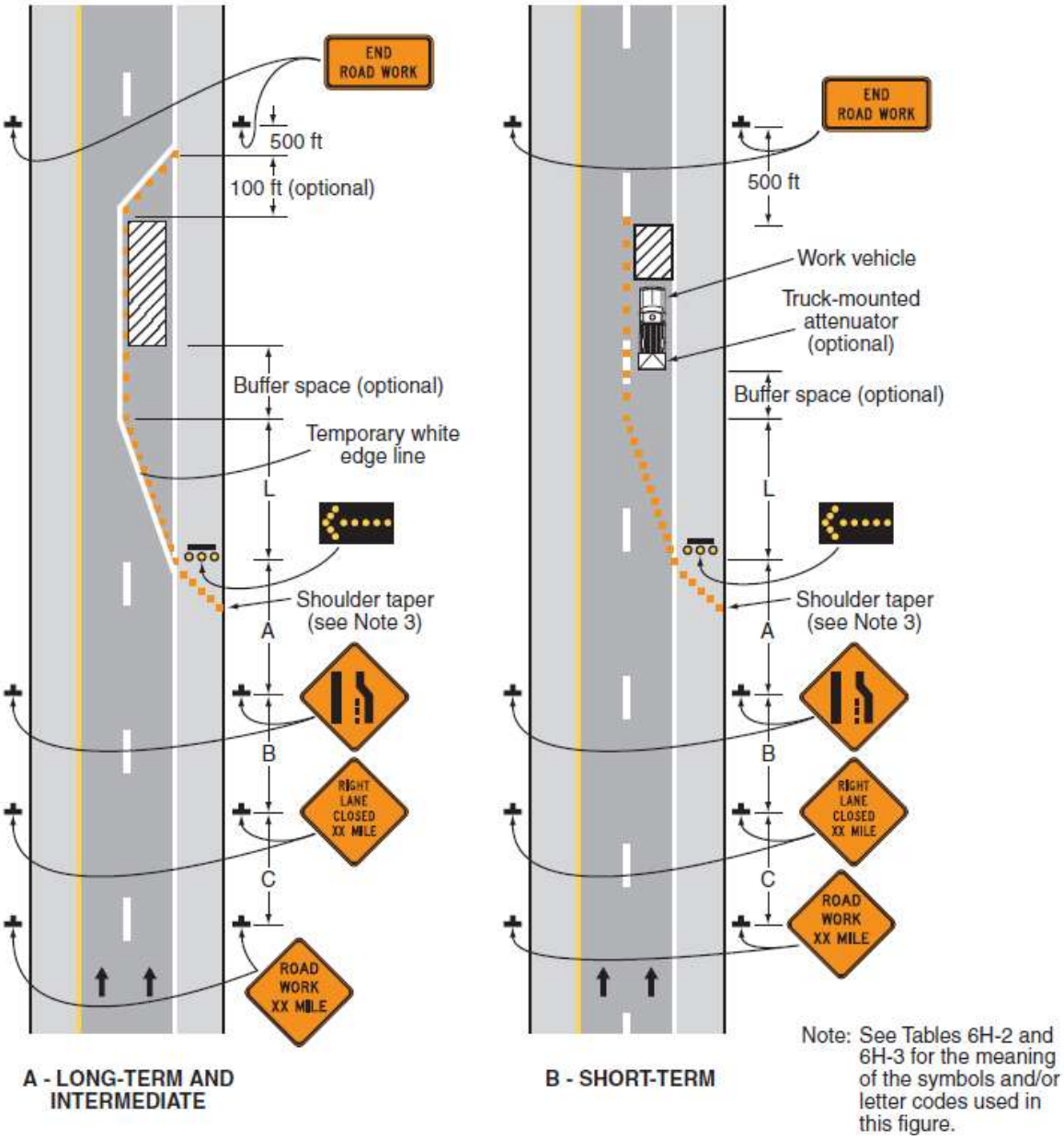


Figure 6H-26. Closure in the Center of an Intersection (TA-26)



Note: See Tables 6H-2 and 6H-3 for the meaning of the symbols and/or letter codes used in this figure.

Figure 6H-33. Stationary Lane Closure on a Divided Highway (TA-33)



SUMMARY

This course discussed how to effectively plan and design temporary traffic controls for work zone locations. The course objective was to give participants an in-depth look at the principles to be considered when selecting and designing for temporary traffic control in work zones.

Traffic signs and pavement markings convey laws and regulations, traffic and roadway conditions, and guidance and other information. These tools provide important information for safe travel on any U.S. roadway system.

Road users process different types of visual and non-visual information differently - speed, roadway conditions, traffic, legal enforcement, noise levels, etc. Traffic signs and pavement markings serve as reminders of important information and keep road users from having to memorize everything.

The goal of signs and markings is to provide drivers with relevant information when they need it - resulting in safer, more efficient roadways with reduced liability risks. However, poor sign management can greatly reduce safety, contribute to roadway incidents, and increase liability exposure.

By completing this course, you should now be familiar with the general design guidelines *(Manual on Uniform Traffic Control Devices – MUTCD, AASHTO "Green Book", Standard Highway Signs and Markings, etc.)* for work zone traffic control. For further information about temporary traffic control in work zones, please refer to **MUTCD Part 6 – Temporary Traffic Control.**

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(Note: All figures, tables, exhibits, etc. contained in this course are from the MUTCD, except where noted otherwise.)

