Guidance

Use of Work Zone Clear Zones, Buffer Spaces, and Positive Protection Deflection Distances

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Work Zone Safety Consortium

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Objectives

This document summarizes available guidance on the use of work zone clear zones, buffer spaces, and positive protection deflection distances.

The purpose of this document is to help work zone designers and workers understand:

- the role of separation distances and positive protection device deflection distances in safety for workers and motorists and
- how properly to install, maintain, and use these methods in various types of work zones.

This document is organized into the following sections:

- Introduction
- Types of Separation Distances
  - Clear Zones
  - Buffer Spaces
- How Large Should Clear Zones and Buffer Spaces Be?
  - Clear Zones and Lateral Buffer Spaces Without Positive Protection
  - Lateral Buffer Spaces When Barrier Are Used
  - Longitudinal Buffer Spaces
  - Buffer Spaces for Short-Duration Maintenance Work Zones

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Work Zone Clear Zones, Buffer Spaces, and Positive Protection Deflection Distances: Why Are These Important?

Introduction

Most work zones are divided into *traffic spaces* where motorists are allowed to travel and *work spaces* where workers are performing their work activities. Figure 1 on page 2 illustrates this division. Keeping work spaces and traffic spaces separate in work zones allows both workers and the motoring public to be as safe as possible.

Unfortunately, motorist-worker accidents can and do occur in both the traffic space (if a worker steps into the travel lane) and the work space (if a motorist leaves the travel lane and intrudes into the work space). Such an accident will typically result in severe injuries or even death to the worker. In addition, many hazards exist within a work space (e.g., drop-offs, equipment, materials, etc.) that will likely cause significant injuries to motorists who accidentally enter the work space and impact those hazards.

Work spaces and traffic spaces are separated in two ways:

- by using traffic barriers and other positive protection devices that restrict:
  a) vehicles from entering the work space and
  b) workers from accidentally walking or moving their equipment into the traffic space.
- by increasing the distance between the two spaces so that motorists or workers who stray out of their respective spaces can recover and return to the proper space.

The choice of which method to use (or whether to use both methods together) depends on many factors, such as:

- the width of the roadway,
- the expected traffic demand through the work zone,
- the expected duration of the work zone,
- the temporary traffic control method used, and
- the speed that traffic is moving at the site.

Although both methods reduce risks of injury and death, they cannot completely eliminate risk. Therefore, work zone designers and workers must understand the risks associated with each method. For example, traffic barriers or other positive protection devices may move significantly when struck by an errant vehicle — depending on how the devices are designed and installed, the speed and angle of impact, and the mass of the impacting vehicle.

A worker standing too close to such a device when it is struck may be hit by the device or pinned against an object within the work space. Likewise, if positive protection devices are not used and only a separation distance is provided, an errant vehicle may not be able to recover within that separation distance and may enter the work space, striking a worker or other hazard (equipment, drop-off, materials, etc.).

Some work zones include concrete barriers to separate the traffic space and the work space *(Source: TTI).*

Some work zones include a large distance separating the traffic space and work space *(Source: TTI).*

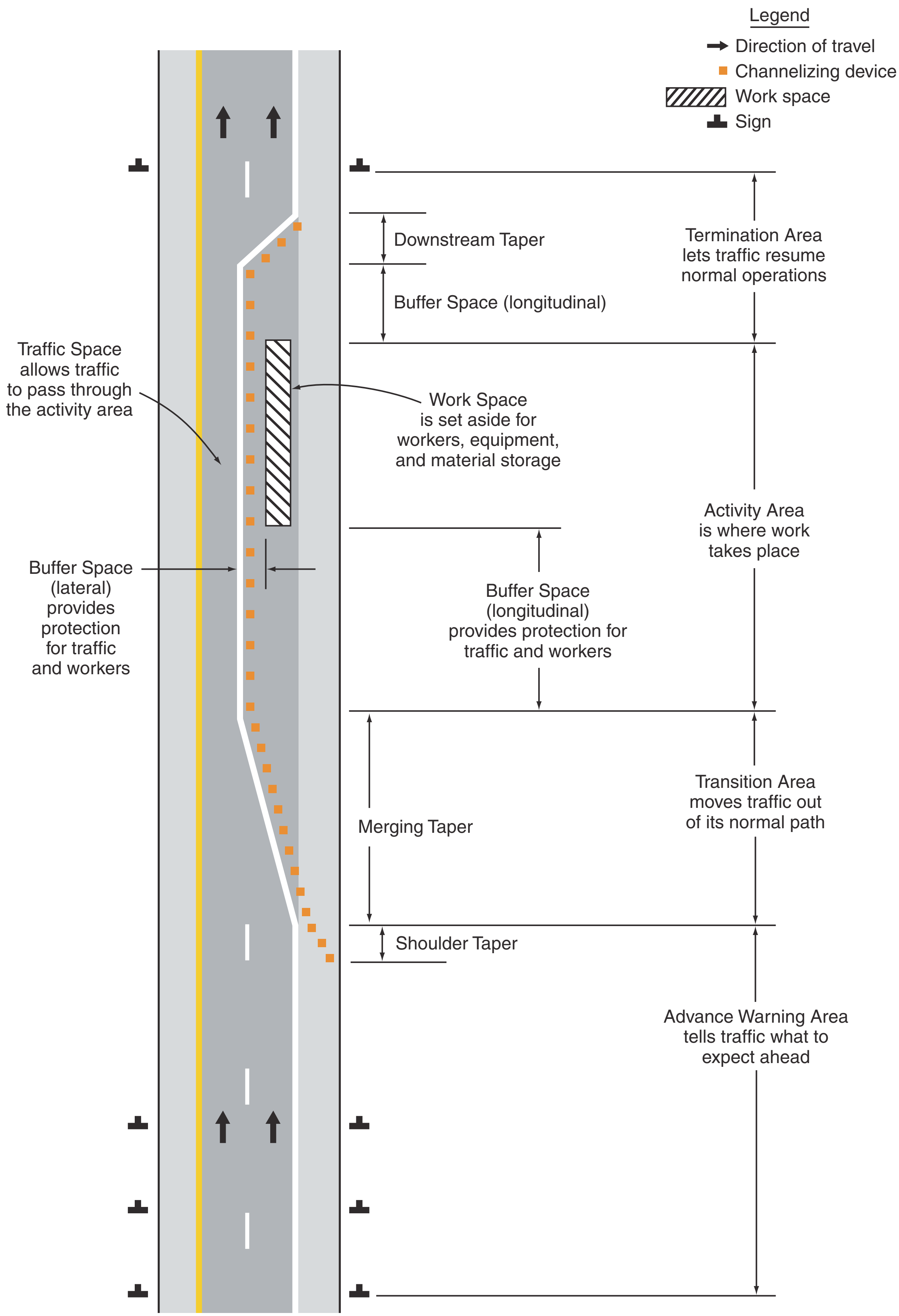


Figure 1. Traffic Space, Work Space, and Buffer Spaces.[1]

The purpose of this guidance document is to help work zone designers and workers understand the role of separation distances and positive protection device deflection distances in the safety of workers and motorists and how to properly install, maintain, and use these methods in various types of work zones.

Types of Separation Distances

Separations between work spaces and traffic spaces in work zones are accomplished through the application of ***clear zones*** and ***buffer spaces***.

Clear Zones

According to the *Roadside Design Guide* [2] of the American Association of State Highway and Transportation Officials (AASHTO), a work zone clear zone is defined as:

"…the unobstructed relatively flat area impacted by construction that extends outward from the edge of the traveled way."

The intent is that the clear zone should be available as an area where drivers of vehicles that have accidently left the traveled way can stop safely or regain control of their vehicles. If any semi-permanent hazards (e.g., pavement drop-offs, excavations, steep slopes, pillars, etc.) remain within the clear zone when work has stopped, these hazards should be shielded with barriers or otherwise protected to reduce the severity of any impacts of errant vehicles with these hazards.

Most agencies require that work zone equipment and materials be stored outside of the clear zone when not in use and that workers' personal vehicles be parked outside of the clear zone as well. In those cases where work equipment, materials, and/or workers are permitted inside the clear zone, a barrier should be used to provide protection. In reality, this is sometimes not feasible during work activity, especially in short-term or short-duration work zones. Nonetheless, the goal of maximizing the distance available for errant vehicle recovery still applies even when work is underway. Therefore, another method that is often used in tandem with the work zone clear zone is the buffer space.

Buffer Spaces

As defined in the national *Manual of Uniform Traffic Control Devices*,[1] a buffer space is:

"…a lateral and/or longitudinal area that separates road user flow (the traffic space) from the work space or other unsafe area, and might provide some recovery space for an errant vehicle."

Figure 1 on page 2 illustrates longitudinal and lateral buffer spaces. Longitudinal buffer spaces are positioned upstream of the work space (and in some cases beyond the work space), whereas lateral buffer spaces are provided between the traffic and the work space. As with clear zones, buffer zones must not be used to store equipment or materials when the work space is inactive. A work zone may contain one or more buffer spaces, as needed. For example, work spaces where traffic is split and passes on both sides may have lateral buffer spaces on each side.

Summary

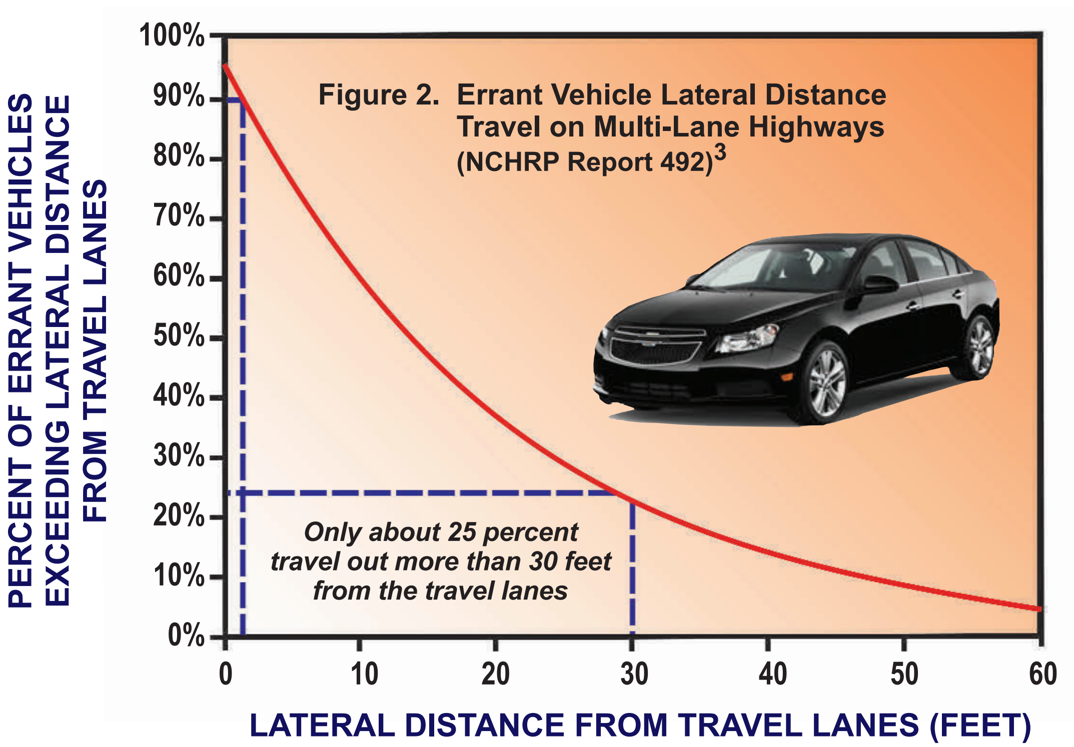
In summary, both clear zones and buffer spaces are provided to increase the likelihood that an errant vehicle can safely stop or recover back onto the travel lane without hitting a hazard (object, equipment, etc.) or a worker. Clear zone criteria normally apply to hazards other than equipment and materials currently in use during a particular work shift and are normally measured laterally from the edge of the travel lanes. By contrast, buffer space criteria refer to how the traffic control plan is implemented during the work activity to provide as much recovery space for errant vehicles as possible. Buffer spaces are defined both longitudinally and laterally.

How Large Should Clear Zones and Buffer Spaces Be?

Clear Zones and Lateral Buffer Spaces Without Positive Protections

The answer to the question above depends on several factors. While it would be preferable to quantify clear zone and buffer space distances at which a given work zone or work space would be considered "safe," the reality is that no clear zone or buffer space can always provide complete safety. However, the greater the distance provided between the travel lanes (i.e., the traffic space) and a hazard, the more safety can be improved.

Figure 2 shows the probability of a vehicle accidentally leaving the traveled way of a multi-lane highway reaching a given distance laterally from the travel lanes before being able to stop or regain control.[3] The greater the lateral distance from the traveled lane, the lower the likelihood that an errant vehicle will travel that distance before stopping or regaining control. For example, more than 90 percent of errant vehicles leaving the travel lanes of an Interstate travel out two feet from the lane before regaining control or stopping. Only about 25 percent travel out more than 30 feet from the travel lanes.



Unfortunately, larger clear zone or buffer space distances reduce the space available for traffic and/or workers to use. Smaller work spaces can increase the amount of time required to complete the work and the overall project cost. Smaller traffic spaces can reduce roadway capacity and increase the potential for traffic queues and rear-end crashes. Therefore, agencies try to balance traffic space and work space needs against the need for clear zone and buffer space to reduce the risk of an errant vehicle crash.

Table 1 on page 5 summarizes examples of work zone clear zone distances established by a number of state agencies. Some states have adopted fairly simple criteria; others consider many different variables and are more complicated. The AASHTO *Roadside Design Guide* [2] provides some general work zone clear zone criteria that many state agencies have adopted. In most cases, these criteria acknowledge that applying clear zone distances used for permanent roadway conditions are often impractical to apply in work zones. Therefore, many agencies allow engineering judgment in applying the criteria. Regardless of the criteria used, it is important for agencies to monitor constantly and ensure compliance is maintained so as to prevent crashes whenever possible and to minimize potential liability if a crash does occur.

Table 1. Examples of Work Zone Clear Distances Used by Some State DOTs

	Work Zone Speed (mph)	Distance to Travel Lanes (ft)	Distance to Auxiliary Lanes (ft)
Florida DOT	60-70	30	18
	55	24	14
	45 - 50	18	10
	30 - 40	14	10
	Curb/gutter sections	4 ft beyond curb	4 ft beyond curb

	Work Zone Speed (mph)	Average Daily Traffic (ADT)	Front Slopes (ft)	Back Slopes (ft)
Illinois DOT	< 35	< 750	4 - 6	4 - 6
		750 - 1500	6 - 10	6 - 8
		1500 - 6000	6 - 10	8 - 10
		> 6000	10 - 12	10
	35 - 50	< 750	6 - 10	4 - 8
		750 - 1500	10 - 14	8 - 10
		1500 - 6000	10 - 16	8 - 12
		> 6000	12 - 18	10 - 14
	55	< 750	6 -12	6 - 8
		750 - 1500	10 - 16	6 - 12
		1500 - 6000	12 - 18	10 - 14
		> 6000	14 - 20	10 - 16
	60	< 750	10 - 16	6 - 10
		750 - 1500	12 - 20	8 - 14
		1500 - 6000	16 - 24	10 - 16
		> 6000	18 - 28	12 - 18
	65	< 750	12 - 16	6 - 10
		750 - 1500	16 - 22	8 - 14
		1500 - 6000	18 - 26	10 - 18
		> 6000	18 - 28	14 - 18

	Work Zone Speed (mph)	Distance from Traveled Way (ft)
Washington State DOT	≤ 35	10
	40	15
	45 - 55	20
	≥ 60	30

	Roadway Type	Work Zone Speed Limit (mph)	Distance from Traveled Way (ft)
Vermont DOT	State/US Routes	All	10
	Interstates *	30 - 40	13
		45 - 50	16
		55	23
		60 - 70	30

*Vermont follows criteria in Table 9-1 of the *Roadside Design Guide* [2]

Lateral Buffer Spaces When Barriers Are Used

Barriers are typically used to shield hazards that must remain located within the work zone clear zone. However, barriers may deflect some distance if hit by an errant vehicle. The lateral buffer space provided between the traffic space and work space when a barrier is present should take into account the amount of barrier deflection that may occur, and the barrier should be positioned so that the work space is located beyond that deflection distance. Otherwise, a worker may be pinned between the barrier and the hazard protected by the barrier or between the barrier and equipment or material (i.e., bridge pier, beam, etc.) when the barrier is hit.

The amount of barrier deflection depends on several factors:

- type of barrier,
- barrier length,
- how barrier components are connected,
- if and how barrier is anchor,
- speed of impacting vehicle,
- angle of impact, and
- mass of impacting vehicle.

Workers should be aware that barriers can deflect when hit by an errant vehicle *(Source: TTI).*

As shown in Figure 3, the length of barrier used must be sufficient to protect motorists from hitting the side as well as the upstream end of the hazard. Also, the length of barrier must be sufficient to give it enough mass and strength to redirect the errant vehicle. Engineering analyses should always be performed to determine this length of need.[2] If any changes are made to the barrier or its deployment in the field, such as changing the method of connecting the barriers or the anchoring method used, the length of need must first be re-analyzed to verify its adequacy.

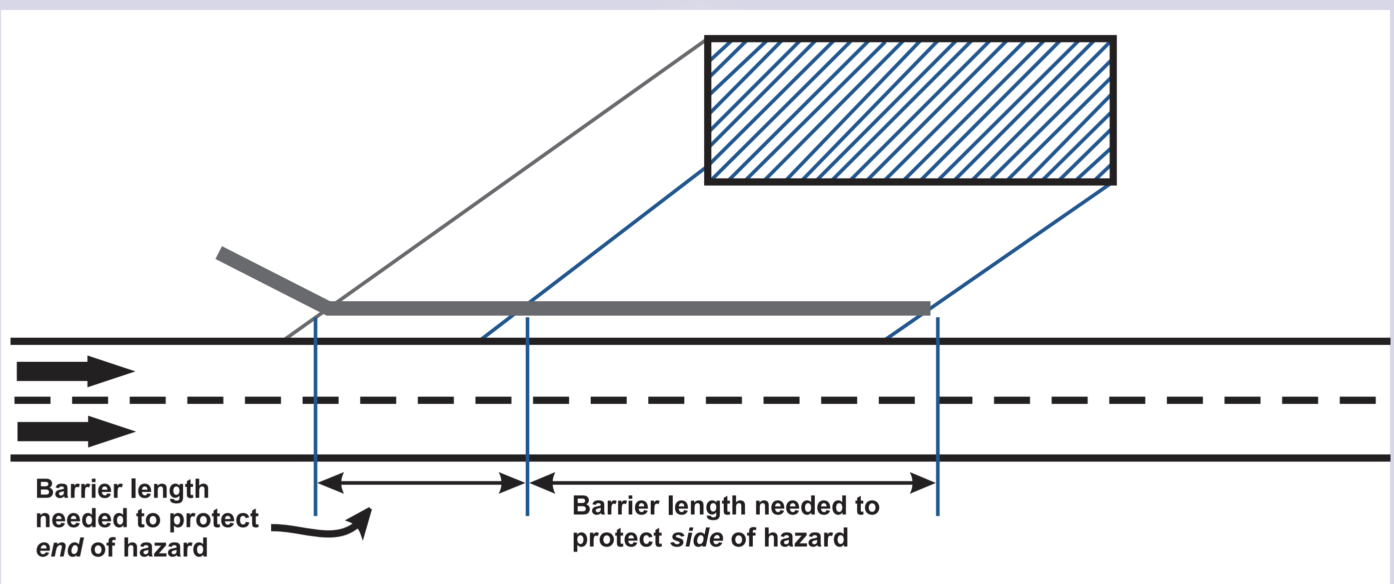


Figure 3. Barrier Lengths to Protect Side and End of Work Zone Hazard.

As suggested in Figure 4 below, long sections of properly-connected portable concrete barrier (PCB) anchored to the pavement may deflect only a few inches when hit. Highly mobile barrier systems (shown at right) towed into place when needed likewise deflect very little. On the other hand, shorter PCB sections that are not anchored may deflect up to 9 feet when hit at high speeds, depending on the type of barrier and anchorage length. Table 2 on page 8 provides examples of barrier deflections under various test conditions. In the extreme cases, water-filled and steel barriers may deflect up to 12 to 23 feet.

The treatment of the end of the barrier in the work zone is also an important consideration. Typically, the barrier may be flared away from traffic and a crash cushion used to protect the end. The effective length of the barrier will vary depending on whether the crash cushion is non-redirective, redirective-gating, or redirective-non-gating. Using a redirective non-gating crash cushion will reduce the amount of barrier needed to protect a hazard because a portion of the crash cushion can be used as part of the length of need. Engineering analyses should be performed to determine the appropriate crash cushion to use in a particular situation.

Barrier ends in work zones must be protected by flaring them and/or providing crash cushions *(Source: TTI).*

Highly-mobile barrier systems deflect very little when hit by an errant vehicle *(Source: QMB Barrier).*

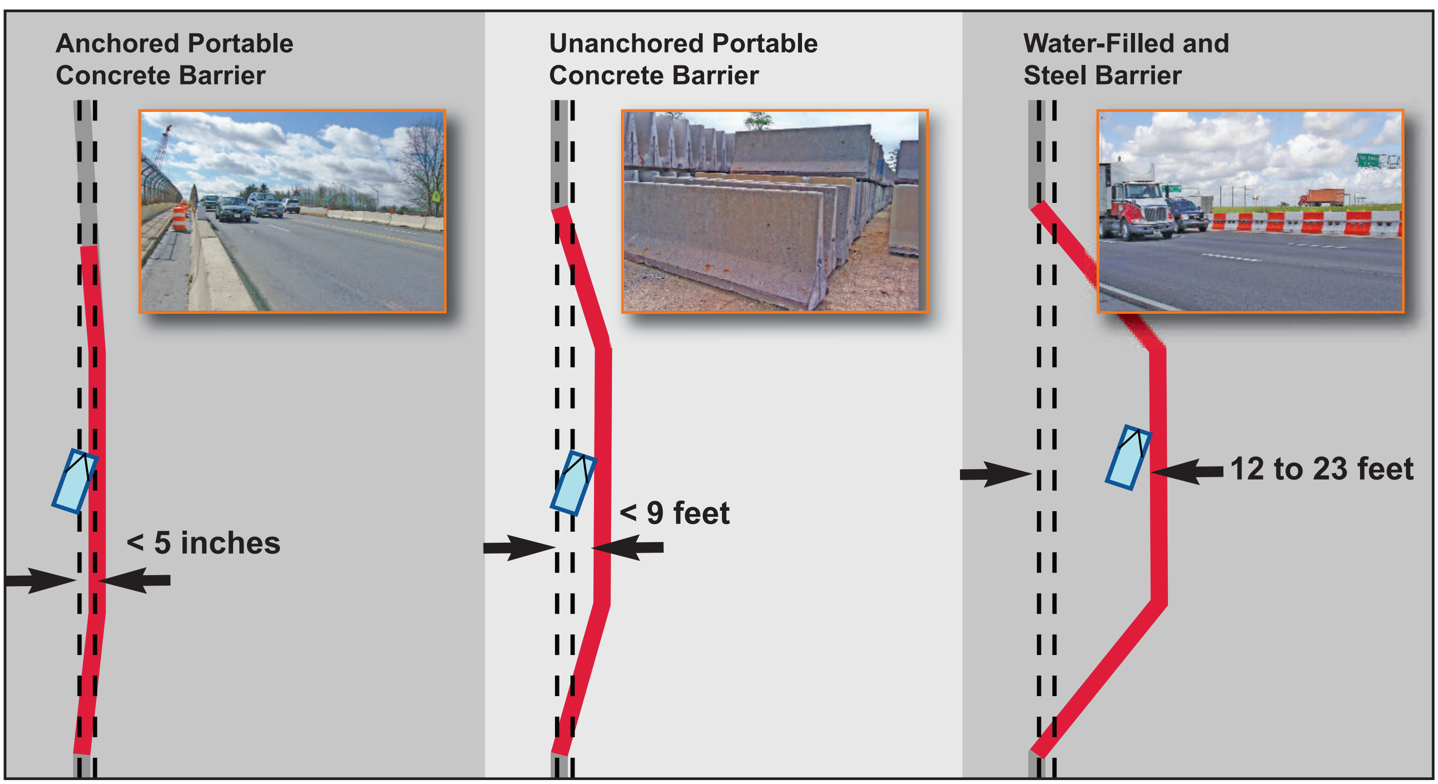


Figure 4. Typical Lateral Deflection Distances of Work Zone Barriers.

Table 2. Traffic Barrier Service Concrete Deflection[4]

Manufacturer	Device Description	Test Level	Dynamic Deflection	Anchorage (a)
Midwest Roadside Safety Facility	Steel strap tie-down system for PCB on bridge decks	TL-3	3' - 2"	46'
Barrier Systems, Inc.	Temporary steel barrier	TL-2 TL-3	3'- 5" 6' - 4"	52' - 6" 105'
CalTrans	4 m (13') long single-slope barrier with double pin & loop connection	TL-3	2' - 5"	85' - 4"
Oregon DOT	42" Tall – 12.5'Lg. F-Shape precast concrete barrier w/pin & loop connection	TL-3 TL-4	2'- 9" 2'- 9"	125' 100'
Indiana DOT	10' Long F-Shape barrier w/pin& loop connection	TL-3	5'- 3"	36'
Pennsylvania DOT	12.5' Long F-Shape temporary barrier w/plate connection	TL-3	8'- 7"	80'
Barrier Systems, Inc.	Steel Reactive Tension System (SRTS) Concrete Reactive Tension System (CRTS)	TL-3 TL-3	2'- 4" 2'- 0"	266' - 8"
Barrier Systems, Inc.	Quickchange Moveable Barrier (QMB)	TL-3	4'- 6"	10'- 4"
Gunnar Prefab AB	GPLINK precast temporary concrete barrier	TL-3	5'- 10"	*
Virginia DOT	20' Long F-Shape barrier w/pin & loop connection	TL-3	6'	60'
Easi-Set Industries	12' Lg. And 20' Lg. F shape barrier w/J-J hook connection	TL-3	4'- 4"	69' - 7"
Rockingham Precast	12' Long F-Shape w/T-Bar connection	TL-3	3'- 10"	60'
University of Nebraska - Lincoln	9'- 4" Long F-Shape barrier w/pin & loop connection	TL-3	6'	11' - 5" Run-on 9' - 10" Run-off
Barrier Systems, Inc.	Narrow Quickchange Moveable Barrier	TL-3	2'- 11"	(b)
Texas A&M (TTI)	Low-Profile Concrete Barrier for Work Zones	TL-2	5"	(c)

* No published information is available.

a – Anchorage is defined as the additional length of barrier needed, upstream and downstream of the work zone, to ensure the system does not exceed the maximum dynamic deflection noted in the adjacent column.

b – System was anchored using two 6" steel tubes and two 1" by 4" steel straps w/turnbuckles.These were attached to two 3' diameter by 8' deep reinforced concrete anchors.

c – System was anchored using a non-crashworthy end treatment. System must be terminated outside of clear zone or shielded with a crashworthy device.

Longitudinal Buffer Spaces

Longitudinal buffer spaces are also intended to be used as available spaces in which to stop errant vehicles before they reach work spaces. Stopping sight distances listed in the national *Manual on Uniform Traffic Control* (MUTCD) Table 6C-2, shown in Table 3, and selected based on the prevailing speed of traffic are desirable. However, if the desirable distance cannot be provided, a shorter buffer space is better than providing no buffer space.

Table 3. Stopping Sight Distance as a Function of Speed.[1]

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

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

Buffer Spaces for Short-Duration Maintenance Work Zones

Many types of maintenance work activities require only a few minutes of work at a location. Often the workers move slowly along the roadway performing repairs. Pothole patching, crack sealing, and raised pavement marker removal and/or installation are a few examples of these activities. These types of work zones present three categories of hazards to workers:

- vehicles approaching from upstream running into the work operation,
- vehicles traveling around the work operation returning to the closed lane too early and intruding into the work space, and
- vehicles coming from the opposite direction encroaching into the work space (in cases with opposing traffic).

To combat such hazards, these activities are typically accomplished using a combination of work vehicles and shadow vehicles to separate the work space and traffic space and protect the workers. An example of this type of operation is shown in Figure 5.

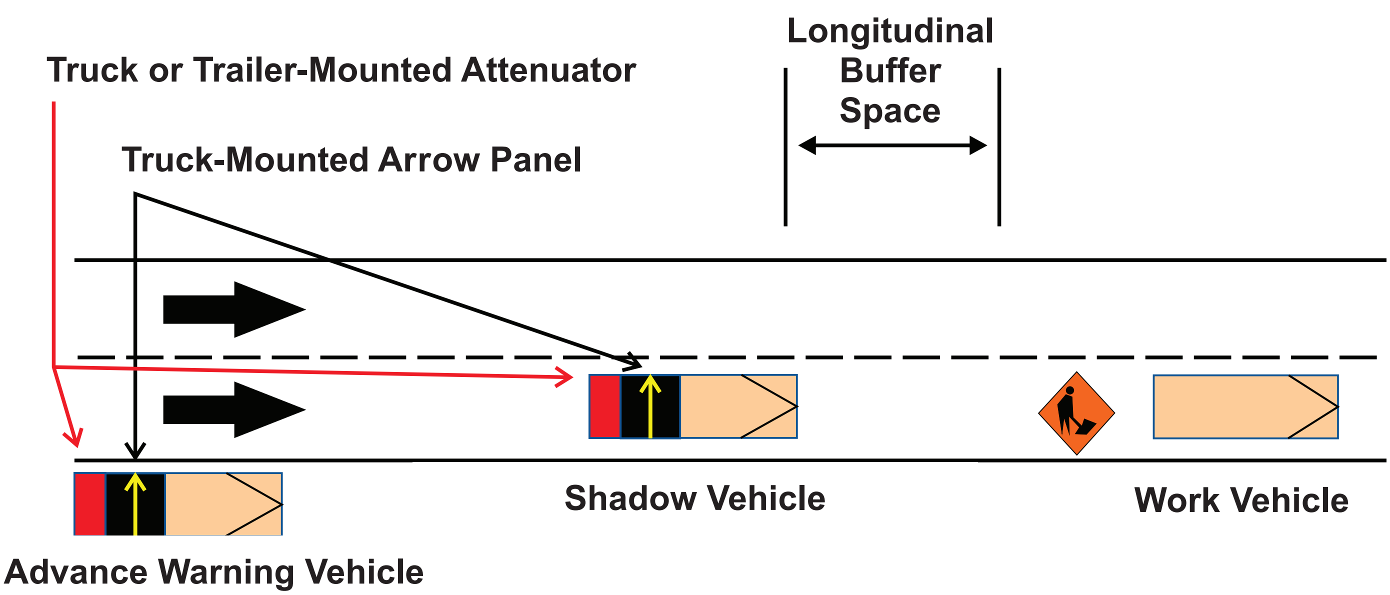


Figure 5. Example of Longitudinal Buffer Space for Short-Duration and Mobile Operations.

The longitudinal buffer space required in these operations must be sufficient to allow the shadow vehicle to move forward if hit from behind by an approaching vehicle. This space, termed the "roll-ahead distance," depends on the size of the shadow truck and the speed and mass of the approaching vehicle.

As shown in the photos at right, trailer or truck-mounted attenuators (TMAs) absorb the tremendous kinetic energies of a rear-end crash and so may reduce the shadow vehicle roll-ahead distance. Consequently, it is important to use TMA-equipped shadow and work vehicles when workers are on foot on high-speed roadways to minimize the chance that the work vehicle is pushed into the workers if struck. Certainly, workers must maintain a position that is greater than the expected shadow vehicle roll-ahead distance, but not so far as to be at risk for vehicles trying to re-enter the lane once past the shadow vehicle.

Studies in Illinois indicate that the risk of intrusions increases significantly if the work space (and workers) are more than 150 feet downstream of the shadow vehicle and if no downstream lead work vehicle is present.[5] Fortunately, use of a lead work vehicle in front of the work space can increase that distance to 200 feet.

Table 4 illustrates the spacing of shadow vehicles to the work space recommended in the *Roadside Design Guide* [2] of the American Association of State Highways and Transportation Officials (AASHTO).

Truck-mounted attenuators before and after a vehicle impact *(TTI).*

Table 4. Recommended Shadow Vehicle Spacing to Work Space. [2]

Operating Speed (mph)	Buffer Space (ft)
Shadow Vehicles weighing 22,000 lbs or more	
>55	150
45 - 55	100
<45	74
Shadow Vehicles weighing less than 22,000 lbs	
>55	172
45 - 55	123
<45	100

Key Points to Remember

- Both clear zones and buffer spaces are provided to allow errant vehicles to stop or recover without impacting a hazard. Clear zone criteria generally apply when no work is occurring. Work zone clear zones should be kept clear of materials, equipment, and personal vehicles. Buffer spaces refer to how the traffic control plan is implemented during work activity to provide as much recovery space as possible for errant vehicles.
- Barriers provide protection from errant vehicles entering the activity area and work space, but barriers do not eliminate worker safety risks. Workers must protect themselves from working too close to a barrier or working between a barrier and a nearby hazard, in the event a barrier is struck and deflects. The amount of barrier deflection depends on the type of barrier used.
- Workers on foot must remain mindful of their positions in relation to shadow and work vehicles during mobile operations. The goal is to remain beyond the potential roll-ahead distance of the trailing vehicle if it is struck from behind, but not too far beyond in case a passing vehicle incorrectly tries to enter the work space.
- Barriers and crash cushions should be installed according to plans. If changes must be made, an engineering analysis should first be performed to ensure adequacy of the change.

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