MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Guidelines for Traffic Barrier Placement and End Treatment Design

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I. Purpose

The *Guidelines for Traffic Barrier Placement and End Treatment Design* (Guidelines) have been prepared as a supplement to the *Roadside Design Guide 2011 Edition* (RDG), published by the American Association of State Highway Transportation Officials (AASHTO), to provide guidance for the design and placement of traffic barriers and their end treatments. The Guidelines include example roadside scenarios, example median scenarios, guidance on improving and upgrading existing traffic barrier, and a summary of the different design practices for urban environments. These Guidelines do not apply to barrier placed on structures. Structure barrier details are provided in the Maryland Department of Transportation State Highway Administration (MDOT SHA) Office of Structures Structural Details and Guidelines (see **Appendix B**).

A. Supplemental References

The following is a list of references that are associated with the Guidelines. The most current adopted versions, including errata, should be consulted for further information (see **Appendix B**):

1. *Roadside Design Guide, 4th Edition, 2011, including all Errata; published by AASHTO* (RDG);
2. *Manual for Assessing Safety Hardware, 2016, including all Errata; published by AASHTO* (MASH 2016);
3. *A Policy on Geometric Design of Highways and Streets, 2018 Edition; published by AASHTO* (AASHTO Green Book);
4. MDOT SHA Book of Standards for Highway and Incidental Structures;
5. MDOT SHA Standard and Supplemental Specifications for Construction and Materials; and
6. MDOT SHA Qualified Products Lists (QPL).

B. How and Where to Apply Guidelines

The Guidelines should be applied to all MDOT SHA projects and roadways under the jurisdiction of MDOT SHA whenever design of new or upgrades to existing traffic barrier or end treatments are required. The Guidelines may also be referenced by other transportation agencies within Maryland for the roadways under their respective jurisdictions. Because these are guidelines and not standards, engineering judgement should be exercised in applying them. For most situations, there are a multitude of solutions, some of which may not be cost-effective or context appropriate. Budgetary and project constraints will dictate prioritization of needs based upon well-founded data and evaluation by trained and knowledgeable engineers. The safety of the traveling public, however, should always be a primary consideration when deviating from these guidelines. Designers should consider risk in their decision-making processes when designing for traffic barriers or providing for safe roadsides. Designers should consider the relative risks when choosing to place traffic barriers to protect a fixed object versus the risk of an errant vehicle striking that fixed object. Risk factors include the available clear recovery area, terrain, traffic composition, and crash history. In some cases, the risk of installing a traffic barrier may be too great and could yield increased safety risk to the traveling public.

II. The Clear Zone Concept

Providing clear roadsides is a proven safety countermeasure in reducing the severity of run-off-the-road crashes. According to the *2021-2025 Maryland Strategic Highway Safety Plan*, an average of 166 fatalities and 699 serious injuries occurred in run-off-the-road crashes each year from 2015 to 2019. A run-off-the-road crash is one where a vehicle strikes a fixed object and leaves the road or where the location of the crash was reported as off-road or in the median. When an errant vehicle leaves the roadway, the probability of a crash occurring depends on the vehicle's speed, the angle at which it leaves the travel lane, and the presence of fixed objects in the path of that vehicle. If a crash does occur, its severity is dependent upon several factors, including the use of restraint systems, vehicle type, and the nature of the roadside environment. Of these factors, the highway designer has a significant measure of control only over the roadside environment. This measure of control can be applied using the "Clear Zone" concept.

The RDG defines the Clear Zone as "the unobstructed, traversable area provided beyond the edge of the through traveled way for the recovery of errant vehicles." The clear zone includes the shoulder, bike lanes, and auxiliary lanes, except those auxiliary lanes that are functionally similar to through lanes. If a bypass lane is present, engineering judgement should be used to determine if it is considered an auxiliary lane or a through traveled lane for the purposes of determining the clear zone. The desirable clear zone width, from a roadside safety standpoint, is as wide as cost-effectively possible. However, some practical value needs to be established for design purposes. Suggested clear zone distances are provided in **Table 1**, on the next page, which is taken directly from Table 3-1 of the RDG. *Information on the different classifications of roadside fore slopes can be found in Section 3.2.1 of the RDG.* **Figure 1** depicts the different classifications of roadside slopes that may be encountered. Clear zone distances from *Table 3-1 of the RDG* may be modified to account for horizontal curvature using the horizontal curve adjustment factors from *Table 3-2 of the RDG.* When determining the clear zone, the design speed of the roadway should be used. The engineer should use the 85th-percentile operating speed of the roadway if the design speed is not available. Consideration should be given to using the 85th-percentile operating speed if it is found to be higher than the design speed. The AASHTO Green Book provides information on "Design Speed" and "Operating Speed" in section 2.3.6.1. *How the clear zone concept applies to different types of projects can be found in Section 3.3 of the RDG – Application of the Clear-Zone Concept.*

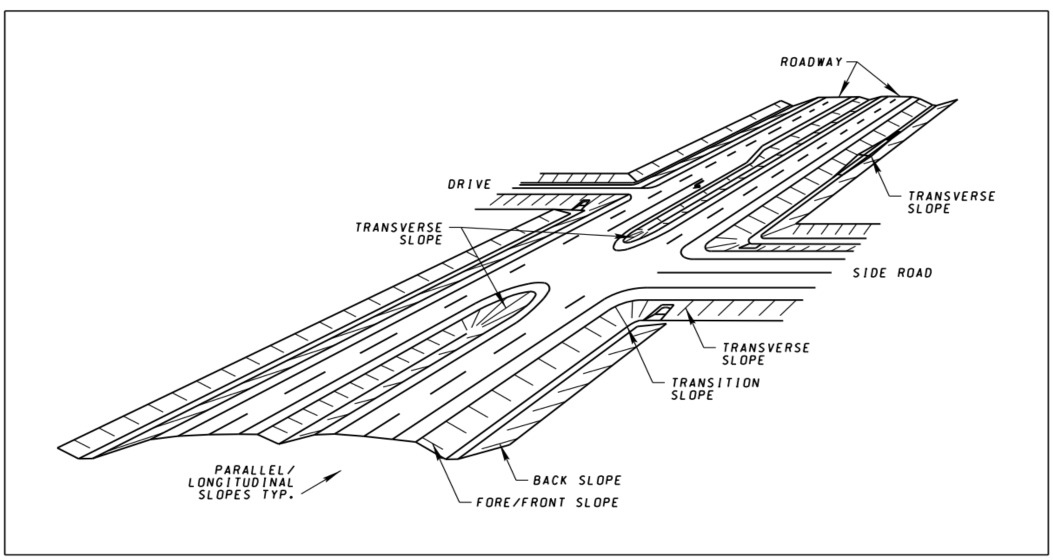


Figure 1: Roadside Slopes (Adapted from Figure 3-1 of the RDG)
Source: AASHTO Roadside Design Guide, 4th Edition

Table 1: Suggested Clear Zone Values (Table 3-1 of the RDG)
Source: AASHTO Roadside Design Guide 4th Edition, includes July 2015 Errata

Design Speed (MPH)	Design ADT	Foreslopes (ft)			Backslopes (ft)		
		1V:6H or flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or flatter
≤40	UNDER 750[c]	7-10	7-10	[b]	7-10	7-10	7-10
	750-1500	10-12	12-14	[b]	10-12	10-12	10-12
	1500-6000	12-14	14-16	[b]	12-14	12-14	12-14
	OVER 6000	14-16	16-18	[b]	14-16	14-16	14-16
45-50	UNDER 750[c]	10-12	12-14	[b]	8-10	8-10	10-12
	750-1500	14-16	16-20	[b]	10-12	12-14	14-16
	1500-6000	16-18	20-26	[b]	12-14	14-16	16-18
	OVER 6000	20-22	24-28	[b]	14-16	18-20	20-22
55	UNDER 750[c]	12-14	14-18	[b]	8-10	10-12	10-12
	750-1500	16-18	20-24	[b]	10-12	14-16	16-18
	1500-6000	20-22	24-30	[b]	14-16	16-18	20-22
	OVER 6000	22-24	26-32[a]	[b]	16-18	20-22	22-24
60	UNDER 750[c]	16-18	20-24	[b]	10-12	12-14	14-16
	750-1500	20-24	26-32[a]	[b]	12-14	16-18	20-22
	1500-6000	26-30	32-40[a]	[b]	14-18	18-22	24-26
	OVER 6000	30-32[a]	36-44[a]	[b]	20-22	24-26	26-28
65-70[d]	UNDER 750[c]	18-20	20-26	[b]	10-12	14-16	14-16
	750-1500	24-26	28-36[a]	[b]	12-16	18-20	20-22
	1500-6000	28-32[a]	34-42[a]	[b]	16-20	22-24	26-28
	OVER 6000	30-34[a]	38-46[a]	[b]	22-24	26-30	28-30

NOTES:

a) When a site-specific investigation indicates a high probability of continuing crashes or when such occurrence are indicated by crash history, the designer may provide clear zone distances greater than the clear zone shown in Table 1. Clear zones may be limited to 30 ft for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

b) Because recovery is less likely on the unshielded, traversable 1V:3H fill slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of the slope. Determination of the width of the recovery area at the toe of the slope should consider right-of-way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of slope. While the application may be limited by several factors, the foreslope parameters that may enter into determining a maximum desirable recovery area are illustrated in Figure 3-2 of the RDG. A 10 ft recover area at the toe of slope should be provided for all traversable, non-recoverable fill slopes.

c) For roadways with low volumes it may not be practical to apply even the minimum values found in Table 1. Refer to Chapter 12 of the RDG for additional considerations for low-volume roadways and Chapter 10 of the RDG and Section XI of these Guidelines for additional guidance for urban applications.

d) When design speeds are greater than the values provided, the designer may provide clear zone distances greater than those shown in Table 1.

III. Roadside Obstacles and Their Treatments

Roadside obstacles include both non-traversable terrain and fixed objects and may be either man-made (such as critical embankments, ditches, bridge piers, signs, or headwalls) or natural (such as trees or boulders). *Sections 3.3.1, 3.3.2 and 3.3.3 of the RDG discuss the differences between recoverable foreslopes, non-recoverable foreslopes, and the critical foreslope, respectively.* Although preferable, a flat clear recovery area may not be feasible due to economic or environmental constraints, such as right-of-way, parklands, historic sites, certain classes of streams, or tidal or non-tidal wetlands. The overall design goal is to provide a forgiving roadside by removing roadside obstacles; but, if that is not possible, the severity of a vehicle impacting a roadside obstruction should be reduced.

Listed below, in order of preference, are several design options for reducing roadside obstacles:

1. Remove the obstacle.
2. Redesign the obstacle so it can be safely traversed.
3. Relocate the obstacle to a point where it is less likely to be struck.
4. Reduce impact severity by using an appropriate breakaway device.
5. Shield the obstacle with a longitudinal traffic barrier designed for redirection or use a crash cushion.
6. Delineate the obstacle.

Section 3.4.3.2 of the RDG discusses traversable designs for drainage features that cannot be removed or relocated.

When breakaway devices are utilized, those devices must have passed the applicable crash testing criteria as defined by MASH 2016 and meet current MDOT SHA specifications. A November 2019 memorandum issued by FHWA and AASHTO providing clarifications on implementing MASH 2016 defines a process that allows states to use devices meeting NCHRP Report 350 criteria if MASH compliant devices are not available. The use of NCHRP Report 350 devices should be approved by MDOT SHA Office of Highway Development (OHD).

The designer is reminded that, while crashworthy, barrier itself is a roadside hazard that when struck at certain speeds or impact angles can cause serious injuries or even death to vehicle occupants. Therefore, traffic barrier should not be used indiscriminately. *The RDG provides guidance in Section 5.2.2 regarding the shielding of roadside obstacles and non-traversable terrain with traffic barrier.*

When considering placement of traffic barrier to shield a fixed object, the designer should determine if that fixed object could be relocated behind existing traffic barrier or if the fixed object can be consolidated with other fixed objects to reduce the number of roadside hazards. An example of this would be placement of a traffic detector on a sign structure support which is already protected by traffic barrier, rather than placing the traffic detector on its own support. New roadside hazards, even those on breakaway supports, should not be placed in front of traffic barriers or within the deflection zone behind traffic barriers.

IV. Roadside Barriers

A roadside barrier is a longitudinal traffic barrier used to shield motorists from natural or man-made obstacles along either side of a traveled way. Barriers may also be used to protect bystanders, pedestrians, and cyclists from vehicular traffic under special conditions as determined by engineering judgment. This section will provide guidance regarding the selection, design, and placement of roadside traffic barriers on Maryland roadways.

A. Guidelines for Determining Roadside Barrier Need

Barrier recommendations are based on the premise that a traffic barrier should generally be installed if it reduces the severity of potential crashes. The installation of barriers could lead to higher overall crash rates due to the proximity of the barriers to the traveled way, so the following considerations should be made when determining the need for traffic barrier:

1. Eliminate the obstacle by removing the obstacle or relocating the obstacle outside of the clear zone or behind existing roadside barrier.
2. If the obstacle cannot be eliminated, determine if the obstacle can be made traversable by redesigning it or if it can be replaced with a crashworthy feature, i.e., a breakaway device.
3. If the obstacle cannot be eliminated, made traversable, or replaced with a crashworthy feature, determine the severity of impacting the obstacle versus impacting traffic barrier.
4. Using engineering judgment, select an end treatment that is the most appropriate and cost-effective for the site (see Section VII).

Warrants for shielding specific roadside hazards located within the design clear zone are provided in **Table 2**, below.

Table 2: Warrants for Shielding of Obstacles within the Design Clear Zone

Roadside Obstacle within Design Clear Zone	Traffic Barrier Warrant
Embankments (critical and traversable, non-recoverable embankments without runout area)	Warranted*
Bridge Piers, Parapets, etc.	Warranted
Signs/lighting standards which cannot be made breakaway	Warranted
Signal Supports (high speed open sections)	Coordinate with the Office of Traffic and Safety (OOTS)
Streams or permanent bodies of water more than 2 feet in depth	Warranted
Large Boulders	Warranted
Utility Poles	Traffic barrier may be warranted on a case-by-case basis
Drainage features – ditches, headwalls	Judgment based on severity of obstacle and site-specific circumstances; redesign if possible to be made traversable
Trees	Judgment based on site specific circumstances *(see also MDOT SHA Landscape Design Guide)*

** Critical slopes less than 7 feet high without obstacles either on or at the bottom of the slope need not be shielded.*

If the project site has been reviewed and it is found that traffic barrier is recommended or traffic barrier is warranted based on Table 2, the type, location, and length of barrier must be determined. The selection of an appropriate end treatment type is dependent upon the site conditions. More information on the selection of end treatments is discussed in Section VII of these Guidelines. *Refer to Section 5.2 of the RDG for more information regarding barrier recommendations in various situations.*

B. Roadside Barrier System Selection

The type of roadside barrier selected for a location should be based on several factors, including, but not limited to, functional classification of the roadway, speed, traffic volume and composition, roadway alignment, available deflection space behind the barrier, sight distance, and other considerations. *Section 5.5 of the RDG provides more guidance regarding selection guidelines for roadside barriers once the need for a roadside barrier has been determined.*

An important selection factor that should be considered is the performance capability of the barrier. The barrier selected should meet the appropriate performance level required for the project site. Performance levels are based on crash test conditions, or Test Levels (TL), as defined by MASH. MASH test levels for roadside barrier are defined as follows:

1. TL-1 – 1100C Vehicle (2,420 lbs.) and 2270P Vehicle (5,000 lbs.) at 31 MPH impacting at 25°
2. TL-2 – 1100C Vehicle (2,420 lbs.) and 2270P Vehicle (5,000 lbs.) at 44 MPH impacting at 25°
3. TL-3 – 1100C Vehicle (2,420 lbs.) and 2270P Vehicle (5,000 lbs.) at 62 MPH impacting at 25°
4. TL-4 – TL-3 and 10000S Single-Unit Truck (22,000 lbs.) at 56 MPH impacting at 15°
5. TL-5 – TL-3 and 36000V Tractor-Van Trailer (80,000 lbs.) at 50 MPH impacting at 15°
6. TL-6 – TL-3 and 36000T Tractor-Tank Trailer (80,000 lbs.) at 50 MPH impacting at 15°

Roadside barriers are typically categorized as flexible, semi-rigid, or rigid, depending on their deflection characteristics resulting from an impact. MDOT SHA utilizes both semi-rigid and rigid barrier systems for its roadside barrier.

Semi-rigid Barrier
The approved semi-rigid barrier system in Maryland is the Midwest Guardrail System (MGS) which is comprised of W-Beam sections mounted to steel posts using wood or composite offset blocks, with a barrier top of rail mounting height of 31-inches (See Std. MD-605.23). The system includes barrier splices mid-span between the posts and utilizes either 8-inch or 12-inch wood or composite offset blocks. *Information on the MGS guardrail system can be found in Section 5.4.1.7 of the RDG.*

Rigid Barrier
The approved roadside rigid barrier system for new barrier installation in Maryland is the F-shape concrete barrier design, which includes a TL-3 design at a height of 34-inches and a TL-4 design at a height of 42-inches. *Information on concrete barrier designs that meet TL-5 and TL-6 requirements can be found in Section 5.4.1.12 of the RDG.*

For concrete roadside barrier installations, the TL-4 design at 42-inches shall be used on all Interstates, freeways, and expressways; on other roadway types with a posted speed limit greater than or equal to 55 MPH; or on other roadways where there is a significant volume of heavy truck traffic, as determined by engineering judgment.

The advantages and disadvantages of W-Beam (semi-rigid) and concrete barrier (rigid) options are shown below in **Table 3**.

Table 3: Advantages and Disadvantages of W-Beam and Concrete Barrier

Type	Advantages	Disadvantages
W-Beam Barrier	• Lower installation costs • Relatively flexible placement criteria (see next section) • Softer impact to occupants	• Generally damaged on impact, incurring maintenance costs and exposing maintenance personnel to traffic during replacement • Must accommodate deflection • Vehicle damage with any impact • Susceptible to damage from maintenance operations (plowing, mowing, etc.)
Concrete Barrier	• Minimal damage on impact, lowering life cycle cost and minimizing exposure of maintenance personnel • Limited deflection • Less vehicle damage on shallow angle impacts	• Higher installation costs • Harsher impacts to occupants • Strict placement criteria • May require installation of storm drain system

C. Roadside Barrier Design

When designing the traffic barrier and end treatments for any project, the highway designer should consider all options available to ensure that the most appropriate solution is selected for the case. For existing facilities, it is important for the highway designer to visit the project site to review the existing conditions and inspect any high crash locations. These field observations can provide additional data in assessing barrier needs and warrants.

The following criteria should be considered for the design of roadside barrier:

1. Lateral Placement

The first design principle is to place W-Beam barrier as far from the traveled way as possible to minimize the probability of impact. Concrete barrier should be placed a minimum of 2 feet from the edge of the shoulder. *Where other criteria or design factors preclude the placement of barrier further away from the roadway, the standard placement of W-Beam is defined in Std. MD-605.31.*

2. Height

To ensure proper performance, W-Beam barrier should be placed at the proper height. The standard top mounting height of W-Beam barrier is 31 inches (*see Std. MD-605.23).* Concrete barrier heights are 34 inches for TL-3 and 42 inches for TL-4 installations.

3. Deflection

The dynamic deflection distance for W-Beam barrier is specified in the 'Minimum Offset to Hazard' details found in Std. MD-605.31 and MD-605.31-01. No fixed object (rigid or breakaway) shall be placed within the dynamic deflection distance from the back of the barrier system.

When the minimum offset to hazard cannot be provided behind traffic barrier W-Beam, stiffening systems can be added. *Section 5.6.1 - Barrier Offset of the RDG discusses these situations.* If the distance from the back of the post to the hazard is between 2 feet and less than 4 feet, the W-Beam shall be stiffened by using half-post spacing beginning 25 feet in advance of the hazard. If the distance from the back of the post to the hazard is between 1 foot and less than 2 feet, the W-Beam shall be stiffened by using half-post spacing beginning 50 feet in advance of the hazard and transition to quarter-post spacing 25 feet in advance of the hazard. The stiffening should continue to the end of the obstacle. If the roadway is two-directional and the W-Beam is within the design clear zone of the opposing traffic, the same stiffening should be provided for the opposing direction as well. *Stiffening methods are provided in Std. MD-605.31-01.*

Concrete barrier, with proper foundation, demonstrates zero dynamic deflection and is appropriate to use when deflection distance is limited. Other roadside barrier can also provide zero deflection, such as bridge railing and barriers within retaining wall systems.

The designer should consider the potential that a truck or similar high-center-of-gravity vehicle may lean over the barrier upon impact, which could require an increased offset to lessen the likelihood of contact with a shielded object. This area is known as the Zone of Intrusion and should be considered to avoid a truck or other larger vehicle leaning over and impacting a fixed object, such as a bridge pier or sign face. *Section 5.5.2 of the RDG provides more information on the Zone of Intrusion.*

4. Soil Backing for W-Beam Barrier

Since there is a considerable contribution to the redirection capability of the system from the strength of the posts, it is necessary to develop adequate soil support for the post to prevent it from pushing backwards too easily upon impact. *Std. MD-605.31 depicts the amount of soil backing necessary for W-Beam traffic barrier and the associated post length (6 foot or 8 foot).*

W-Beam traffic barrier systems that can be installed on 2:1 slope have been successfully crash tested to MASH 2016 criteria. If slopes cannot be adjusted to meet *Std. MD-605.31*, consideration should be given to using a system designed for installation on steeper side slopes with the approval of OHD.

5. Flare Rate

Flare rates are discussed in section 5.6.3 Flare Rates of the RDG. Additional guidance is provided on Std. MD-605.32. **Table 4** provides the maximum recommended flare rates for rigid and semi-rigid traffic barriers based on design speed.

Table 4: Maximum Flare Rates for Traffic Barrier

Design Speed (MPH)	Flare Rates for Traffic Barrier	
	Rigid	Semi-Rigid
70	20:1	15:1
60	18:1	14:1
55	16:1	12:1
50	14:1	11:1
45	12:1	10:1
40	10:1	8:1
30	8:1	7:1

D. Special W-Beam Barrier Treatments

1. Long Span W-Beam

Std. MD-605.26 provides details for a W-Beam system that is designed to span a bridge or culvert where posts cannot be installed. This system allows a clear span of up to 25'-0" and utilizes Controlled Release Terminal (CRT) posts on either side of the spanned opening. A clear span of 18'-9" provides for the *omission* of two posts and a clear span of 25'-0" provides for the *omission* of three posts. The maximum clear span is 25'-0". Long-span W-Beam systems cannot be used within the limits of transitions or end treatments.

Std. MD-605.23 provides guidance for the *omission* of one traffic barrier post which can be utilized in situations where a single post is in conflict with an underground utility, a curb opening, or other similar obstruction. The omitted post cannot be within the limits of the end treatment or within a transition section.

2. Extra Offset Blocks

When a post cannot be driven in its normal location due to an underground utility conflict or similar obstruction, one additional offset block may be added to one or two posts to provide up to a 24-inch offset, allowing the post to be placed in a position to avoid the underground conflict. Extra offset blocks cannot be added within the limits of an end treatment or within a transition section.

E. Curb Use With W-Beam Barrier

The combination of curb and W-Beam traffic barrier is discussed in section 5.6.2.1 of the RDG and illustrated on Std. MD-605.31. The end treatment for W-Beam barrier should be located beyond the need for the curb. If the curb must continue in advance of the barrier need, the curb should be dropped to a maximum 2-inch height, starting 50 feet in advance of the end treatment and through the length of the end treatment.

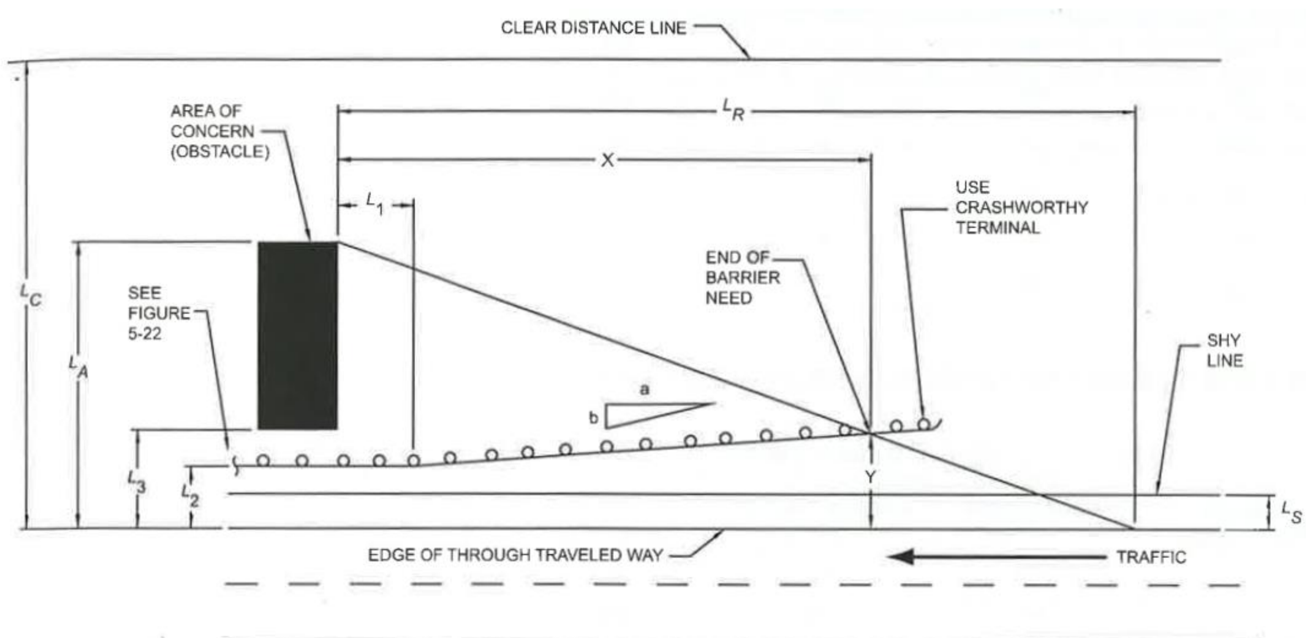
For a closed section on an urban street, see Section XI, Urban Street Sections.

F. Length of Need Determination

Length of Need (LON) is defined as the length of effective barrier needed upstream, beginning at the obstacle, to adequately shield the obstacle. When the LON is provided, vehicles leaving the travel way in advance of an obstacle should either be:

1. Safely brought to a stop before impacting the obstacle if the departure is in advance of the barrier and the vehicle gets behind the barrier; or
2. Redirected by the barrier along its face (or impact its crashworthy end treatment).

Determination of LON is discussed in section 5.6.4 of the RDG and various example situations and associated calculations are provided to guide the designer in the proper application of LON. In some cases, the most difficult task is determining the physical limits of the obstacle. An example would be determining the beginning of a critical embankment (refer to Section VIII. A.). Once the physical limits of the obstacle are determined, the values from **Figure 2** are input into one of the equations in **Table 5**, on the next page. Runout lengths for various design speeds are provided in **Table 6**.



Definition of Variables

X = Length of Need (LON)
*L_R = Runout length, measured along the edge of the travel lane as shown based on design speed and ADT (see **Table 6**)*
L_A = Lateral Extent of the Area of Concern, distance (ft.) from edge of travel lane to back of obstacle or design clear zone width, whichever is less.
L_C = Distance (ft) from edge of travel lane to outside edge of clear zone
L_S = Shy Line Offset, distance (ft) from the edge of traveled way beyond which traffic barrier will not perceived as an obstacle and result in a motorist's reducing speed or changing vehicle position on the roadway (see Section 5.6.1 of the RDG)
L_1 = Tangent length (ft) of barrier upstream from the obstacle, selected by designer (see Section 5.6.4 of the RDG)
L_2 = Distance (ft.) from edge of travel lane to face of traffic barrier measured at obstacle
L_3 = Distance (ft) from edge of travel lane to face of obstacle (includes barrier deflection)
*b/a = Flare rate of traffic barrier for selected design speed (see **Table 4**)*
Y = Lateral offset (ft) from the edge of the traveled way to the beginning of the LON (see Section 5.6.4 of the RDG)

Figure 2: Length of Need (LON) Layout Variables (Figure 5-39 of the RDG)
Source: AASHTO Roadside Design Guide, 4th Edition

Table 5: Length of Need (LON) Equations and Variables
Source: AASHTO Roadside Design Guide 4th Edition

Parallel Installation	Flared Installation*
$\boldsymbol{LON = \frac{L_R(L_A - L_2)}{L_A}}$	$LON = \frac{L_A + \left(b/a\right)(L_1) - L_2}{\left(b/a\right) + \left(L_A/L_R\right)}$

Where:

L_A = *Distance (ft.) from edge of travel lane to back of obstacle or design clear zone width, whichever is less.*

L_2 = *Distance (ft.) from edge of travel lane to face of traffic barrier measured at obstacle*

b/a = *Flare rate for the selected design speed (see **Table 4**)*

L_R = *Runout length, measured along the edge of the travel lane as shown based on design speed and ADT (see **Table 6**)*

**Flared installations of traffic barrier are not very common, so this formula is seldom used.*

Table 6: Suggested Runout Lengths for Traffic Barrier Design
Source: AASHTO Roadside Design Guide 4th Edition

Design Speed (MPH)	Runout Length (L_R) Given Traffic Volume (ADT) (ft)			
	>10,000 veh/day	5,000 – 10,000 veh/day	1,000 – 5,000 veh/day	< 1,000 veh/day
80	470	430	380	330
70	360	330	290	250
60	300	250	210	200
50	230	190	160	150
40	160	130	110	100
30	110	90	80	70

Caution: The cross-section geometry of the roadway can influence the amount of barrier needed. For example, in a cut section, the backslope may redirect a vehicle back toward an obstacle on the foreslope. In this case, application of the LON formula would provide a supposedly sufficient amount of barrier to shield the obstacle; but good engineering judgement would propose additional length of barrier to protect against this scenario.

The LON generally includes some portion of the end treatment, usually starting at the third post, or 12’-6”, from the face of the end treatment, or as defined by the manufacturer of the end treatment. After calculating the LON, the value should be adjusted to account for standard lengths of guardrail sections at 12’-6” increments. For example, if the LON is calculated as 76’-6”, an uneven number of guardrail sections (6.1 sections) would be needed. In this case, the LON should be rounded up to 7 sections of guardrail, or 87’-6”.

The minimum run of barrier upstream of an obstacle, including LON and the total end treatment, is 75 feet unless site conditions dictate otherwise.

Determining the LON for opposing traffic is determined in the same manner and described in Section 5.6.4 of the RDG.

When successive runs of barrier are spaced 300 feet or less apart, end-to-end, the traffic barrier should be made continuous to eliminate the space unless other conditions (i.e. maintenance) preclude it. This is considered safer and more cost effective than leaving a gap and placing successive end treatments.

A "field expedient" procedure for determining the approximate LON on high speed roadways is provided in **Figure 3** and is intended to be used on field reviews. This procedure will be close to the formula application for obstacles that extend beyond the design clear zone but will yield somewhat lesser values, as the back of the obstacles is less distance from the edge of the pavement. It is acceptable for rough applications.

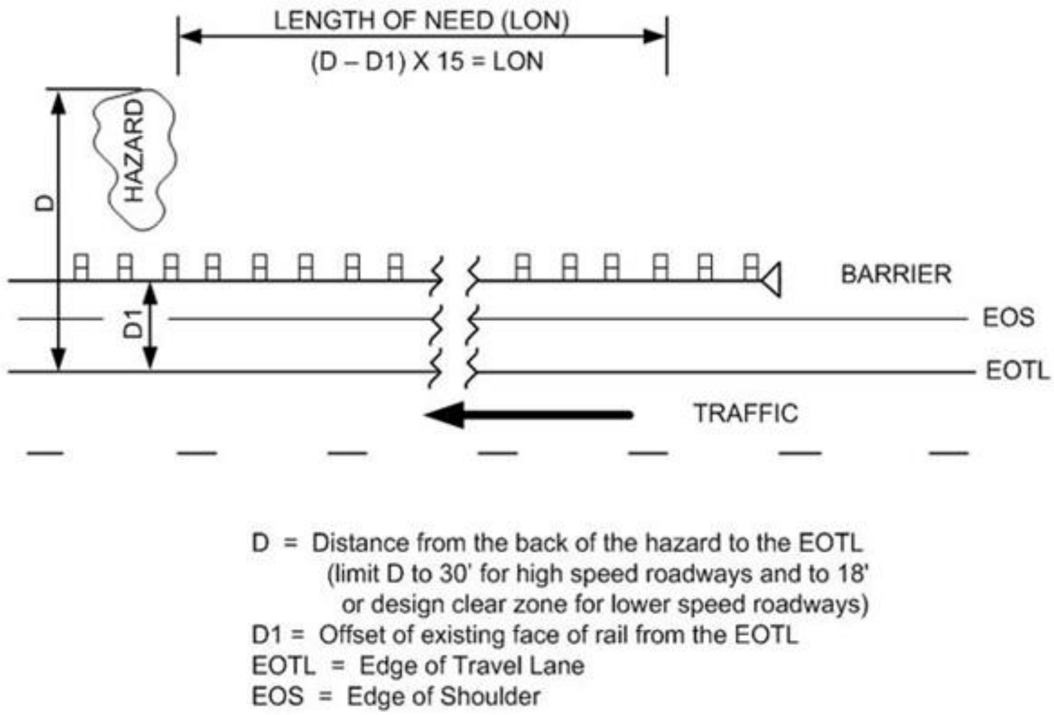


Figure 3: Field Expedient *Approximation* for LON
(from *W-Beam Guardrail Repair*, FHWA, Nov. 2008)

If there is a significant difference between the LON determined using the above procedure and either the existing or proposed installation location, the site should be reviewed to ensure appropriate application of LON.

V. Median Barriers

The function of a median barrier is to prevent a vehicle from crossing the median of a divided roadway and striking opposing traffic. Most median barriers are similar in design and function to roadside barriers discussed in Section IV.

A. Median Barrier Systems and Their Characteristics

The barrier systems available for median applications include flexible, semi-rigid, and rigid systems which are all intended to redirect vehicles striking either side of the barrier system. The following systems are approved for median applications in Maryland:

High-Tension Cable Barrier – Flexible proprietary systems, which are described in section 6.4.1.3 of the RDG.

Blocked-Out W-Beam (Strong Post) – Semi-rigid system, which is described in section 6.4.1.5 of the RDG.

F-Shape and Single Slope Concrete Barriers – Rigid systems, which are described in section 6.4.1.8 of the RDG.

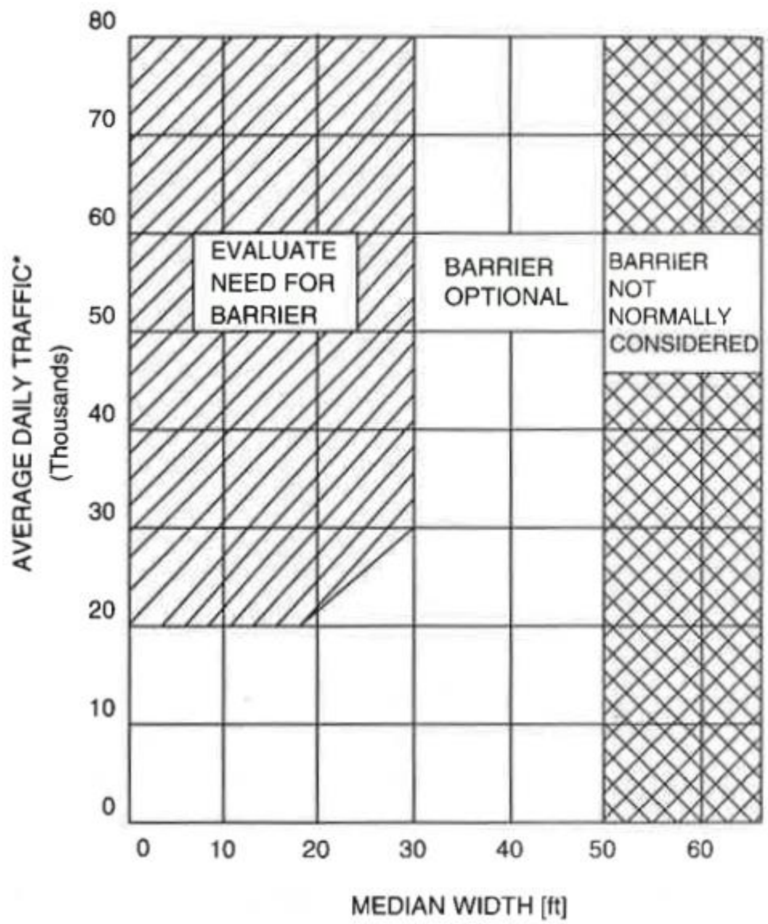
B. Median Barrier Warrants

The need for median barrier on facilities with full control of access should be determined by consulting Section 6.2 of the RDG, which provides guidance for median barrier application, based on median width and average daily traffic volumes. ***Figure 4****, on the next page, from the RDG, provides guidelines for determining the need for median barrier on fully controlled-access roadways. The need for median barrier on non-access controlled facilities should be based on a review of crash history, guidance in Section 6.2 of the RDG, and engineering judgement.*

The median width is measured from the left edge of the travel lane to the left edge of the opposing travel lane. Median shoulders are included in the overall median width.

If a barrier is proposed in the median, consult section 6.2 of the RDG to determine whether a one-sided or two-sided barrier is necessary. If the back of the barrier is within the "Barrier Not Normally Considered" region of Figure 6-1 of the RDG, a single-sided barrier system should be used. If the back of the barrier is within the "Barrier Optional" or "Evaluate Need for Barrier" regions of Figure 6-1 of the RDG, the back of the barrier should have redirective capabilities, e.g. a double-sided median barrier.

Where a section of highway less than one mile in length does not meet the requirements for median barrier and is bordered on each end by a section where median barrier is required, the barrier should be extended through the subject section if the ADT for the subject section meets three-quarters of the ADT criteria for median barrier placement. Openings in the median barriers may be provided when necessary for authorized vehicle crossovers and routine maintenance operations, in which case appropriate end treatments are required.



**Based on a 5-year projection*

Figure 4: Guidelines for Median Barrier on High Speed, Fully Controlled-Access Roadways (Figure 6-1 of the RDG)
(Source: AASHTO Roadside Design Guide, 4th Edition)

C. Median Barrier Selection

Median barrier systems approved for use on Maryland roadways have passed the basic MASH acceptance testing as defined in Section IV.B., however, there are significant differences in performance capabilities for each of the barrier systems. Selection of a particular system is dependent upon median width, roadway type, traffic volume and composition, median slopes, aesthetics, and safety of workers maintaining the system. Flexible systems are generally placed in wider medians due to the system's deflection characteristics, whereas rigid concrete barrier systems are generally placed on high volume urban freeways with limited median widths where space for deflection is not available.
All the factors mentioned in section 6.5 of the RDG, should be considered when determining the appropriate median barrier system for a project.

The advantages and disadvantages of the three types of median barrier systems are shown in **Table 7**, on the next page.

Table 7: Advantages and Disadvantages of Median Barrier Systems

Type	Advantages	Disadvantages
High-Tension Cable	• Initial installation cost similar to W-Beam • Flexible placement criteria on slopes • Relatively soft impact to occupants • System still effective after impacts if system remains tensioned • Fairly simple repair • Long distance (10,000 feet) between anchorage • Anchorages are crashworthy when impacted on the end	• Vehicle damage with any impact • If anchorage system is impacted, a significant length (1,000 feet) of system is ineffective, increasing urgency of repair. • Placement must occur such that deflection prevents intrusion into opposing traffic. • More frequent inspections due to non-reported impacts
W-Beam Barrier	• Moderate installation costs • Relatively flexible placement criteria (see next section) • Relatively soft impact to occupants	• Generally damaged on impact, incurring maintenance costs and exposing maintenance personnel to traffic • Must accommodate moderate deflection • Vehicle damage with any impact
Concrete Barrier	• Minimal damage on impact, lowering life cycle cost and minimizing exposure of maintenance personnel. • Tractor-trailer containment • Minimal deflection • Minimal vehicle damage on shallow angle impacts	• Higher installation costs • Harder impacts to occupants • Strict placement criteria • Generally, requires installation of storm drain system • May reduce available sight distance

If median barrier is recommended for a project, the following guidance should be considered when selecting a median barrier system:

1. For rural areas with relatively flat side slopes (10:1 or flatter), open drainage, and wide medians (greater than 20 feet), high-tension cable barrier may be used. High-tension cable barriers can be used in wide medians with slopes up to 4:1 or flatter if the system has been tested to the appropriate criteria.
2. For urban areas with closed drainage and narrow median widths (less than 14 feet), concrete barrier should be used to minimize the need for maintenance after impacts.
   a. 42-inch tall barriers shall be used on Interstates, freeways, expressways; on other roadways with a posted speed limit greater than or equal to 55 MPH; or where there is a significant

volume of truck traffic, as determined by engineering judgment. Single slope barriers should be used on Interstates, freeways, and expressways and F-shape barrier used on all other roadways.

   b. 34-inch tall F-Shape barriers should be used on arterials and other lower classified roadways, with a posted speed limit less than 55 MPH

3. W-Beam median barrier should be used in all other situations.
   a. If a single face W-Beam traffic barrier is used based on median width, refer to Section IV for design and placement criteria.
   b. If a double-faced W-Beam traffic barrier (Traffic Barrier W-Beam – Median Barrier, TBWB-MB) is used based on median width, follow the placement criteria below. *Std. MD-605.28 provides details on the placement of TBWB-MB.*

D. Median Barrier Placement

The placement of median barrier is discussed in section 6.6 of the RDG.

Even if the back of the barrier is outside of the clear zone for the opposing traffic, all barrier that is placed in compliance with the median barrier warrant shall be redirectional on both sides (unless it is virtually impossible to be impacted from the back).

For depressed medians, whether symmetrical or bifurcated, one side of the barrier will generally be exposed to vehicles approaching on an upslope. In this situation, the following should be used:

1. Concrete – the back face should not be exposed to any upslope steeper than 10:1; if the barrier is located at the top of a steeper slope, the ground immediately adjacent to the back face should be flattened to 10:1 for at least 10 feet. A vertical back face for the barrier should be used if any steeper slope must be maintained, and even used with a 10:1 upslope, to limit the uplift on an impacting vehicle.

2. W-Beam – For upslopes 6:1 or flatter, the back rail is set at the same elevation as the front rail as detailed on Std. MD-605.28. For upslopes steeper than 6:1, a bottom rail is added as detailed on Std. MD-605.28-01. Neither a back rail nor a bottom rail is required if the barrier is more than 10 feet up a 2:1 or steeper slope.

3. High-Tension Cable – due to the potential for underride or override of the cables, placement of high-tension cable barrier in a depressed median should follow this general guidance:

   a. For medians with slopes flatter than 6:1, the barrier should not be placed in an area of the upslope that is between 1'-0" and 8'-0" from the ditch bottom.
   b. For medians with slopes of 6:1 to 4:1, the barrier should be placed no further than 4'-0" on the downslope from the shoulder break point and not closer than 12'-0" from the ditch bottom (see **Figure 5**). These distances may vary based on the system being installed but should be used as a general rule of thumb for design and layout. In all cases, the manufacturer's placement requirements must be followed.

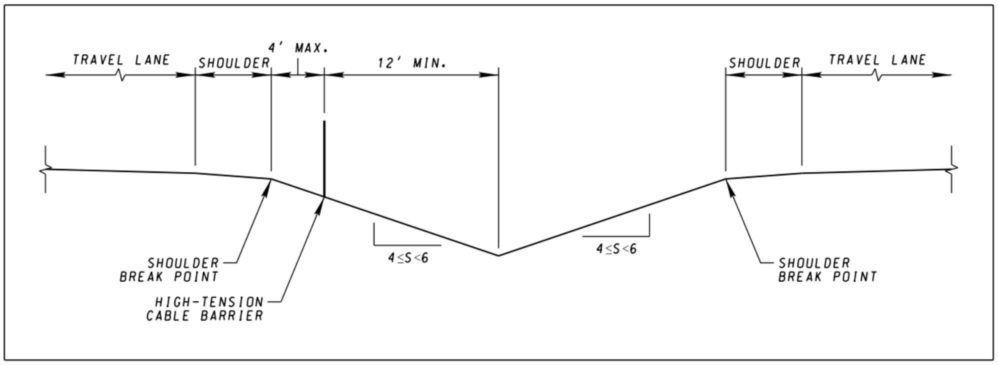


Figure 5: High-Tension Cable Barrier Placement on Slopes of 6:1 to 4:1

In some situations, it is desirable to change the median barrier location, such as shifting from adjacent to one directional roadway to be adjacent to the other directional roadway. As long as the median is flat (10:1 or flatter), any barrier can be moved using the appropriate flare rate. If the barrier is being flared toward approaching traffic, *the flare rates given in Std. MD-605.32 should be used*. Long flares should be used. If the barrier is being flared away from approaching traffic, flare rates as steep as 2:1 can be used. If the side slopes are steeper than 10:1 but no steeper than 6:1, a flare rate of 2:1 is used. With the exception of approved high-tension cable barrier systems, no barrier is placed on slopes steeper than 6:1. Consideration should be given to the placement of median barrier within horizontal curves. Median barrier should be placed further from the edge of the travel way on the outside of horizontal curves to provide recoverable area in front of the median barrier to minimize nuisance strikes by motorists that may not navigate the curve appropriately.

For narrow, flat medians, less than 18 feet wide, it is desirable to offset the barrier to one side of the center. It is undesirable to present an offset between the edge of the travel lane and the face of the median barrier that is less than 8 feet (but more than 4 feet), as it misleads motorists to a refuge area that is not safe. For example, placing a 2 feet wide median barrier in the center of a 14 feet median would leave only 6 feet refuge on both sides. By offsetting that same barrier to have only 4 feet on one side, a minimum 8-foot refuge would be available on the other. This is also helpful on the inside of curves for sight distance.

No median grading changes are required for cable barrier systems when the slope is between 10:1 and 4:1 as long as the system proposed is recommended for use on slopes as steep as 4:1. For W-Beam traffic barrier, the median slopes must be adjusted if they are not between 10:1 and 6:1. *A solution is to modify the standard W-Beam by using a double rail transition system, similar to what is described in Std. MD-605.01-01 for the one-sided buried-in-backslope end treatment. The double rail section must extend through the area where standard W-Beam barrier is not recommended, as defined on Std. MD-605.31, and then transition back to normal W-Beam barrier outside of the specified area (generally in 25 feet).* The approach end of the bottom panel must be hidden to prevent snagging, either by tucking it into the web of the post or by flaring it behind the post. *Only one rail element is needed on the back of the double rail section once it returns to the height specified in Std. MD-605.31. Flare rates shall be from Std. MD-605.32*. (This same treatment can also be applied to roadside W-Beam barrier.) Refer to **Appendix A** for guidance regarding the Double Rail Transition section.

VI. Transitions

Connecting a flexible barrier system to a semi-rigid system, or a semi-rigid system to a rigid barrier system or rigid object, requires the use of a transition to gradually increase the stiffness without creating a wheel snagging or pocketing condition upon impact. Rigid objects are defined as any unyielding obstacle, such as piers, bridge parapet ends, concrete barrier, and retaining walls. MDOT SHA has developed new MASH-compliant details for transition from W-Beam barrier (semi-rigid) to concrete parapets (rigid). This transition includes a concrete buttress or end post with a vertical face, a nested Thrie-beam element, and a transition from Thrie-beam to W-Beam. The concrete buttress, or end post, provides a transition from the vertical face Thrie-beam attachment to the appropriate concrete parapet safety shape. Concrete buttress designs are available from the Office of Structures.

Stds. MD-605.41, 605.41-01, and 605.41-02 depict the details for transitioning from W-Beam guardrail to a concrete buttress or end post.

There are currently no MASH-compliant transitions from roadside W-Beam to rigid barrier or other rigid objects that are not bridge related. Transitions from roadside W-Beam to existing rigid barrier tested under NCHRP Report 350 criteria may be used until a MASH-compliant alternative is available. Contact OHD for guidance if this type of transition is required for a project.

There are currently no MASH-compliant transitions from two-sided W-Beam to rigid barrier. Transitions from two-sided W-Beam to existing rigid barrier tested under NCHRP Report 350 criteria may be used until a MASH compliant alternative is available. Contact OHD for guidance if this type of transition is required for a project.

More information regarding transitions to rigid objects can be found in section 7.8 of the RDG.

Transitioning from high-tension cable barrier to W-Beam traffic barrier can be accomplished by overlapping the end of the high-tension cable barrier and the beginning of the W-Beam traffic barrier. The W-Beam traffic barrier and end treatment is placed behind the high-tension cable barrier (see **Figure 6**). The offset between the two barrier types is 10-feet minimum as shown in **Figure 6**, which is a function of the deflection of the high-tension cable barrier. **Figure 6** assumes that the end treatment for the W-Beam traffic barrier is outside of the clear zone for the opposing direction. If not, a two-sided end treatment should be considered. The designer should depict the layout within the project plans.

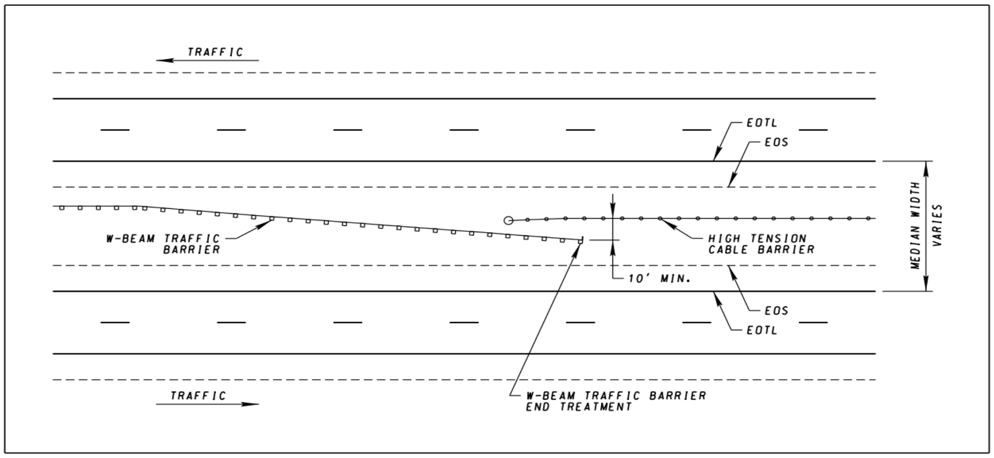


Figure 6: High-Tension Cable Barrier/W-Beam Traffic Barrier Transition Layout

VII. End Treatments

MDOT SHA shall install traffic barrier end treatments that have been tested to the latest MASH crash testing guidelines and are eligible for reimbursement by the Federal Highway Administration (regardless of funding source). End treatments are tested under crash test levels TL-1, TL-2, and TL-3. The ends of all existing and proposed high-tension cable barrier, W-Beam, or concrete traffic barrier for all highway projects shall have a crashworthy end treatment, unless there is no opposing traffic within 30-feet or the design clear zone, whichever is greater, measured from the closest opposing travel lane. In this case an appropriate end anchorage shall be used as noted below.

- **Anchorages** – These devices are designed to anchor a flexible or semi-rigid barrier system and develop tensile strength in the system. They are typically used on the trailing ends of barrier systems and generally are not designed to be crashworthy for end-on impacts (i.e., an impact into the nose or "head" of the end treatment). Some anchorages have been crash tested for redirective capabilities when impacted on the side. **Anchorages for high-tension cable barrier systems have been tested and are considered to be crashworthy when impacted on the end.**
- **End Treatments** – These devices are crashworthy end anchorages that are designed for end-on impacts and side impacts. These devices have both crash absorbing and redirective capabilities, depending upon where the device is struck. There are one-sided and two-side end treatments available for roadside and median use.
- **Crash Cushions** – Also known as impact attenuators, these devices are typically placed to provide end protection for rigid barrier systems or other rigid objects such as bridge piers. They can be used in roadside or median applications.

The function of an end treatment is two-fold. First, if a vehicle strikes the end treatment in a head-on impact (i.e., end-on), it must minimize the injury to the vehicle's occupants; second, it must develop the necessary tension at the end of a tension-requiring system in order to redirect a vehicle on a downstream impact. The end treatments discussed below have all successfully passed the required testing defined in MASH for Test Level 3 criteria. *End treatments can either be energy absorbing or non-energy absorbing and the two types are described in section 8.3.2.1 of the RDG.*

Grading adjacent to, and in advance of, an end treatment is essential to ensuring its performance and is discussed in section 8.3.3 of the RDG. Without proper grading, the end treatment will not function as it did in crash testing. Grading requirements for each type of end treatment are typically shown on the specific standard detail. Some end treatments have specific grading requirements which are noted in the manufacturer's recommendations. Consider right-of-way and environmental impacts that may be associated with grading requirements for end treatments. Fixed objects, including those with breakaway supports, should not be placed within the grading limits of an end treatment and the area behind the end treatment should be clear to allow the end treatment to gate or to provide space for any extruded guardrail that may occur upon impact. Additionally, placement of the end treatment with respect to underground utilities is extremely important, as the end treatment must be installed exactly according to the manufacturer's recommendations and posts may not be omitted to avoid an underground utility.

Table 8 depicts each type of end treatment and anchorage used by MDOT SHA and a summary of their characteristics is provided on the next page.

Table 8: End Treatment Types and Anchorages

MDOT SHA Designation	End Treatment Type	Description	Device Example
OS-BIB	Type A	One-Sided Buried-in-Backslope	
OS-ET	Type C	One-Sided End Treatment	
OS-DS	Type K	One-Sided Downstream End Treatment	
OS-R	Type L	One-Sided Radius Anchorage	
TS-G	Type D	Two-Sided Gating End Treatment	
TS-NG	Type E	Two-Sided Non-Gating End Treatment	
TS-NG-LM	Type J	Two-Sided Non-Gating Low-Maintenance End Treatment	

Approved end treatments can be found on the Qualified Product List (QPL) at https://www.roads.maryland.gov/mdotsha/pages/Index.aspx?PageId=600.

A. *Roadside W-Beam End Treatment Characteristics*

1. **One-Sided Buried-in-Backslope (OS-BIB, Type A)**: This is the **most desirable method** to terminate barrier as the barrier end is not exposed to an errant vehicle; however, mounds are not to be constructed for the purpose of terminating a barrier as they create an obstacle. The burying must provide the necessary anchorage to develop the tension forces and must be deep enough so that the end of the rail will not become exposed. *Information on the allowable foreslopes for the OS-BIB as well as where the LON begins is provided in section 8.3.6.1 of the RDG. This end treatment is detailed on Stds. MD-605.01, 605.01-01, and 605.01-02, which explains measurement and payment.*

   Rail that extends upstream from a ditch bottom – a maximum of 50 feet – is not necessarily an effective barrier (especially that portion that is buried in the ground). The determination of how far the point of effectiveness is in advance of the obstacle – the LON – depends on the backslope where the anchorage is being established, as follows:

   a. For backslopes steeper than 2:1 – the barrier is anchored in the backslope as quickly as possible but not exceeding an 8:1 flare rate; the intention is solely to establish tension continuity as the steep backslope is considered a barrier itself.

   b. For backslopes 2:1 or flatter but steeper than 3:1, a minimum of 75 feet from the upstream face of the obstacle to the point of effectiveness is required. The flare rate may be flatter than the flare rate shown on the standard to achieve the minimum length; (the prime example of this would be where there is no ditch – fully effective barrier would be required for either 75 feet upstream of the obstacle **before** the 50 feet anchorage begins).

   c. If the OS-BIB were to be used with backslopes 3:1 or flatter, a calculation of LON is required using the procedure in Section IV. OS-BIB should not be used for these flatter backslopes if the toe of the backslope is less than 20 feet from the edge-line. *Section 8.3.6.1 of the RDG, provides guidance for the area behind the W-Beam when these shallow backslopes are used.*

   The OS-BIB should be used even when the barrier system LON would normally end downstream of a cut slope if the cut slope is within 200 feet and there is not a large available runout area (400 feet x 50 feet) beyond the cut slope.

   The OS-BIB may not be the best end treatment selection when the backslope is not very high. The height of the backslope should be a minimum of 3 feet. Offset of the toe of slope may also affect the decision to use the OS-BIB; good engineering judgment must be exercised.

2. **One-Sided End Treatment (OS-ET, Type C):** This type of end treatment is designed to allow a vehicle impacting head on to be brought to a controlled stop by absorbing its energy. For higher angle end impacts, the vehicle will pass through with little absorption of energy and reduction in speed, which is called "gating". The point of effective barrier (length-of-need point) for this system is typically at the third post. When installed parallel, the first post should generally be offset 1 foot from the normal run of barrier to prevent nuisance hits, such as impacts from snowplows and roadside maintenance equipment. If the offset to the traffic barrier is less than 4 feet from the edge of the shoulder/pavement, the end treatment shall be flared in accordance with the end treatment at a rate of 25:1 over the full length of the end

treatment unless the manufacturer specifies a smaller flare (*see Std. MD-605.03*). The specific model of OS-ET will specify whether it can be installed on a curve and, if so, the minimum allowable radius. In any case, the system must be placed on a **straight line**. *Std. MD-605.03 specifies grading and other requirements for an OS-ET.*

One-Sided Downstream End Anchorage (OS-DS, Type K): The downstream end treatment is not crashworthy for end-on impacts and is designed only to develop tension and to be used on the downstream end of one-sided traffic barrier, where the system is placed more than 30 feet from opposing traffic. These end treatments have redirective capabilities when impacted along the face of the barrier. *The OS-DS end treatment is detailed on Stds. MD-605.10 and 605.10-01.* The third post is taken as the point of effective barrier for this system. Therefore, the third post must be at or beyond the end of effective barrier need. For simplicity, the end of need is generally taken as the end of the obstacle. However, if the obstacle is offset well behind the barrier, a significant length (20 feet±) of unnecessary barrier may be eliminated. This is done by establishing a 25º line (approximated by a longitudinal distance equal to twice the offset between the face of the barrier and the front face of the obstacle) from the end of the obstacle back to the third post from the end of the barrier.

3. **One-Sided Radius Anchorage (OS-R, Type L):** This system is an enhanced version of the common radius treatment used at turnouts on lower speed roadways. It adds a cable anchor, like the OS-DS end anchorage, located at the post before the radius begins, developing tension downstream of the cable attachment. (When used with only a 12’-6” panel beyond the anchorage post, bent at a 16-foot radius, it is a crashworthy terminal for NCHRP 350 TL-2). Systems tested using MASH criteria do not currently exist. This system is only for use on roadways with posted speeds of 40 MPH or less and Average Daily Traffic less than 10,000 vehicles per day. *The OS-R end anchorage is detailed on Std. MD-605.13.*

B. Two-Sided End Treatments and Characteristics

These systems are typically used to provide crashworthy end treatments for median barriers and are detailed on *Std. MD-605.12. Section 8.3.6.5 of the RDG provides additional information regarding median terminals.*

1. **Two-Sided Gating (TS-G, Type D):** The TS-G end treatment is best used as end protection for a median barrier in wide, flat areas, at least 12 feet from the edge of roadway. These end treatments are energy absorbing, but also “gate” during shallow angle impacts allowing the striking vehicle to pass through the end treatment.

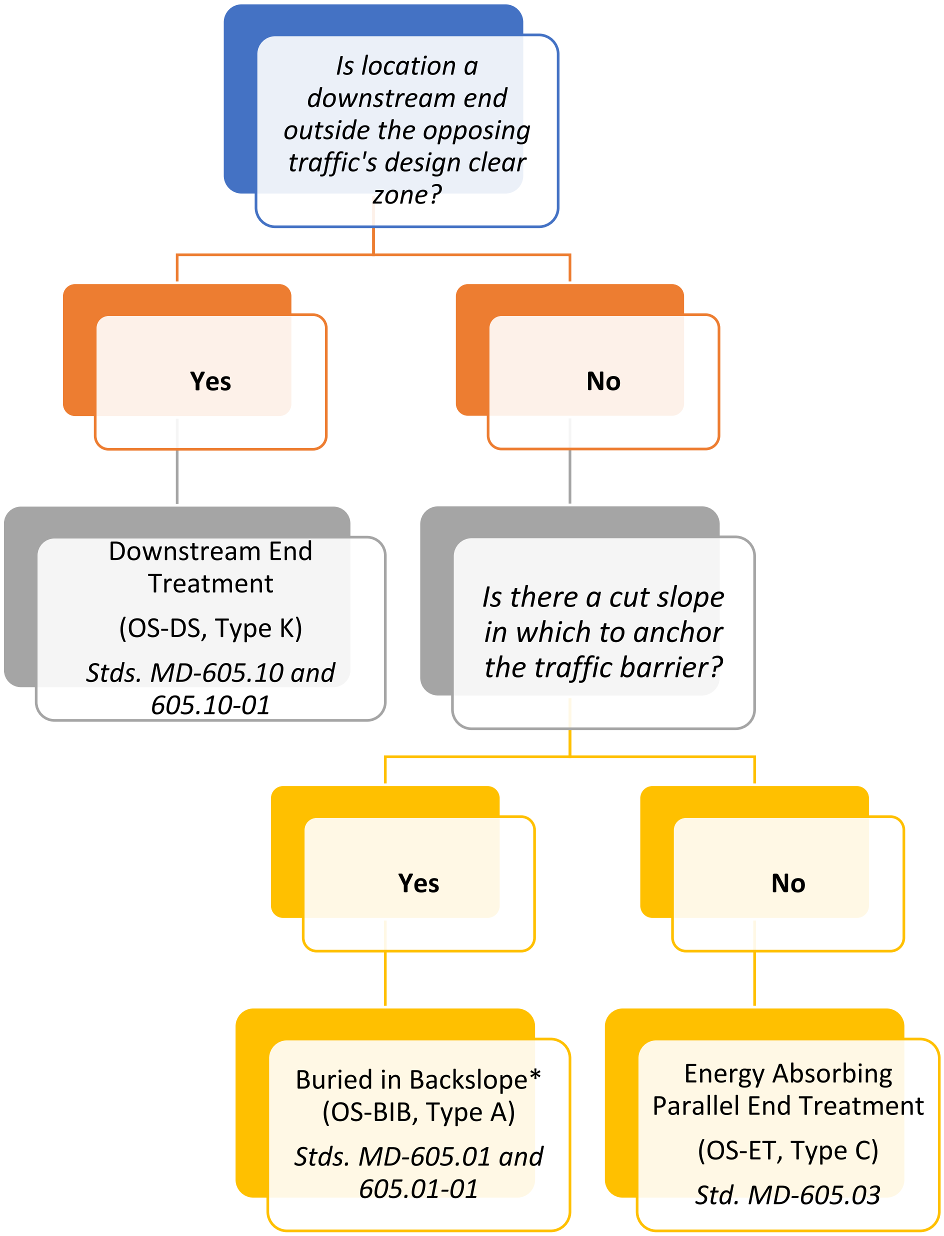
2. **Two-Sided Non-Gating (TS-NG, Type E):** The TS-NG system is an energy absorbing system with no gating characteristics and should be used in locations where gating systems are not appropriate, i.e., narrow medians with no runout areas. Examples for their use would be at maintenance openings on a high-volume urban freeway with a paved median and continuous concrete median barrier, or in gore areas of similar roadways. Units often come in various widths so that they can be used to shield wider obstacles. The designer must determine the required back-up width and then determine if an appropriate TS-NG end treatment is available to protect that width. If the back-up width is too wide, consider the use of two separate end treatments.

3. **Two-Sided Non-Gating Low Maintenance (TS-NG-LM, Type J):** The TS-NG-LM is a type of TS-NG, but with an additional self-restoring or low maintenance capability. It is best used in locations where frequent strikes on the end treatment are expected, or where maintenance repairs might require a lane closure or otherwise puts maintenance personnel at high risk. Confer with MDOT SHA District Maintenance on whether this end treatment should be used as opposed to a normal TS-NG. Care must also be exercised if the height of a specific system could impact sight distance.

When none of the standard end treatments are applicable, a "Bullnose" end treatment may be acceptable. A Bullnose end treatment is essentially a crashworthy 180º± radius barrier and conforms to NCHRP 350 TL-3. *The minimum distance to an obstacle from the front of the Bullnose is specified in section 8.4.2.1.1 of the RDG*. Due to the amount of deflection in an end-on impact, the nose of the system should be located a minimum of 62 feet in advance of the shielded object and any transition to a bridge rail should not begin sooner than the ninth post from the nose. The Bullnose end treatment has not yet been MASH tested and if this treatment is used, prior approval by OHD is required.

Two flow charts are presented on the following pages which serve as guidance for the selection of an appropriate end treatment for roadside (**Flow Chart 1**) and median (**Flow Chart 2**) applications. These flow charts do not account for all conditions or situations; therefore, sound engineering judgment should be used in selecting the appropriate end treatment for all situations.

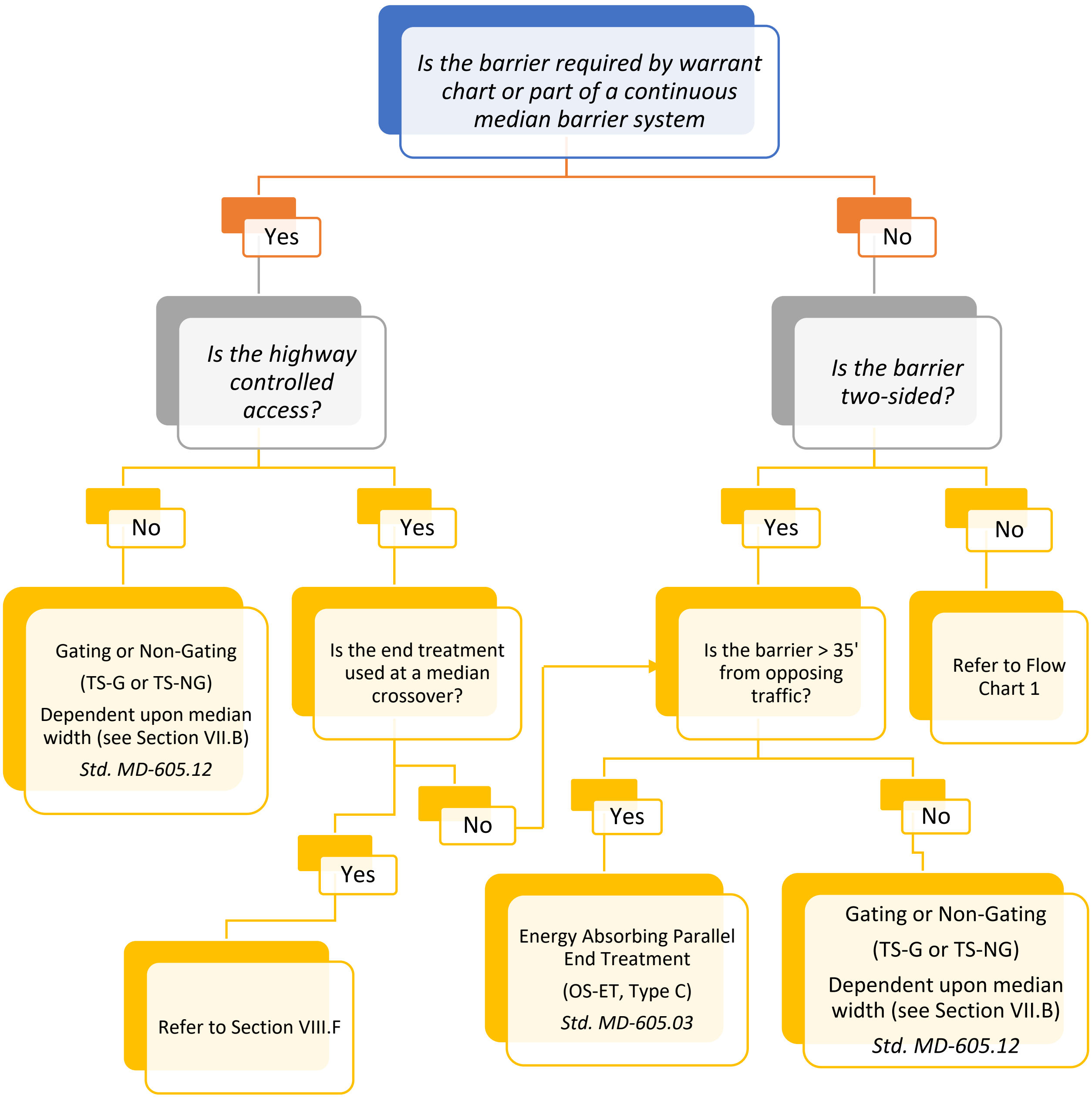
Flow Chart 1: Roadside End Treatment Selection Guidance



*Use appropriate LON; Refer to Section VII.A.1

Provide necessary grading adjustment for end treatments to allow system to operate at maximum potential.

Flow Chart 2: Median End Treatment Selection Guidance



VIII. Common Barrier Installation Treatments and Conditions

The following special case conditions and treatments are examples of actual field situations that have been addressed and are provided to assist in determining the most appropriate traffic barrier placement and end treatment. Note that the example provided for each situation may not be the best option and that other alternatives should be investigated. It is impossible to include or document all field conditions that require treatment or all possible treatments for a given situation. Good engineering judgment in applying proper barrier principles is to be used for all situations. (The following acronyms are used in the figures and discussion below: Edge of Travel Lane [EOTL], Edge of Shoulder [EOS], Traffic Barrier W-Beam – Median Barrier [TBWB-MB].)

A. *Roadside Barrier to Shield a Critical Embankment (Figure 7)*

Many existing barrier installations intended to shield critical embankments are significantly short of the required LON. Identifying the upstream face of the obstacle can be difficult. When there is a non-crashworthy obstacle at the toe of the slope, the upstream face of the embankment obstacle will be the location where the slope measures steeper than 4:1, Point 1 as shown in **Figure 7**. If the area at the toe of slope is free of obstacles and is expected to remain so, the upstream face of the embankment obstacle will be the location where the slope measures steeper than 3:1, Point 2. If there are obstacles on the slope, regardless of the steepness, LON will need to be determined for these obstacles. Refer to Section IV.F for LON determination and definition of factors.

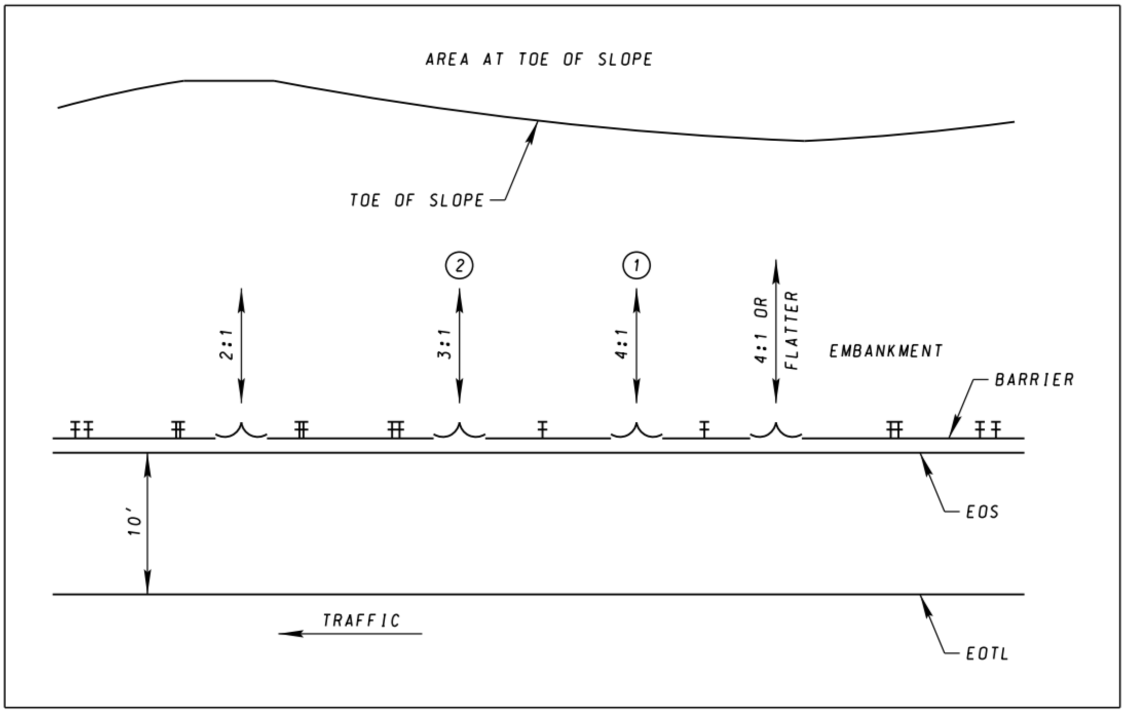


Figure 7: Example: Critical Embankment

Example: High speed/ high volume roadway with Design Clear Zone = 30' (L_C = 30'),
L_R = 475', L_2 = 12' (2' W-Beam offset + 10' shoulder)

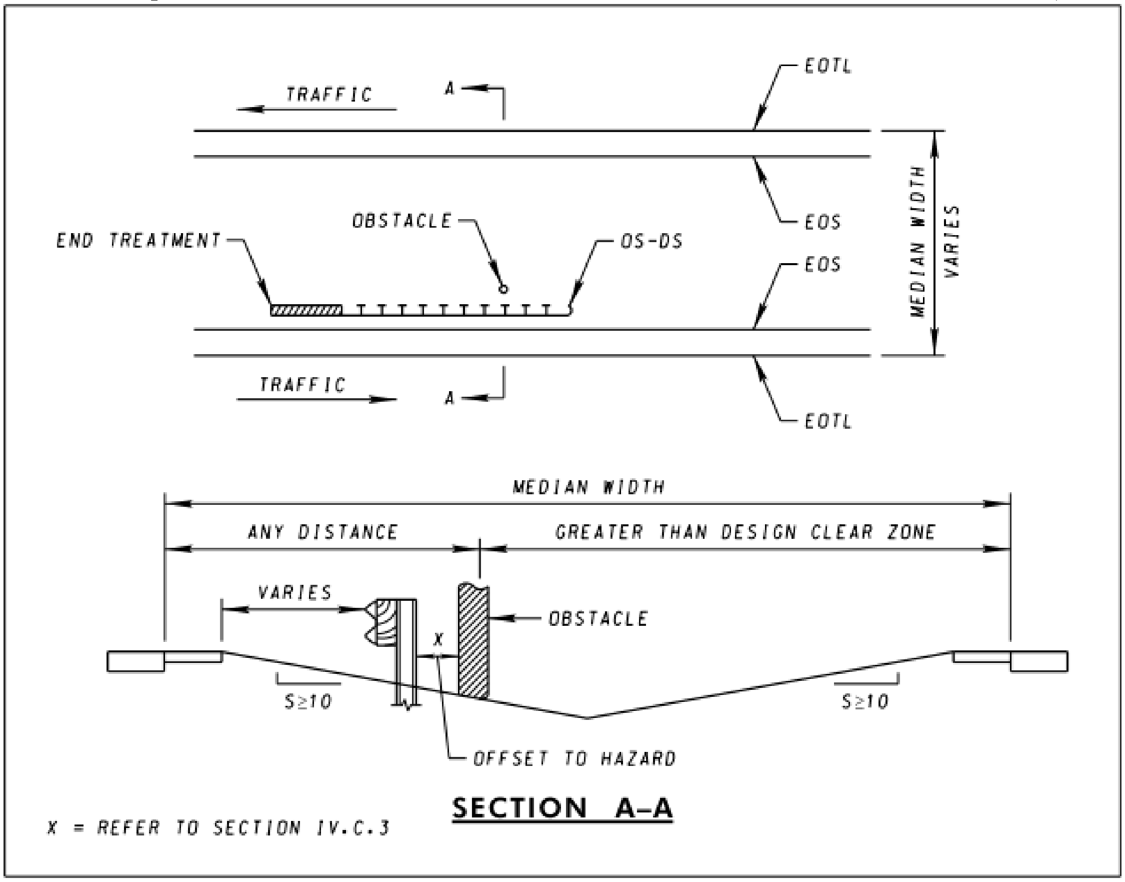
$$LON = \frac{L_R \times (L_C - L_2)}{L_C} = \frac{475 \times (30 - 12)}{30} = 285'$$

*The LON is 285 feet in **advance of** Point 1 or Point 2, whichever is applicable. Accounting for 12'-6" standard lengths of guardrail, 23 sections of guardrail are needed in advance of Point 1 or Point 2 equating to a total distance of 287.5 feet.*

B. Isolated Obstacle in Open Median (no continuous median barrier)

1. The obstacle is within the Design Clear Zone of only one roadway (**Figure 8**)

   Design the LON for a typical roadside obstacle. *If the back of the barrier is within the "Barrier Optional" or "Evaluate Need for Barrier" regions of Figure 6-1 of the RDG, a TBWB-MB is required.* Since the obstacle is outside of the design clear zone for the opposing edge of travel lane and is of short length, barrier is not necessarily required along that side (but the TBWB-MB rail could be split to shield the back of the obstacle if the obstacle is close behind the barrier).



Note 1: If the end treatment is 35 feet or less from the opposing traffic, use a two-sided end treatment if the barrier is a TBWB-MB. Do not use a two-sided end treatment to end single face W-Beam in the median.

Figure 8: Example: Median, Flat Side Slope, Isolated Obstacle Inside Design Clear Zone of One Roadway

2. The obstacle is within the Design Clear Zone for both roadways (Figures 9 and 10)

   If the median slopes are flat (10:1 or flatter), the barrier would be placed on either side of the obstacle (just beyond the deflection distance) and would be terminated by bringing both runs together, with the appropriate approach flare rates, to a TS-G end treatment. Typically, the upstream end treatment would be placed farther away from approaching traffic than the downstream end treatment to minimize nuisance strikes from approaching traffic (see **Figure 9**).

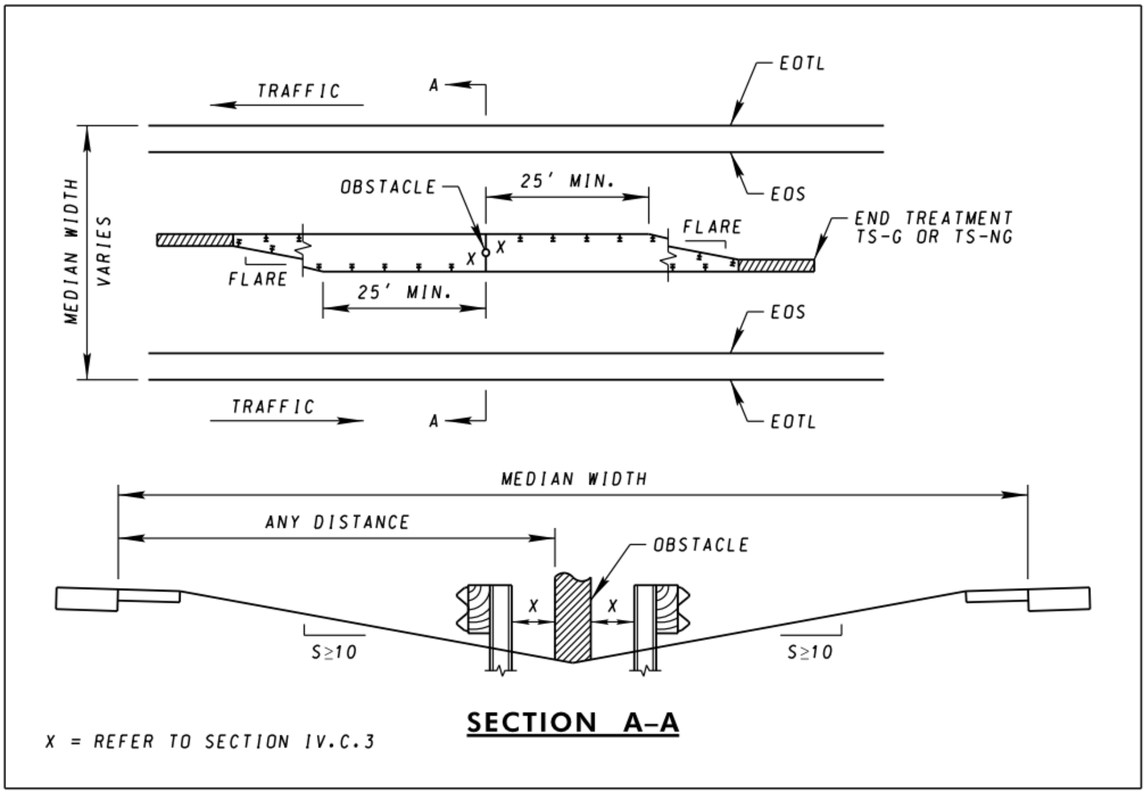
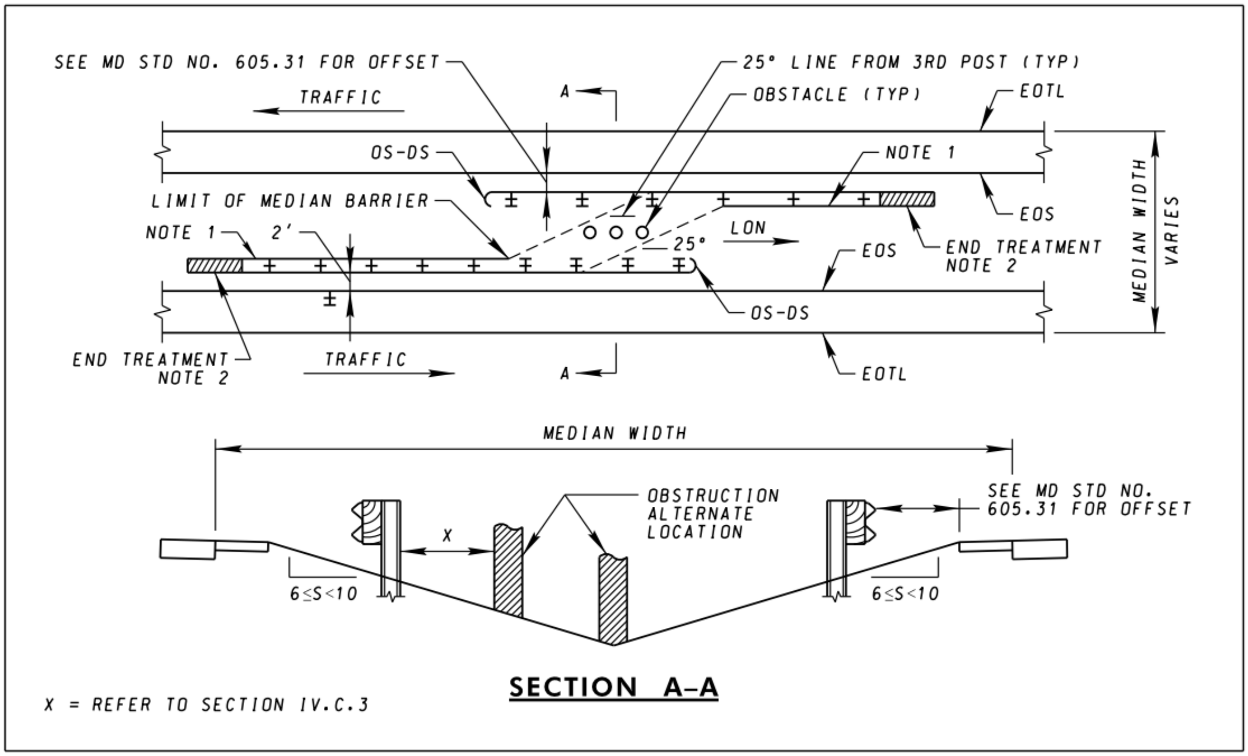


Figure 9: Example: Median, Flat Side Slope, Isolated Obstacle Inside Design Clear Zone of Both Roadways

If the median slopes are steeper than 10:1 but no steeper than 6:1, the location of the barrier must comply with the placement criteria for barrier on slope as shown on Std. MD-605.31 (see **Figure 10**). The barrier would extend upstream by the LON and have the appropriate end treatment. The downstream ends would be terminated with OS-DS end treatments as described in Section VII.



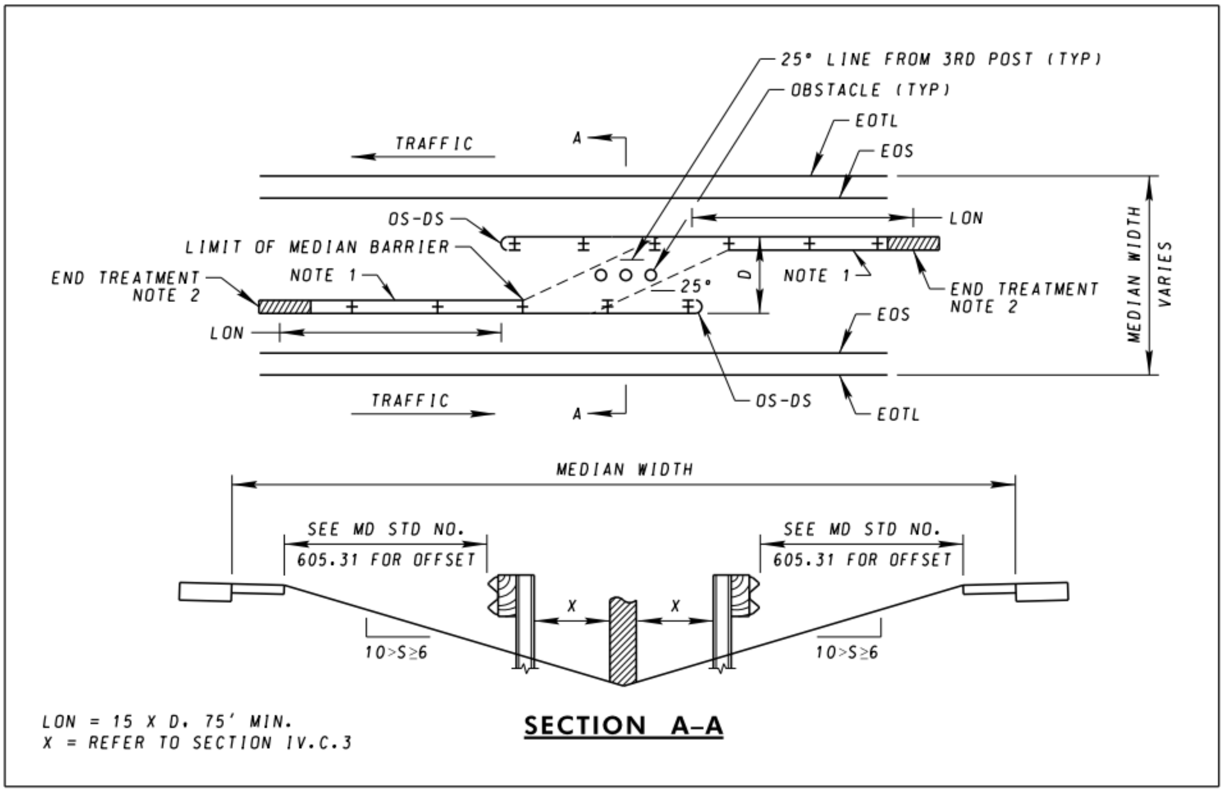
Note 1: If the back of the barrier is within the "Barrier Optional" or "Evaluate Need for Barrier" regions of Figure 6-1 of the RDG, a TBWB-MB is required

Note 2: If the end treatment is 35 feet or less from the opposing traffic, use a two-sided end treatment if the barrier is a TBWB-MB. OS-ET can be used beyond 35 feet even if the barrier is a TBWB-MB. Do not use a two-sided end treatment to end single face W-Beam in the median.

Figure 10: Example: Median, Steeper Side Slope, Isolated Obstacle, Barrier Near Shoulder Edge, Overlap Installation

However, if the barrier can be placed down the slope, barrier should be placed on each side of the obstacle. There are two options to terminate it:

1. If drainage can be accommodated, the two parallel barriers would be brought together and a TS-G end treatment could be used as shown in **Figure 9**.
2. Upstream end treatments would be in accordance with **Figure 11** with OS-DS end treatments on the downstream ends. The “controlling” obstacle for the LON (the amount of rail in advance) would be the OS-DS end treatments and the LON would be 15 times the distance between the barriers, but not less than 75 feet.



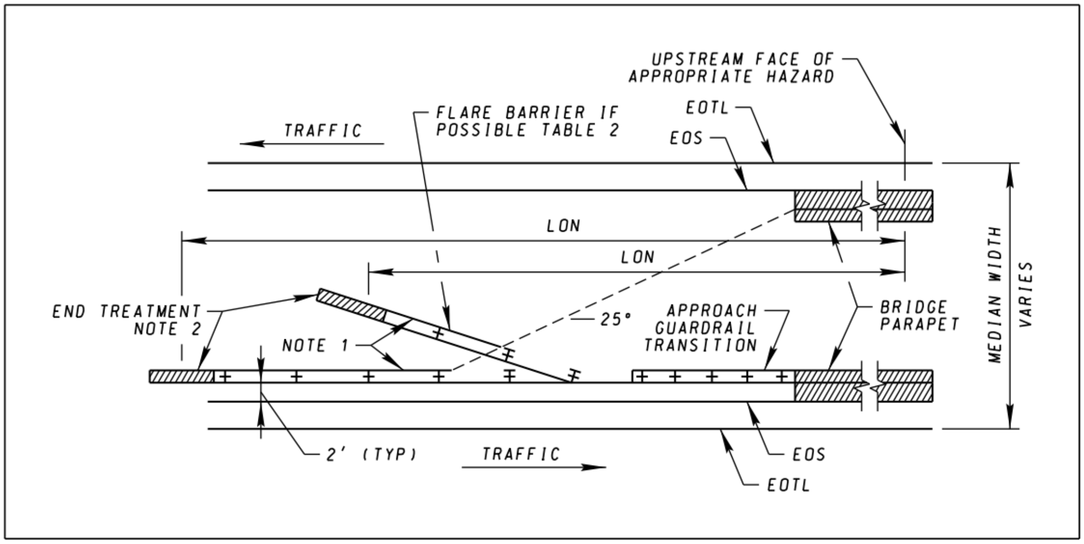
Note 1: If the back of the barrier is within the “Barrier Option” or “Evaluate Need for Barrier” regions of Figure 6-1 of the RDG, a TBWB-MB is required

Note 2: If the end treatment is 35 feet or less from the opposing traffic, use a two-sided end treatment if the barrier is a TBWB-MB. OS-ET can be used beyond 35 feet even if the barrier is a TBWB-MB. Do not use a two-sided end treatment to end single face W-Beam in the median.

Figure 11: Example: Median, Flat Side Slope, Isolated Obstacle, Barrier Greater Than or Equal to 12 feet from the Shoulder Edge

C. "Elephant Trap" in an Open Median (no median barrier) (Figure 12)

An "elephant trap" is defined as the opening between dual bridges on a divided roadway. As shown in **Figure 12**, barrier is designed for the approach end of the near side parapet only as a roadside barrier using the procedure in Section IV.F, with the back of obstacle being either the opposing traffic bridge parapet or the Design Clear Zone, whichever is less. No barrier is used on the departure end of the parapet unless the median has an obstacle not shielded by the end of the parapet determined by the 25º line. If there is an obstacle beyond this line, the W-Beam barrier would be extended to the appropriate length to place an OS-DS end treatment.



Note 1: If the back of the barrier is within the "Barrier Optional" or "Evaluate Need for Barrier" regions of Figure 6-1 of the RDG, a TBWB-MB is required.

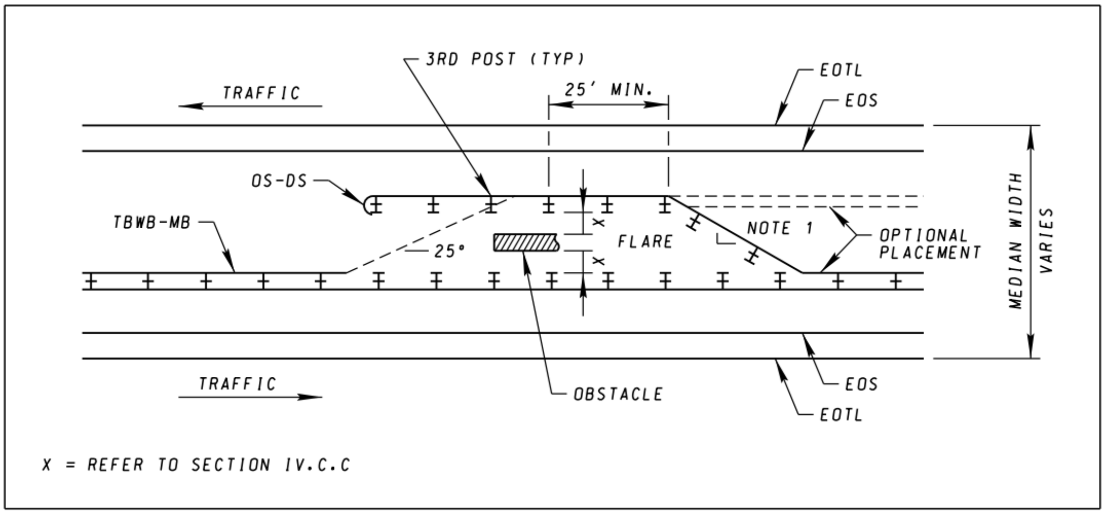
Note 2: If the end treatment is 35 feet or less from the opposing traffic, use a two-sided end treatment if the barrier is a TBWB-MB. OS-ET can be used beyond 35 feet even if the barrier is a TBWB-MB. Do not use a two-sided end treatment to end single face W-Beam in the median.

Figure 12: Example: "Elephant Trap", Open Median

D. *Isolated Obstacle in Median with Continuous Median Barrier (Figure 13)*

As shown in **Figure 13**, the upstream near side face of the median barrier would be extended in front of the obstacle for both approaches. For W-Beam barrier, an OS-DS traffic barrier end treatment would terminate one end of the separated barrier and the TBWB-MB would begin again where the 25º line from the third post would intersect the continuing barrier.

Note: If median barrier is carried continuously on one side of the roadway and a separate run of single-sided barrier is placed along the other roadway, the median barrier is required to have a back rail only where it is within a longitudinal distance, determined as 10 times the transverse separation between the barriers, or 300 feet maximum, from the beginning of the end treatment for the single-sided barrier.

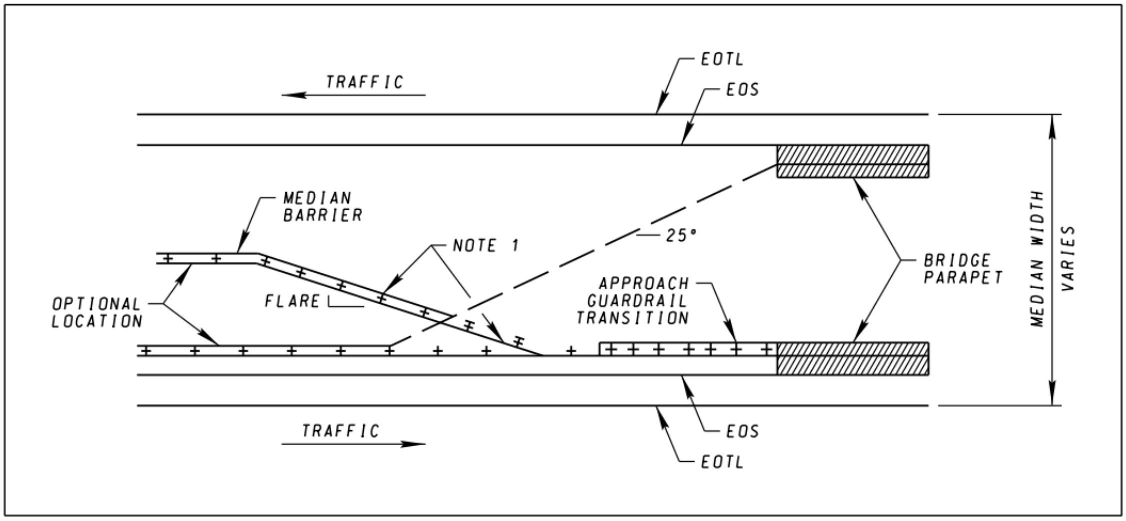


Note 1: For W-Beam traffic barrier, barrier should not be placed in areas that are not areas recommended in MD Std. No. 605.31 unless the slopes are modified as described in Section V of these Guidelines.

Figure 13: Example: Isolated Obstacle, Continuous Median Barrier

E. *'Elephant Trap" in Median with Continuous Median Barrier (Figure 14)*

The median barrier will be connected into the approach side of the bridge parapet (see **Figure 14**). No barrier is required at the departure end of the bridge parapet (unless there is an obstacle in the median). For TBWB-MB, the two-sided barrier will continue until it becomes shielded by the downstream end of the parapet for the opposing traffic bridge determined by the 25º line, then single-sided barrier can continue to the upstream side parapet (with appropriate transition).

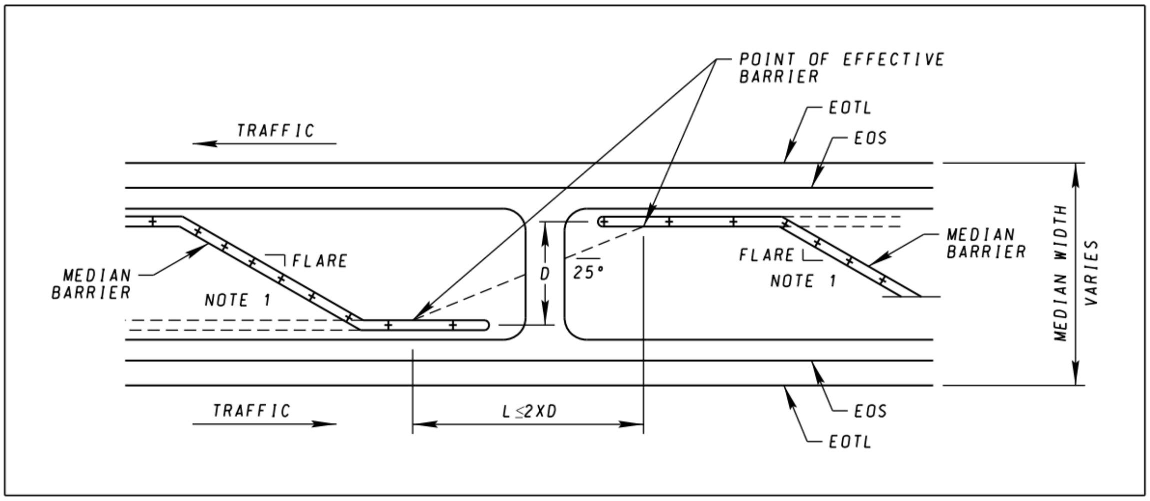


Note 1: For W-Beam barrier, barrier should not be placed in areas that are not recommended in Std. MD-605.31 unless the slopes are modified as described in Section V of these Guidelines.

Figure 14: Example: "Elephant Trap", Continuous Median Barrier

F. Median Opening in Continuous Median Barrier (Figure 15)

When median barriers must be broken to provide emergency or maintenance access, or cross streets on uncontrolled or partially access controlled facilities, there are several methods for treatment of the ends of the barrier. Most commonly, crashworthy end treatments are applied to the barrier as described in Section VII. The most effective and preferred treatment is to offset the departure end treatments to the nearside roadways. A cost-effective treatment is not to use crashworthy end treatments, but to offset the blunt ends of the barrier such that they are hidden by each other (see **Figure 15**). The maximum width of the opening between the ends of effective barrier (L) is determined by the 25º line between the points of effectiveness of the barrier (approximated by twice the offset [D] between the points of effectiveness). For concrete barrier, the point of effectiveness is the actual end of the barrier. For W-Beam barrier using an OS-DS end treatment to establish tension, the point of effectiveness is the third post. Designs establishing redirection through the entire length of the barrier (in essence, an energy absorbing, non-crashworthy end treatment) allow for elimination of any ineffective barrier and maximization of the actual available opening width. This offset configuration should be used even when the barrier ends cannot be protected by the overlap such that crashworthy end treatments are used.



Note 1: For W-Beam barrier, barrier should not be placed in areas that are not recommend in Std. MD-605.31 unless the slopes are modified as described in Section V of these Guidelines.

Figure 15: Example: Median Opening in Continuous Barrier

G. Non-Access Controlled Roadways – Access Breaks in Roadside Barrier

When an entrance causes a break in what would otherwise be a continuous run of barrier, and provision of an OS-ET would not provide any substantial benefit, an OS-R end treatment may be the best alternative as detailed on Std. MD-605.13. This end treatment is only for roadways with a posted speed limit less than or equal to 40 MPH and ADT less than 10,000.

IX. Gore Treatments

Many times, the area between a continuing roadway and an exit ramp, or between two diverging roadways, contains obstacles requiring barrier to be placed along both traveled ways. The design of the end treatments for these barriers includes several options, as follows:

A. Access Between Barrier does not Present Significant Hazard (Figure 16)

If a vehicle passing between the end treatments for both runs of barrier will not result in more serious harm than impacting a two-sided end treatment, standard roadside barrier end treatments (OS-ET) may be used. However, care must be taken to ensure that their installation will allow each end treatment to work as designed. The designer should also determine if there is a risk of impacting the back of the one-sided end treatments. Desirably, there should be at least 7 feet lateral separation between the end posts so that no more than one end treatment would be impacted (see **Figure 16**). The end treatment must have sufficient clear area behind it to allow the distorted rail element(s) to extrude out the back without interference; no end treatment should be used without this clear area. (An approximation of the area needed would be the area inside a 45º line extending back behind the system from post #1.) Where there is concern about this clear area in back, an end treatment that extrudes its distorted rail to the traffic side of the barrier or collapses upon itself with no extruded rail should be used.

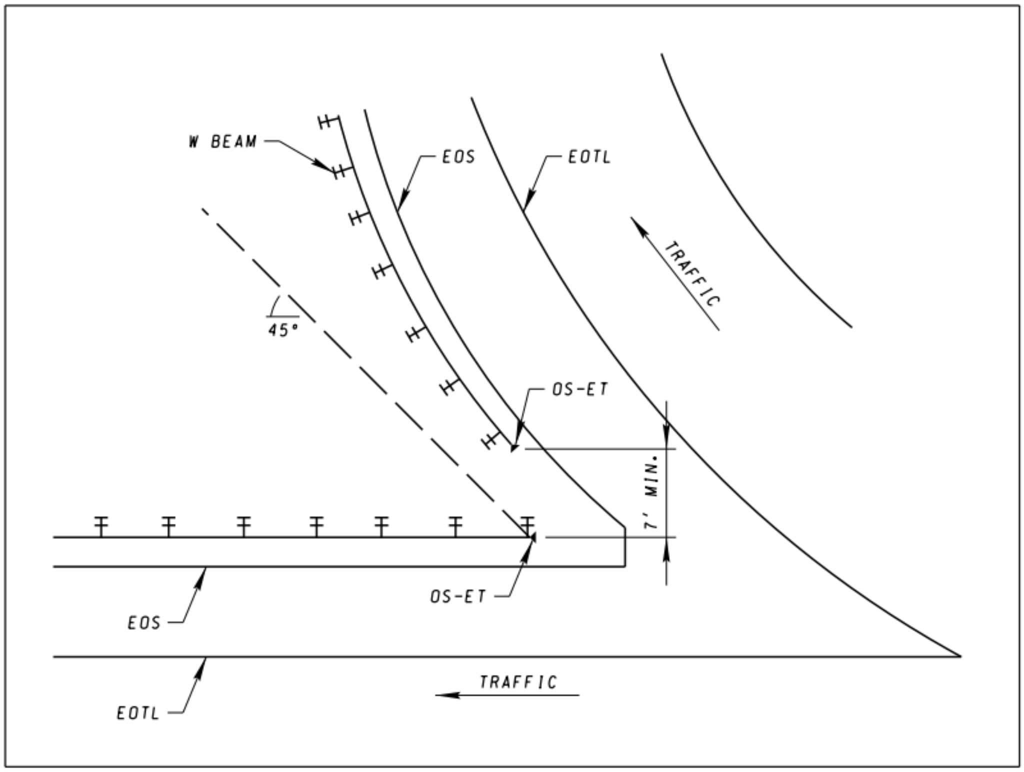


Figure 16: Gore End Treatment – OS-ET

B. Access Between Barrier must be Prevented

The two barrier runs are brought parallel to each other, and a two-sided end treatment (TS-NG) is provided. There must be sufficient distance in advance of the standard barrier to install the two-sided end treatment. If there is a likelihood of frequent severe impacts, a TS-NG-LM end treatment may be the most cost-effective. Regardless of the type of end treatment selected, closure of access to the gore infield needs to be discussed with MDOT SHA District Maintenance prior to final design/installation.

If the barrier runs cannot be brought parallel, or there is insufficient room, a wide TS-NG end treatment that can cover the gap may be necessary. If there is very little likelihood of an impact, or if the width required to be shielded is greater than what is available with the TS-NG, the use of sand barrels as an end treatment is acceptable (Std. MD-104.01-70 through Std. MD-104.01-73). If sand barrels are used, the standard barrier must be anchored to develop tension in the system using OS-DS end treatments and, because sand barrels are non-redirective crash cushions, the barrier ends must be shielded behind the last sand barrel. *Sand barrels are discussed in section 8.4.3 of the RDG.* If the sand barrels are unacceptable (clear with MDOT SHA District maintenance before using them) and the standard barrier runs diverge at a wide angle, use of the special NCHRP 350 approved Bullnose may be the best solution as this is, in effect, a radius treatment that has been designed to be crashworthy. *The minimum distance to an obstacle from the front of the Bullnose is specified in section 8.4.2.1.1 of the RDG*. Contact OHD for details of this design.

X. Upgrading Traffic Barrier and End Treatments

Any new barrier installation or barrier that is impacted by construction and will be replaced as part of a project should comply with the MASH 2016 testing standards. If a MASH compliant version of the system being upgraded does not exist, it is permissible to use a system tested to NCHRP Report 350 with approval of OHD (see Section III for more information).

Replacement of existing traffic barrier that is not impacted by a project, but is within the project's limits, is heavily dependent on the funding type that the project falls under, project scope, the condition of the existing barrier, and whether it meets previous NCHRP 350 crash testing standards. Existing traffic barrier that is damaged beyond repair shall be replaced with traffic barrier that complies with MASH 2016.

Table 9 provides general guidance on how to approach traffic barrier replacement based on project funding and scope. Any traffic barrier that is impacted by a project will need to be replaced, regardless of the funding type, but the extent of impact and replacement will vary among different funding sources and the scope of the project and the types of funds expended. Safety-focused projects should, by their nature, look more carefully at all existing barrier in the project limits and replace as necessary or as directed, depending on the scope and funding of the project. A roadway reconstruction project may replace only that barrier, which is impacted by construction, leaving existing barrier that is not damaged beyond repair and compliant with NCHRP 350. When traffic barrier is damaged beyond repair, it shall be upgraded to the current standards (MASH 2016), depending on the project type and scope. The length of barrier that gets replaced will also be dependent on the project scope.

Below is some general guidance for replacement of W-Beam traffic barrier:

1. All replacement barrier should meet the current standard (MASH 2016 compliant) unless noted.
2. Any end treatments affected by the replacement of barrier shall be replaced with an end treatment that is currently listed on the MDOT SHA QPL.
3. Turndown style (OS-TD) end treatments shall be replaced with a compliant end treatment (see Section VII).
4. *To transition from new barrier (height specified on Std. MD-605.23, splice at mid-span) to existing barrier (shorter height, splice at post), see Std. MD-605.32.*

For maintenance contracts and for maintenance repairs after a crash, please see **Table 10** for guidance on replacement of damaged sections of existing traffic barrier.

Table 9: W-Beam Traffic Barrier Replacement Matrix by Project Type

Project Type	Should Replace	Consider Replacement
Reconstruction Projects	• Meet current standards with new runs of barrier or barrier that is impacted by construction • Barrier that is damaged or less than 28 inches should be replaced with W-Beam meeting current standards • Steel offset blocks should be replaced with approved wood or composite offset blocks • End treatments within the limits of work that are damaged or not on the current QPL should be replaced	• All existing barrier within Limit of Disturbance (LOD) (depending on purpose/scope of improvements)
Intersection Improvements/ Spot Safety	• Meet current standards with new runs of barrier or barrier that is impacted by construction • Barrier that is damaged or less than 28 inches should be replaced with W-Beam meeting current standards • Steel offset blocks should be replaced with approved wood or composite offset blocks • End treatments within the limits of work that are damaged or not on the current QPL should be replaced	• All existing barrier within LOD (depending on purpose/scope of improvements)
Resurfacing	• Barrier that is damaged or less than 27 inches should be replaced with W-Beam meeting current standards • Steel offset blocks should be replaced with approved wood or composite offset blocks • End treatments within the Limit of Work that are damaged or of the turndown type should be replaced	• Barrier that is less than 29 inches should be replaced with W-Beam meeting current standards • On interstates and other high-speed facilities, replace end treatments that are not on the current QPL
Areawide Traffic Barrier Contracts	• Any barrier impacted by construction • Barrier that is damaged or less than 27 inches should be replaced with W-Beam meeting current standards • Steel offset blocks should be replaced with approved wood or composite offset blocks • End treatments within the Limit of Work that are damaged or of the turndown or two-sided turndown type should be replaced	• Barrier that is less than 29 inches should be replaced with W-Beam meeting current standards • On interstates and other high-speed facilities, consider replacing end treatments that are not on the current QPL
Bridge Rehabilitation and Replacement	• Any barrier impacted by construction • Ensure that transitions from W-Beam to concrete bridge parapet meet current standards • End treatments within the LOW that are damaged or of the turndown two-sided turndown type should be replaced	
Pedestrian/Bike Improvements	• Any barrier impacted by construction	
Hydraulics/ Environmental	• Any barrier impacted by construction	

Table 10: W-Beam Traffic Barrier Replacement Matrix for Maintenance Contracts

Length of Impacted Section	Replacement Height	Replacement Splice Location	Replacement Offset Block	Replacement End Treatment (if need)
100 feet or less	Same height as existing rail[1]	Same as existing rail (likely at the post)	Composite or wood	Same type as existing, ensuring that the product is on the QPL[3]
More than 100 feet	New standard height[2]	New standard location (mid-span between posts)	Composite or wood	Same type as existing, ensuring that the product is on the QPL[3]

[1] *If the height of the existing rail is less than 27 inches (to the top of the barrier), the traffic barrier should be programmed for full replacement as prioritized by the MDOT SHA District.*

[2] *To transition from the new barrier (height specified on MD STD No. 605.31, splice at mid-span) to existing barrier (shorter height, splice at post), see MD STD No. 605.32.*

[3] *OS-TD (turndown) end treatments are prohibited on all roadways.*

Concrete barriers are rigid barriers that require almost no maintenance because they are rarely damaged due to an impact. When concrete barriers are repaired, it is often to just replace the damaged barrier in kind. While this is often the best course of action, regardless of the shape or height of the barrier, there are times when replacing a section of the barrier may be advantageous. Please see **Table 11** for concrete barrier repair and replacement guidelines. When the location warrants a TL-4 barrier, existing 34-inch F-shape barrier should be upgraded to a 42-inch barrier. See Section IV for guidance regarding roadside concrete barrier and Section V for guidance regarding median barrier.

Table 11: Concrete Barrier Repair/Replacement Matrix

Replace with Existing Shape/Height	Upgrade Barrier to TL-4 barrier
• If affected barrier area is in the middle of a run of barrier • If conditions still warrant a TL-3 barrier • If a major reconstruction project is planned in the area that will impact or replace concrete barrier	• If there is a terminus of the barrier within 100 feet of the affected area, replace from affected area to terminus • If changing traffic conditions warrant a new TL-4 barrier (reconstruction)

XI. Urban Street Section

Urban streets provide direct access to adjacent properties in developed areas. There are sidewalks, driveways, storefronts, porches, utility poles, fire hydrants, and other objects adjacent to the roadway. Traffic barriers following curb radii at intersections have a higher potential for being impacted at adverse angles. These installations also have the potential to impede pedestrian traffic. There are also certain areas where the use of traffic barrier end treatments can create sight distance problems. For these reasons, refrain from installing traffic barrier on curbed urban street sections. Type A curbs/combination curb and gutter are generally used on these types of roadways and, although they do not provide any significant redirection capability, they are a visual deterrent to the motorist.

There are site specific applications where traffic barrier is appropriate in urban street sections. Traffic barriers are usually placed at bridges where errant vehicles could fall onto roadways below, in high fill areas, in sensitive areas such as school playgrounds, or where errant vehicles could impact hazardous storage structures. *When W-Beam must be installed, it should be installed according to Std. MD-605.31 and with guidance from section 10.2.1.1 of the RDG, pages 10-7 and 10-8.*

End treatments should conform to the applicable standards for the type of end treatment being installed. If the section of roadway where an end treatment is installed has curbing, the curb should be eliminated or lowered to a maximum height of 2 inches in advance of and through the limits of the end treatment. If sidewalk is behind the curb, the sidewalk area should be lowered in a similar fashion as well, considering potential drainage and other secondary impacts.

XII. Pavement Overlay Considerations

Pavement overlays may affect the height at which a vehicle impacts traffic barrier. Any concrete barrier that is less than 32 inches or 39 inches high, for TL-3 and TL-4 respectively, after a pavement overlay is placed needs to be modified to the appropriate height (see **Figure 17**). Existing W-Beam with splices between posts whose height after pavement overlay is less than 31 inches must be reset to a height of 31 inches above the new pavement surface. Existing W-Beam with splices at the post whose height after pavement overlay is less than 28 inches should be replaced with W-Beam meeting current standards. Existing W-Beam that is damaged beyond repair shall be replaced with traffic barrier meeting current standards. If the existing W-Beam barrier to be reset has steel offset blocks, the offset blocks must be replaced with approved wood or composite offset blocks. See Section X for further information regarding upgrading existing traffic barrier and end treatments.

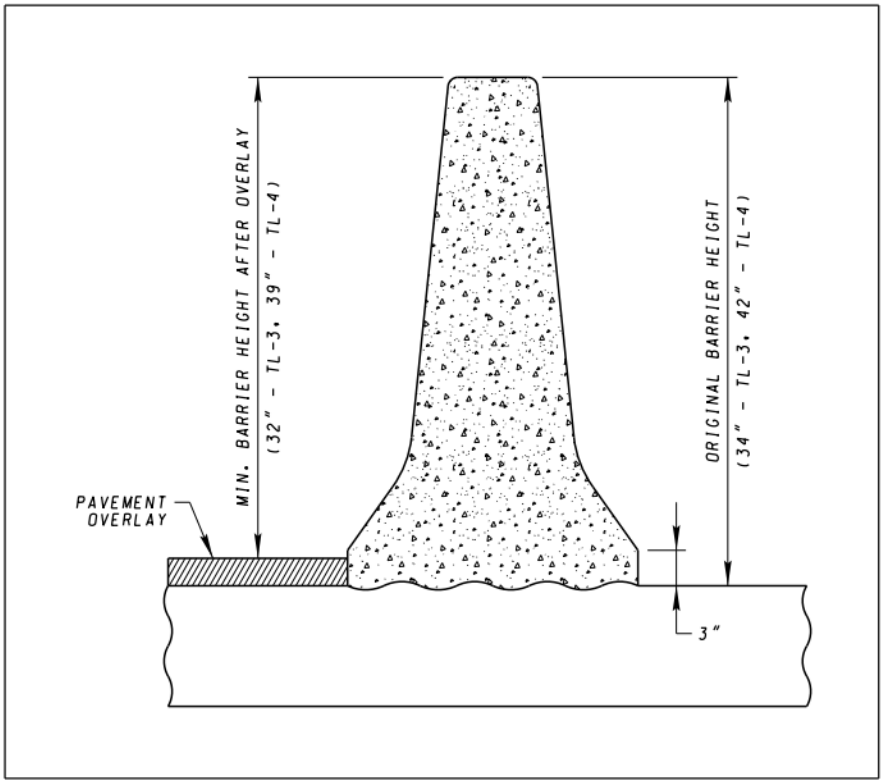


Figure 17: Pavement Resurfacing Considerations for Concrete Barrier

XIII. Temporary Traffic Barrier

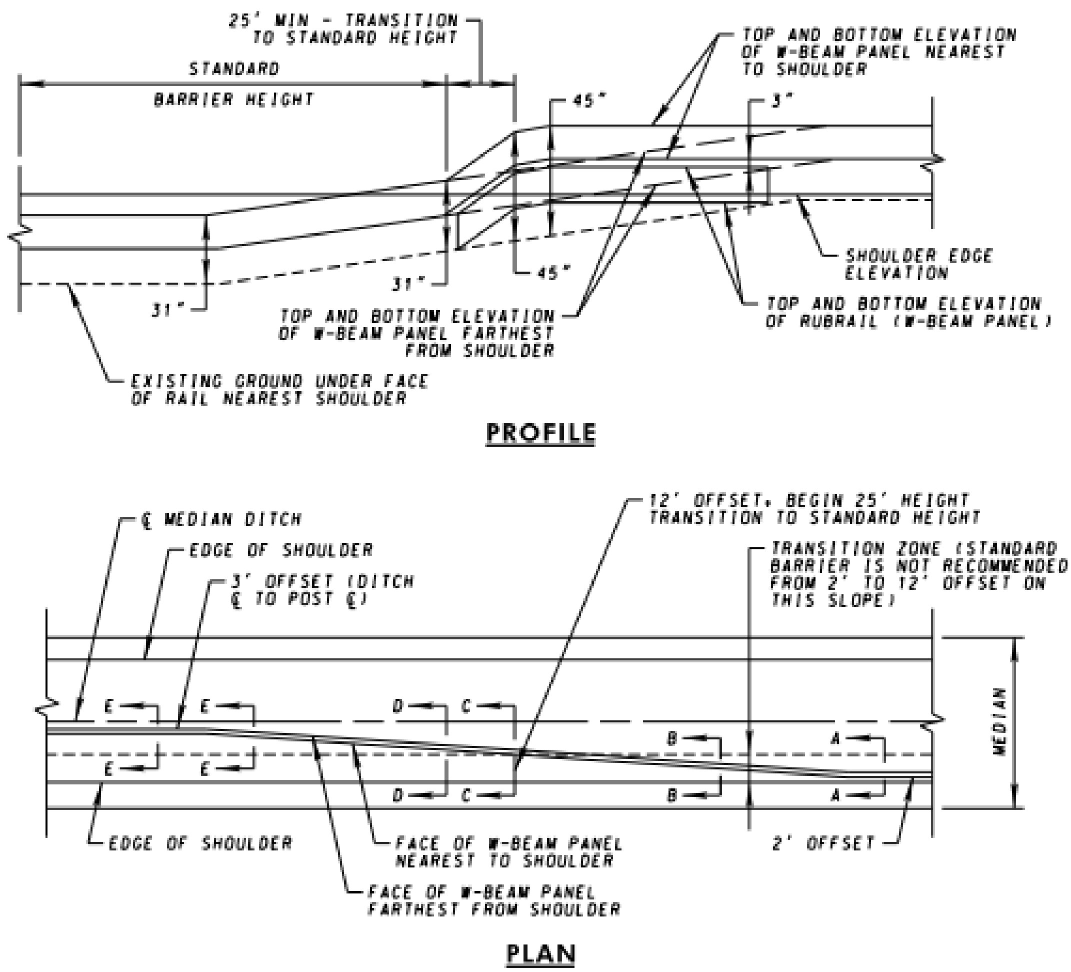
Temporary traffic barriers are used in work zones to provide positive protection for workers, reduce work zone intrusions by errant vehicles, protect construction such as falsework for bridges or pavement edge drop-offs, separate two-way traffic, or separate pedestrians from vehicular traffic. For specific requirements regarding the use of temporary traffic barrier in work zones, refer to the MDOT SHA Policy for the Use of Temporary Traffic Barriers in Work Zones. *Additional information regarding temporary traffic barriers can be found in section 9.2.1.2 of the RDG.*

Temporary traffic barrier used on roadways for work zones must be crashworthy. The FHWA/AASHTO Joint Implementation Agreement provides guidance for when MASH compliant temporary traffic barrier is required and provides some allowances for the use of NCHRP Report 350 compliant temporary traffic barrier. Only traffic barrier systems shown on the QPL are approved for use. Concrete temporary traffic barrier systems are typically used in work zones. These systems develop tension continuity from one segment to the next. These systems are not considered to be rigid systems as they exhibit deflection upon impact. *Minimizing deflection in temporary concrete barrier systems is discussed in section 9.2.1.2.16 of the RDG.* Temporary concrete barrier used on roadways is not designed for use on bridges; for bridge temporary concrete barrier, refer to the bridge plans or details.

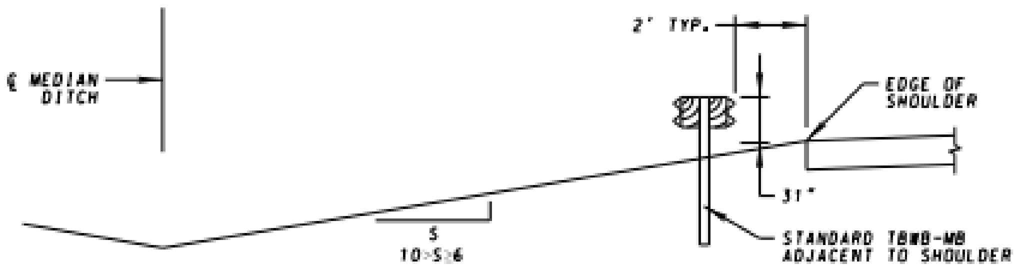
End protection is required when using temporary traffic barrier. Unless the barrier segments themselves are firmly anchored, they will incur even more significant deflection if impacted near a free end – full redirection capability generally does not begin until around the fifth segment. Likewise, the blunt end of the barrier must be shielded. If the system is free-standing (without an approved transition to permanent traffic barrier on the upstream end), an approved end treatment or sand-filled barrel array crash cushion from the QPL shall be applied to the upstream end. For free-standing locations with a higher likelihood of impacts and/or where lateral space limitations preclude the use of sand-filled barrel arrays, the use of the of the TS-NG or TS-NG-LM type end treatments can be called for. *Section 9.3.1 of the RDG discusses crash cushions used in work zones, including sand filled plastic barrels in section 9.3.1.1 and redirective systems in sections 9.3.1.2 and 9.3.1.3*

Use of a "Movable Barrier System" may be appropriate for some projects. This system allows the special barrier segments to be moved from one location to a parallel location up to 16 feet away in a very short time (hours). *An example of such a system can be found in section 9.2.1.3.1 of the RDG.* This permits use of a travel lane during certain periods while providing a protected work area during other periods for the same area.

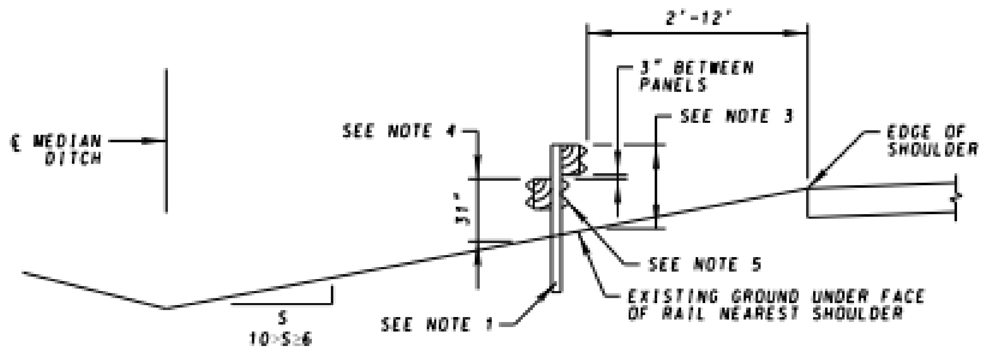
Appendix A
Double Rail Transition
(Across Slopes 10:1 to 6:1)



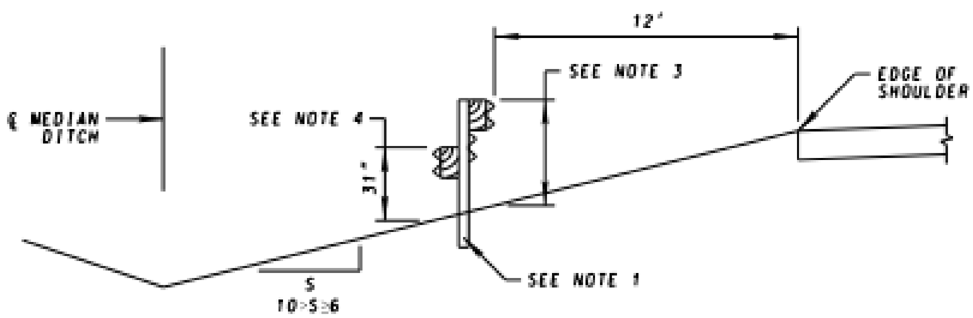
DOUBLE RAIL TRANSITION
(ACROSS SLOPES 10:1 TO 6:1)



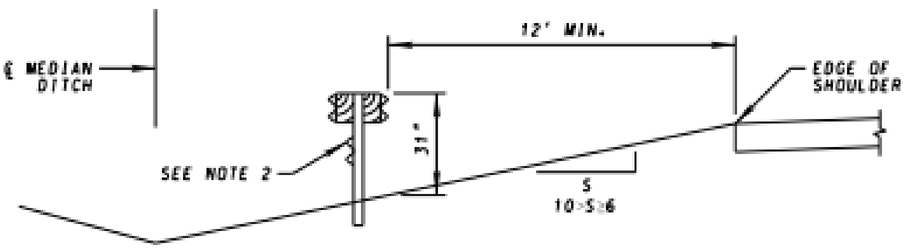
SECTION A-A
STANDARD TBWB-MB AT 2' OFFSET



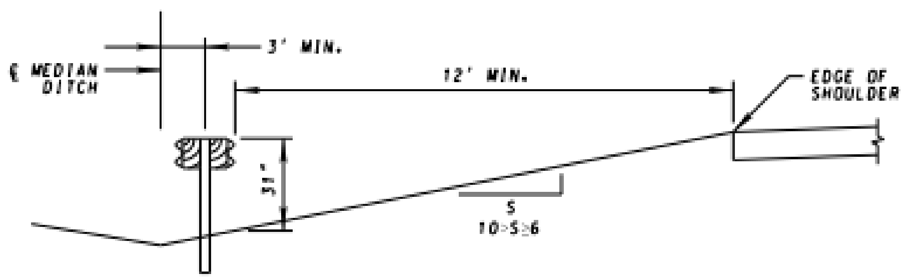
SECTION B-B
TRANSITION ZONE – 2' TO 12' OFFSET



SECTION C-C
END OF TRANSITION AT 12' OFFSET



SECTION D-D
TBWB-MB AT THE END OF HEIGHT TRANSITION



SECTION E-E
NORMAL TBWB-MB AT 12' OR GREATER OFFSET

DOUBLE RAIL TRANSITION
(ACROSS SLOPES 10:1 TO 6:1)

NOTES

1. USE 8' POSTS FOR THE DOUBLE RAIL TRANSITION WHEN THERE IS A BOTTOM RAIL. OFFSET BLOCKS ARE NOT REQUIRED FOR THE BOTTOM RAIL.
2. THE BOTTOM RAIL SHALL BE TUCKED BEHIND AND BOLTED TO POST AT D-D USING A 5/8" DIAMETER HEXAGONAL HEAD BOLT.
3. THE TOP OF RAIL SHALL MAINTAIN ITS HEIGHT RELATIVE TO THE EDGE OF SHOULDER UNTIL A MAXIMUM HEIGHT OF 45" ABOVE THE GROUND IS ATTAINED AT FACE OF RAIL.
4. WHEN MEDIAN BARRIER IS TRANSITIONING ACROSS SLOPES THE HEIGHT OF THE RAIL FARTHEST FROM TRAFFIC WILL BE 31" ABOVE THE GROUND WHEN THERE ARE TWO RAILS ON THE FRONT. IT WILL BE THE SAME HEIGHT AS THE FRONT RAIL WHEN ONLY A SINGLE RAIL.
5. USE RUBRAIL (W-BEAM) WHEN BOTTOM OF TOP RAIL IS MORE THAN 18" ABOVE THE GROUND AT THE FACE OF RAIL. ATTACH THE RUBRAIL TO POST 3" BELOW BOTTOM OF TOP RAIL.
6. TRANSITION HEIGHT FROM HEIGHT ABOVE GROUND AT SECTION C-C TO HEIGHT OF 31" OVER A LENGTH OF 25' MINIMUM.
7. USE FLARE RATE BASED ON DESIGN SPEED.

Appendix B
Supplemental References

The following are links to supplemental references that are complimentary to these Guidelines. The most current adopted versions, including errata should be consulted as needed.

- *MDOT SHA Book of Standards for Highway and Incidental Structures*
  https://www.roads.maryland.gov/mdotsha/pages/Index.aspx?PageId=69
- *MDOT SHA Standard and Supplemental Specifications for Construction and Materials*
  https://www.roads.maryland.gov/mdotsha/pages/sscm.aspx?PageId=853&lid=SSP
- *MDOT SHA Structural Details and Guidelines*
  https://www.roads.maryland.gov/mdotsha/pages/Index.aspx?PageId=777
- *MDOT SHA Landscape Design Guide*
  https://www.roads.maryland.gov/OED/SHALandscapeDesignGuide.pdf
- *MDOT SHA Qualified Producers and Product List*
  https://www.roads.maryland.gov/mdotsha/pages/Index.aspx?PageId=600
- *MDOT SHA Policy for the Use of Temporary Traffic Barriers in Work Zones*
  https://www.roads.maryland.gov/OOTS/WorkZoneTemporaryTrafficBarrierPolicies.pdf
- *Clarifications on Implementing the AASHTO Manual for Assessing Safety Hardware, 2016*
  https://design.transportation.org/wp-content/uploads/sites/21/2020/03/Clarifications-on-Implementing-MASH-2016-aka-MASH-QA-Updated-Mar-24-2020.pdf
- Task Force 13 – resources for bridge and roadside hardware
  https://www.tf13.org/
- FHWA Eligibility Letters, Guidance, Policies and Resources
  https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/