CHAPTER TEN

ROADSIDE SAFETY

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Chapter Ten

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Chapter Ten

ROADSIDE SAFETY

10-1 ROADSIDE CLEAR ZONES

10-1.01 General Definitions

1. ***Clear Zone***. The distance beyond the edge of travel lane that should be clear of any non-traversable hazards or fixed objects.

2. ***Travel Lane***. The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

3. ***Non-Traversable Hazard.*** A general term to describe roadside features which cannot be safely traversed by a run-off-the-road vehicle.

4. ***Parallel Slope***. Cut or fill slope for which the toe runs approximately parallel to the flow of traffic.

5. ***Transverse Slope.*** Cut or fill slope for which the toe runs approximately perpendicular to the flow of traffic. Transverse slopes are typically formed by intersections between the mainline and driveways, median crossovers, or side roads.

6. ***Recoverable Parallel Slope***. Slope which can be safely traversed and upon which an errant motorist has a reasonable opportunity to stop and return to the roadway. Fill slopes 4:1 and flatter are considered recoverable.

7. ***Non-Recoverable Parallel Slope***. Slope which can be safely traversed but upon which an errant motorist is unlikely to recover. The run-off-the-road vehicle will likely continue down the slope and reach its toe. Fill slopes 3:1 and flatter but steeper than 4:1 are considered non-recoverable parallel slopes.

8. ***Critical Parallel Slope***. Slope which cannot be safely traversed by a run-off-the-road vehicle. Depending on the encroachment conditions, a vehicle on a critical slope may overturn. Fill slopes steeper than 3:1 are considered critical.

10-1.02 General Application

The clear zone widths presented in this *Guide* must be placed in proper perspective. The distances imply a degree of accuracy that does not exist. They do, however, provide a good frame of reference for making decisions on providing a safe roadside area. Each application of the clear zone distance must be evaluated individually, and the designer must exercise good judgment. In general, the designer should provide as much clear zone as can be practically obtained.

The following factors must be considered in determining the recommended clear zone:

1. ***Scope of Work/Roadway Classification***. The recommended clear zone distance will be based on the roadway classification (i.e. NHS/Non-NHS) and scope of work (i.e. new construction, reconstruction, rehabilitation, overlay).

2. ***Speed/Traffic Adjustments***. The recommended clear zone distance will be based on the highway design speed and traffic volumes.

3. ***Roadside Cross Section***. The recommended clear zone distance will be based on the type of side-slopes.

4. ***Traffic Distribution (Multi-Lane Highways).*** Table 10-1 presents traffic volume distribution by lane for both 4-lane and 6-lane facilities. Although no specific adjustments are presented for clear zone values, these lane distributions should be considered. For example, all other factors being equal, Table 10-1 indicates that the clear zone on the right side of a 4-lane divided facility should be more than that on the median side.

When using recommended clear zone distances, the designer should consider the following:

1. ***Context.*** If an obstacle lies just beyond the clear zone, it may be appropriate to remove or shield the obstacle if costs are reasonable. Conversely, the clear zone should not be achieved at all costs. Limited right-of-way or unacceptable construction costs may lead to installation of a barrier or a design exception allowing no protection at all.

2. ***Boundaries.*** The designer should not use the clear zone distances as boundaries for introducing roadside hazards such as bridge piers, non-breakaway sign supports, utility poles or landscaping features. These should be placed as far from the roadway as practical.

Clear zones should be free of all non-traversable hazards and fixed objects. These include, but are not limited to, the following:

1. bridge piers and abutments,

2. boulders,
3. culvert headwalls,
4. retaining walls,
5. non-breakaway sign and luminaire supports,
6. trees,
7. utility poles,
8. permanent bodies of water, and
9. embankments

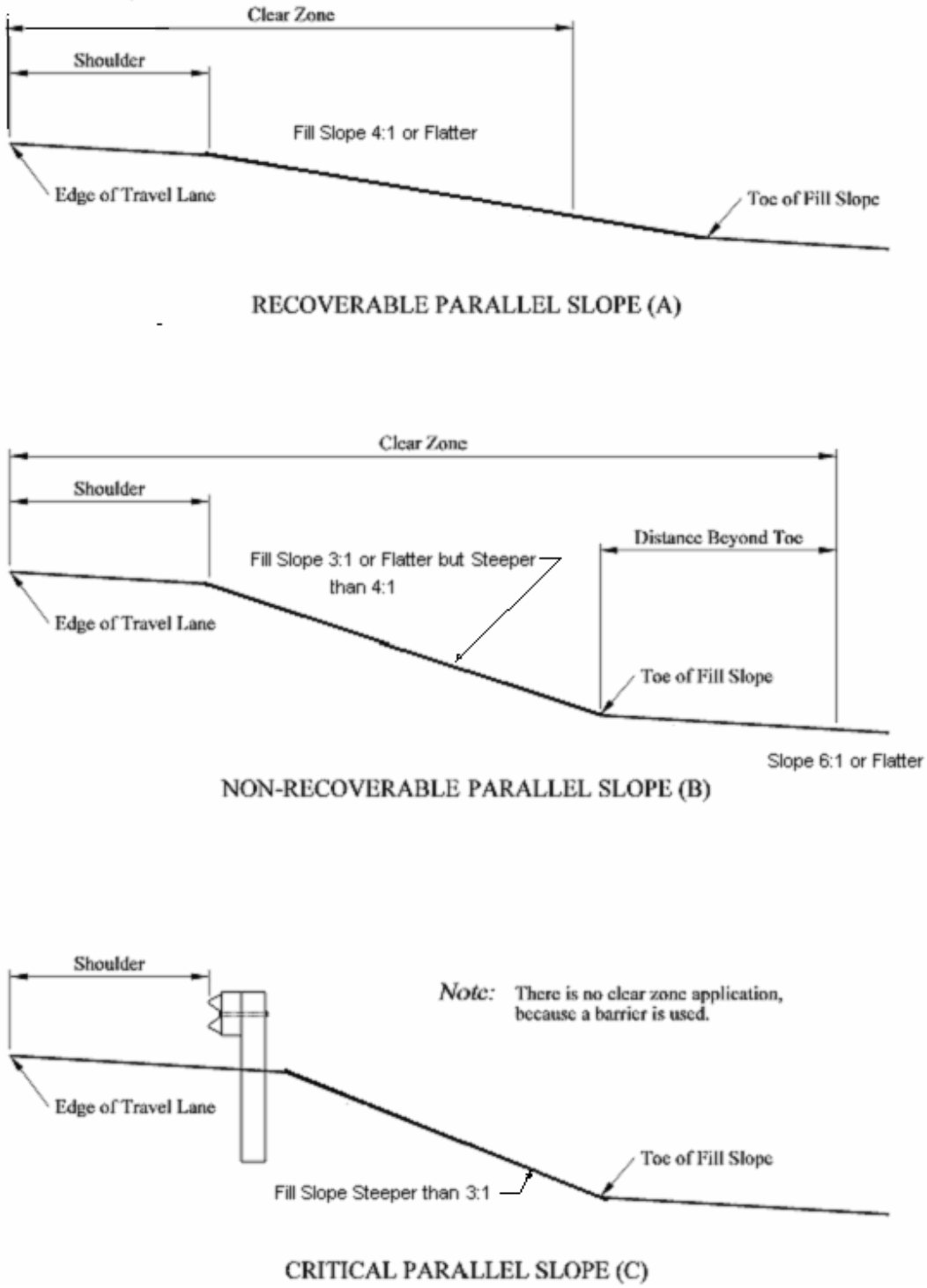
For roadside features within the clear zone, a determination that the feature is a hazard will be made on a case-by-case, project-by-project basis.

4-Lane Roadway		
AADT	***Median Lane (%)***	***Right Lane (%)***
12,000	20	80
24,000	25	75
36,000	33	67
48,000	41	59
60,000	50	50

6-Lane Roadway			
AADT	***Median Lane (%)***	***Center Lane (%)***	***Right Lane (%)***
24,000	22	47	31
48,000	31	43	26
72,000	35	40	25
96,000	37	38	25
120,000	37	37	26

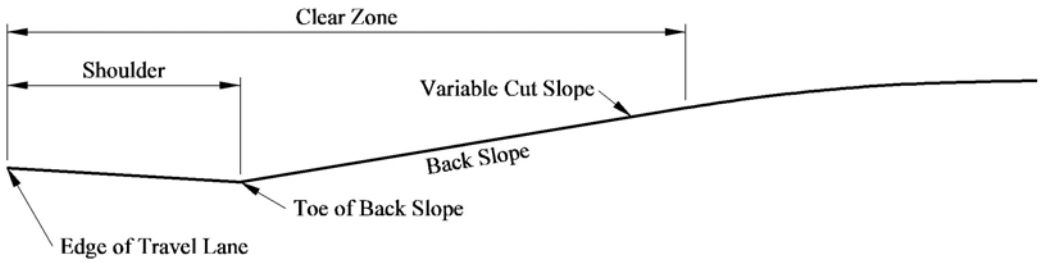
LANE DISTRIBUTION OF TRAFFIC VOLUMES
(Multi-Lane Highways)

Table 10-1

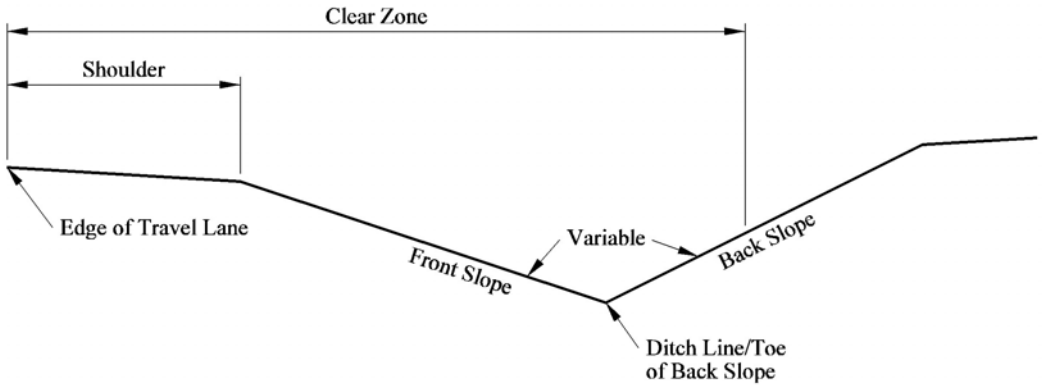


ROADSIDE CROSS SECTION SCHEMATICS
(Clear Zone Application)

Figure 10-1



CUT SLOPE (Without Ditch) (D)



CUT SLOPE (With Ditch) (E)

ROADSIDE CROSS SECTION SCHEMATICS
(Clear Zone Application)
(Continued)

Figure 10-1

10-1.03 Parallel Slopes

Roadside clear zones will vary depending on the type of parallel slope.

Recoverable Fill Slopes. For parallel slopes 4:1 and flatter (Figure 10-1(A)), the recommended clear zone distance can be determined directly from Table 10-2. This table applies to new construction or reconstruction projects on the NHS. The recommended clear zone for other projects can be determined directly from other appropriate tables in this Guide.

Non-Recoverable Fill Slopes. For parallel slopes steeper than 4:1 but 3:1 or flatter (Figure 10-1(B)), the recommended clear zone includes a clear distance beyond the toe of the slope, according to the following procedure:

a. The slope beyond the toe of the non-recoverable fill slope will probably be 6:1 or flatter. Determine the clear zone distance for a 6:1 or flatter slope from Table 10-2.

b. Subtract the shoulder width from this clear zone distance.

c. The remaining distance will be the required distance beyond the toe of the slope. The minimum distance will be 10 feet.

If this clear zone cannot be achieved, barrier shall be required.

This procedure applies to new construction or reconstruction projects on the NHS. Clear zone for other projects can be determined using this procedure in conjunction with other appropriate tables in other chapters this Guide. Barrier should be considered but will not be required on other project types if clear zone conditions cannot be met at the toe of slope.

Critical Fill Slopes. For parallel slopes steeper than 3:1 (Figure 10-1(C)), barrier will be required on all project types.

Cut Slopes (Without Ditch). For parallel cut slopes that don't have a ditch (Figure 10-1(D)), determine the clear zone distance for 6:1 or flatter slope from Table 10-2 for all project types. Slope requirements related to stability and safety shall be considered.

The following examples illustrate how to determine the clear zone for various parallel slopes.

* * * * * * * * * *

NEW CONSTRUCTION/RECONSTRUCTION PROJECTS
(NHS and Major Arterials)

Design Speed (mph)	Design AADT **	Fill Slopes			Cut Section With Ditch Figure10-1(E)
		Recoverable (Figure 10-1(A))		Non-recoverable Figure10-1(B)	
		6:1 or Flatter	5:1 to 4:1		
40 or Less	Under 750 750 - 1500 1500 - 6000 Over 6000	7 - 10 10 - 12 12 - 14 14 - 16	7 - 10 12 - 14 14 - 16 16 - 18	SEE PROCEDURE IN SECTION 10-1.03	SEE PROCEDURE IN SECTION 10-1.04
45 - 50	Under 750 750 - 1500 1500 - 6000 Over 6000	10 - 12 14 - 16 16 - 18 20 - 22	12 - 14 16 - 20 20 - 26 24 - 28		
55	Under 750 750 - 1500 1500 - 6000 Over 6000	12 - 14 16 - 18 20 - 22 22 - 24	14 - 18 20 - 24 24 - 30 26 - 32*		
60	Under 750 750 - 1500 1500 - 6000 Over 6000	16 - 18 20 - 24 26 - 30 30 - 32*	20 - 24 26 - 32* 32 - 40* 36 - 44*		
65 - 70	Under 750 750 - 1500 1500 - 6000 Over 6000	18 - 20 24 - 26 28 - 32* 30 - 34*	20 - 26 28 - 36* 34 - 42* 38 - 46*		

* *On non-freeways, the clear zone distance may be limited to 30 feet for practicality and to provide a consistent roadway template.*

** *Use the AADT projected for the design year for the overall project.*

RECOMMENDED CLEAR ZONE DISTANCES
(In Feet Measured From Edge of Travel Lane)

Table 10-2

Example 1 (Recoverable Fill Slope)

Given: Project Scope of Work – Reconstruction, NHS
Fill Slope – 4:1
Design Speed – 60 mph
Design AADT – 7000

Problem: Determine the recommended clear zone distance.

Solution: From Table 10-2, the clear zone distance should be 36 feet - 44 feet. Note that this distance will apply regardless of the shoulder width. However, as indicated in a footnote to the table, the clear zone distance may be limited to 30 feet based on specific site conditions to provide a more practical design.

Example 2 (Non-Recoverable Fill Slope)

Given: Project Scope of Work – Reconstruction, NHS
Fill Slope – 3:1
Design Speed – 60 mph
Design AADT – 2000
Shoulder Width – 6 ft

Problem: Determine the recommended clear zone distance.

Solution: If the slope can be flattened to a 4:1 slope practically and economically, the clear zone distance can be taken directly from Table 10-2 as in Example 1. If this is not possible, a clear distance must be provided at the toe of the slope. From Table 10-2 the clear zone distance should be 26 feet – 30 feet for a 6:1 slope. After subtracting the 6 foot shoulder, a minimum 20 foot clear area is required at the toe of the slope. If this clear zone cannot be achieved, a barrier shall be required.

* * * * * * * * * *

10-1.04 Cut Slopes (With Ditches)

Ditch sections, as illustrated in Figure 10-1(E), are frequently constructed in roadside cuts. The applicable clear zone across a ditch section will depend upon the front slope, the back slope, the horizontal location of the toe of the back slope, and various highway factors. The designer will use the following procedure to determine the recommended clear zone distance.

The following procedure applies specifically to new construction or reconstruction projects on the NHS. Clear zone for other projects can be determined using procedures and discussions in the other chapters of the Guide according to the project types.

1. ***Check Front Slope***. Slopes steeper than 3:1 will require guardrail. Slopes steeper than

4:1 but flatter than 3:1 will require a clear distance beyond the toe of front slope as described for non-recoverable fill slopes, except that the back slope may be as steep as 2:1. For slopes 4:1 or flatter determine the clear zone based on the ditch front slope as described for recoverable fill slopes. Back slopes within the clear zone should be 4:1 or flatter, but may be as steep as 2:1.

2. ***Check Location of Ditch Line*.** If the front slope is 4:1 or flatter, determine if the toe of the back slope is within the clear zone. If the toe is at or beyond the clear zone, then the designer usually need only consider roadside hazards within the clear zone on the front slope. If the toe is within the clear zone, the designer should evaluate the practicality of relocating the toe of back slope. This may be accomplished by, for example, providing a flat bottom ditch or by deepening the ditch line. If the toe of back slope will remain within the clear zone, or if the front slope is steeper than 4:1, #3 below will apply.

3. ***Check Back Slope*.** If the toe of the back slope is within the clear zone distance from #1 above, a clear zone should be provided on the back slope. This clear zone will be determined as follows:

   a. Back Slope 3:1 or Steeper (V > 50 mph). The clear zone will be 10 feet beyond the toe or the distance determined in Step #1 beyond the edge of travel lane, whichever is less.

   b. Back Slope 3:1 or Steeper (V ≤ 50 mph). The clear zone will be 5 feet beyond the toe or the distance determined in Step #1 beyond the edge of travel lane, whichever is less.

   c. Back Slope Flatter than 3:1. The clear zone will be the distance determined in Step #1 beyond the edge of travel lane.

* * * * * * * * * *

Example 3 (Clear Zones) (cut slope with ditch)

Given: Front Slope – 4:1
Ditch Bottom Width – 0 ft (V-ditch)
Back Slope – 2:1
Design Speed – 60 mph
Design AADT – 4000

Problem: Determine the recommended clear zone distance.

Solution: Using the procedure in Section 10-1.04, the following applies:

1. ***Check Front Slope*.** According to Table 10-2, the clear zone distance for the front slope is 32 feet – 40 feet, with a practical limit of 30 feet acceptable.

2. ***Check Location of Ditch Line.*** Desirably, the toe of the back slope will be at or beyond 30 feet. If this is not practical, #3 below will apply.

3. ***Check Back Slope.*** For a 2:1 back slope and a design speed of 60 mph, the clear zone distance will be to 10 feet beyond the toe of back slope or to 30 feet from the edge of travel lane, whichever is less.

* * * * * * * * * *

10-1.05 Horizontal Curves

On the outside of horizontal curves, run-off-the-road vehicles may travel a greater distance from the travel lane before regaining control of the vehicle. The designer may choose to modify the clear zone distance obtained from Table 10-2 for horizontal curvature. These modifications are normally only considered where crash history indicates a need, or a specific site investigation shows a definitive crash potential which could be significantly lessened by increasing the clear zone width and such increases are cost effective.

Where adjustments will be applied, Table 10-3 provides recommended factors for clear zones on horizontal curves. A diagram illustrates the application on a curve.

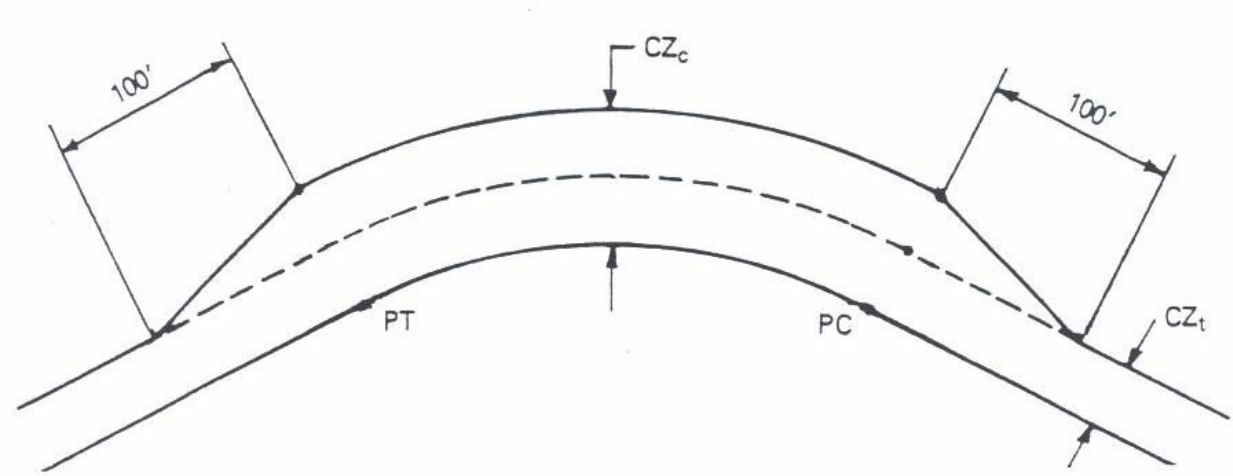
10-1.06 Curbed Sections

Most curbs do not have a significant re-directional capability and therefore a minimum clear zone commensurate with prevailing traffic volumes and design speeds should be provided where practical. Curb should not be a justification for reducing clear zone. In urban areas with posted speed limits of 35 mph or less, aboveground utility poles may be installed 5 feet behind the face of curb. In locations where insufficient right-of-way or other restrictions are present and no other practical solution exists, aboveground utility poles may be installed 1 foot behind the face of curb. A minimum 3 foot clear zone should be provided at intersections and driveways.

Degree of Curve	K_{CZ}, Curve Correction Factor						
	Design Speed (mph)						
	40	*45*	*50*	*55*	*60*	*65*	*70*
2.0	1.08	1.10	1.12	1.15	1.19	1.22	1.27
2.5	1.10	1.12	1.15	1.19	1.23	1.28	1.33
3.0	1.11	1.15	1.18	1.23	1.28	1.33	1.40
3.5	1.13	1.17	1.22	1.26	1.32	1.39	1.46
4.0	1.15	1.19	1.25	1.30	1.37	1.44	
4.5	1.17	1.22	1.28	1.34	1.41	1.49	
5.0	1.19	1.24	1.31	1.37	1.46		
6.0	1.23	1.29	1.36	1.45	1.54		
7.0	1.26	1.34	1.42	1.52			
8.0	1.30	1.38	1.48				
9.0	1.34	1.43	1.53				
10.0	1.37	1.47					
15.0	1.54						

$$CZ_C = (CK_T)(K_{CZ})$$

Where: CZ_C = clear zone distance on outside of curve, ft
CZ_T = clear zone distance on tangent section, ft
K_{CZ} = curve correction factor, ft



HORIZONTAL CURVE ADJUSTMENTS

Table 10-3

10-2 ROADSIDE BARRIER WARRANTS

10-2.01 Embankments

A roadside barrier shall be considered where an embankment is steeper than 4:1 on NHS and other major arterials and will be warranted if a clear area cannot be provided at the toe of the slope. On all roads, a roadside barrier will be warranted where an embankment is steeper than 3:1.

10-2.02 Roadside Hazards

The recommended clear zone distances for various highway conditions, should be free of any fixed objects and non-traversable hazards. The need for a barrier will be based on the relative severity between impacting a barrier and impacting the hazard. Based on the discussion in Section 10-1.02, the designer must use judgment to determine whether or not a roadside feature is a roadside hazard. The decision for barrier protection will be based on site-specific factors, including traffic volumes, design speed, alignment, proximity of hazard to travel lane, and crash history.

Once the designer has concluded that a barrier is warranted, the first attempt should be to eliminate the need for the barrier. This may be accomplished by removing or relocating the hazard or by making the hazard breakaway. If these are not practical, a barrier should be installed only if engineering judgment indicates it is practical. For example, it would probably not be practical to install a barrier to shield an isolated point obstacle, such as a tree, located near the edge of the clear zone.

10-2.03 Bridge Rails/Parapets

Barrier protection is normally warranted on all approach ends to bridge rails or parapets, and it is warranted on the trailing ends on two-way roadways. No roadside barrier is needed on the trailing end on a one-way roadway, unless a barrier is warranted for other reasons (e.g., steep slopes).

All designs for barrier/bridge rail connections should be coordinated with the Urban and Federal Bridge Program.

10-3 ROADSIDE BARRIER TYPES

Table 10-4 presents the most common types of roadside barriers that are approved for use in Maine. The table summarizes the hardware requirements for each system and references the *MDOT Standard Details* for more information. The next two sections briefly describe each system and its typical usage.

10-3.01 "W" Beam

The "W" beam system with strong posts is a semi-rigid system. This system consists of a steel “W” beam or rail, an offset block, and wood or steel posts. A major objective with a heavy post system is to prevent a vehicle from "snagging" on the posts. This is achieved by using blocks to offset the posts from the longitudinal beam and by establishing 6’-3”as the maximum allowable post spacing.

The Department has approved the use of two guardrail "W" beam systems. One uses 6” x 8” timber posts, and the other uses W6x8.5 or W6x9 steel posts. On non-freeways, the two systems are usually presented on a competitive bid basis in the contract proposal. On freeways, the steel post system is designated.

10-3.02 Thrie Beam

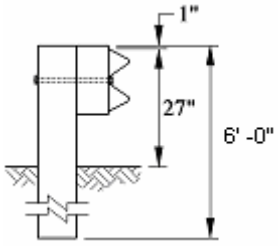
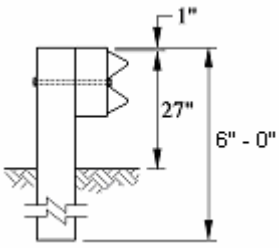
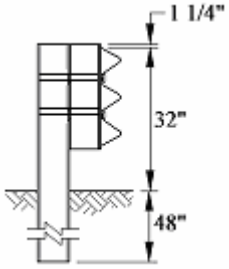
The thrie beam guardrail is also a semi-rigid system with strong posts. The depth of the beam and the offset bracket is approximately 1½ times as great as those for the "W" beam. The thrie beam is primarily used when there is inadequate deflection distance (e.g., less than 3 feet) for the "W" beam.

10-3.03 Other Types

Several other types of guardrail are approved for use in specific situations. Steel backed timber guardrail may be used in areas where aesthetic requirements exist, such as on scenic highways or in historic districts. Corrosion resistant steel guardrail (rusty rail), a variation of the “W” Beam, may be used in similar situations. There are several cable guardrail systems that meet current standards which may be considered. These can only be used when large deflection distances can be accommodated, and when exposure to significant snowplow contact is not expected. Cable guardrail may be considered when visibility through the guardrail is necessary or desired.

10-3.04 Guardrail and Guardrail Terminal Selection

Guardrail and guardrail terminal selection shall be based on the highway system as recommended in the Guardrail and Guardrail Terminal Policy. Refer to the current policy for details.

			
System	"W" Beam Guardrail (Wood Posts)	"W" Beam Guardrail (Steel Posts)	Thrie Beam Guardrail (Steel Posts)
AASHTO Designation	SGR04b	SGR04b	SGR09c
MDOT Standard Detail	606(03)	606(03)	606 (25)
Post Spacing	6'-3"	6'-3"	6'-3"
Deflection Distance *	3'-0"	3'-0"	2'-0"
Post Type	6x8 Treated Wood Post	W6x9 Steel Post	W6x9 Steel Post
Beam Type	Steel "W" Section 12 ga.	Steel "W" Section 12 ga.	Steel Thrie Beam 12 ga.
Offset Blocks	6x8x14 Treated Wood Block Or Composite Plastic Block	6x8x14 Treated Wood Block Or Composite Plastic Block	6x8x21½ Treated Wood Block Or Composite Plastic Block

* Clear distance from the back of the post to the roadside object.

ROADSIDE BARRIERS

Table 10-4

10-4 ROADSIDE BARRIER LAYOUT

10-4.01 Length of Need

Length of need is generally defined as the distance from the point where the hazard ends to the third post in from the end of the guardrail terminal. The length of need determination criteria in Section 10-4 apply to guardrail applications in all scopes of work on NHS and Non-NHS projects.

The designer must determine the beginning and ending of the barrier length of need to properly shield the roadside obstacle or embankment. The following discussion will apply.

General Approach/Application

The Department has adopted two methodologies to determine the length of need for roadside barriers:

1. ***Method No. 1***. On NHS projects use a 10° and on Non-NHS projects use a 15° angle off the back of the hazard to locate the beginning of the barrier need.

2. ***Method No. 2.*** Use the methodology presented in the AASHTO *Roadside Design Guide* to locate the beginning of the barrier need.

Method No. 2 may yield, depending on site conditions, considerably longer lengths of barrier than Method No. 1. At some sites, these longer lengths are not considered cost effective, and Method No. 1 is judged to be a more reasonable application. The following summarizes the Department's application of the two Methods for determining the length of need for specific sites:

1. ***Embankments.*** Use Method No. 1.

2. ***Roadside Obstacles.*** Use Method No. 2. Check to see if one of the following conditions exist at the site:

   a. Because of the nature of the terrain, it may be improbable or impossible for a run-off-the-road vehicle to traverse behind the barrier and reach the roadside obstacle.

   b. Because of the location of the barrier, it may be that a run-off-the-road vehicle would have to exceed the clear zone distance to reach the roadside obstacle.

   If either of the conditions exist at the site, it is acceptable to use Method No. 1 to determine the barrier length of need. In addition, based on a site-by-site evaluation, it is acceptable to use Method No. 1 to shield roadside obstacles if, in the judgment of the designer, it is not cost-effective to install the additional length of barrier required by Method No. 2.

3. ***Bridge Parapet/Rails.*** The length of barrier in advance of bridge parapets/rails will be 100 feet or the length-of-need calculation based on Method No. 2, whichever is greater. For the

trailing end on two-way roadways, it will be 50 feet or the length-of-need calculation based on Method No. 2, whichever is greater. Based on a site-by-site evaluation, it is acceptable to use Method No. 1 to shield a bridge parapet/rail if, in the judgment of the designer, it is not cost effective to install the additional length of barrier required by Method No. 2. The 100-ft minimum (approach end) or 50-ft minimum (trailing end) will govern if greater than the length of barrier from Method No. 1.

The following sections present the design details for Methods No. 1 and No. 2.

Method No. 1

Method No. 1 determines the barrier length of need based on an angle off the back of hazard. On NHS projects use a 10° and on Non-NHS projects use a 15° angle. The following figures illustrate the application of Method No. 1:

1. Figure 10-2 presents the methodology as it applies to embankments.
2. Figure 10-3 presents an example for the application to embankments.
3. Figure 10-4 presents the methodology as it applies to roadside obstacles.
4. Figure 10-5 presents an example for the application to roadside obstacles.

$$L = \frac{L_H - L_B}{\tan 10°} \quad \text{or} \quad L = \frac{L_H - L_B}{\tan 15°} \qquad \text{(Equation 10-2)}$$

L = length of need.

L_H = distance from edge of travel lane to back of obstacle. May be equal to the clear zone.

L_B = distance from edge of travel lane to face of guardrail. The barrier offset should be considered as discussed in Section 10-4.02.

Other variables to consider:

L_C = recommended clear zone.

L_F = distance from edge of travel lane to front of obstacle, based on deflection distance from Table 10-4 and barrier offset.

Method 1 Steps

1. **Determine Clear Zone (L_C).**
   Obstacles: Clear zone determination will be based on the roadway classification, etc., as discussed in Section 10-1.

   Embankments: The clear zone will be to the toe of the embankment.

2. **Determine Barrier Offset (L_B).** Determine offset based on proposed shoulder width. Lateral placement will be discussed in Section 10-4.02

3. **Determine Lateral Offset. (L_H).**
   Obstacles: Determine the offset to back of obstacle and compare to clear zone. The lesser distance may become L_H, but use of the more conservative greater distance should be given careful consideration.

   Embankments: Equal to the clear zone distance.

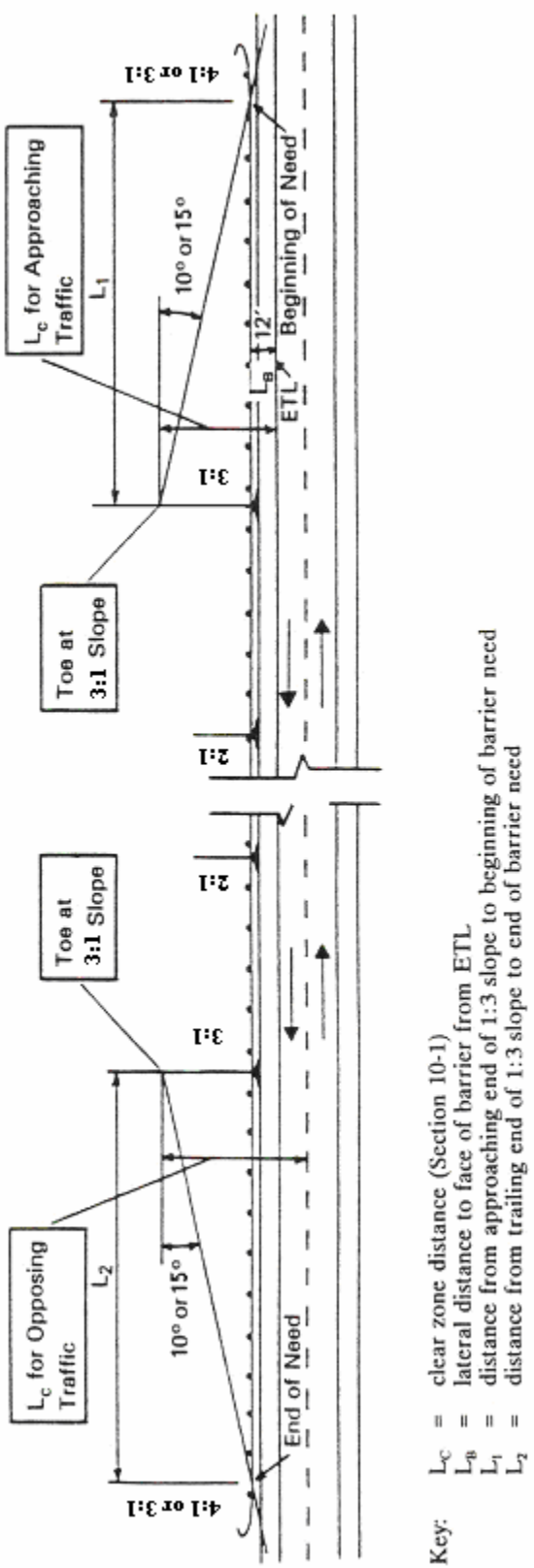
4. **Apply Angles.** Measure 10° or 15°, as appropriate, from the lateral offset. See the following Figures. The intersection of this line and the run of barrier will locate the end of the length of need. The following step gives an equation for this distance.

5. **Determine Length of Need (L) .** Use the following equation:
   $L = \frac{L_H - L_B}{\tan 10°}$ $L = \frac{L_H - L_B}{\tan 15°}$ $\tan 10° = 0.176327$ $\tan 15° = 0.267807$

6. **End Treatment**. A crashworthy terminal should be used at the end of the guardrail run. Most terminals have full redirectional capabilities beyond the third post. In general, the first 12.5 feet of the terminal can be outside the length of need. The third post would be placed at the length of need. This should be verified by checking the manufacturer's reccomendations. For a one-way roadway, an unanchored end is acceptable at the trailing end. The end will be located a minimum of 50 feet beyond an obstacle and 66 feet beyond a steep embankment.

7. **Opposing Traffic.** For opposing traffic on a two-way roadway, a length of need calculation for the trailing end is necessary if the break in the embankment slope or any part of the obstacle is within the clear zone as measured from the centerline of the roadway. See Step 8. The trailing end of the barrier will be 50 feet beyond the end of the roadway hazard, including end treatments.

8. **Opposing Traffic Length of Need.** Where needed, the length of need calculation for opposing traffic is determined using the same procedure as for approaching traffic, except that all distances will be measured from the centerline of the roadway. The minimum distance to the end of the barrier, excluding end treatment, will be 50 feet beyond the end of an obstacle and 66 feet beyond the end of a steep embankment.



BARRIER LENGTH OF NEED (Method 1)
(Embankments)

Figure 10-2

BARRIER LENGTH OF NEED (Method 1)
(Embankments)

Figure 10-2

Example:

Given:

Project Scope	–	Reconstruction
Roadway	–	Two-way traffic, 12-foot lanes, 10-foot typical shoulders
Design Speed	–	60 mph
AADT	–	7000
Roadside	–	4:1 fill slope leading to 2:1 slope. At the point where the slope is 3:1, the height of embankment is 10 feet. The distance from the ETL to the break in the fill slope is 15 feet.

L_B = 12 feet from the ETL

Problem: Determine beginning and ending of barrier run.

Solution: Following the step-by-step procedure on Figure10-2 (Method No. 1):

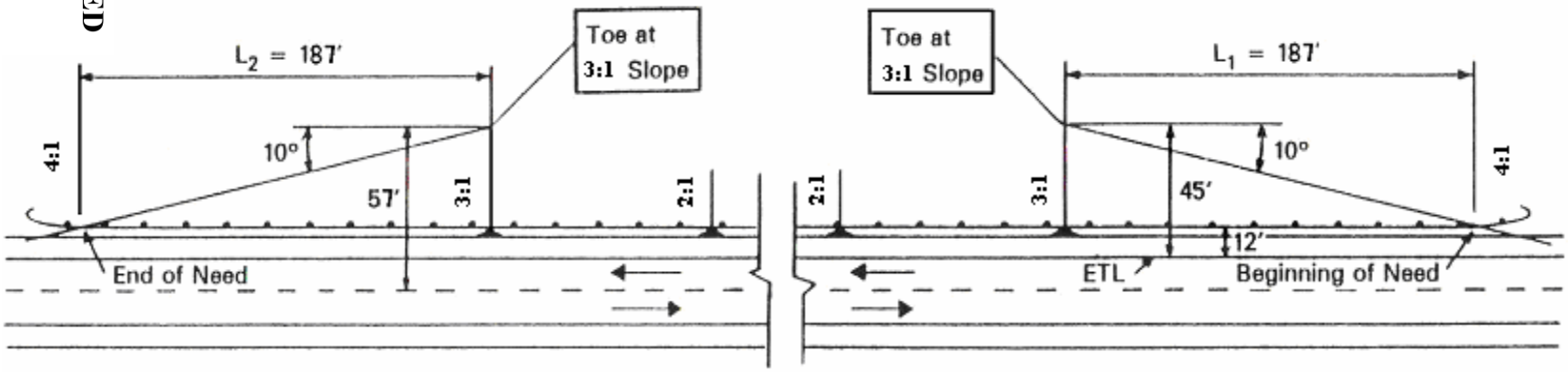
1. Table 10-2 applies to a reconstruction project. Based on the highway conditions (4:1 slope), the clear zone range is 36-44 feet, with a practical limit of 30 feet from the edge of travel lane. Because the 3:1 slope begins within the clear zone, a clear distance should be provided to the toe of the 3:1 slope. Based on an embankment height of 10 feet, the lateral distance to the toe of the 3:1 slope is 15' (to the slope break) + 30' (3:1 slope for 10') = 45'
2. The 10° angle is plotted on the example figure below.
3. The distance L_1 is:

   $L_1 = \frac{(45 - 12)}{.176327} = 187$ feet

4. For the opposing traffic, the break in the embankment slope is 27 feet from the roadway centerline (15' + 12'). From Table 10-2, the clear zone is 30-32 feet (flat slope across the roadway). Therefore, the embankment is within the clear zone for opposing traffic. The total clear zone for opposing traffic is measured from the roadway centerline to the toe of the 3:1 slope. Therefore, L_C = 12' + 15' + 30' = 57'
5. The offset to the barrier is 24 feet (12' + 12'). The distance L_2 is:

   $L_2 = \frac{(57 - 24)}{.176327} = 187$ feet

6. Not applicable.

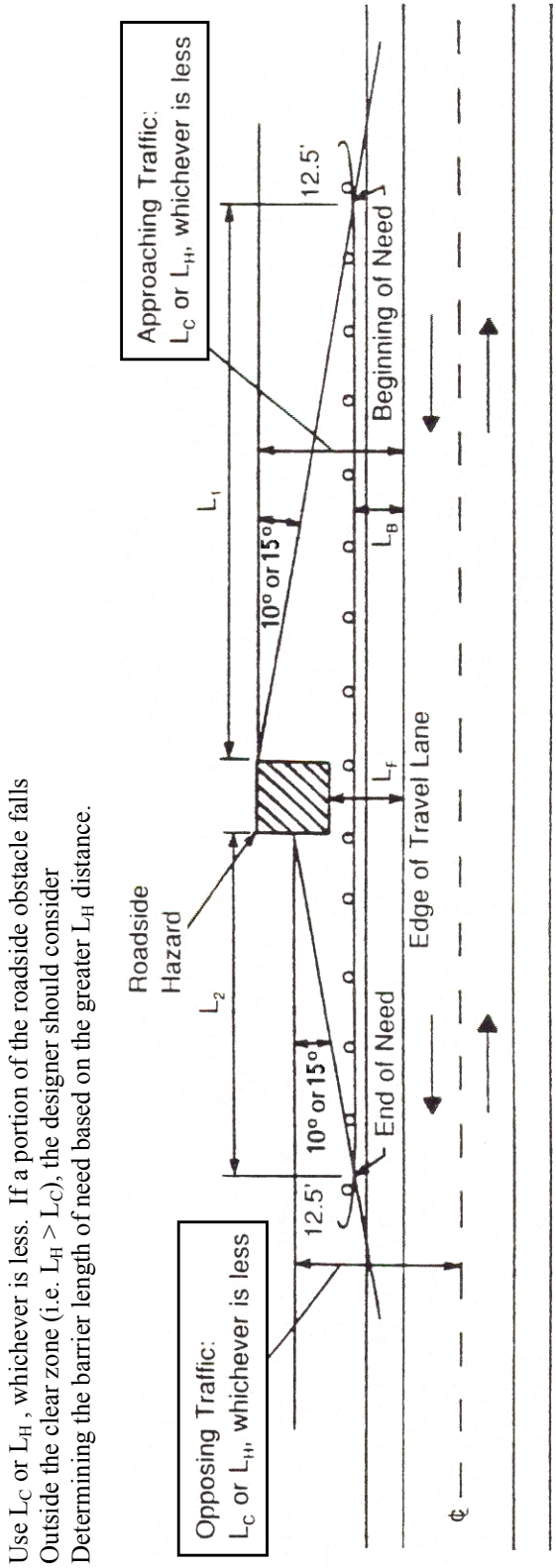


BARRIER LENGTH OF NEED (Method 1)
(Example - Embankments)

Figure 10-3

BARRIER LENGTH OF NEED (Method 1)
(Example - Embankments)

Figure 10-3



Note: Use L_C or L_H, whichever is less. If a portion of the roadside obstacle falls Outside the clear zone (i.e. $L_H > L_C$), the designer should consider Determining the barrier length of need based on the greater L_H distance.

Key:
L_C = clear zone distance (Section 10-1)
L_F = lateral distance to front of roadside obstacle from ETL
L_H = lateral distance to back of roadside obstacle from ETL
L_B = lateral distance to face of barrier from ETL
L_1 = distance from approaching end of roadside obstacle to beginning of barrier need
L_2 = distance from trailing end of roadside obstacle to end of barrier need

BARRIER LENGTH OF NEED (Method 1)
(Roadside Obstacles)

Figure 10-4

BARRIER LENGTH OF NEED (Method 1)
(Roadside Obstacles)

Figure 10-4

Example:

Given:

Project Scope	–	Reconstruction
Roadway	–	Two-way traffic, 12-foot lanes, 10-foot typical shoulders
Design Speed	–	60 mph
AADT	–	4000
Roadside	–	4:1 fill slope

L_F = 15 feet from the ETL
L_H = 25 feet from the ETL
L_B = 12 feet from the ETL

Problem: Determine beginning and ending of barrier run.

Solution: Following the step-by-step procedure on Figure10-4 (Method No. 1):

1. Table 10-2 applies to a reconstruction project. Based on the highway conditions the clear zone range is 32-40 feet, with a practical limit of 30 feet from the edge of the travel lane.

2. For traffic approaching the obstacle, the back of the obstacle is within the clear zone (25 feet from ETL). Therefore, the 25-foot distance will apply.

3. The 10° angle is plotted on the example figure below.

4. The distance L_1 is:

$$L_1 = \frac{(25 - 12)}{.176327} = 74 \text{ feet}$$

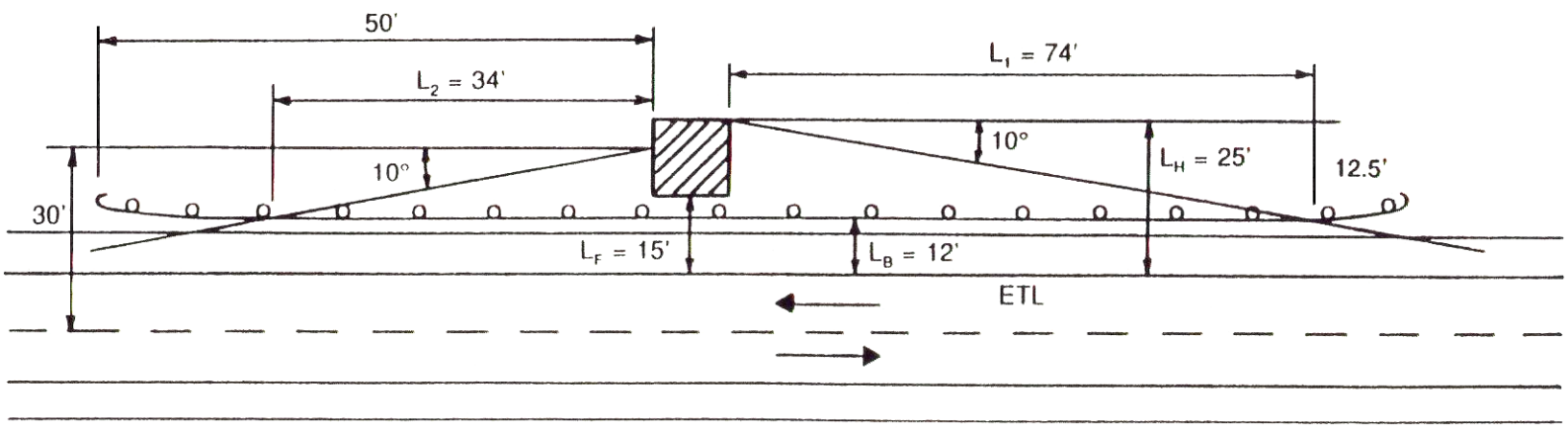
5. For the opposing traffic, the front of the obstacle is 27 feet from the roadway centerline (15' + 12'). Therefore, the obstacle is within the clear zone of 30 feet.

6. The back of the obstacle is 37 feet from the centerline. Therefore, at a minimum, the 30-foot clear zone distance will apply in determining the end of barrier need. The offset to the barrier is 24 feet (12' + 12'). The distance L_2 is:

$$L_2 = \frac{(30 - 24)}{.176327} = 34 \text{ feet}$$

The end of the barrier would be 34' + the portion of the guardrail terminal end that is gateable. In most cases this is 12.5' , so 34' + 12.5' = 46.5'

7. Not applicable.



BARRIER LENGTH OF NEED (Method 1)
(Example - Roadside Obstacles)

Figure 10-5

BARRIER LENGTH OF NEED (Method 1)
(Example - Roadside Obstacles)

Figure 10-5

Method No. 2

Figure 10-6 illustrates the variables that must be considered in designing a roadside barrier to shield an obstacle using Method No. 2, which comes from the AASHTO *Roadside Design Guide*. This method applies to both flared and tangential approaches to guardrail end terminals as shown in Figure 10-6. Only tangential guardrail approaches should be used. Once the appropriate variables have been selected, the required length of need can be calculated from the following formulas:

Unflared Design:

$$X = \frac{L_R (L_H - L_2)}{L_H} \qquad \text{(Equation 10-3)}$$

where:

$$Y = L_2 \qquad \text{(Equation 10-4)}$$

X, Y = coordinates of end of barrier need.

L_R = runout length (see Table 10-5).

L_H = distance from edge of travel lane to back of obstacle. The AASHTO *(Roadside Design Guide)* refers to this distance as Lateral Extent.

L_2 = distance from edge of travel lane to face of guardrail.

Other variables to consider:

L_C = recommended clear zone.

L_S = shy line offset, or distance at which barrier is no longer perceived as an obstacle by a driver (see Table 10-5).

L_3 = distance from edge of travel lane to front of obstacle. Equals L_2 + minimum deflection distance from Table 10-4.

Method 2 Steps

1. **Determine Clear Zone.** Find the clear zone based on Table 10-2. Compare with L_H , the distance to back of obstacle. Use the smaller distance as L_H in determining length of need.

2. **Determine Barrier Offset (L_2).** Find L_S , the shy line offset from Table 10-6. As discussed in Section 10-4.02, L_2 should be at the shy line or the shoulder width, whichever is greater. Desirably, the shoulder will be widened by 2 feet and the barrier face will be placed at the edge of the widened shoulder.

3. **Determine Offset to Obstacle (L_3).** Find the deflection distance from Table 10-4 for the guardrail. The distance to the front of the obstacle, L_3, can be no less than the barrier offset, L_2 , plus the deflection distance.

4. **Determine Runout Length (L_R).** Use Table 10-5.

5. **Determine Length of Need Coordinates (X,Y).** Use Equations 10-3 and 10-4.

Example 4

Given: The following site conditions apply to a roadside obstacle (see Figure 10-7):

ADT = 7000
V = 60 mph
Slope = 6:1 fill slope
Shoulder Width = 8 ft
L_H = 25 ft (to back of obstacle)

Problem: Determine the details of barrier location. Use the W-beam system with an unflared layout. $L_1 = 0$.

Solution: The following steps apply:

1. ***Determine Clear Zone.*** From Table 10-2, the clear zone is 30 ft. Therefore, $L_C = 30$ ft. The obstacle is within the clear zone and, therefore, $L_H = 25$ ft.

2. ***Determine Barrier Offset (L_2).*** From Table 10-5, $L_S = 8.0'$ (the shy line offset). This equals the shoulder width. With the desirable 2' extra widening, for this example, use $L_2 = 10'$.

3. ***Determine Offset to Obstacle (L_3).*** From Table 10-4, the deflection distance for the W-beam guardrail is 3'. $L_3 = L_2 + 3' = 13'$. Therefore, the front of the obstacle can be no closer than 13' from the edge of travel lane.

4. ***Determine Runout Length (L_R).*** From Table 10-5, L_R = 425'.

5. ***Determine Length of Need Coordinates (X,Y).*** For the approaching traffic, Equations 10-3 and 10-4 yield the following:

$$X = \frac{425\ (25\ -10)}{25} = 255\text{ft}$$

$$Y = 10\text{ ft}$$

For the opposing traffic and assuming 12' travel lanes, the following adjustments are made:

$$L_C = 30\ ft$$

$$L_H = 37\ ft$$

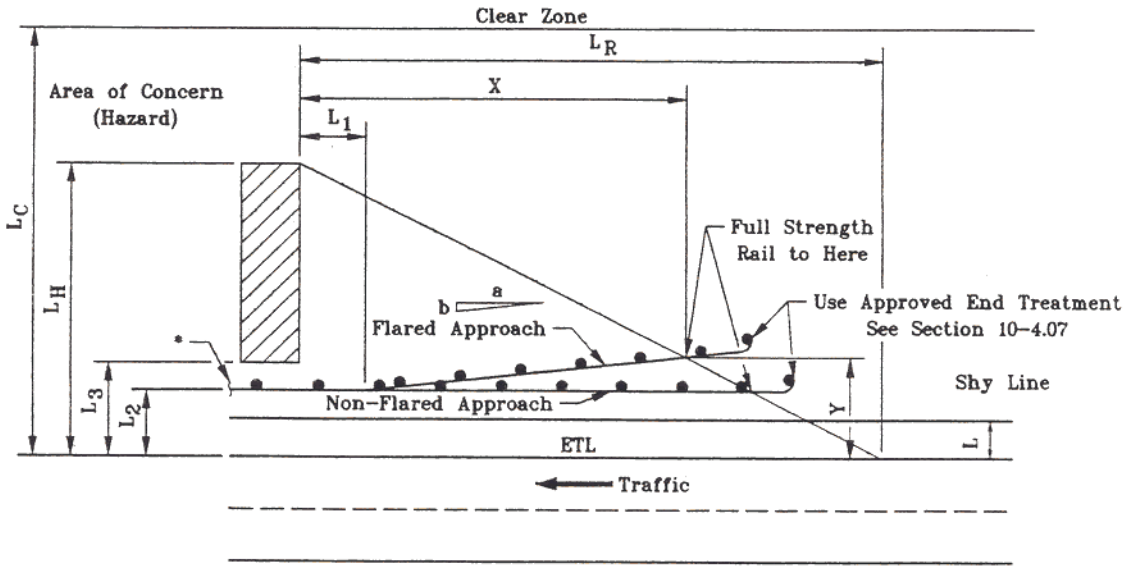
Since the back of the obstacle is outside of the clear zone for opposing traffic, *L_H may be set equal to L_C = 30'.* However, for illustration, the X,Y coordinates for the trailing end are calculated assuming L_H = 37' (i.e., to the back of the obstacle):

$$L_2 = 10\ ft + 12\ ft = 22\ ft$$

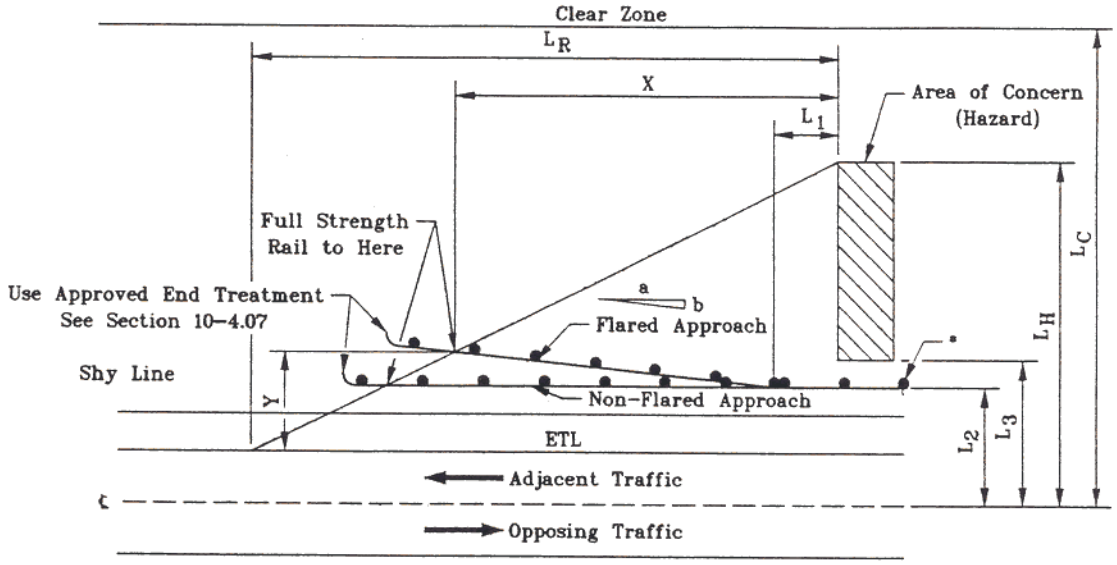
$$L_R = 425\ ft$$

$$X = \frac{425(37 - 22)}{37} = 172'$$

$$Y = 22'$$



APPROACH TREATMENT FOR ONCOMING TRAFFIC (a)



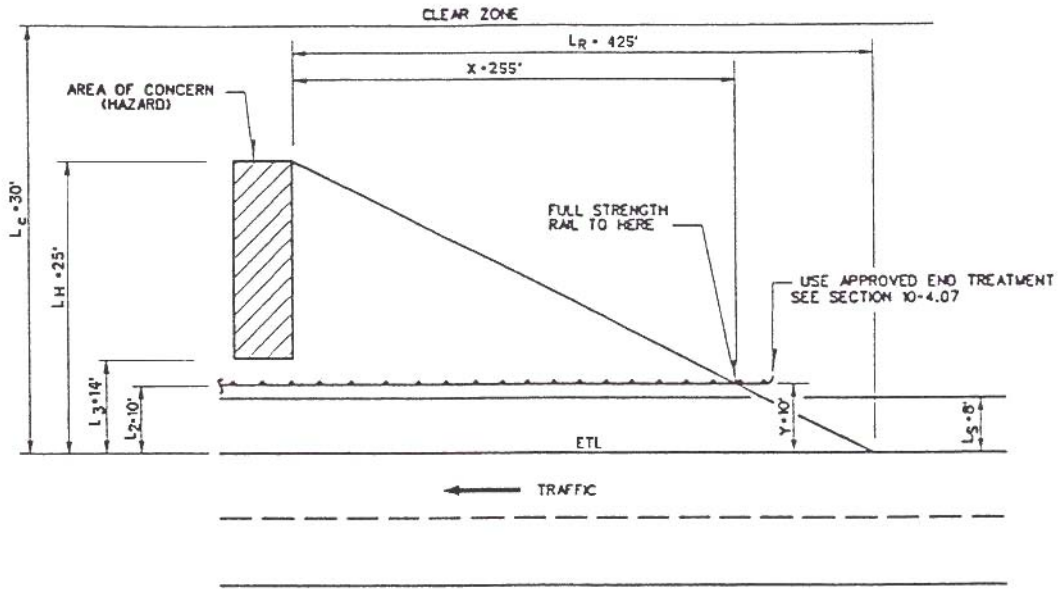
APPROACH TREATMENT FOR OPPOSING TRAFFIC (b)

* The distance beyond the hazard should be 50’ or as determined by a length-of-need calculation for opposing traffic

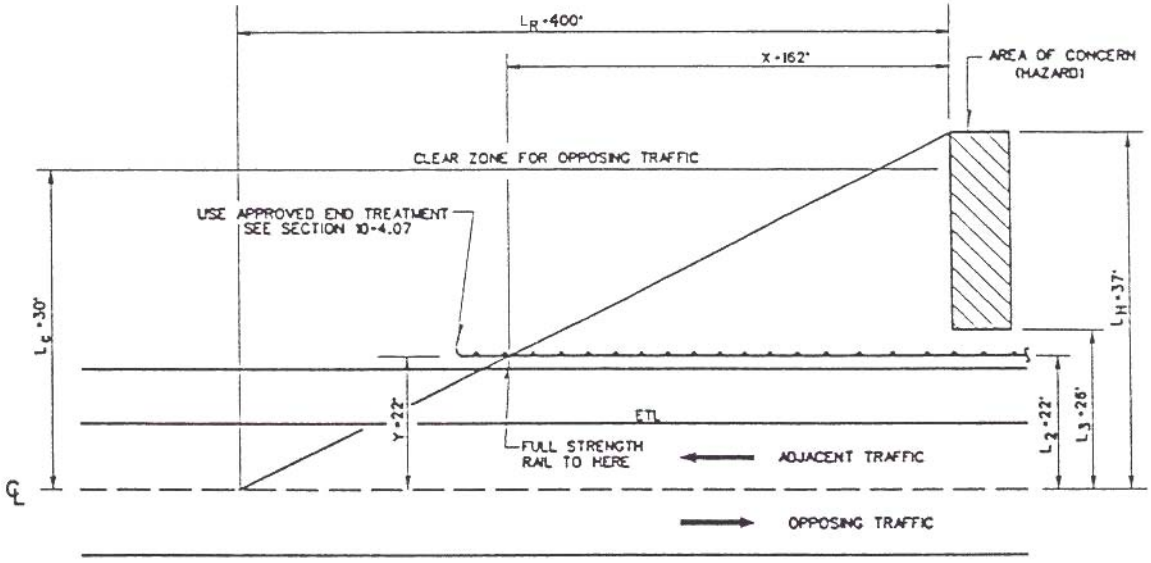
Note: X and Y are shown for the flared approach

BARRIER LENGTH OF NEED FOR ROADSIDE OBSTACLE (Method 2)

Figure 10-6



APPROACH TREATMENT FOR ONCOMING TRAFFIC (a)



APPROACH TREATMENT FOR OPPOSING TRAFFIC (b)

BARRIER LENGTH OF NEED FOR ROADSIDE OBSTACLE (Method 2)
(Example 4)

Figure 10-7

Design Speed (mph)	Design Traffic Volume (ADT)				L_S Shy Line Offset (ft)	Flare Rates		
	Over 6000	*2000-6000*	*800-2000*	*Under 800*		Inside of Shy Line	*Outside of Shy Line*	
	L_R (ft)	L_R (ft)	L_R (ft)	L_R (ft)			Guardrail	CMB*
70	475	445	395	360	10.0	30:1	15:1	20:1
65	450	425	370	345	9.0	28:1	14:1	19:1
60	425	400	345	330	8.0	26:1	14:1	18:1
55	360	345	315	280	7.25	24:1	12:1	16:1
50	330	300	260	245	6.5	21:1	11:1	14:1
45	260	245	215	200	5.75	18:1	10:1	12:1
40	230	200	180	165	5.0	16:1	8:1	10:1
35	200	185	165	150	4.25	15:1	8:1	9:1
30	165	165	150	130	3.5	13:1	7:1	8:1
25	140	130	120	110	2.75	12:1	7:1	8:1
20	110	100	90	80	2.0	10:1	7:1	8:1

* Concrete Median Barrier

DESIGN ELEMENTS FOR BARRIER LENGTH OF NEED

Table 10-5

10-4.02 Lateral Placement

The following will apply to the lateral placement of a roadside barrier:

1. ***Relative to Shoulder.*** Typical barrier location relative to the shoulder shall be two feet beyond the normal shoulder edge. In restricted locations, it is acceptable to place the barrier at the normal shoulder edge, but only if the following conditions can be met. Guardrail should not be placed closer than 4 feet from the edge of travel lane or 17 feet from the

centerline. The greater distance will control. The 17 feet minimum is critical to accommodate snowplow widths without excessive encroachment on the opposing lane.

2. ***Deflection Distance.*** The dynamic deflection of the barrier, as presented in Table 10-4, cannot be violated. Double-nesting the rails or decreasing the post spacing to 3' 1.5" will decrease the deflection distance by 50%. Either method must extend at least 25 feet in advance of and beyond the trailing end of the obstacle being shielded.

3. ***Relative to Embankments.*** A minimum of 3 feet should be provided between the face of the barrier and the break in a fill embankment. When minimal impacts are an issue, a 2 foot space may be used, but longer guardrail posts are required.

4. ***Bridge Approaches.*** Short runs of barrier at less than the desirable lateral offset are acceptable at bridges where the bridge width is narrower than the normal face-of-barrier-to-face-of-barrier width.

5. ***Shy Line Offset.*** It is desirable that a barrier be placed at or beyond the shy line offset, which is the distance beyond which a barrier will not be perceived as a hazard. See Table 10-5 for shy line offset criteria.

10-4.03 Barrier Gaps

Barrier gaps of less than 200 feet should be connected, unless the gap is needed for access (e.g., driveways, maintenance operations).

10-4.04 Placement on Slopes

Roadside barriers should not be placed on roadside slopes steeper than 10:1. This also applies to the area approaching the beginning of the barrier installation.

10-4.05 Placement Behind Curbs

If practical, roadside barriers should not be placed in conjunction with sloping or vertical curbs. Where this is necessary, the following will apply:

1. ***Barrier/Curb Orientation.*** The face of the barrier should be flush with the face of the curb (i.e., at the gutter line). The height of the barrier is measured from the pavement surface. Curb height shall not exceed 4 inches.

2. ***Sidewalks.*** A barrier may be warranted where a curb and sidewalk are provided. If the sidewalk is adjacent to the curb, it will likely not be practical to place the barrier flush with the curb. Table 10-6 presents the criteria for placement of a barrier beyond the curb. If a barrier will be placed closer to the curb than these distances, a thrie beam or rub rail should be used.

3. ***Sidewalks and Bridge Rails.*** A barrier may be warranted approaching a bridge rail and a sidewalk may be provided across the bridge. When guardrail is offset from the face of curb, the height of the barrier is measured from the ground beneath the rail. It may not be practical to meet the criteria in Table 10-6. The desirable treatment in these cases will be determined on a case-by-case basis.

4. ***Guardrail Terminal/Curb Orientation.*** Guardrail terminals should not be placed behind curb. Where there is no alternative, curb height should be reduced to 2 inches approximately 50 feet in advance of the terminal. For flared terminals, the 2 inch height should be carried an additional 37 feet beyond the upstream end. For tangent terminals, the 2 inch height should be carried 12 feet beyond the upstream end and the terminal should be offset 1 foot to keep the impact head behind the face of curb.

10-4.06 Rub Rails

The placement of a barrier in combination with a side slope or curb may create the possibility that the bumper on an impacting vehicle will contact the barrier below the longitudinal member (e.g., the "W" beam). This may cause the vehicle to snag the posts supporting the longitudinal member. In these cases, a rub rail should be considered where a potential snagging problem may exist.

10-4.07 Guardrail Terminals

The following will apply to the barrier end treatment:

1. ***Approach End.*** If the approach end is within the clear zone, an approved terminal will be required. Where there is physically not space available for an approved flared terminal, the designer may consider using a tangential terminal on the approach ends of roadside barriers. In addition, a designer may consider other end treatments described in the AASHTO *Roadside Design Guide* (e.g., buried-in-back slope) in special situations. Guardrail should not be terminated with an unanchored radius. If an approved terminal is not feasible, consideration should be given to use of a curved guardrail system with breakaway posts and an anchorage assembly. See the MDOT Standard Details for more information.

2. ***Trailing End.*** On the trailing end of barrier runs on a one-way roadway, an unanchored terminal may be used. An approved terminal should always be used on the trailing end of a barrier on a two-way roadway.

3. ***End Treatment Selection.*** Guardrail terminal selection shall be based on the highway system designation. Refer to the current Guardrail and Guardrail Terminal Policy for details.

Design Speed (mph)	Recommended Distance Behind Face of Curb7 for Placement of Barrier	
	Desirable	***Acceptable***
< 45	Barrier will be flush with face of curb at gutter line.	≥ 6 ft.
≥45		> 11 ft

Notes: 1. These criteria apply to both sloping and vertical curbs.

2. Where barrier will be placed closer to curb than recommended distance, a thrie beam or rub rail should be used.

BARRIER PLACEMENT BEHIND CURBS

Table 10-6

10-5 ROADSIDE DRAINAGE FEATURES

The primary purpose of roadside drainage is to properly convey water away from or below the roadway (e.g., storm runoff, rivers, streams). Chapter Twelve discusses drainage design in detail. However, the designer must also consider the safety aspects of roadside drainage features. The following presents the Department's criteria:

1. ***Roadside Ditches***. As discussed in Section 10-1.04, the designer should locate the toe of the back slope outside of the clear zone, if practical. However, if this is not practical, a barrier will not normally be warranted to shield the roadside ditch, unless other roadside hazards are within the clear zone.

2. ***Curbs.*** See Section 10-4.05 for criteria on the use of curb and barrier in combination.

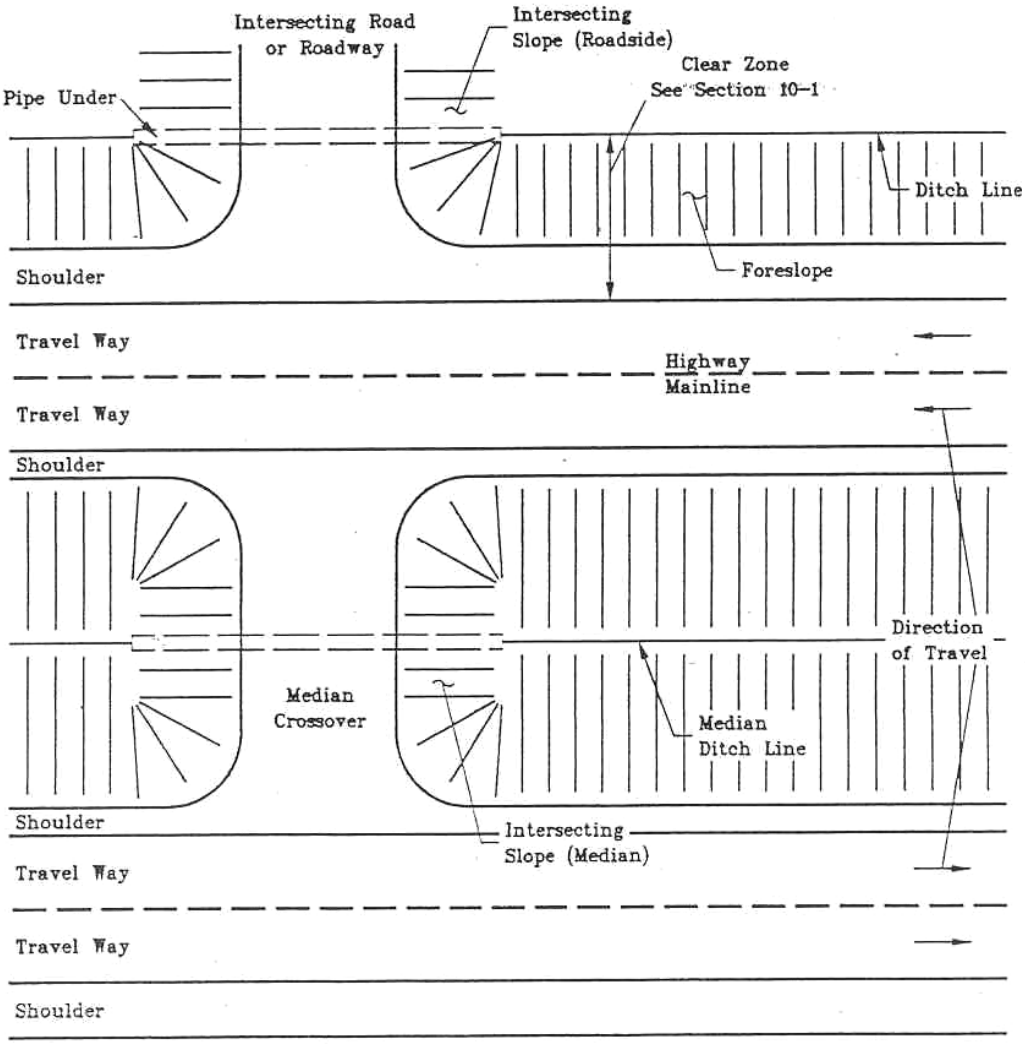
3. ***Cross Drainage Structures (Culverts).*** These convey water beneath the roadway. Ideally, the culvert end sections will be outside of the roadside clear zone as determined from Section 10-1. However, this may be impractical because it may require a major discontinuity in the shape of the fill slope. The MDOT Standard Details present the Department's typical design for culvert end sections based on the type of culvert, culvert size and fill slope. These end sections are typically used for all culverts whether they are within or outside of the clear zone.

4. ***Intersecting Slopes/Drainage Structures.*** A highway mainline may intersect a driveway, side road or median crossing. This will present a slope that may be impacted at a 90-degree angle by run-off-the-road vehicles from the mainline. See Figure 10-8. The following criteria will apply:

   a. Medians -- Intersecting slopes in the median should be 10:1.

   b. Roadside -- For all roads and driveways that intersect the mainline, the desirable intersecting slope is 6:1 within the clear zone. It is acceptable for the intersecting slope to be as steep as the side slope along the main road, but not to exceed 3:1. Where a barrier is shielding the slope, intersecting slopes steeper than 3:1 are acceptable.

5. ***Catch Basins.*** These should be flush with the roadway or ground surface.



INTERSECTING SLOPES

Figure 10-8

10-6 MEDIAN BARRIERS

10-6.01 Warrants

The following summarizes the Department's criteria:

1. ***Freeways.*** Figure 10-9 presents the warrants for a median barrier based on median width and traffic volumes. Note that the traffic volumes are based on a five-year projection. In the areas shown as optional, the decision to use a median barrier will be based on construction and maintenance costs and crossover accident experience. A median barrier may also be warranted on medians not within the optional or warranted area, if a significant number of crossover accidents have occurred.

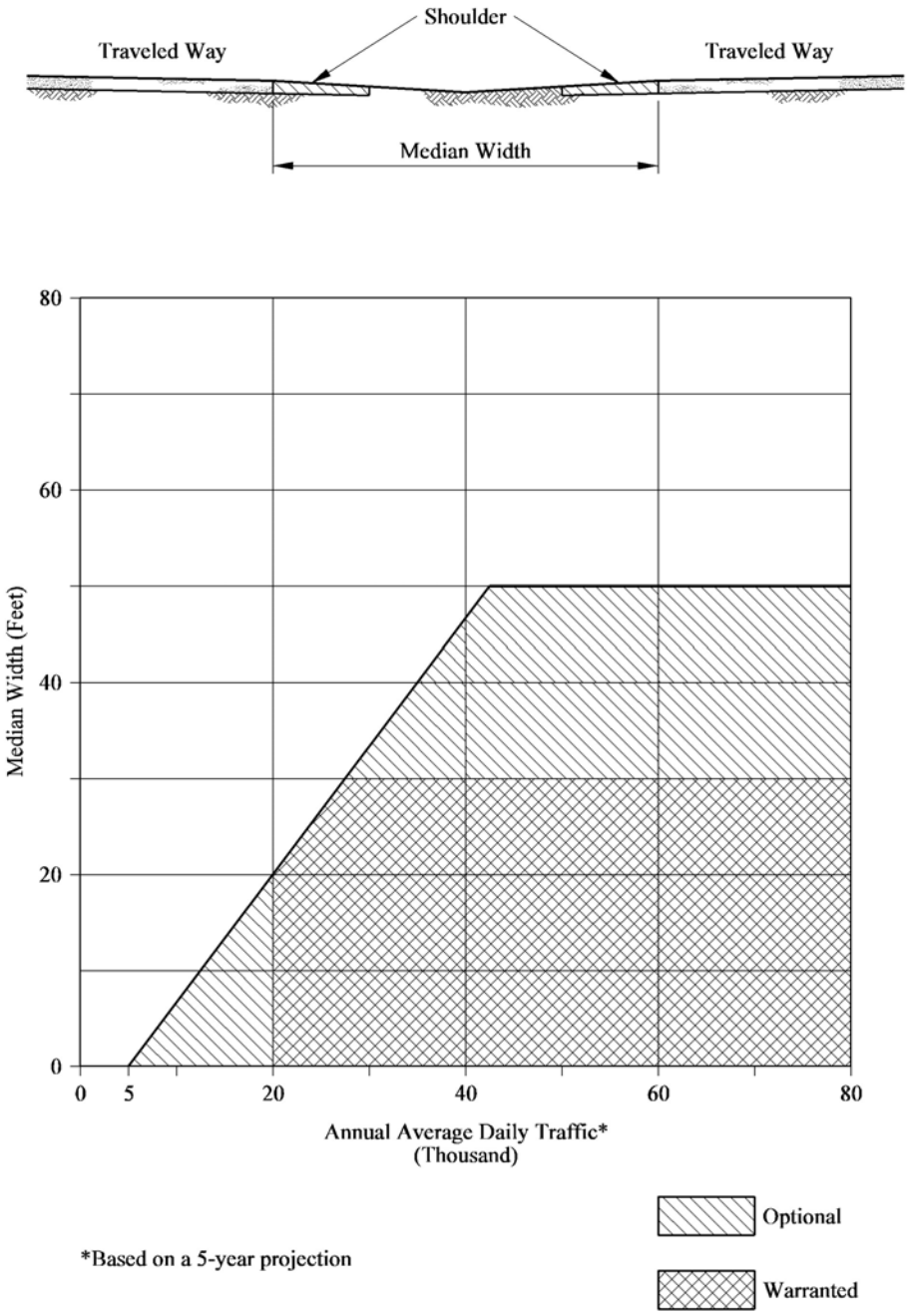
2. ***Non-Freeways.*** On other highways, some judgment must be used to determine median barrier warrants. On highways without full access control, the median barrier must terminate at each at-grade intersection, which is undesirable. In addition, lower speeds will reduce the likelihood of a crossover accident. Therefore, on non-freeway highways, the designer should evaluate the crash history, traffic volumes and speeds, median width, alignment, sight distance and construction costs to determine the need for a median barrier. Figure 10-9 can be used for some guidance.

10-6.02 Types

Table 10-7 presents the types of median barriers that are approved for use in Maine. The following briefly describes each type:

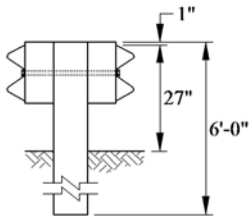
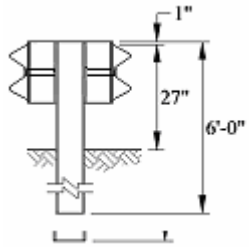
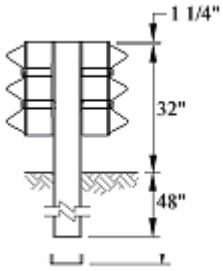
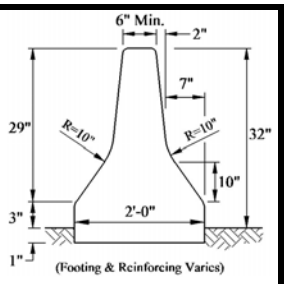
1. ***"W" Beam.*** The "W" beam median barrier with strong posts is a semi-rigid system. Its performance is similar to the "W" beam guardrail system. This median barrier is most applicable to medians with intermediate width. A special application of the W-beam median barrier is for the separation of adjacent on/off ramps at interchanges.

   The Department has approved the use of two "W" beam median barriers. One uses 6x8 timber posts, and the other uses W6x8.5 or W6x9 steel posts. On non-freeways, the two systems are usually presented on a competitive bid basis in the contract proposal. On freeways, the steel post system is designated.



MEDIAN BARRIER WARRANTS

Figure 10-9

				
System	"W" Beam Median Barrier (Wood Posts)	"W" Beam Median Barrier (Steel Posts)	Thrie Beam Median Barrier (Steel Posts)	Concrete Median Barrier
AASHTO Designation	SGM04b	SGM04b	SGM09c	SGM11a
Post Spacing	6'-3"	6'-3"	6'-3"	N/A
Deflection Distance *	3'-0"	3'-0"	2'-0"	0
Post Type	6x8 Treated Wood Post	W6x9 Steel Post	W6x9 Steel Post	N/A
Beam Type	Steel "W" Section 12 ga.	Steel "W" Section 12 ga.	Steel Thrie Beam 12 ga.	N/A
Offset Brackets	6x8x14 Treated Block	6x8x14 Treated Wood Block Or Composite Plastic Block	6x8x21½ Treated Wood Block Or Composite Plastic Block	N/A

* Clear distance from the face of the rail to the roadside object.

MEDIAN BARRIERS

Table 10-7

2. ***Thrie Beam***. The thrie beam median barrier on strong posts is also a semi-rigid system. It performs similar to the thrie beam guardrail system. As with the thrie beam guardrail, the thrie beam median barrier is primarily used where there is inadequate deflection distance (e.g., less than 3 feet) for the "W" beam median barrier

3. ***Concrete Median Barrier.*** The concrete median barrier (CMB) is a rigid system that does not deflect upon impact. A variation is a half-section of the CMB system. These may be necessary where the median barrier must divide to go around a fixed object in the median (e.g., bridge piers).

10-6.03 Median Barrier Selection

The Department has not adopted specific criteria for the selection of median barrier systems. This involves a objective evaluation of the many trade-offs between systems. The designer should evaluate each of the following factors when selecting a median barrier:

1. ***Median Width.*** The median width will significantly affect the probability of impact (i.e., the number of hits) and the likely angles of impact. The former will influence maintenance costs; the latter influences safety. The greater the offset to the barrier, the higher the likely angle of impact. Specifically for the CMB, offsets of more than 15 feet should be avoided. Therefore, considering both maintenance and safety, this favors the use of the CMB on median widths up to about 30 feet and either the "W" beam or thrie beam system for wider medians.

2. ***Traffic Volumes.*** The higher the traffic volume, the greater the likelihood of impacts on the median barrier. From a maintenance perspective, this favors the CMB; from a safety perspective, this favors the metal beam systems.

3. ***Heavy Vehicle Traffic.*** The CMB is more likely to restrain and redirect heavy vehicles (trucks and buses) than the metal beam systems. Therefore, where there is a high volume of heavy vehicles, this may favor the CMB even on medians wider than 30 feet. Considering the two metal beam systems, the thrie beam performs somewhat better when impacted by heavy vehicles.

4. ***Costs.*** The initial cost of the CMB will exceed, perhaps by a wide margin, the initial cost of the two metal beam median barriers. The CMB may also require a closed drainage system in the median, further increasing initial costs. However, the maintenance costs per impact on the CMB will probably be far less, which favors the CMB in narrow medians and/or on high-volume highways.

5. ***Maintenance Operations.*** Two factors are important. First, maintenance response time will influence safety. The longer that a damaged section of median barrier is present, the greater the likelihood of a second impact on a substandard barrier. This observation favors the use of the CMB which normally sustains far less damage when impacted. Second, the

maintenance operations for repairing damaged barrier can interrupt traffic operations. It is particularly undesirable to close a traffic lane to repair a barrier. The consideration of maintenance operations generally favors the use of the CMB in narrow medians and/or on high-volume highways.

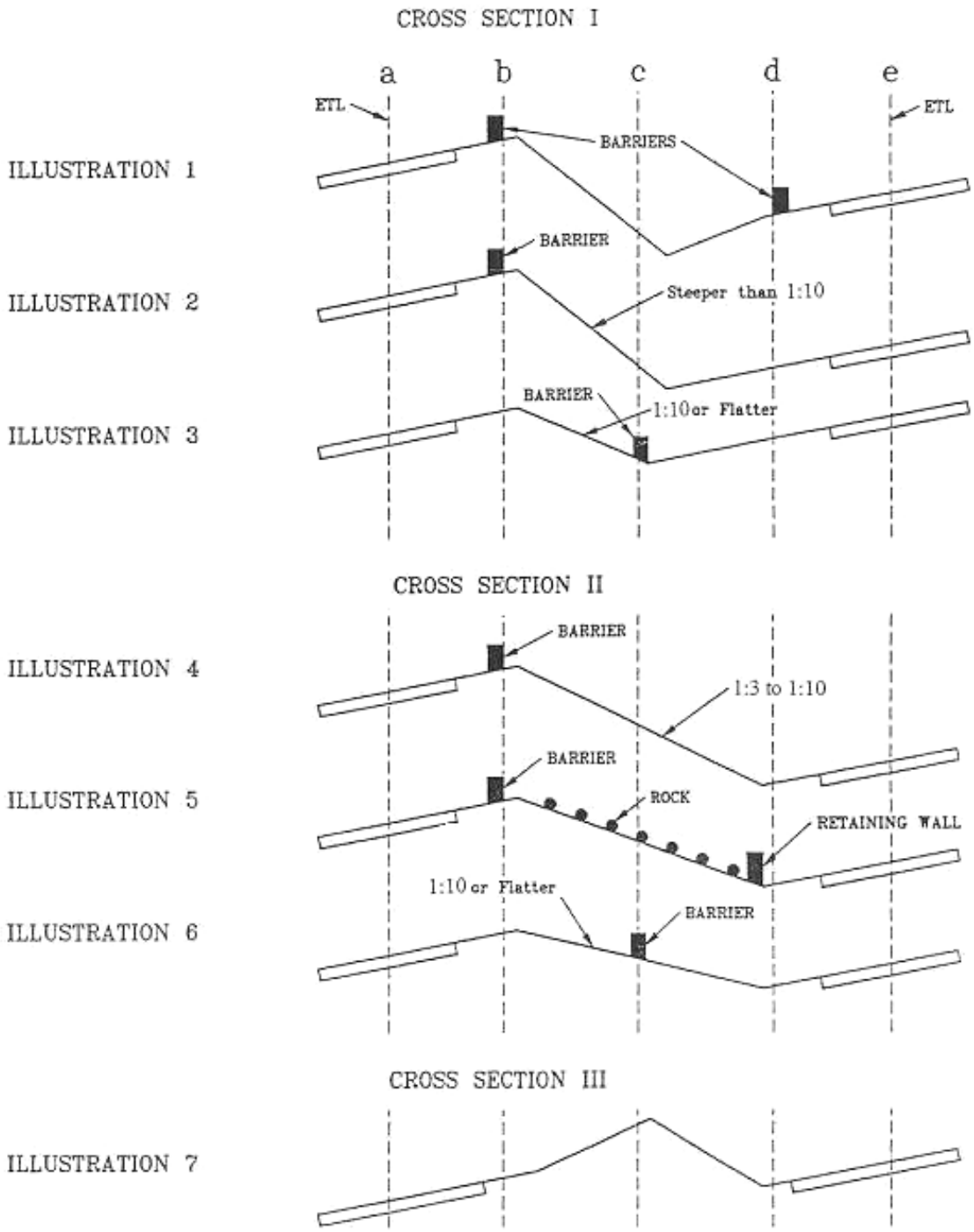
10-6.04 Median Barrier Layout

The information presented in Section 10-4 on roadside barrier layout also applies to median barriers (e.g., placement behind curbs). The following presents criteria specifically for the design of median barriers:

Sloped Medians

A median barrier should not be placed on a slope steeper than 10:1. Where the median slopes are steeper than 10:1, the designer should give special consideration to median barrier placement. Figure 10-10 illustrates three basic types of sloped medians. The following discusses barrier placement for each type (assuming a median barrier is warranted):

1. For Cross Section I, the designer should determine if the individual slopes warrant protection based on the criteria in Section 10-2. If both slopes warrant protection (Illustration 1), a roadside barrier should be placed at "b" and "d". If only one slope warrants protection, the median barrier should be placed to shield that slope. If "W" beam is used, a rub rail should be placed on the median side of the median barrier for potential impacts on that side. If neither slope warrants protection and both slopes are steeper than 10:1 (Illustration 2), median barrier should be placed at "b" or "d", whichever is shielding the steeper slope. Again, a rub rail should be used with the "W" beam median barrier. If the slopes are 10:1 or flatter (Illustration 3), the median barrier should be placed in the center of the median.



MEDIAN BARRIER PLACEMENT
(Sloped Medians)

Figure 10-10

2. For Cross Section II, the slope in the median will determine the proper treatment. If the slope is steeper than 10:1 but flatter than 3:1 (Illustration 4), the median barrier should be placed at "b". If the median slope is 3:1 or steeper, a roadside barrier at "b" is the only necessary treatment. If the median slope is a roadside hazard (e.g., rough rock cut) (Illustration 5), a roadside barrier should be placed at both "b" and "d". If the median slope is 10:1 or flatter (Illustration 6), the median barrier should be placed in the center of the median.

3. For Cross Section III (Illustration 7), the redirective capacity of the median slope will determine the proper treatment. If the median slope is 3:1 or steeper and 3 feet or higher, no roadside or median barrier is necessary. If the median slopes are flatter than 3:1, and/or not 3 feet high, the median barrier should be placed at the apex of the cross section. A rub rail should be placed on both sides of the barrier.

Flared/Divided Median Barriers

It may be necessary to intermittently divide a median barrier or to flare the barrier from one side to the other. The slope criteria or a fixed object in the median may require this. The median barrier may be divided by one of these methods:

1. A fixed object may be encased by a CMB.

2. A half-section CMB may be used on both sides to shield a fixed object.

3. The metal beam median barriers can be split into two separate runs of barrier passing on either side of the median hazard (fixed object or slope).

If a median barrier is split, the design should adhere to the acceptable flare rates. Desirably, the flare rate will be 50:1. The maximum flare rate for the CMB is 20:1; for the metal beam barriers, it is 15:1.

End Treatments

If the end of the median barrier is within the clear zone, an impact attenuator will be used. See Section 10-7. In addition, the designer may consider other end treatments described in the AASHTO *Roadside Design Guide* in special situations.

10-6.05 Glare Screens

Glare screens can be used in combination with median barriers to eliminate headlight glare from opposing traffic. The Department has not adopted specific warrants for the use of glare screens. The typical application, however, is on urban freeways with narrow medians and high traffic volumes. Another application is between on/off ramps at interchanges where the two ramps adjoin

each other. Here, the sharp radii of curvature and the narrow separation may make headlight glare especially bothersome. The designer should consider the use of glare screens at these sites.

Blocking headlight glare can be achieved in several ways, and several commercial glare screens are available. Considering both effectiveness and ease of maintenance, the paddle glare screen barrier may be the best choice.

Glare screens should be designed for a "cutoff angle" of 20°. This is the angle between the median centerline and the line of sight between two vehicles traveling in opposite directions. The glare screen should be designed to block the headlights of oncoming vehicles up to the 20° cutoff angle. On horizontal curves, the design cutoff angle should be increased to allow for the effect of the curvature on headlight direction. The criteria is:

$$\text{Cutoff Angle (in degrees)} = 20 + \frac{5729.58}{R} = 20 + D$$

Where: R = radius of curve (ft)
D = degree of curve

The designer should also evaluate the impact of a glare screen on horizontal sight distance on curves to the left. The screen could significantly reduce the available middle ordinate for stopping sight distance. See Section 5-2.06 for a discussion of sight distance at horizontal curves.

10-7 IMPACT ATTENUATORS

10-7.01 Warrants

Warrants for impact attenuators are the same as barrier warrants. Once a hazard is identified, the designer should first attempt to remove, relocate or make the hazard breakaway. If the foregoing is impractical, then an impact attenuator should be considered. Impact attenuators are most often installed to shield fixed-point hazards. Examples include exit gore areas (particularly on structures), bridge piers, non-breakaway sign supports and median barrier ends.

10-7.02 Types

The following impact attenuators are just three of the many that have been approved for use in Maine. For a complete, current listing of acceptable attenuators, refer to the FHWA website at

http://safety.fhwa.dot.gov/fourthlevel/hardware/term_cush.htm

The designer should note that each of these attenuators is patented. Selection shall be made on a case by case basis. Consideration should be given to space available and the likelihood of multi-directional hits.

1. CAT- 350**.** The Crash Cushion/Attenuating Terminal (CAT) uses energy absorbing beam elements, breakaway wooden posts and a cable anchorage system to gradually dissipate the vehicle's kinetic energy during impact. The system also provides adequate anchorage for the ends of double-beam guardrail and concrete median barriers. Figure 10-11 illustrates a typical design.

2. REACT - 350. The Reusable Energy Absorbing Terminal (REACT) uses plastic cylinders to provide safe deceleration for occupants in a vehicle. It is designed to withstand a series of impacts without need for major repairs. There are various cylinder arrangements possible for different situations. Figure 10-12 illustrates one of these arrangements.

3. QuadGuard. During head-on impacts, the QuadGuard Systems telescope rearward and crush the cartridges to absorb the energy of the impact. When impacted from the side, the QuadGuard Systems safely redirect the errant vehicle back toward its original travel path. Figure 10-13 illustrates different QuadGuard models for different uses.

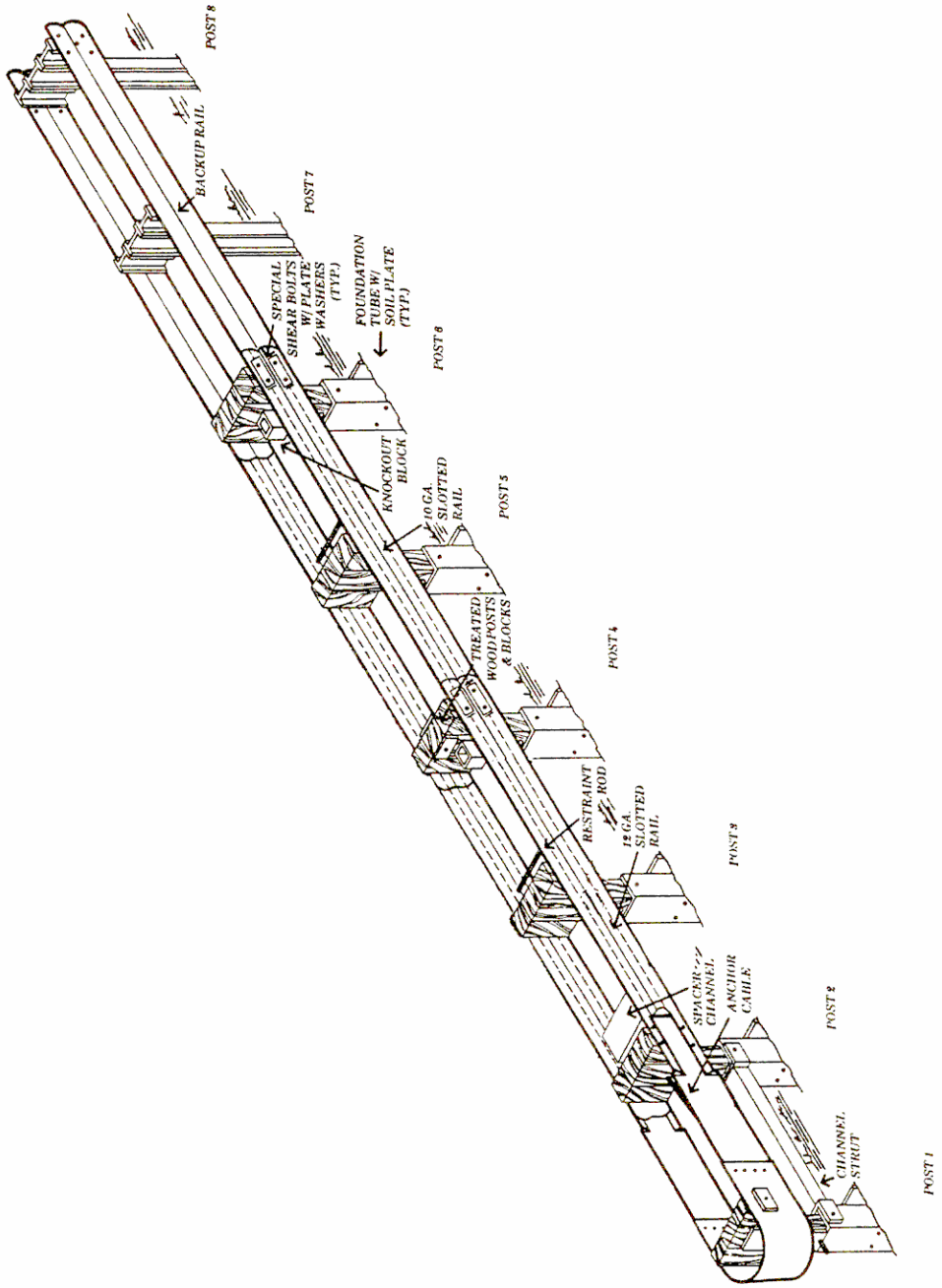

POST 8
BACKUP RAIL
POST 7
SPECIAL SHEAR BOLTS W/ PLATE WASHERS (TYP.)
FOUNDATION TUBE W/ SOIL PLATE (TYP.)
POST 6
KNOCKOUT BLOCK
10 GA. SLOTTED RAIL
POST 5
TREATED WOOD POSTS & BLOCKS
POST 4
RESTRAINT ROD
12 GA. SLOTTED RAIL
POST 3
SPACER CHANNEL
ANCHOR CABLE
POST 2
CHANNEL STRUT
POST 1

Figure 10-11

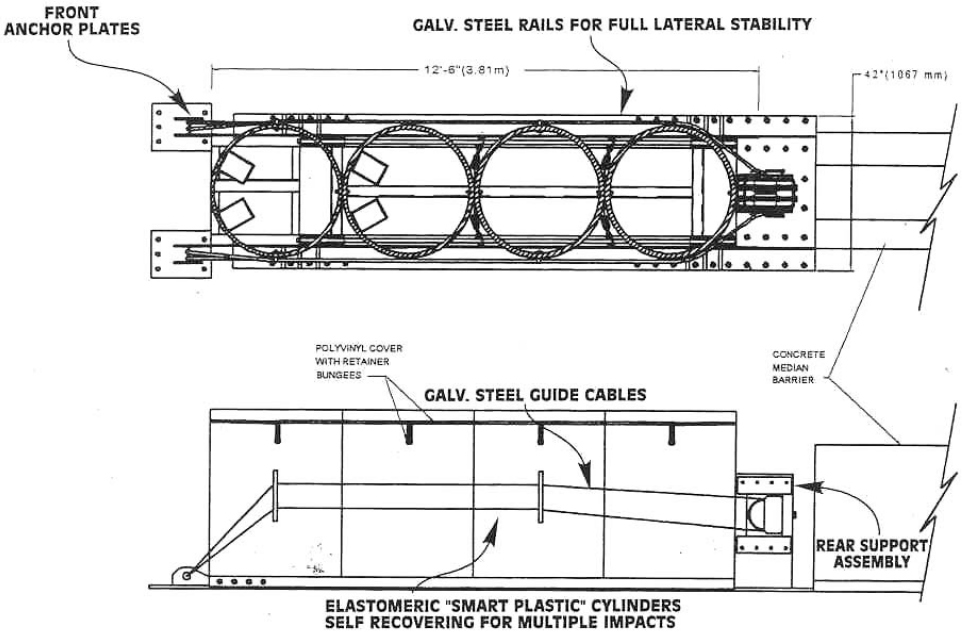
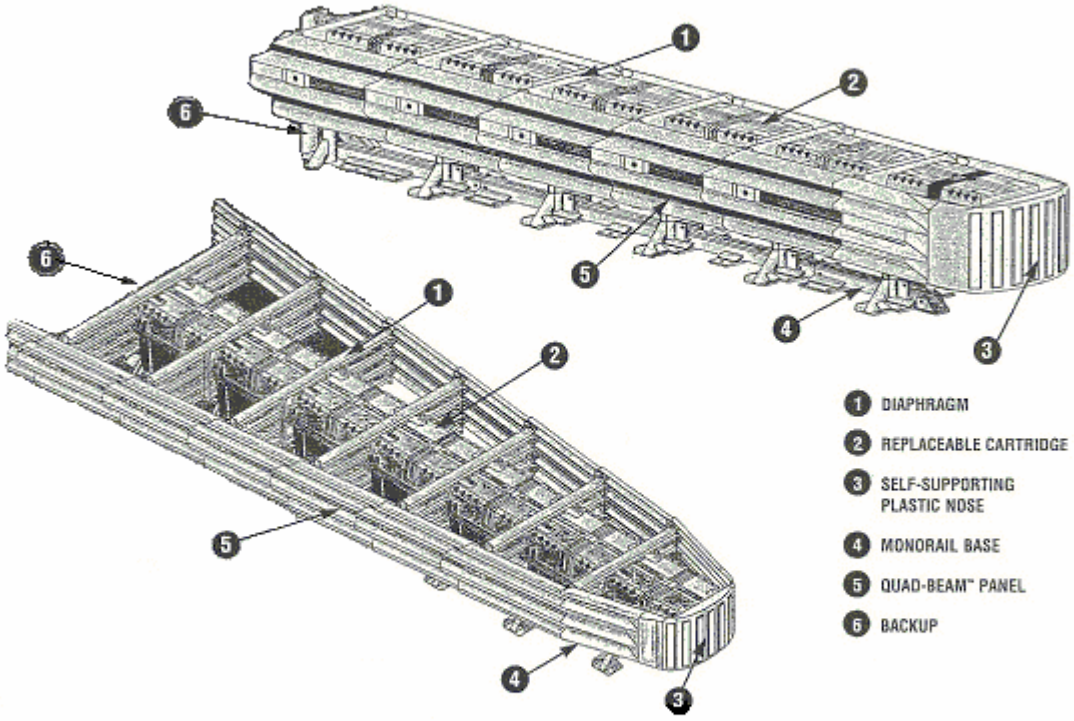

FRONT
ANCHOR PLATES
GALV. STEEL RAILS FOR FULL LATERAL STABILITY
12'-6"(3.81m)
42"(1067 mm)
POLYVINYL COVER
WITH RETAINER
BUNGEES
GALV. STEEL GUIDE CABLES
CONCRETE
MEDIAN
BARRIER
REAR SUPPORT
ASSEMBLY
ELASTOMERIC "SMART PLASTIC" CYLINDERS
SELF RECOVERING FOR MULTIPLE IMPACTS

Figure 10-12



QuadGuard

Figure 10-13

In the future, other impact attenuator systems may be developed and approved for use by the Department.

10-7.03 Impact Attenuator Design

Once an impact attenuator has been selected, the designer must ensure that its design is compatible with the traffic and physical conditions at the site. For the patented attenuators, the designer should coordinate with the manufacturer for all design features.

Impact Speed

An initial impact speed must be assumed in selecting an attenuator. Table 10-8 presents the Department's criteria.

Highway Design Speed (V in mph)	Impact Speed (mph)	
	Freeways	*Non-Freeways*
$V \geq 60$	60	60
$40 < V < 60$	60	Design Speed
$V \leq 40$	-	40

IMPACT SPEED FOR IMPACT ATTENUATORS

Table 10-8

Deceleration

For impact attenuators, acceptable vehicular deceleration is determined by the criteria which has been adopted by FHWA. The manufacturer is responsible for ensuring that the system meets the FHWA deceleration criteria.

Placement

Several factors should be considered in the placement of an impact attenuator:

1. ***Level Terrain.*** The attenuator should be placed on a level surface or on a cross slope not to exceed 5 percent.

2. ***Curbs.*** No curbs should be present at proposed new installations.

3. ***Surface***. A paved, bituminous or concrete pad should be provided under the attenuator.

4. ***Orientation.*** The proper orientation angle will depend upon the design speed, roadway alignment and lateral offset distance to the cushion. For most roadside conditions, a maximum angle of approximately 10°, as measured between the highway and attenuator longitudinal centerlines, is considered appropriate.