Chapter Thirty-eight

ROADSIDE SAFETY

BUREAU OF DESIGN AND ENVIRONMENT MANUAL

Chapter Thirty-eight
ROADSIDE SAFETY

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The ideal roadway would be entirely free of any roadside obstructions or other hazardous conditions. This is rarely practical because of natural, economic, and environmental factors. Chapter 38 presents clear zone distances which should adequately provide a clear recovery area for about 80% of the errant vehicles that run off the road and the chapter provides criteria for the use of roadside barriers, median barriers, and impact attenuators where providing the clear zone is not practical. The chapter also discusses the use of cost-effective methodologies to determine roadside safety treatments.

Information applicable to roadside safety is also included in the following Chapters:

- Chapter 7 - roadside safety near railroads.
- Chapter 17 - roadside safety along bikeways.
- Chapter 34 – roadside safety addressed through shoulder rumble strips and stripes
- Chapter 49 - roadside safety on 3R projects on rural and urban highways.
- Chapter 50 - roadside safety on 3R projects on freeways.
- Chapter 55 - roadside safety in work zones.

38-1 APPLICATION

This Section presents the IDOT application of roadside safety decisions based on project type and appurtenance type.

38-1.01 <u>Project Type</u>

The following summarizes the use of the *BDE Manual* for roadside safety applications based on the project type or project scope of work:

1. <u>New Construction/Reconstruction Projects</u>. Chapter 38 presents the roadside safety criteria for all new construction/reconstruction projects.
2. <u>3R Non-Freeway Projects</u>. Chapter 49 presents the roadside safety criteria for non-freeway 3R rural and urban highway freeway projects. Roadside safety criteria not covered in Chapter 49 shall be as described in Chapter 38. For example, Chapter 49 modifies clear zone values, however it does not modify their application on non-recoverable slopes. Clear recovery area at the toe-of-slope of non-recoverable slopes is controlled by Chapter 38.
3. <u>3R Freeway Projects</u>. Chapter 50 presents the roadside safety criteria for 3R freeway projects. Roadside safety criteria not covered in Chapter 50 shall be as described in Chapter 38.

4. Highway Safety Improvement Projects. The IDOT Bureau of Safety Programs and Engineering (BSPE) is responsible for approving the project scope of work for highway safety improvement projects (HSIP) that use the Federal-aid funds set aside for highway safety improvements. The scope of work for these projects may include roadside safety improvements. In this case, the designer will use the criteria in Chapter 38 with the specific application determined on a case-by-case basis considering:

   - the crash patterns at the site,
   - the project scope as outlined by the BSPE,
   - the project budget, and
   - the estimated construction costs of an application as compared to the anticipated safety benefits and the costs of other design solutions.

5. Work Zones. Chapter 55 presents the roadside safety criteria for work zones.

38-1.02 Appurtenance Type

The following summarizes the Department's roadside safety responsibilities based on type of appurtenance:

1. Bridge Rails. The IDOT Bureau of Bridges and Structures is responsible for establishing Department criteria for the selection and design of all bridge rails. The Bureau of Design and Environment (BDE) is responsible for establishing selection and design criteria for the roadside barrier and terminal section approaching the bridge rail.

2. Traffic Control Devices. The Bureau of Operations and the Bureau of Bridges and Structures are jointly responsible for establishing Department criteria for the design of structural supports for traffic control devices (e.g., breakaway bases for large signs). For the location of traffic control devices, the Bureau of Operations determines the initial placement and the road designer ensures that the proposed location is compatible with the roadway design.

3. All Other Appurtenances. BDE and BSPE are jointly responsible for establishing Department criteria for all other roadside safety appurtenances (e.g., roadside barriers, median barriers, impact attenuators, lighting).

38-2 DEFINITIONS

1. Back Slope. The side slope created by connecting the ditch bottom, shelf, or shoulder at the hinge point, upward and outward, to the natural ground line.

2. Barrier (Vertical) Curb. A longitudinal element placed at the edge of the traveled way to provide delineation, to control drainage, to manage access, and to minimize right-of-way acquisition. Barrier curbs range between 6 in. and 9 in. (150 mm to 230 mm) in height with a face steeper than 3 vertical to 1 horizontal. Barrier curbs do not have significant re-directional capability for errant vehicles.

3. Barrier Terminals. End treatments for both roadside barriers and transitions to other types of barriers (e.g., to bridge rails).

4. Clear Zone. The area provided beyond the edge of through traveled way for the recovery of errant vehicles, which ideally should be kept clear of any non-traversable hazards or fixed objects. The clear zone includes shoulders, bike lanes, and auxiliary lanes, except those auxiliary lanes that function like through lanes.

5. Concrete Barrier. A rigid barrier typically constructed in a narrow median where no deflection distance is available and which can accommodate most vehicular impacts without penetration. In most applications these barriers are double-faced as shown on the Highway Standard.

6. Critical Parallel Slope. Fill sections with front slopes steeper than 1V:3H that cannot be safely traversed by a run-off-the-road vehicle. Depending on the encroachment conditions, a vehicle on a critical slope may overturn.

7. End Treatments. The terminal devices for roadside barriers, including both the approaching and departing ends.

8. Enhanced Lateral Offset. An offset in an urban environment beyond that used to provide clearance to keep the overhang of a truck from striking an object [1.5 ft (0.5 m) from the face of the curb], but less than the normal clear-zone width. The recommended offset to obstructions typically range from 4 ft to 6 ft (1.2 m to 1.8 m) from the face of curb and 8 ft (2.4 m) without a vertical curb. A 12 ft (3.6 m) offset is recommended for urban areas which are without a vertical curb and on the outside of a horizontal curve.

9. Experimental System. A roadside barrier, end terminal, or impact attenuator which has performed satisfactorily in full-scale crash tests but has not been installed in sufficient locations or exposed to traffic for a sufficient time to adequately evaluate its in-service performance.

10. Front Slope (or Foreslope). The side slope created by connecting the shoulder or shelf at the hinge point, downward and outward, to the ditch bottom or natural ground line.

11. Gating. A term used to describe barrier end treatments which are designed to allow controlled penetration by an impacting vehicle.

12. <u>Hinge Point</u>. The first major discontinuity in the roadway encountered by the vehicle after it leaves the traveled way and shoulder. The top of the front slope. The planar intersection between the shoulder and the front slope when the slope of the shoulder is 1H:10V or flatter.

13. <u>Impact Angle</u>. For a longitudinal barrier, the angle between a tangent to the face of the barrier and a tangent to the vehicular path at impact. For an impact attenuator, it is the angle between the axis of symmetry of the impact attenuator and a tangent to the vehicular path at impact.

14. <u>Impact Attenuator (Crash Cushion)</u>. A protective device used to safely shield roadside hazards, typically point obstacles, from approximately head-on impacts by errant vehicles.

15. <u>Length of Need</u>. Total length of a longitudinal barrier, measured with respect to the centerline of roadway, needed to shield an area of concern. The length of need (LON) is measured to the last point of redirective rail. The beginning point of the length of need is referred to as the BLON (beginning length of need) point.

16. <u>MASH</u>. Manual for Assessing Safety Hardware, AASHTO 2016. The processes and testing described in MASH typically represent the latest requirements for the range of roadside safety hardware required for use on the state highway system. The assessment of roadside hardware for crashworthiness continues to transition from NCHRP 350 standards to MASH standards, and the term *crashworthy* is used in this chapter as the general term to describe devices that satisfy current Department requirements.

17. <u>Median Barrier</u>. A longitudinal barrier used to prevent an errant vehicle from crossing the median of a divided highway thereby preventing head-on collisions between opposing traffic.

18. <u>Mountable (Sloping) Curb</u>. A longitudinal element placed at the edge of traveled way to provide delineation, to control drainage, to manage access, and to outline corner islands. Mountable curbs have a height of 6 in. (150 mm) or less with a sloping face of approximately 45 degrees. Mountable curbs do not have significant re-directional capability for errant vehicles.

19. <u>Non-Recoverable Parallel Slope</u>. Slopes which can be safely traversed but upon which an errant vehicle is unlikely to recover. The run-off-the-road vehicle will likely continue down to the toe of the slope. For most embankment heights, if a front slope is between 1V:3H (inclusive) and 1V:4H (exclusive), it is considered a non-recoverable parallel slope.

20. <u>Non-Redirective</u>. A descriptive term which indicates that the roadside safety device will not redirect an impacting vehicle but will, rather, “capture” the vehicle (e.g., sand barrels) or allow the vehicle to pass through (e.g., breakaway sign supports).

21. <u>Operational System</u>. A roadside barrier, end terminal, or crash cushion that has performed satisfactorily in full-scale crash tests and has demonstrated satisfactory in-service performance.

22. Parallel Slopes. Front and back slopes for which the toe runs approximately parallel to the roadway.

23. Pocketing. The potential for a vehicle impacting a redirective device to undergo relatively large lateral displacements within a relatively short longitudinal distance.

24. Recoverable Parallel Slope. Slopes that can be safely traversed and upon which an errant motorist has a reasonable opportunity to regain control of the vehicle. Front slopes 1V:4H and flatter are considered recoverable.

25. Redirective. A term which indicates that the roadside safety device is designed to redirect an impacting vehicle approximately parallel to the longitudinal axis of the device.

26. Roadside Barrier. A longitudinal barrier (e.g., guardrail, concrete barrier) used to shield roadside hazards while addressing the safety of vehicle occupants. A longitudinal barrier may occasionally be used to shield pedestrians from vehicular traffic.

27. Roadside Hazards. A general term to describe roadside features that cannot be safely impacted by a run-off-the-road vehicle. Roadside hazards include both fixed objects and non-traversable roadside features (e.g., rivers).

28. Roadway. The combination of the traveled way, both shoulders or curb and gutters, and any auxiliary lanes on the mainline highway. Traveled ways separated by a depressed median have two (or more).

29. Shy Distance. The distance from the edge of traveled way beyond which a roadside object will not be perceived as an immediate hazard by the typical driver, to the extent that the driver will change vehicular placement or speed.

30. Side Slope. A ratio used to express the steepness of a slope adjacent to the roadway. The ratio is expressed as vertical to horizontal (V:H).

31. Test Level. The test levels represent sets of conditions defined in terms of vehicular type and mass, vehicular speed, and vehicular impact angle that quantify the impact severity of a matrix of crash tests. Six performance levels, or test levels, are available. Test Levels 1 through 3 use a small passenger car and a pickup truck as design vehicles. Test Level 1 (TL-1) is applicable at roadside design speeds up to 30 mph (50 km/hr), TL-2 up to and including 45 mph (70 km/hr), and TL-3 up to 60 mph (100 km/hr). Higher test levels retain the TL-3 performance requirements for the small passenger car and pickup truck, but also introduce larger trucks. TL-4 includes a 22,000 pound (10,000 kg) single unit truck, TL-5 an 80,000 pound (36,000 kg) tractor-van trailer, and TL-6 an 80,000 pound (36,000 kg) tractor-tanker trailer.

32. Toe of Slope. The intersection of the front slope or back slope with the natural ground line or ditch bottom, before any rounding is applied.

33. Top of Slope. The intersection of the back slope with the natural ground line, before any rounding is applied.

34. Transverse Slopes. Front and back slopes for which the toe runs approximately perpendicular to the flow of traffic on the major roadway. Transverse slopes are typically formed by intersections between the mainline and entrances, median crossovers, or side roads.

35. Traveled Way. The portion of the roadway for the movement of vehicles, exclusive of medians, shoulders, curb and gutter, and auxiliary lanes.

36. Warrant. The criteria by which the justification for a safety treatment or improvement can be determined. The warrant may be based on IDOT/AASHTO guidelines, on a "cost-effective" assessment, or on engineering judgment.

38-3 ROADSIDE CLEAR ZONES

38-3.01 Background

The clear zone widths are based on limited empirical data that has then been extrapolated to a wide range of conditions. Therefore, 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.

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

1. Project Scope of Work. The clear zone distances in Section 38-3 apply to all freeway projects and to new construction/reconstruction projects on non-freeways. Chapter 49 presents the criteria for 3R projects on non-freeways.

2. Context. If a formidable 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 (see item 4 below) or unacceptable construction costs may lead to installation of a barrier or perhaps no protection at all. As a general statement, the use of an appropriate clear zone distance is a compromise between maximum safety and minimum construction costs.

3. Boundaries. The designer should not use the clear zone distances as boundaries for introducing roadside hazards (e.g., bridge piers, non-breakaway sign supports, utility poles, landscaping features). These should be placed as far from the traveled way as practical.

4. Right-of-Way. Even for new construction/reconstruction projects, the availability of right-of-way may be a serious project issue. The acquisition of additional right-of-way solely to provide the clear zone distance may not be cost effective. If, on the other hand, the right-of-way width exceeds the design clear zone, this may offer an opportunity to increase safety by removing all hazards within the right-of-way.

38-3.02 Clear Zone Values

Figure 38-3.A presents clear zone distances for design. The following discusses the use of Figure 38-3.A to determine the applicable clear zone.

38-3.02(a) Speed

The designer will use the design speed for the facility from Figure 38-3.A to determine the applicable clear zone.

Design Speed (mph)	Design Year ADT	Front Slopes			Back Slopes		
		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	7 – 10	7 – 10	**	7 – 10	7 – 10	7 – 10
	750 – 1500	10 – 12	12 – 14	**	10 – 12	10 – 12	10 – 12
	1500 – 6000	12 – 14	14 – 16	**	12 – 14	12 – 14	12 – 14
	Over 6000	14 – 16	16 – 18	**	14 – 16	14 – 16	14 – 16
45 – 50	Under 750	10 – 12	12 – 14	**	8 – 10	8 – 10	10 – 12
	750 – 1500	12 – 14	16 – 20	**	10 – 12	12 – 14	14 – 16
	1500 – 6000	16 – 18	20 – 26	**	12 – 14	14 – 16	16 – 18
	Over 6000	18 – 20	24 – 28	**	14 – 16	18 – 20	20 – 22
55	Under 750	12 – 14	14 – 18	**	8 – 10	10 – 12	10 – 12
	750 – 1500	16 – 18	20 – 24	**	10 – 12	14 – 16	16 – 18
	1500 – 6000	20 – 22	24 – 30	**	14 – 16	16 – 18	20 – 22
	Over 6000	22 – 24	26 – 32*	**	16 – 18	20 – 22	22 – 24
60	Under 750	16 – 18	20 – 24	**	10 – 12	12 – 14	14 – 16
	750 – 1500	20 – 24	26 – 32*	**	12 – 14	16 – 18	20 – 22
	1500 – 6000	26 – 30	32 – 40*	**	14 – 18	18 – 22	24 – 26
	Over 6000	30 – 32*	36 – 44*	**	20 – 22	24 – 26	26 – 28
65 – 70[6]	Under 750	18 – 20	20 – 26	**	10 – 12	14 – 16	14 – 16
	750 – 1500	24 – 26	28 – 36*	**	12 – 16	18 – 20	20 – 22
	1500 – 6000	28 – 32*	34 – 42*	**	16 – 20	22 – 24	26 – 28
	Over 6000	30 – 34*	38 – 46*	**	22 – 24	26 – 30	28 – 30

* *Clear zones may be limited to 30 ft for practicality and to provide a consistent roadway template. When a site-specific investigation indicates a high probability of continuing crashes or when such occurrences are indicated by crash history, the designer should consider clear zone distances greater than the clear zone shown above.*

** *See procedure in Section 38-3.03(b).*

Notes:

1. *All distances are measured from the edge of the traveled way. For opposing traffic on an undivided two-way roadway, the traveled way begins at the centerline separating opposing traffic.*
2. *For clear zones, the "Design Year ADT" will be the total ADT for both directions of travel for the design year. This applies to both divided and undivided facilities. Traffic volumes will be based on a minimum 20-year projection from the anticipated date of construction.*
3. *The values for “back slopes” only apply to a section where the toe of the back slope is adjacent to the shoulder; see Figure 38-3.B(d). For sections with roadside ditches, see Section 38-3.04.*
4. *The values in the figure apply to tangent sections of highway. See the discussion in Section 38-3.02(e) for possible adjustments on horizontal curves.*
5. *The values in the figure apply to all uncurbed sections and curbed sections in rural areas. See Section 38-3.02(f) for curbed sections in urban areas.*
6. *70 mph is highest design speed provided in the Roadside Design Guide. When design speeds are greater than the values provided, the designer may provide clear-zone distances greater than those shown in the table.*

RECOMMENDED CLEAR ZONE DISTANCES (ft)
(New Construction/Reconstruction)
(US Customary)

Figure 38-3.A

Design Speed (km/hr)	Design Year ADT	Front Slopes			Back Slopes		
		1V:6H or Flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or Flatter
≤ 60	Under 750	2.0 – 3.0	2.0 – 3.0	**	2.0 – 3.0	2.0 – 3.0	2.0 – 3.0
	750-1500	3.0 – 3.5	3.5 – 4.5	**	3.0 – 3.5	3.0 – 3.5	3.0 – 3.5
	1500-6000	3.5 – 4.5	4.5 – 5.0	**	3.5 – 4.5	3.5 – 4.5	3.5 – 4.5
	Over 6000	4.5 – 5.0	5.0 – 5.5	**	4.5 – 5.0	4.5 – 5.0	4.5 – 5.0
70-80	Under 750	3.0 – 3.5	3.5 – 4.5	**	2.5 – 3.0	2.5 – 3.0	3.0 – 3.5
	750-1500	4.5 – 5.0	5.0 – 6.0	**	3.0 – 3.5	3.5 – 4.5	4.5 – 5.0
	1500-6000	5.0 – 5.5	6.0 – 8.0	**	3.5 – 4.5	4.5 – 5.0	5.0 – 5.5
	Over 6000	6.0 – 6.5	7.5 – 8.5	**	4.5 – 5.0	5.5 – 6.0	6.0 – 6.5
90	Under 750	3.5 – 4.5	4.5 – 5.5	**	2.5 – 3.0	3.0 – 3.5	3.0 – 3.5
	750-1500	5.0 – 5.5	6.0 – 7.5	**	3.0 – 3.5	4.5 – 5.0	5.0 – 5.5
	1500-6000	6.0 – 6.5	7.5 – 9.0	**	4.5 – 5.0	5. 0 – 5.5	6.0 – 6.5
	Over 6000	6.5 – 7.5	8.0 – 10.0*	**	5.0 – 5.5	6.0 – 6.5	6.5 – 7.5
100	Under 750	5.0 – 5.5	6.0 – 7.5	**	3.0 – 3.5	3.5 – 4.5	4.5 – 5.0
	750-1500	6.0 – 7.5	8.0 – 10.0*	**	3.5 – 4.5	5.0 – 5.5	6.0 – 6.5
	1500-6000	8.0 – 9.0	10.0 – 12.0*	**	4.5 – 5.5	5.5 – 6.5	7.5 – 8.0
	Over 6000	9.0 – 10.0*	11.0 – 13.5*	**	6.0 – 6.5	7.5 – 8.0	8.0 – 8.5
110[6]	Under 750	5.5 – 6.0	6.0 – 8.0	**	3.0 – 3.5	4.5 – 5.0	4.5 – 5.0
	750-1500	7.5 – 8.0	8.5 – 11.0*	**	3.5 – 5.0	5.5 – 6.0	6.0 – 6.5
	1500-6000	8.5 – 10.0*	10.5 – 13.0*	**	5.0 – 6.0	6.5 – 7.5	8.0 – 8.5
	Over 6000	9.0 – 10.5*	11.5 – 14.0*	**	6.5 – 7.5	8.0 – 9.0	8.5 – 9.0

* *Clear zones may be limited to 9.0 m for practicality and to provide a consistent roadway template. When a site-specific investigation indicates a high probability of continuing crashes or when such occurrences are indicated by crash history, the designer may provide clear zone distances greater than the clear zone shown above.*

** *See procedure in Section 38-3.03(b).*

Notes:

1. *All distances are measured from the edge of the traveled way. For opposing traffic on an undivided two-way roadway, the traveled way begins at the centerline separating opposing traffic.*
2. *For clear zones, the "Design Year ADT" will be the total ADT for both directions of travel for the design year. This applies to both divided and undivided facilities. Traffic volumes will be based on a minimum 20-year projection from the anticipated date of construction.*
3. *The values for "back slopes" only apply to a section where the toe of the back slope is adjacent to the shoulder; see Figure 38-3.B(d). For sections with roadside ditches, see Section 38-3.04.*
4. *The values in the figure apply to tangent sections of highway. See the discussion in Section 38-3.02(e) for possible adjustments on horizontal curves.*
5. *The values in the figure apply to all uncurbed sections and curbed sections in rural areas. See Section 38-3.02(f) for curbed sections in urban areas.*
6. *110 km/hr is highest design speed provided in the Roadside Design Guide. When design speeds are greater than the values provided, the designer may provide clear-zone distances greater than those shown in the table.*

RECOMMENDED CLEAR ZONE DISTANCES (m)
(New Construction/Reconstruction)
(Metric)

Figure 38-3.A

38-3.02(b) Design Year

For all freeway projects and non-freeway new construction/reconstruction projects, the design year for safety features will be a minimum of 20 years from the anticipated date of construction.

38-3.02(c) Traffic Volumes

As indicated in Figure 38-3.A, the ADT is a parameter when determining the clear zone value. The figure is divided into ranges of traffic volumes and ranges of recommended clear zones. In general, the higher clear zones apply to the higher traffic volumes.

38-3.02(d) Side Slopes

The roadway side slope will influence the recommended clear zone distance from Figure 38-3.A. Figure 38-3.B presents a schematic of the general side slope configurations, which may include:

- a straight front slope,
- a variable or barn roof section,
- a section with a roadside ditch, or
- a section where the toe of the back slope is adjacent to the edge of shoulder.

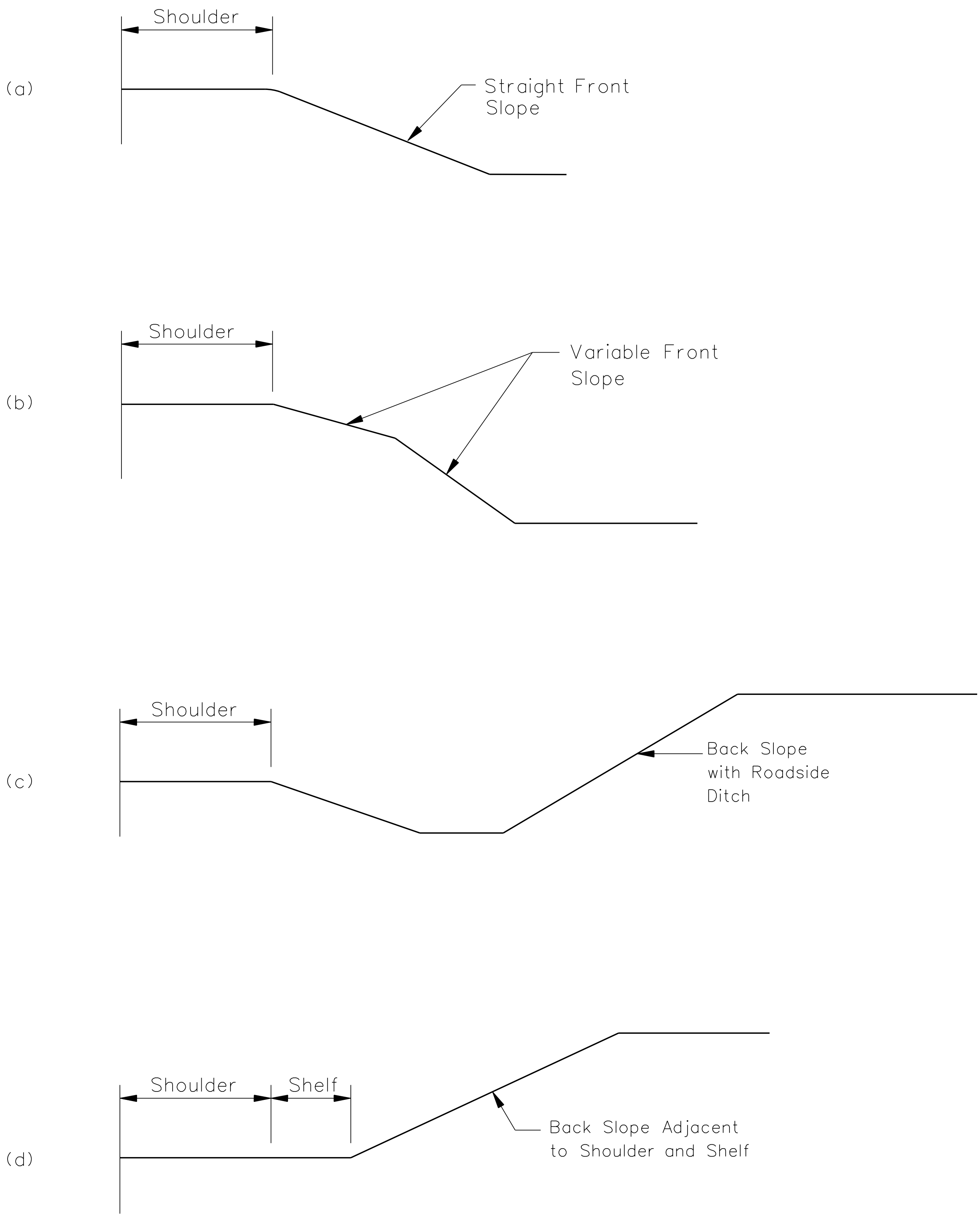
Note: The values in Figure 38-3.A for back slopes only apply to a section as illustrated in Figure 38-3.B(d); they do not apply where a roadside ditch is present.

Many variables influence the selection of a clear zone distance for the various side slope configurations. Sections 38-3.03, 38-3.04, and 38-3.05 discuss side slopes in detail.

38-3.02(e) Alignment (Horizontal Curve Adjustment)

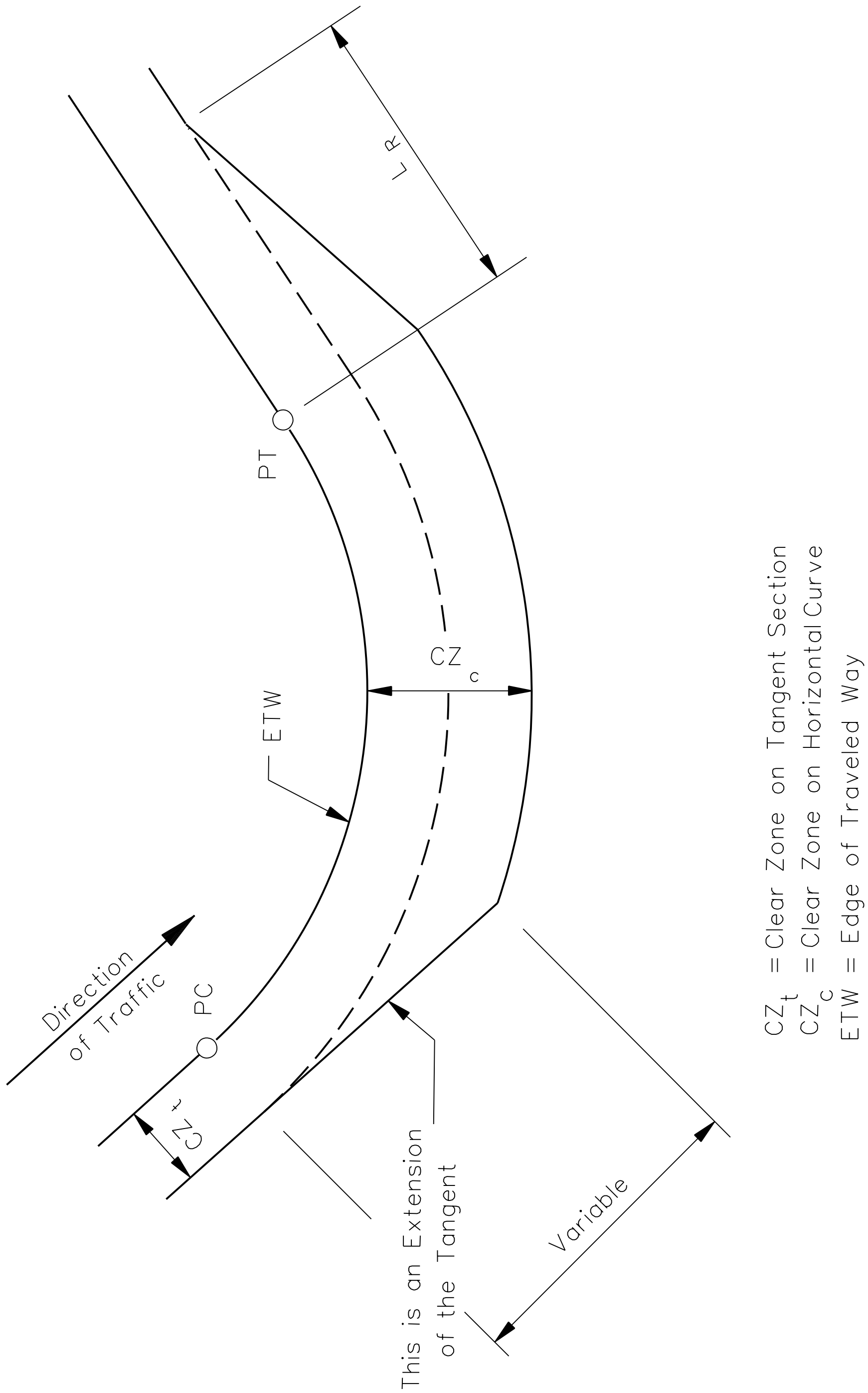
The clear zone values in Figure 38-3.A assume a tangent alignment. Horizontal curves may increase the angle of departure from the roadway, and thus increase the distance the vehicle will need to recover. Adjustments to the clear zone for curved alignment are considered only when the crash histories indicate such a need, as when a specific site investigation shows a definitive crash potential that could be significantly lessened by increasing the clear zone width, and when such increases are cost-effective.

It is unnecessary, to purchase additional right-of-way solely to provide the clear zone adjusted for horizontal curvature, unless inclusion of all right-of-way costs and impacts still shows a cost-effective safety improvement. See Section 38-4.01 for the recommended cost effectiveness software. Where adjustments are determined to be cost effective, Figure 38-3.C illustrates the application of the clear zone adjustment on a curve. Figure 38-3.D provides recommended adjustments for clear zones on horizontal curves.



SIDE SLOPE CONFIGURATIONS

Figure 38-3.B



Note: See Figure 38-6.E for L_R distances.

CLEAR ZONE WIDENING ON THE OUTSIDE OF HORIZONTAL CURVES

Figure 38-3.C

Radius (ft)	Design Speed (mph)						
	40	45	50	55	60	65	70 and greater
2860	1.1	1.1	1.1	1.2	1.2	1.2	1.3
2290	1.1	1.1	1.2	1.2	1.2	1.3	1.3
1910	1.1	1.2	1.2	1.2	1.3	1.3	1.4
1640	1.1	1.2	1.2	1.3	1.3	1.4	1.5
1430	1.2	1.2	1.3	1.3	1.4	1.4	
1270	1.2	1.2	1.3	1.3	1.4	1.5	
1150	1.2	1.2	1.3	1.4	1.5		
950	1.2	1.3	1.4	1.5	1.5		
820	1.3	1.3	1.4	1.5			
720	1.3	1.4	1.5				
640	1.3	1.4	1.5				
570	1.4	1.5					
380	1.5						

Notes:

1. *Adjustments apply to the outside of a horizontal curve only.*
2. *No adjustments are warranted for curve radii greater than 2860 ft.*
3. *The applicable clear zone distance on a horizontal curve is calculated by:*

   $$CZ_c = (K_{cz})(CZ_t)$$

   where:
   CZ_c = *clear zone on a curve, ft*
   K_{cz} = *curve adjustment factor*
   CZ_t = *clear zone on a tangent section from Figure 38-3.A, ft*

   Round calculated CZ_c up to the next highest 1 ft increment.
4. *For curve radii intermediate in the figure, use a straight-line interpolation.*
5. *See Figure 38-3.C for the application of CZ_c to the roadside around a curve.*

CLEAR ZONE ADJUSTMENT FACTORS FOR HORIZONTAL CURVES (K_{CZ})
(US Customary)

Figure 38-3.D

Radius (m)	Design Speed (km/hr)					
	60	70	80	90	100	110 and greater
900	1.1	1.1	1.1	1.2	1.2	1.2
850	1.1	1.1	1.1	1.2	1.2	1.3
800	1.1	1.1	1.1	1.2	1.2	1.3
750	1.1	1.1	1.1	1.2	1.2	1.3
700	1.1	1.1	1.2	1.2	1.2	1.3
650	1.1	1.2	1.2	1.2	1.3	1.4
600	1.1	1.2	1.2	1.2	1.3	1.4
550	1.1	1.2	1.2	1.3	1.3	1.4
500	1.1	1.2	1.2	1.3	1.3	1.4
450	1.2	1.2	1.3	1.3	1.4	
400	1.2	1.2	1.3	1.3	1.4	
350	1.2	1.2	1.3	1.4		
300	1.2	1.3	1.4	1.5		
250	1.3	1.3	1.4			
200	1.3	1.4				
150	1.4	1.5				
100	1.5					

Notes:

1. *Adjustments apply to the <u>outside</u> of a horizontal curve only.*

2. *No adjustments are warranted for curve radii greater than 900 m.*

3. *The applicable clear zone distance on a horizontal curve is calculated by:*

   $CZ_c = (K_{cz})(CZ_t)$

   where: CZ_c = *clear zone on a curve, m*
   K_{cz} = *curve adjustment factor*
   CZ_t = *clear zone on a tangent section from Figure 38-3.A, m*

   Round calculated CZ_c *up to the next highest 0.5 m increment.*

4. *For curve radii intermediate in the figure, use a straight-line interpolation.*

5. *See Figure 38-3.C for the application of* CZ_c *to the roadside around a curve.*

CLEAR ZONE ADJUSTMENT FACTORS FOR HORIZONTAL CURVES (K_{CZ})
(Metric)

Figure 38-3.D

Example 38-3.02(1)

Given: Design Speed = 55 mph
Design ADT = 3000
Horizontal curve with a radius of 2000 ft
Flat side slope

Problem: Find the clear zone adjusted for the horizontal curve.

Solution: From Figure 38-3.A, the clear zone on the tangent (CZ_t) = 20 ft.

From Figure 38-3.D, the curve correction factor (K_{cz}) = 1.2.
The clear zone for the curve (CZ_c) = (20)(1.2) = 24 ft.

The transition length (equal to the runout length (L_R)) from Figure 38-6.E = 185 ft.

* * * * * * * * * * *

38-3.02(f) Curbed Sections

The values in Figure 38-3.A apply to curbed sections in rural areas and all uncurbed sections of highway. Where curbs are present, the following additional considerations will apply:

1. Urban/Suburban Facilities. A minimum horizontal, obstruction-free clearance of 1.5 ft (500 mm) should be provided as measured from the face of the curb. This offset provides sufficient clearance to keep the overhang of a truck from striking an object. See Section 38-9 for guidance regarding an enhanced lateral offset. This applies to both barrier and mountable curbs, except that M2 (M5) curb will be treated as an uncurbed section.

   Because curbs do not have re-directional capabilities, except at speeds below 25 mph (40 km/hr), the presence of curbs does not affect determination or application of the calculated clear zone value. See Section 38-9 for more discussion of roadside safety for urban cross sections.

5. Rural Facilities. For specific field conditions, it may be acceptable to use mountable curbs on rural facilities or barrier curbs in conjunction with standard guardrail. See Chapter 34. However, the clear zone will be determined assuming that the facility is uncurbed; i.e., the clear zone criteria presented in Chapter 38 will apply to all rural facilities whether curbed or uncurbed. Limit the location of curbs along high-speed rural facilities to the outer edge of the shoulder. See point 3 under Section 34-2.04(a) for more information.

38-3.02(g) Lane Width

The clear zone distances in Figure 38-3.A are, theoretically, predicated upon a 12 ft (3.6 m) lane width. However, they will be used for any lane width.

38-3.02(h) Auxiliary Lanes

Auxiliary lanes are defined as any lanes beyond the basic through travel lanes that are intended for use by vehicular traffic for specific functions. These include turn lanes at intersections, truck-climbing lanes, weaving lanes, acceleration/deceleration lanes at interchanges, etc. The clear zone for auxiliary lanes will be determined as follows:

1. Turn Lanes at Intersections. Where the intersection is uncurbed, clear zones will be determined based on the design speed and traffic volumes associated with the through travel lanes; i.e., the presence of the turn lane is ignored when determining clear zones, provided that a minimum 10 ft (3.0 m) clear zone is maintained beyond the outside edge of the shoulder. Where the intersection is curbed, the criteria in Section 38-3.02(f) will apply; i.e., the minimum obstruction-free zone is 1.5 ft (500 mm) from the gutter line with an enhanced lateral offset of 4 ft to 6 ft (1.2 m to 1.8 m) preferred.

2. Auxiliary Lanes Adjacent to Mainline. Use the following clear zone applications for climbing lanes, acceleration/deceleration lanes, ramp terminals, weaving lanes, etc. Two independent clear zone determinations are necessary. First, the designer calculates the clear zone from the edge of the through traveled way based on the total traffic volume, including the auxiliary lane volume. Second, the designer calculates the clear zone from the edge of the auxiliary lane based on the traffic volume in the auxiliary lane. The clear zone distance that extends further will apply.

38-3.03 Front Slopes

Figure 38-3.B illustrates the two basic configurations for front slopes (i.e., straight slope or variable slope). Section 38-2 presents definitions of parallel front slopes that apply to clear zone determinations. Figure 38-3.E presents schematics for these definitions, and the following discusses the clear zone application in conjunction with Figure 38-3.A.

38-3.03(a) Recoverable Front Slopes

For parallel front slopes 1V:4H and flatter [Figure 38-3.E(a)], the recommended clear zone distance can be determined directly from Figure 38-3.A.

38-3.03(b) Non-Recoverable Front Slopes

For parallel front slopes steeper than 1V:4H, but 1V:3H or flatter [Figure 38-3.E(b)], a clear runout area beyond the toe of the non-recoverable front slope is recommended. The width of the non-recoverable front slope is not to be counted as part of the clear runout width. Use the following procedure to determine the clear zone:

1. Determine the clear zone for a 1V:6H or flatter slope from Figure 38-3.A for the applicable design speed and traffic volume.

2. To determine the clear runout area beyond the toe, subtract the shoulder width [or the distance from the edge of traveled way to the hinge point, noted as “A” in Figure 38-3.E(b)] from the distance in Step 1.

3. The clear runout area beyond the toe shall be the greater distance of the value determined in Step 2 or 10 ft (3.0 m).

Example problem 38-3.03(2) illustrates this procedure.

38-3.03(c) Barn-Roof Front Slope (Recoverable/Non-Recoverable)

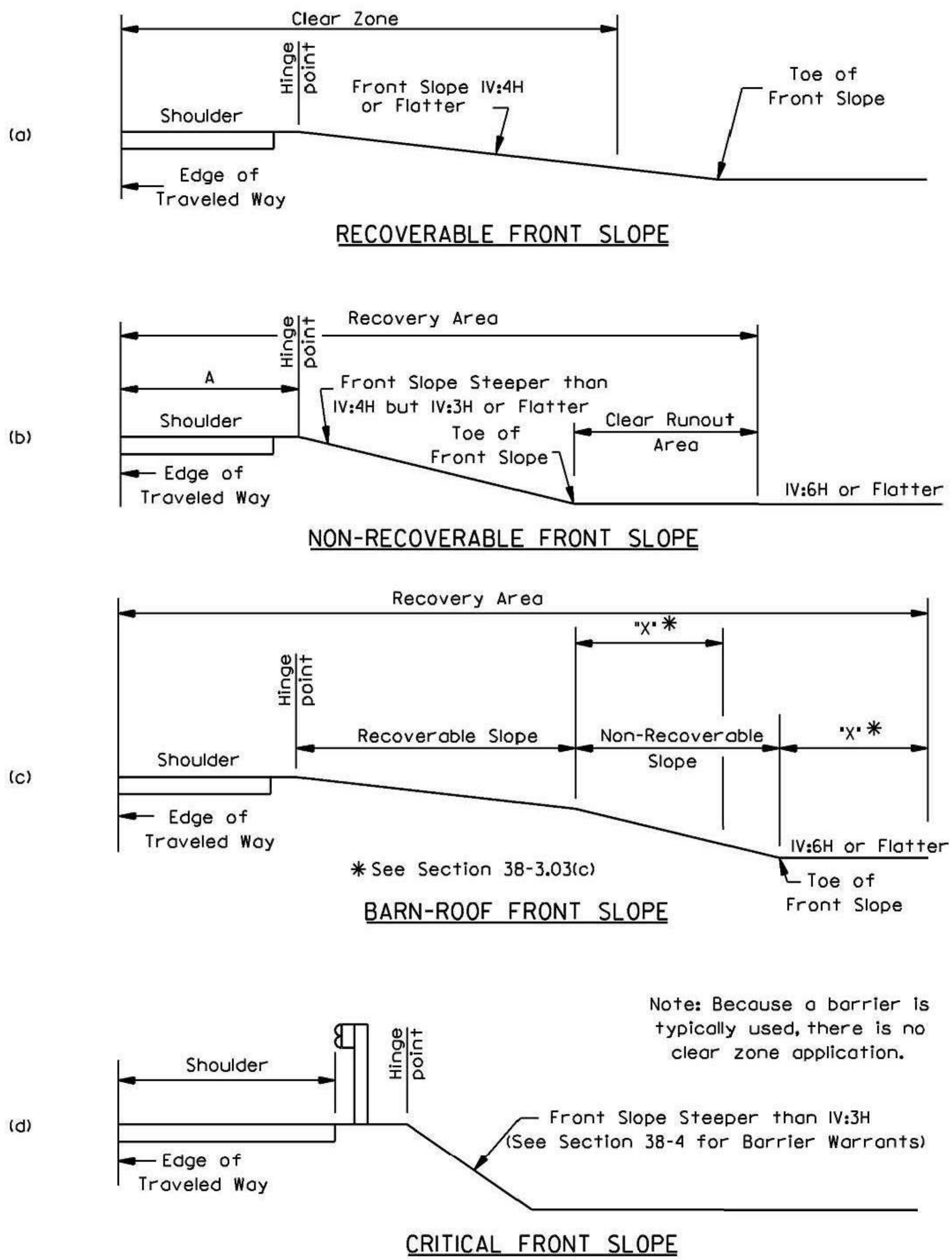
Barn-roof front slopes may be designed with a recoverable slope leading to a non-recoverable slope; see Figure 38-3.E(c). This design requires less right-of-way and embankment material than a continuous, flatter slope. The distance from the break between the two slopes to the clear zone [noted as “X” on Figure 38-3.E(c)] should be applied as an addition outside the toe of the non-recoverable slope. This addition should be a minimum of 10 ft (3.0 m) wide; i.e., a clear area of 10 ft (3.0 m) beyond the toe of slope will be needed where the clear zone extends beyond the break between the recoverable and non-recoverable slopes. If the distance from the edge of traveled way to the break between the two slopes is a minimum of 30 ft (9.0 m), no additional clear area will be required at the toe of slope.

38-3.03(d) Barn-Roof Front Slope (Recoverable/Recoverable)

Barn-roof front slopes may also be designed with consecutive recoverable slopes — the second slope steeper, but also recoverable, than the slope adjacent to the shoulder. Although a weighted average of the slopes may be used, a simple average of the clear zone distances for each slope is sufficiently accurate, if the variable slopes are approximately the same width. If one slope is significantly wider, the clear zone computation based on that slope alone may be used.

38-3.03(e) Critical Front Slope

Front slopes steeper than 1V:3H are critical [Figure 38-3.E(d)]. These typically require a barrier and, therefore, there is no clear zone application; see Section 38-4.



CLEAR ZONE APPLICATION FOR FRONT SLOPES
(Uncurbed)

Figure 38-3.E

Example 38-3.03(1) (Recoverable Front Slope)

Given: Front Slope — 1V:4H
Design Speed — 60 mph
Design ADT — 7000

Problem: Determine the recommended clear zone distance.

Solution: From Figure 38-3.A, the clear zone distance should be 36 ft to 44 ft. However, as indicated in a footnote to the figure, the clear zone distance may be limited to 30 ft based on specific site conditions to provide a more practical design.

* * * * * * * * * *

Example 38-3.03(2) (Non-Recoverable Front Slope)

Given: Front Slope — 1V:3H
Shoulder Width — 10 ft
Design Speed — 60 mph
Design ADT — 7000

Problem: Determine the recommended clear zone distance.

Solution: The procedure in Section 38-3.03(b) for non-recoverable front slopes is used as follows:

1. From Figure 38-3.A, the clear zone for a front slope 1V:6H or flatter is 30 ft to 32 ft.

2. The recommended clear distance beyond the toe of the non-recoverable slope (1V:3H) is 30 ft to 32 ft (9.1 m to 9.8 m) minus 10 ft (3.0 m) shoulder width yields 20 ft to 22 ft (6.1 m to 6.7 m).

3. The clear distance beyond the toe of slope shall be the greater of the value determined in Step 2 [20 ft to 22 ft (6.1 m to 6.7 m)] , or 10 ft (3.0 m), therefore the clear zone extends to 20 ft to 22 ft (6.1 m to 6.7 m) beyond the toe of the front slope.

* * * * * * * * * *

38-3.04 Back Slopes

Back slopes in cut sections or slope walls at overhead bridges may be traversable depending upon their surface conditions and presence of fixed objects. Where the front slope is 1V:3H or flatter and the back slope is stable, firm, and free of fixed objects or snag points it may not be a significant hazard. However, back slopes that are rough-faced rock cuts, tree-lined, or where significant wheel rutting would be expected are examples of back slopes that would pose significant hazards.

Where a pier for an overhead structure is located near a back slope (i.e. a slopewall), design the roadside guardrail for the pier using a minimum clear zone value of 25 ft (7.6 m).

38-3.05 Roadside Ditches

Ditch sections, as illustrated in Figure 38-3.F, are typically constructed in roadside cut sections without curbs. Figure 38-3.H provides preferred ditch sections based on slopes and bottom widths.

When a preferred ditch cross section, according to Figure 38-3.H, is not used, the applicable clear zone across a ditch section will depend upon the front slope, the ditch width, the back slope, the horizontal location of the toe of the back slope, and various highway factors. The designer shall use the following procedure to determine the recommended clear zone distance when a preferred ditch cross section is not used:

1. Determine the Nominal Clear Zone. Use Figure 38-3.A to determine the clear zone based on the ditch front slope.

2. Check the Location of the Toe of the Back Slope. Based on the distance determined in Step 1, refer to Section 38-3.03 to establish if the toe of the back slope is within the clear zone. The toe of back slope is defined as the point at which the ditch rounding ends and the (uniform) back slope begins. 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 or within the ditch. If the toe is within the clear zone, the designer should evaluate the practicality of relocating the toe of back slope. If the toe of back slope will remain within the clear zone, Step 3 below will apply to ditch sections in earth cuts.

3. Determine Clear Zone on Back Slope (Earth Cuts). If the toe of the back slope is within the clear zone distance, a clear zone should be provided on the back slope. This clear zone will be a distance beyond the toe of back slope as follows:

    a. Where the back slope is 1V:6H or flatter, treat the back slope as level and use the clear zone based on the front slope rate to determine the clear zone limit on the back slope.

    b. Where the back slope is steeper than 1V:6H but 1V:3H or flatter [Figure 38-3.F(b)], assume the vehicle cannot make it up to the top of the back slope, if the slope is at least 10 ft (3.0 m) wide. The initial 10 ft (3.0 m) beyond the toe of the back slope or the distance in Step 3a, whichever is less, should be clear of roadside hazards. Any obstacles beyond this point would be considered outside of the clear zone.

c. Where the back slope is steeper than 1V:3H [see Figure 38-3.F(c)], the initial 5 ft (1.5 m) beyond the toe of the back slope should be clear of roadside hazards.

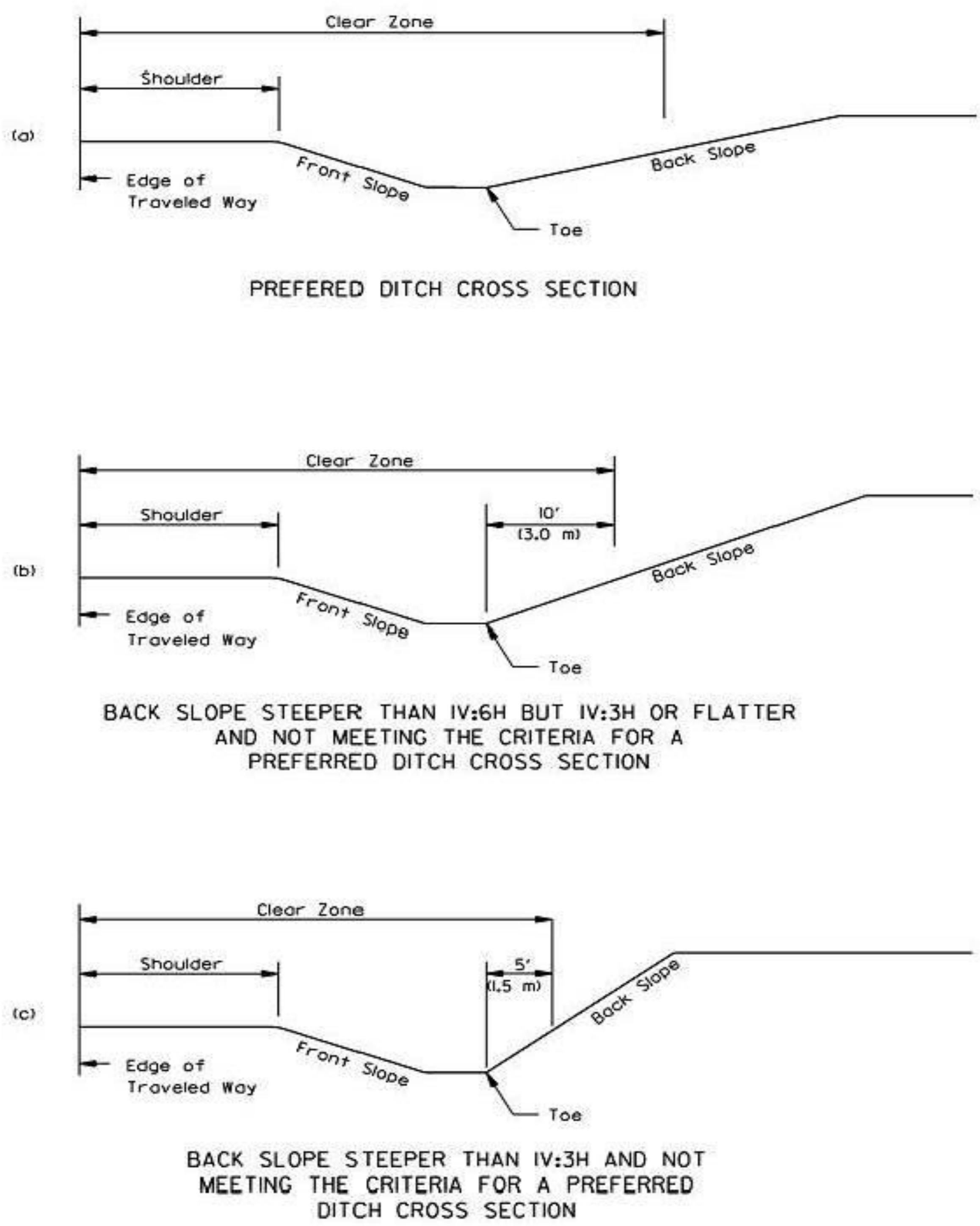
4. Clear Zones (Rock Cuts). No clear zone is required beyond the toe of back slope for rock cuts with steep back slopes. However, the rock cut should be relatively smooth to minimize the hazards of vehicular snagging. If the face of the rock is rough or rock debris is present, a barrier may be warranted.

   The Department's configuration for rock cuts, typically, is the following:

   - a 1V:6H front slope,
   - a 1.5 ft (500 mm) ditch bottom plus additional width for falling rock, and
   - a 1V:0.25H back slope or as required by rock type.

5. Deep Cuts. For earth cuts where the height of the cut from the bottom of the ditch is greater than 10 ft (3.0 m), the designer may consider using a 1V:2H back slope above the 10 ft (3.0 m) elevation to reduce costs.

Example problem 38-3.04(1), below, illustrates the method to determine the clear zone when a preferred ditch cross section is not used.



CLEAR ZONE APPLICATION FOR ROADSIDE DITCHES

Figure 38-3.F

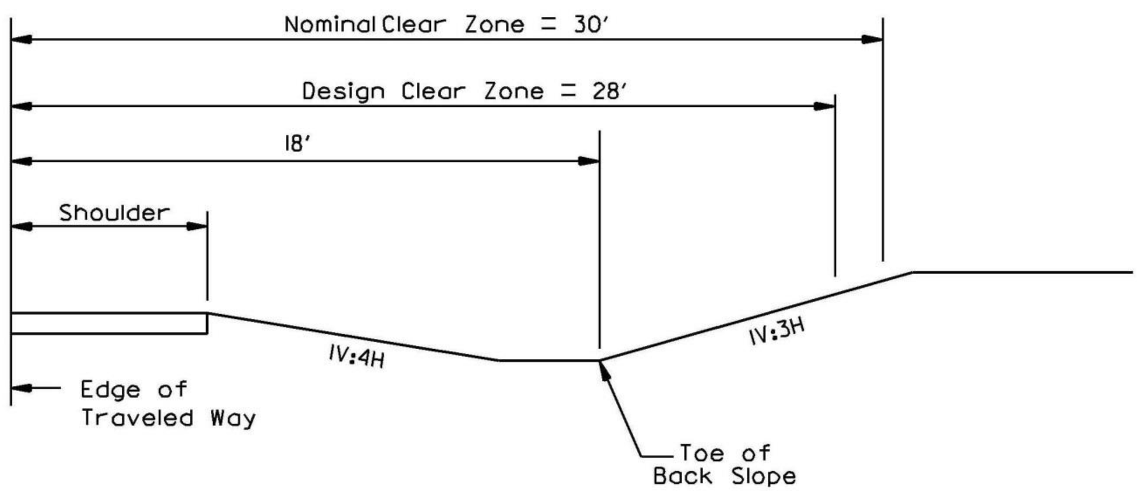
Example 38-3.04(1) (Not a Preferred Ditch Section)

Given: Design ADT = 7000
V = 60 mph
Front Slope = 1V:4H
Ditch Width = 2 ft
Back Slope = 1V:3H
Toe of back slope is 18 ft from edge of traveled way
See Figure 38-3.H

Problem: Determine the clear zone application across the ditch section.

Solution: From Figure 38-3.G, the 1V:4H front slope with 2 ft bottom and 1V:3H back slope does not meet the criteria for a preferred ditch. Using the procedure in Section 38-3.04:

1. Determine the Clear Zone. Figure 38-3.A yields a clear zone of 36 ft to 44 ft for a 1V:4H front slope. However, as indicated in the footnote, a 30-ft clear zone may be used.
2. Check the Location of the Toe of the Back slope. The toe of back slope is within the clear zone. Therefore, proceed to Step 3.
3. Determine the Clear Zone on the Back slope (Earth Cuts). With a 1V:3H back slope, the criteria in Step 3.b. will apply. Based on these criteria, the lesser of 10 ft beyond the toe of back slope or the clear zone from Step 1 above will control. 10 ft beyond the toe of back slope yields a total distance of 28 ft from the edge of traveled way versus 30 ft from Step 1. Therefore, the procedure yields a 28 ft clear zone for the roadside.



CLEAR ZONE AT DITCH SECTION
Example 38-3.04(1)

Figure 38-3.G

38-3.06 Transitional Slopes

As practical, slopes that transition between differing slope rates, types of slopes (e.g. transverse slope to front slope), or from a fill section to a cut section should be designed to provide a recoverable and forgiving roadside by meeting or exceeding the various design criteria for slopes from Section 38-3 and 38-4. Transitions of parallel front slopes, parallel back slopes, or ditch side slopes should be, over a distance, sufficient to avoid the perception of a transverse slope (suggested 25H:1V or flatter). Transitions from fill slopes to cut slopes should be designed on a case-by-case basis, with special attention given to the drainage channel created where these cross sections transition.

PREFERRED DITCH CROSS SECTIONS		
	Preferred Maximum Ditch Back Slope	
Front Slope	Trapezoidal Ditch with Vee or <4 ft (1.2 m) Flat Bottom	Trapezoidal Ditch with Minimum 4 ft (1.2 m) Flat Bottom
1:8	1:3.5	1:2.5
1:6	1:4	1:3
1:5	1:5	1:3.5
1:4	1:6	1:4

Note: For front or back slope values falling between those given above, round down to the next steeper slope, i.e., do not interpolate between slope values.

PREFERRED DITCH CROSS SECTIONS

Figure 38-3.H

38-4 ROADSIDE HAZARD REMEDIATION

During Phase I of a project the designer evaluates and establishes the roadside barrier warrants. Refer also to Section 11-2.04(g). Safety design decisions may affect right-of-way needs, earthwork quantities, and other design elements that must be recognized early in project development. Safety issues must be addressed early so as to not severely restrict the designer's options. Design exceptions related to roadside hazards should be very uncommon and will require approval and documentation in the Phase I engineering report. Refer to Section 31-7 for the design exception process and Chapter 12 regarding Phase I engineering report content.

38-4.01 Examples of Roadside Hazards

Examples of roadside hazards include:

- non-breakaway sign supports, non-breakaway luminaire supports, traffic signal poles, and railroad signal poles;
- concrete footings, traffic signal foundations, etc., extending more than 4 in. (100 mm) above the ground;
- bridge piers and abutments at underpasses;
- culvert headwalls;
- trees with diameters greater than 4 in. (100 mm) (at maturity);
- rough rock cuts;
- large boulders;
- critical parallel slopes (i.e., embankments);
- streams or permanent bodies of water (where the depth of water ≥ 2 ft (600 mm));
- non-traversable ditches;
- utility poles or towers;
- drainage appurtenances; and
- transverse slopes.

The severity of a specific roadside hazard will depend upon many factors. The Roadside Safety Analysis Program (RSAP) may be used to quantify the relative severity of roadside hazards. The RSAP software, user's manual, engineer's manual, and programmer's manual are found at: http://rsap.roadsafellc.com/. For questions about the RSAP, contact the Bureau of Safety Programs and Engineering.

38-4.02 Range of Treatments

If a roadside hazard is within the clear zone, the designer should select the treatment that is judged to be the most practical and cost-effective for the site conditions. The range of treatments, in order of preference, includes:

- Eliminate the hazard (flatten embankment, remove rock outcroppings, etc.);
- redesign the hazard so it can be safely traversed (e.g., culvert grating);
- relocate the hazard to a point where it is less likely to be struck;
- where applicable, make the hazard breakaway (sign posts, luminaire supports);
- shield the hazard with a roadside barrier;
- delineate the hazard; or
- do nothing.

38-4.03 Warrant Methodologies

Warrants for roadside barriers imply that other options higher in the preference order for range of treatments (see Section 38-4.02) have first been considered. Whether objectively or subjectively, the decision will be based upon the traffic volumes, roadway geometry, proximity of the hazard to the traveled way, nature of the hazard, expected crash severity, installation costs and, where applicable, crash experience. The following briefly discusses the Department's decision-making methods for barrier warrants.

38-4.03(a) Department Policy

For specific applications, the Department has adopted policies on warrants for roadside barriers. These are documented throughout Section 38-4.

38-4.03(b) Cost-Effectiveness Method

Where practical, the designer should use an approved cost-effectiveness methodology to determine roadside barrier warrants. This will provide an objective means to analyze many of the factors that impact roadside safety, and it will support effective use of funds to realize safety benefits. It will also promote uniformity of decision-making for roadside safety throughout the Department. The currently approved cost-effectiveness method is the Roadside Safety Analysis Program (RSAP) software presented in Section 38-4.01.

38-4.03(c) Engineering Judgment Method

Until the development of cost-effectiveness models, barrier warrants were typically determined based on engineering judgment. With this approach, the designer first analyzes the site by a "relative severity" assessment—which is the greater hazard, the roadside barrier or the roadside hazard? Next, the designer subjectively evaluates the site-specific parameters (e.g., traffic volumes, design speed, location of hazard, barrier installation costs) to determine if a barrier installation is a reasonable and practical solution. If yes, a barrier is warranted; if no, the do-nothing alternative is selected. For example, it would probably not be practical to install a barrier to shield an isolated point obstacle (e.g., tree) located near the edge of the clear zone. The designer must realize that a barrier is also a hazard and, if a clear decision cannot be reached, the general rule of “when in doubt, leave it out” should apply.

It is acceptable to use engineering judgment to determine the warrants for roadside barriers for two conditions:

1. If the decision is obvious for a specific site, the designer may forego the use of a cost-effectiveness method and use engineering judgment to install or not install a roadside barrier.

2. If extenuating circumstances exist, the designer may override Department policies for barrier warrants or the results of a cost-effectiveness method, either to install or not install a roadside barrier. In this case, the designer must document the reasons for the decision. This documentation should include crash histories for the section of roadway, traffic volumes, posted speed, and roadway geometry.

38-4.04 <u>Embankments</u>

Figure 38-4.A presents barrier warrants for embankments.

38-4.05 <u>Transverse Slopes</u>

Where the mainline highway intersects an entrance, side road, or median crossing, a slope transverse to the mainline will be present; see Figure 38-4.B. Even at moderate speeds, vehicles encountering transverse slopes can become airborne. Abrupt transverse slopes may also snag errant vehicles. In general, transverse slopes should be as flat as practical. Figure 38-4.C presents IDOT criteria for transverse slopes within the clear zone based on the type of facility and design speed.

The bridge cones of overhead roadway structures also introduce transverse slopes. Both the transverse slope intersecting the ditch and the transverse slope beyond the ditch, but within the clear zone, should be addressed with the slopes given in Figure 38-4.C. The recommended transverse slopes intersecting the ditch should reach to approximately 4 ft (1.2 m) vertical above the shoulder. The recommended transverse slopes beyond the ditch should reach approximately 4 ft (1.2 m) above the natural or graded ground out to the clear zone. Treat any parallel culvert as instructed in Section 38-4.06.

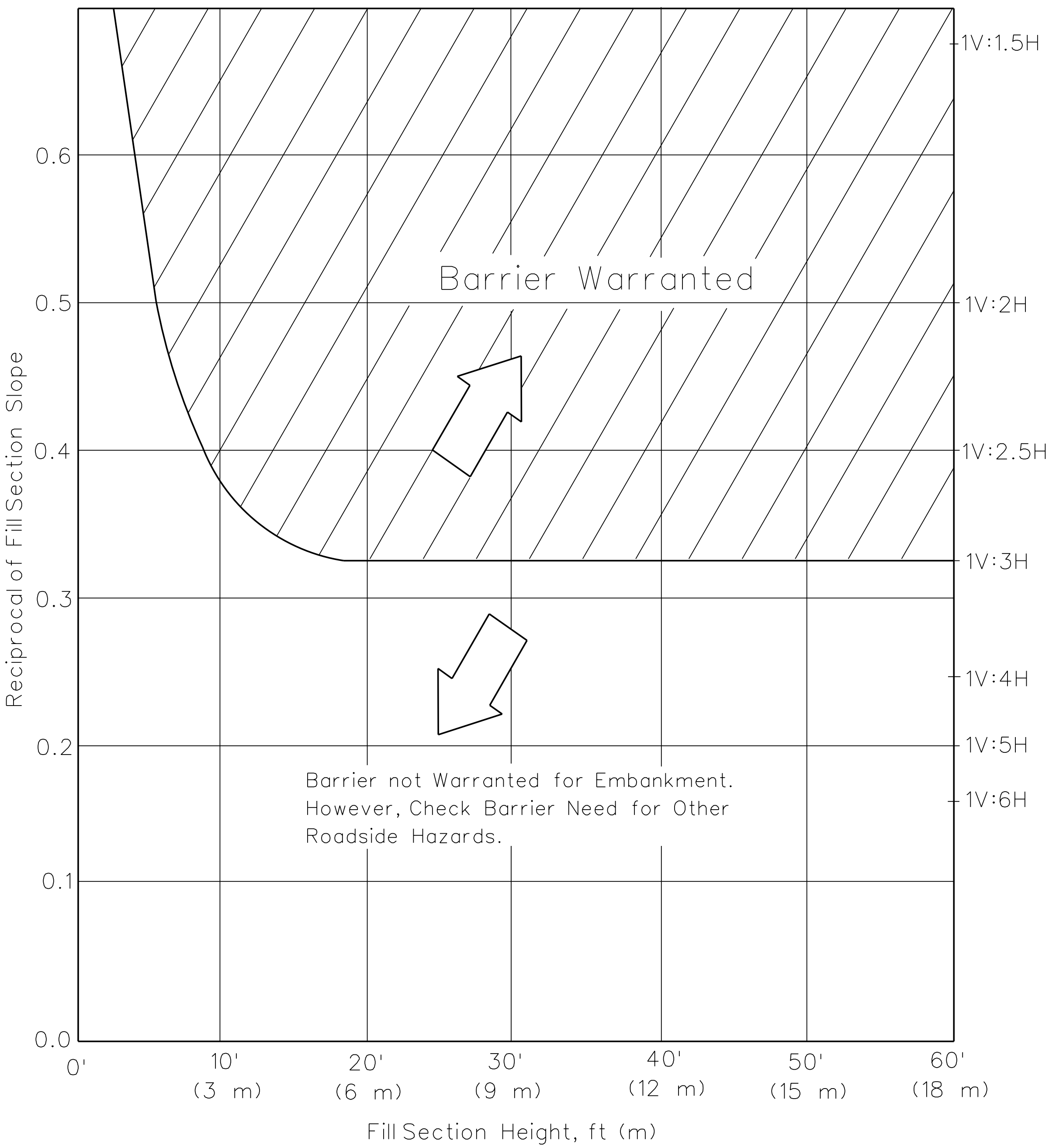
Figure 38-4.C presents both desirable (i.e., flatter) and acceptable (i.e., steeper) transverse slopes. The application at a specific site will depend upon an evaluation of many factors, including:

- height of transverse embankment,
- traffic volumes,
- design speed,
- presence of culverts and practicality of treating the culvert end (see Section 38-4.06),

- construction costs, and
- right-of-way and environmental impacts.

Although the 1V:10H transverse slope may be desirable, its practicality may be limited because of drainage structures, width restrictions, and maintenance problems associated with the long tapered ends of pipes or culverts. On arterial highways including freeways, however, the 1V:10H transverse slope should be used unless regrading of existing 1V:6H transverse slopes would require the installation of new drainage features.

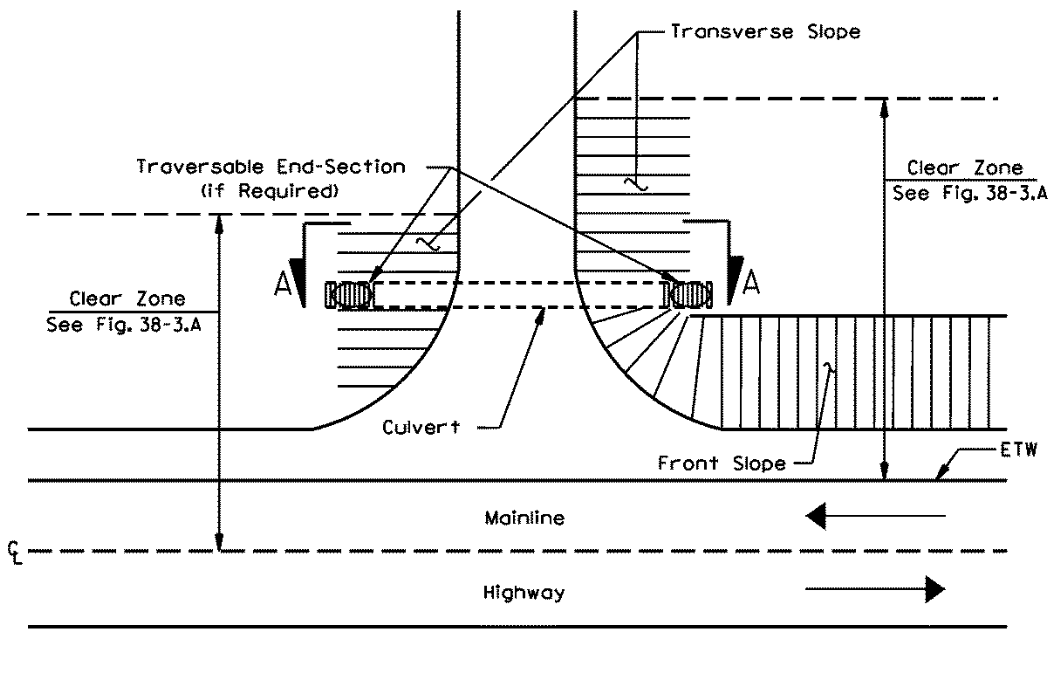
If the criteria in Figure 38-4.C cannot be met, the designer should consider the installation of a roadside barrier.



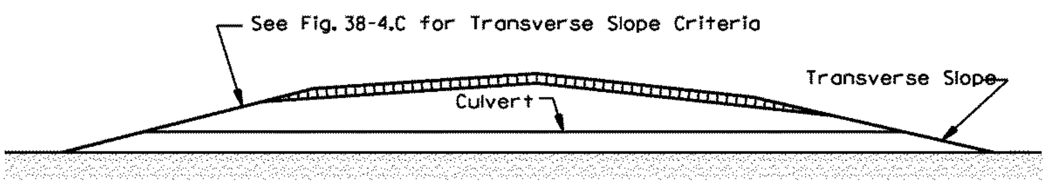
Note: Points that fall on the solid line do not warrant a barrier.

BARRIER WARRANTS FOR EMBANKMENTS

Figure 38-4.A



Note: On a one-way facility, the traversable end-section on the departure end is not required.



SECTION A-A

TRANSVERSE SLOPES ON A TWO-LANE, TWO-WAY ROADWAY

Figure 38-4.B

Type of Facility	Desirable (V:H)	Acceptable (V:H)
Freeway	1:10	1:6
Rural Non-Freeways (V ≥ 50 mph (80 km/hr))	1:10	1:6
Urban Non-Freeways (V ≥ 50 mph (80 km/hr))	1:6	1:4
Urban and Rural Low-Speed Facilities (V ≤ 45 mph (70 km/hr))	1:6	1:4

RECOMMENDED TRANSVERSE SLOPES

Figure 38-4.C

38-4.06 Roadside Drainage Features

Effective drainage is a critical element in the design of a highway or street. In addition to hydraulic considerations, ditches, curbs, culverts, and drop inlets should be designed and constructed considering their consequences to roadside safety.

The *Illinois Drainage Manual* and Chapter 40 of the *BDE Manual* discuss the Department's practices for hydrology and hydraulics and for the physical design of roadside drainage structures. Sections 38-4.06(b) discusses the safety design of these structures.

38-4.06(a) Curbs

Curbs are typically used to control drainage or to protect erodible soils. Chapter 34 and the *IDOT Highway Standards* provide detailed information on the warrants and types of curbs used by the Department. Curbs may pose a roadside hazard because of their potential to adversely affect a run-off-the-road vehicle. When evaluating curbs relative to roadside safety, the designer should consider the following:

1. Design Speed. On high speed roadways, curbs may cause errant vehicles to overturn or become airborne. Facilities with a design speed greater than 45 mph (70 km/hr) should be designed without curbs.

   However, if necessary along high-speed roadways, a 4 in. (100 mm) Type M (sloped) curb or Type B gutter may be used and placed only at the outside of the paved shoulder. If a shoulder is initially designed with aggregate, and a curb is proposed at the back of the aggregate width, change the aggregate width to a paved surface. See Section 34-2.04 for curb types for facilities with a design speed of 45 mph (70 km/hr) or less.

   Where a guardrail is proposed, a 6 in. (150 mm) barrier curb may be used if it is placed such that the face of the guardrail is within 6 in. (150 mm) behind the face of the curb.

Guardrail terminals should be placed beyond the limits of the curb in this situation. See Section
38-6.05, item 1, for more guidance regarding guardrail placement along curb.

2. Roadside Barriers. The use of curbs with a roadside barrier is discouraged and, specifically, curbs higher than 6 in. (150 mm) should not be used with a barrier. See Sections 38-6.03 and 38-6.05. If a guardrail adjacent to a curb is unavoidable, the lateral placement of the guardrail relative to the curb face is critical. Refer to the *Highway Standards* for proper guardrail placement and coordination with the design speed.

3. Redirection. Curbs offer no safety benefits on high-speed roadways and will not redirect errant vehicles.

4. M2 (M5) Curb. It is acceptable to use the 2 in. (50 mm) high M2 (M5) curb in conjunction with a roadside barrier.

38-4.06(b) Culverts

1. Cross Drainage Structures. Cross drainage structures are designed to convey water through the roadway embankment. If not properly designed, they and their associated end sections, roadside slopes and ditches may present a hazard to run-off-the-road vehicles. In priority order, the available roadside safety treatments to minimize the potential hazard of the end sections for cross drainage culverts are:

   a. eliminate the culvert;

   b. provide a traversable end section;

   c. extend the culvert opening beyond the clear zone with smooth, traversable graded earth transitions;

   d. shield the culvert with a roadside barrier; or

   e. delineate the culvert if the above alternatives are not feasible.

   The following summarizes the Department's practices for providing a traversable end section for cross drainage structures within the clear zone (note that metal end sections on front slopes are only available for slopes of 1V:4H and 1V:6H):

   - for culverts less than 27 in. (700 mm) in diameter, install an end section from the *Illinois Highway Standards* which matches the front slope; or

   - for culverts 27 in. (700 mm) and greater in diameter, install an end section with a traversable grate from the *Illinois Highway Standards* which matches the front slope. Elliptical pipe culverts are listed by equivalent round size in the Standards.

   The above requirement for a traversable grate is based upon Section 3.4.2.1 of AASHTO's *Roadside Design Guide*, which states that structures with end sections having more than a 3 ft (900 mm) wide opening can be made traversable by using a pipe grate. When evaluating the need for a traversable grate for multi-cell pipe culverts, elliptical pipes, pipe arches, or box culverts, the same end section criteria should be applied.

If the culvert end section cannot be made traversable, install an appropriate end section and then determine if guardrail is warranted based on analyses throughout this chapter.

2. Parallel Drainage Structures. Parallel drainage structures, those that are oriented parallel to the main flow of traffic, must be considered when within the mainline clear zone. They are typically used under driveways, field entrances, access ramps, intersecting side roads, and median crossovers. Such culverts represent a hazard because an errant vehicle may impact the open end of the culvert. Therefore, the designer must coordinate design of the drainage structures with that of the surrounding transverse slope (Section 38-4.05) to minimize the hazard.

   Safety treatment options are very similar to those for cross-drainage structures. In priority order, the options are:

   a. eliminate the culvert;
   b. provide a traversable end section;
   c. move the culvert laterally to a less vulnerable location;
   d. shield the culvert with a roadside barrier; or
   e. delineate the culvert if the above alternatives are not feasible.

   Figure 38-4.D presents a generic design for grate protection of a parallel drainage structure. *Highway Standards* 542411 and 542416 depict design specifications for metal end sections. Safety treatment is also subject to the following considerations for travel along both the highway and entrance:

   - For metal culverts less than 24 in. (600 mm) in diameter, install a metal end section from the *Illinois Highway Standards* which matches the transverse slope.
   - For metal culverts 24 in. (600 mm) or greater in diameter, install a metal end section and a traversable grate for metal end sections from the *Illinois Highway Standards* which matches the transverse slope.
   - If the proposed end section is an unacceptable hazard from only the entrance, driveway, etc., look to decrease the hazard along the entrance by following the guidance for cross drainage structures in the preceding section. If a guardrail installation is indicated, consider its relation to both roadways.
   - If the proposed end section remains an unacceptable hazard to both roadways and a roadside barrier is proposed along both roadways, a grate is not required. Use of guardrail will create a short radius guardrail installation, refer to 38-6.09.

   Note that per Section 38-4.05, the transverse slope should be as flat as practicable, with 1V:6H or flatter considered desirable for most urban facilities and required for freeways and rural high-speed roadways.

Parallel drainage structures may be closely spaced because of frequent driveways and intersecting roads. In such locations, it may be desirable to convert the open ditch into a closed drainage system and backfill the areas between adjacent driveways. This treatment will eliminate the ditch section and the transverse embankments with pipe inlets and outlets. However, care must be used to avoid creation of open frontage that would allow uncontrolled access.

38-4.06(c) Roadside Ditches (Earth Cuts)

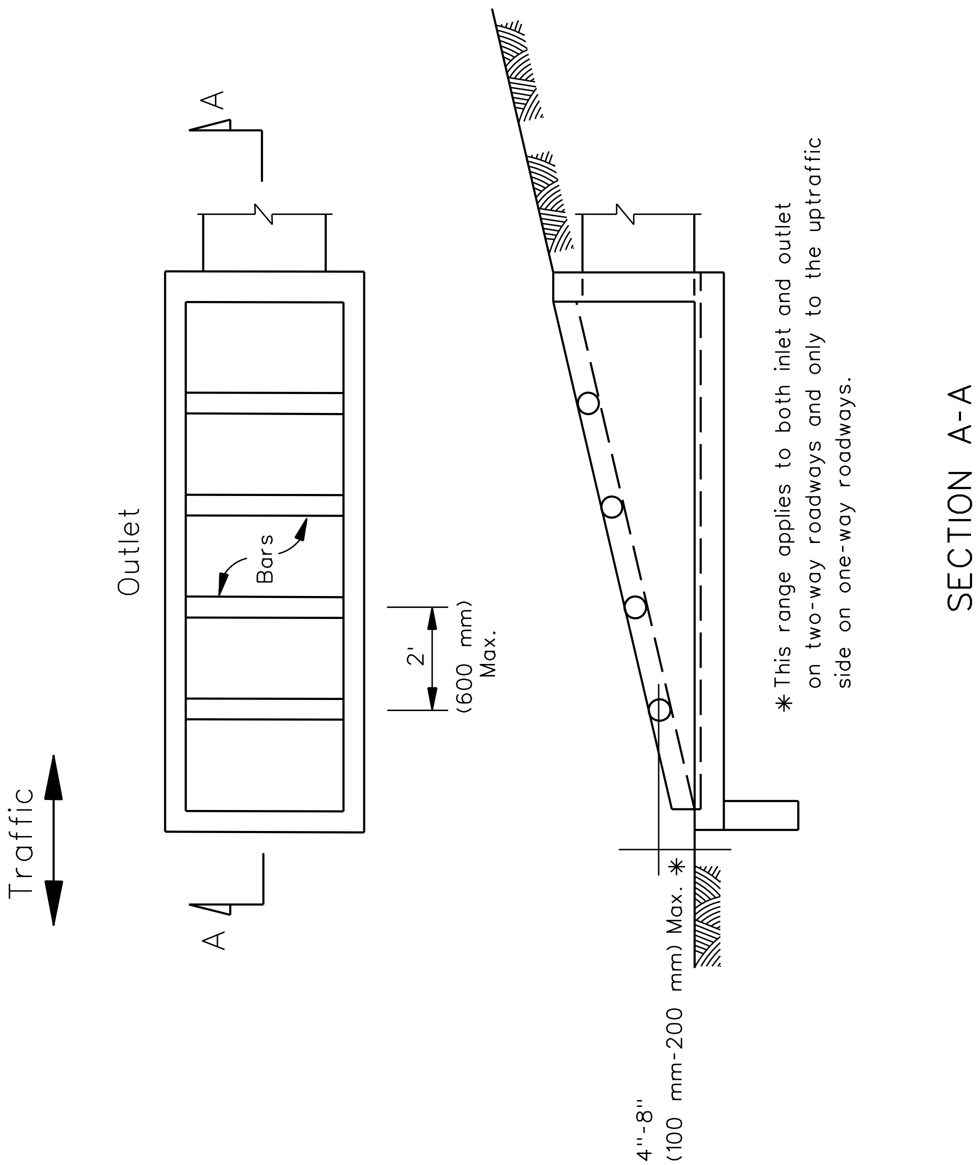
In the absence of other information (e.g., crash data), a roadside barrier is not warranted for the preferred ditch configuration shown in Figure 38-3.F. For other ditch configurations that would introduce a more abrupt change in direction for errant vehicles than a preferred ditch, the designer should conduct a cost-effective analysis to determine:

1. if a revised ditch configuration is appropriate,
2. if a roadside barrier is warranted, or
3. if the do-nothing alternative is appropriate.

38-4.07 Rock Cuts

If the toe of the rock cut is outside of the clear zone, or if the toe of the rock is within the clear zone and the rock face is smooth, a roadside barrier is not warranted unless other information (e.g., crash data) indicates otherwise. If the toe is within the clear zone and the rock face will cause excessive vehicle snagging, the designer should conduct a cost-effectiveness analysis to determine:

1. if the rock cut should be relocated outside of the clear zone or the face made smooth,
2. if a roadside barrier is warranted, or
3. if the do-nothing alternative is appropriate.



DESIGN FOR PARALLEL DRAINAGE STRUCTURES
(Diameter ≥ 24 in. (600 mm))

Figure 38-4.D

38-4.08 Bridge Parapet Ends

For bridge parapet ends on two-way roadways without median, a roadside barrier and transition should be installed at each corner unless the posted speed limit is less than 25 mph on an urban curbed section. No roadside barrier is needed on the departure end of a one-way roadway, unless a barrier is warranted for other reasons (e.g., front slopes steeper than 1V:3H).

If other hazards [e.g., permanent body of water more than 2 ft (600 mm) deep] exist, then additional guardrail may be considered. To determine the required length of need for the opposing traffic, use the L_C for the approach end measured from the centerline. L_B and the departing point for L_R will be measured from the centerline; also see Figures 38-6.A and 38-6.B for definitions of L_C, L_B, and L_R.

38-4.09 Retaining Walls

Barrier protection is not necessary for the face of retaining walls that are considered smooth (i.e., the general absence of any unevenness in the wall that may adversely affect an impacting vehicle). Retaining walls built of sheet piling, H-piling with timber, or precast concrete inserts are usually considered smooth. In addition, the following will apply to the roadside safety aspects of retaining walls:

1. Flare Rates. Use the same rates as those for concrete barrier. See Figure 38-6.X.

2. End Treatment. Preferably, the retaining wall will be buried in a back slope thereby shielding its end. If this is not practical, use a crashworthy end treatment or impact attenuator. Where the design speed is 35 mph (60 km/hr) or less, it is acceptable to transition the top of the wall from its normal height down to the ground line.

38-4.10 Traffic Control Devices

Traffic control devices include highway signs and traffic signals. If not properly designed and located, these devices may become a hazard to errant vehicles. The Bureau of Operations is responsible for the initial placement of traffic control devices, based on proper conveyance of information to the motorist, and the road designer reviews the location to ensure that it is compatible with the roadway design.

38-4.10(a) Highway Signs

For roadside safety applications, the following will apply to highway signs:

1. Design. The *Illinois Highway Standards* and *Sign Structures Manual* contain the Department's details for structural supports for traffic control devices.

2. Supports for Small Roadside Signs. All supports for small [< 50 ft^2 (5.0 m^2)] roadside signs should be made breakaway or yielding, including those outside of the clear zone. Where practical, the designer should locate signs behind a roadside barrier that is warranted for other reasons. There should be adequate clearance to the back of the guardrail post to provide for the barrier dynamic deflection; see Section 38-6.02. In addition, sign supports should not be placed in drainage ditches where erosion and freezing might affect the proper operation of breakaway supports. It is also possible that a vehicle entering the ditch will be inadvertently guided into the support.

   It is critical that breakaway supports not be located where a vehicle is likely to be partially airborne at the time of impact. Supports placed on a front slope of 1V:6H or flatter are acceptable. Supports placed on front slopes that are 1V:4H to 1V:6H are only acceptable when the face of the support is within 2 ft (600 mm) of the intersection of the shoulder slope and front slope.

3. Supports for Large Roadside Signs. Large signs [over 50 ft^2 (5.0 m^2) in area] should have slip base breakaway supports, whether within or outside the clear zone, and/or be located behind a roadside barrier. Where practical, the designer should locate large signs behind a roadside barrier that is warranted for other reasons, or at other locations where they are very unlikely to be hit.

   It is critical that breakaway devices, including slip bases, not be located where a vehicle is likely to be partially airborne at the time of impact. Supports placed on a front slope of 1V:6H or flatter are acceptable. Supports placed on front slopes that are 1V:4H to 1V:6H are only acceptable when the face of the support is within 2 ft (600 mm) of the intersection of the shoulder slope and front slope.

   Breakaway sign supports should not be located in or near the flow line of ditches. If these supports are placed on a back slope, they should be offset at least 5 ft (1.5 m) from the toe of the back slope of the ditch.

4. Overhead Sign Supports. All overhead signs will use non-breakaway supports. Within the clear zone, the designer should conduct a cost-effectiveness analysis to determine if these structures should be protected with a roadside barrier or, where applicable, with an impact attenuator.

38-4.10(b) Traffic Signal Equipment

In general, the designer has limited options available in determining acceptable locations for the placement of signal pedestals, signal poles, pedestrian detectors, and controllers. Considering roadside safety, these elements should be placed as far from the roadway as practical. However, due to visibility requirements, limited mast-arm lengths, limited right-of-way, restrictive geometrics, or pedestrian requirements, traffic signal equipment often must be placed relatively close to the traveled way. The designer should consider the following when determining the placement of traffic signal equipment:

1. Clear Zones. If practical, the placement of traffic signals on new construction and reconstruction projects should meet the clear zone criteria presented in Section 38-3. A cost-effectiveness analysis may be used to support this decision. In lower speed urban and suburban areas where it is not practical to place traffic signal supports outside the clear zone, the obstruction-free clearance criteria and enhanced lateral offset described in Section 38-9 apply. Where it is not practical to place isolated traffic signal supports outside the clear zone on rural high-speed facilities, evaluate shielding them with impact attenuators.

2. Controller. In determining the location of the controller cabinet, the designer should consider the following:

   a. The controller cabinet should be placed in a position so that it is unlikely to be struck by errant vehicles. It should be outside the clear zone or obstruction-free zone, if practical.

   b. The controller cabinet should be located where it can be easily accessed by maintenance personnel.

   c. The controller cabinet should be located so that a technician working in the cabinet can see the signal indications in at least one direction.

   d. The controller cabinet should be located where the potential for water damage is minimized.

   e. The controller cabinet should not obstruct intersection sight distance.

   f. The power service connection should be reasonably close to the controller cabinet.

3. Pedestrians. If the signal pole must be located very near or within the sidewalk, it shall be placed in a location that minimizes pedestrian conflicts. In addition, the signal pole shall not restrict access to curb ramps or reduce the sidewalk width below minimum; see Chapter 58.

4. Channelizing Islands. It is preferable not to place traffic signal equipment on islands within the roadway or intersection. However, the designer may need to use the islands for traffic signal placement to balance signal visibility, safety, cost and practicality.

38-4.11 Lighting

Because of the potential hazard posed to vehicles by roadside fixed objects, the general approach to lighting standards will be to use breakaway supports wherever possible. All new lighting standards located within the clear zone of a roadway where no pedestrian facilities exist will be placed on breakaway supports, unless they are located behind or on a barrier or protected by impact attenuators, which are necessary for other roadside safety reasons. Poles outside the clear zone on these roadways should be breakaway where there is a possibility of being struck by errant vehicles.

Breakaway devices should be given first consideration, except where extensive pedestrian exposure exists. Breakaway devices should be considered in urban areas where the combination of pedestrian activities concentrate during daylight hours and run-off-the road crashes are more prevalent outside of this period.

Although breakaway devices generally should receive first consideration, in some cases extensive pedestrian exposure may override the fixed object concern. Examples of locations where the hazard potential to pedestrian traffic indicate the use of non-breakaway devices include:

- transportation terminals,
- sports stadiums and associated parking areas,
- tourist attractions,
- school zones, or
- central business districts and local residential neighborhoods where the posted speed limit is 30 mph or less.

Other locations that require the use of non-breakaway bases, regardless of the pedestrian traffic volume, are rest areas and weigh station parking lots and combined light and traffic signal poles.

It is critical that breakaway devices be located where a vehicle is likely not to be partially airborne at the time of impact. Supports placed on a front slope of 1V:6H or flatter are acceptable. Supports placed on front slopes that are 1V:4H to 1V:6H are only acceptable when the face of the support is within 2 ft (600 mm) of the intersection of the shoulder slope and front slope.

Breakaway devices should not be located in or near the flow line of ditches. If these supports are placed on a back slope, they should be offset at least 5 ft (1.5 m) from the toe of the back slope of the ditch.

38-5 ROADSIDE BARRIERS

38-5.01 Types

The FHWA requires roadside safety hardware used on the National Highway System (NHS) to be crashworthy. IDOT then extends this requirement to all State jurisdiction routes for consistency. To be considered crashworthy, a piece of hardware is typically subjected to laboratory crash testing and engineering analysis which is then supported by in-service performance data. The hardware which has been accepted for use in Illinois can be found on one of several Qualified Products Lists (QPLs), as well as the *Illinois Highway Standards* maintained on the Department's website.

38-5.01(a) Steel Plate Beam Guardrail (Semi-Rigid Types)

Steel plate beam guardrail (SPBGR), commonly known as the W-beam system, is a semi-rigid system when installed with strong posts. The Department uses the Midwest Guardrail System (MGS), developed by the Midwest Roadside Safety Facility (MwRSF) under a pooled fund in which Illinois participates. Versions of the MGS using blockouts display better safety performance and are preferred over non-blocked versions of the MGS. The use of the non-blocked MGS should be limited to locations where the MGS with blockouts is not practical due to roadway width and/or steep front slope constraints. Various adaptations of the MGS are included in the *Illinois Highway Standards* and are briefly described below:

1. Type A. Type A guardrail is an MGS version with blockouts and with posts spaced at 6 ft 3 in. (1905 mm). The Type A guardrail meets Test Level 3 and is the most commonly used roadside barrier on Illinois highways. Refer to Figure 38-6.V for guardrail deflection criteria. Refer to Section 38-6.03 and Highway Standard 630001 for grading requirements behind guardrail.

2. Type B. Type B guardrail is an MGS version with blockouts and with posts at a reduced spacing of 3 ft 1½ in. (953 mm). The Type B guardrail meets Test Level 3. Type B is used where a semi-rigid roadside barrier is needed but the deflection space behind the posts is somewhat limited. Refer to Figure 38-6.V for guardrail deflection criteria. Refer to Section 38-6.03 and Highway Standard 630001 for grading requirements behind guardrail.

3. Type D. Type D guardrail is an MGS adaptation with blockouts for use as a semi-flexible median barrier. See Section 38-7.02(b) for the use of this guardrail type.

4. W-beam Guardrail with Quarter-post Spacing. This system with blockouts uses a further-reduced spacing of 1 ft 6¾ in. (476 mm). It is used where the deflection distance for the Type B system is not available. Though feasible for use in rare conditions, this post spacing is not shown in the *Illinois Highway Standards,* and job-specific details and pay items are needed in order to utilize it. Refer to Figure 38-6.V for guardrail deflection criteria.

5. Attached to Culverts. The primary MGS adaptation for attachment to culvert headwalls uses weak posts (S3 X 5.7 [S76 X 8.5]) and post spacing of 3 ft 1½ in. (953 mm) with blockouts. The posts are placed in steel sockets that are mounted to the face or top of the headwall. Various mounting options for the sockets allow for six cases (Case I through VI). As another option, a separate highway standard shows a strong post version of the MGS with blockouts that can be attached to the top slab of a culvert, inboard of the culvert headwall. The post spacing for the strong post system is 6 ft 3 in. (1905 mm). For either system, the attachment to the culvert is calibrated to match the strength of driven posts and no special transition to Type A or Type B guardrail is needed.

6. Long Span Guardrail. This MGS adaptation with blockouts allows for omitting a few posts in order to span up to 25 ft (7.62 m) over low-fill culverts or where there are other obstructions to post placement. This version includes three “controlled release terminal” (CRT) posts on either side of the long span, and requires a minimum installation length to assure performance consistent with the crash tested hardware. This system meets Test Level 3.

7. Non-Blocked Steel Plate Beam Guardrail. The MGS without blockouts uses strong steel posts spaced at 6 ft 3 in. (1905 mm). The non-blocked guardrail meets Test Level 3; however, this system cannot be used everywhere that Type A, Type B, or guardrail with quarter-post spacing can be used. Specifically, Non-Blocked Steel Plate Beam Guardrail:

   - May not be used at the three control release terminal (CRT) post locations on either side of a long span guardrail’s gap in posts. Only the CRT posts and blockouts may be used at these six posts.
   - When used where a slope steeper than 1V:3H is present within 24 in. (610 mm) from the back of post, the longer post as shown on the Standard shall be used, and a minimum top of rail height is 31 in. (787 mm).
   - Shall not be placed adjacent to or behind a curb.
   - Shall not be placed within 25 ft (7.62 m) of the pay limits of any bridge rail transition (e.g., Type 6, Type 6A, Type 6B, Type 5).
   - Shall not be placed within 12.5 ft (3.81 m) of the pay limits of any Type 1 terminal.
   - Shall not be placed within 50 ft (15.24 m) of the pay limits of a Type 2 terminal.
   - Shall not be used where the post spacing is other than 6 ft 3 in. (1905 mm).
   - Shall not be used with wood posts.
   - Shall not be flared. It must run parallel to the traveled way.

See Section 38-6 for other roadside barrier layout requirements.

38-5.01(b) Concrete Barrier (Rigid Type)

Concrete barrier is a rigid barrier system that does not deflect upon impact. See Section 38-5.02 for information on where concrete barrier should be used.

The Department will meet MASH Test Level 5 criteria for concrete barrier at new or replacement locations. For Test Level 5 under MASH a minimum of 42 in. (1065 mm) height may be used with either a single slope barrier or vertical face barrier. However, the Department has adopted a taller concrete barrier height of 44 in. (1120 mm) to accommodate a future 2 in. (50 mm) profile increase. The barrier is single slope with a 10.3 degree slope and a top width of 19 in. (480 mm). See *Highway Standard 637006*.

For use of concrete barrier as a roadside barrier (i.e. a single faced barrier), the standard single slope shape should be used along the traffic side with a vertical face on the back. Backfill behind the barrier for lateral support (retaining wall design) or use a special footing design (e.g., barrier tied to a concrete footing with reinforcing steel). Contact BSPE for design parameters.

38-5.01(c) High-Tension Cable Barrier (Flexible Type)

Cable barrier is a flexible barrier system with weak posts. The posts are designed to bend over or break off upon impact. Cable barrier and other weak-post systems provide a forgiving impact with low deceleration forces exerted on vehicle occupants. See Section 38-5.02 for information on where cable barrier may be used.

IDOT requires the use of high-tension cable barriers that have passed Test Level 4 crash test criteria on flat slopes or Test Level 3 crash test criteria with slopes steeper than 1V:6H to as steep as 1V:4H. Deflection distances for these proprietary systems are greater than W-beam guardrail and vary depending on the product and the post spacing. See Section 38-6 for additional guidance on high-tension cable barriers.

38-5.01(d) Cable Road Guard Single Strand

Cable Road Guard Single Strand (Highway Standard 636001) is not a roadside safety system. Its only use is to inhibit unwanted vehicular encroachments. Place Cable Road Guard as far as practical from the traveled way, and well outside the clear zone.

38-5.01(e) Other Systems

Many other roadside barrier systems are available which may have application at specific sites (e.g., thrie-beam guardrail). The designer should reference the latest edition of the AASHTO *Roadside Design Guide* for information on these systems. Both BDE and BSPE must approve the use of any system not included on one of the several QPLs or in the *Illinois Highway Standards*.

38-5.01(f) Aesthetic Treatments

Aesthetic treatments are not included in the *Illinois Highway Standards* due to concerns of safety performance, durability, and cost. Weathering steel guardrail has produced excessive rusting at lap joints and has performed poorly, thus it should not be installed. Experience from other States with winter road salting have shown that embossed (form liner) patterns for concrete parapets and barriers can trap salt and accelerate deterioration. These treatments should not be used on the traffic face of any concrete barrier. Contact BSPE for information regarding suitability of any aesthetic treatments.

38-5.02 Barrier Selection

This section presents considerations when selecting barriers for specific applications along roadways in Illinois.

1. Test Levels. The designer should consider the expected speeds and vehicle composition when selecting a test level for a barrier. Barriers that have passed Test Level 3 criteria are required on high-speed roadways (design speeds higher than 45 mph [70 km/hr]). There is no Test Level defined for speeds higher than 60 mph (100 km/hr) and studies of crashes have shown that Test Level 3 is adequate for the typical mix of vehicles where the design speed is higher than 60 mph (100 km/hr). However, if the objective is a higher probability of containing large trucks or commercial passenger vehicles such as buses, a barrier that has passed Test Level 4 or 5 may be appropriate. Barriers tested at Test Level 2 may be appropriate for roadways where the design speed is 45 mph (70 km/hr) or less and this is judged to represent the typical roadway operating speed.

2. Dynamic Deflection. Allowable dynamic deflection affects barrier selection. A barrier should be selected that is consistent with the available deflection space between the barrier and fixed objects behind the barrier; see Figure 38-6.U. Figure 38-6.V provides the deflection distances for guardrail and Section 38-7.03(b)3 discusses deflection distances for high-tension cable barrier (flexible).

3. Maintenance Considerations. Review the following maintenance issues when selecting a barrier:

   - W-beam guardrail will require structural repair after hits that contain or redirect vehicles, and nuisance hits may inflict tears or kinks requiring repairs. In high-speed, high-traffic locations it may be unacceptable to have damaged sections of guardrail at locations where repair operations can create hazardous conditions for repair crews and can degrade traffic operations and safety.
   - Concrete barrier may be the best choice in locations where traffic and speed dictate that a damaged barrier and subsequent traffic disruption for repairs are not acceptable.

- High-tension cable barriers will require repairs for virtually all nuisance and other hits. Depending upon the design specified, many repairs may be performed without specialized or heavy equipment.
- Taller and more substantial barriers may aggravate snow drifting.

4. Preferred Barriers. W-beam guardrail is the preferred roadside barrier for non-freeways and for rural freeways where there is adequate deflection space. However, other barriers may be considered based on site-specific traffic volumes, speeds, vehicle mix, available deflection space and cost of installation. *NCHRP Report 638*, "Guidelines for Guardrail Implementation" provides general guidance that may apply for recommending higher test levels for roadside barriers in Illinois. Detailed analysis of project alternatives may be made using the Roadside Safety Analysis Package (RSAP) software.

5. Concrete Barrier Uses. Consider using concrete barrier for urban freeways (double-faced) and the following additional cases (single- or double-faced):

- to shield objects close to the roadway where deflection space is limited;
- where there is a high volume of heavy trucks;
- where there is a high volume of commercial passenger vehicles, such as buses;
- to minimize repair and maintenance. Concrete barrier will often remain undamaged after an impact, while guardrail will require more frequent maintenance and repair;
- to reduce headlight glare into nearby buildings or other sensitive areas;
- to reduce headlight glare between frontage roads and the mainline, especially where the alignment directs headlights at opposing traffic; and
- areas where it is especially critical to contain errant vehicles.

Figure 38-5.A summarizes the advantages and disadvantages of the roadside barriers used by IDOT and provides their typical usage. Figure 38-5.B summarizes the general selection criteria that apply.

System	Advantages	Disadvantages	Typical Usage
High Tension Cable Barrier	1. Lower initial cost. 2. More forgiving impact. 3. Weak-post systems maintain vehicle stability. 4. Relatively easy installation. 5. Remains functional after moderate collisions. 6. Some systems have features that make repair more efficient. 7. Minimizes snow drifting.	1. Larger deflection spaces needed. 2. Less likely to contain large vehicles than concrete barrier, although the systems used by IDOT have passed Test Level 4 (single-unit truck crash test) on slopes of 1:6 or flatter. 3. Some potential for vehicles to under ride the barrier. 4. Cannot be used in conjunction with curbing. 5. Any impact requires repair.	1. Non-freeways. 2. Rural freeways. 3. Side hazards where deflection space is adequate and a Test Level 4 barrier is preferred.
W-Beam Guardrail	1. Lower initial cost. 2. High level of familiarity by maintenance personnel. 3. Can safely accommodate a wide range of impact conditions for passenger vehicles. 4. Relatively easy installation. 5. Remains functional after nuisance collisions. 6. Can be used in conjunction with curbing.	1. Less likely to contain large vehicles than concrete barrier or cable barrier. 2. At high-impact locations, will require frequent maintenance. 3. Will cause more snow drifting than cable barrier. 4. Hits that redirect or contain vehicles will require repair.	1. Non-freeways with narrow medians. 2. Rural freeways. 3. Side hazards where deflection space is adequate.
Concrete Barrier	1. Can accommodate most vehicular impacts without penetration. 2. No deflection distance required behind barrier. 3. Little or no damage sustained for most vehicular impacts; therefore, least need for maintenance. 4. Minimal vehicular under ride/ override potential for snagging potential.	1. Highest initial cost. 2. For given impact conditions, highest occupant decelerations; therefore, least forgiving of barrier systems 3. Reduced performance where offset between traveled way and barrier exceeds 12 ft (3.6 m). 4. Usually requires subsurface drainage. 5. Increased snow drifting.	1. Urban freeways. 2. Where very high traffic volumes are present. 3. Where high volumes of large vehicles are present. 4. Narrow medians.

ROADSIDE BARRIER SELECTION

Figure 38-5.A

Criteria	Comments
1. Performance Capability	Barrier must be structurally able to contain and redirect design vehicle.
2. Deflection	Adequate deflection space should be available so that the barrier can deflect on impact without contacting fixed objects behind the barrier.
3. Site Conditions	Slope approaching the barrier, slope behind the barrier, and distance from traveled way may preclude use of some barrier types.
4. Compatibility	Barrier must be compatible with planned terminal treatment and capable of transition to other barrier systems (e.g., bridge railing).
5. Cost	Standard barrier systems are relatively consistent in cost, but special-use systems can cost significantly more.
6. Maintenance	
a. Routine	Few systems require a significant amount of routine maintenance.
b. Collision Damage	W-beam guardrail will require the most extensive repair after a collision. Many high-tension cable barriers will require less extensive repair. Concrete barrier will have the least repair requirements after a collision.
c. Nuisance Hits	High-tension cable barrier will require the most frequent attention for nuisance hits (e.g., mowers, snowplows, minor vehicular encroachments). W-beam guardrail will require repairs where nuisance hits causes kinks or tears or disturbance of terminal impact heads. Concrete barrier will seldom require repairs for nuisance hits.
d. Materials Storage	The fewer the number of different systems used, the fewer inventory items/storage space required. High-tension cable barrier specifications allow a number of competing proprietary systems.
e. Simplicity	Simpler designs, in addition to costing less, are more likely to be repaired properly by field personnel.
7. Aesthetics	Use caution in applying aesthetic treatments to roadside hardware. See Section 38-5.01.
8. Field Experience	The performance and maintenance requirements of existing systems should be monitored to identify problems that could be lessened or eliminated by using a different barrier type.

SELECTION CRITERIA FOR ROADSIDE BARRIERS

Figure 38-5.B

38-6 ROADSIDE BARRIER LAYOUT

38-6.01 Length of Need

A roadside barrier must intercept and contain or redirect errant vehicles before they reach the roadside hazard or area to be shielded. The barrier should extend a sufficient distance upstream and/or downstream of the hazard such that a vehicle does not travel behind the barrier and reach the hazard.

Figures 38-6.A and 38-6.B show the principal dimensions and relationships necessary to design a roadside barrier system that will adequately shield traffic from reaching a hazard area. Figure 38-6.A is applicable to a one-way roadway and to a two-way roadway where the roadside hazard and guardrail is not within the clear zone for opposing traffic. Figure 38-6.B applies to a two-way roadway where the hazard is within the clear zone for opposing traffic. The essence of the procedure is to find the intersection of the vehicle's runout path for use in setting the location of the beginning of redirective barrier (the beginning of length of need point, or BLON point) of the proposed guardrail or other barrier.

The clear zone on the right begins at the edge of the traveled way. For traffic on a two-way roadway without a median, the clear zone on the left begins at the centerline of the roadway. The departure end of a roadside barrier on a two-way roadway may or may not be within the clear zone of the opposing traffic. However, this departure end of the roadside barrier is a formidable hazard introduced to the roadside and should typically be shielded, regardless of lateral offset. When beyond the clear zone for opposing traffic, at a minimum, provide an approved crashworthy end section to the end of the roadside barrier facing opposing traffic.

Terminal ends for guardrail are discussed in Section 38-6.06. The selection of the terminal end in the design phase will affect LON. Therefore Section 38-6.06 should be reviewed along with Figures 38-6.A and 38-6.B, the example problems located in this section, and specific manufacturer information available on the IDOT Qualified Products List (QPL) when determining LON and quantities for design purposes. The procedures presented in this chapter will result in sufficient quantities of guardrail being included in the plans. The contractor's selection of terminals will affect the final contract quantity of guardrail. Conservative assumptions are necessary in the design process to prevent conflicts with adjacent driveways or field entrances during construction, assure that appropriate length of need will be installed in the field, and ensure sufficient guardrail quantity is provided in the construction plans.

Example problems 38-6.01(1) through 38-6.01(6) show how to determine the required LON for various design situations. The assumptions made for TBT T1 devices in these examples do not reflect actual MASH devices and are meant only to illustrate the procedures. Note that calculations are typically not rounded in these examples; the designer should apply significant figures consistent with actual design precision. Guardrail quantity rounding is covered in Chapter 64.

Note that Figures 38-6.A and 38-6.B are depicted for a tangent alignment, as are the following development of length of need examples. When curves are present, a graphical, plan-based solution is necessary, as described below. Designers may also reference the equations in the Roadside Design Guide.

Divided highway medians warrant unique considerations. The practice of limiting clear zone widths based on practicality often may not be appropriate. Median piers should be shielded with barrier runs or crash cushions in accordance with Section 38-8.2. The openings created when freeways overpass roadways, railroads and rivers may be considered by designers to represent severe hazards that can be addressed by shielding a wider-than-typical clear zone. Refer to Example 38-6.01(4) for further discussion.

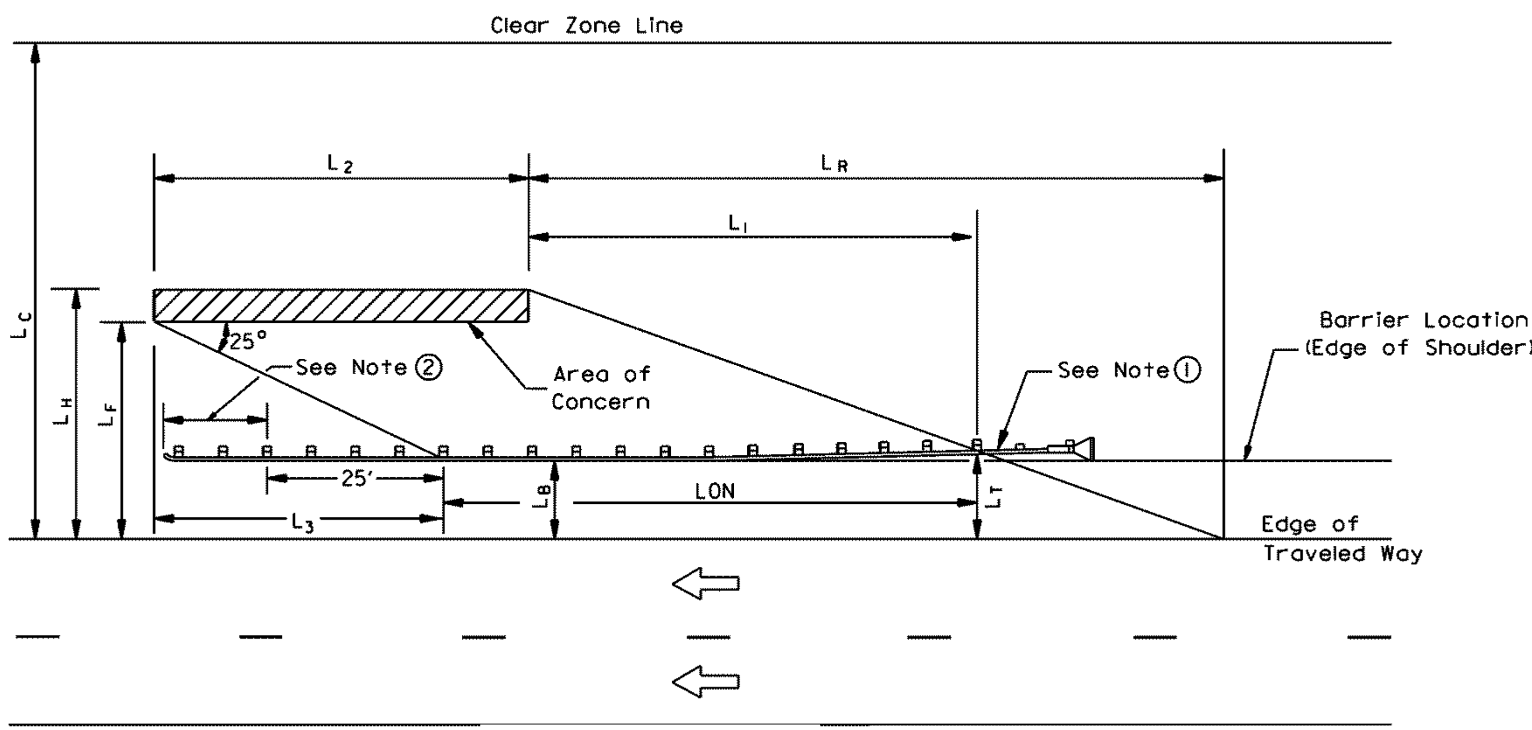
38-6.01(a) Graphical Solution

Whether on tangent or curved alignment, the preferred way to lay out guardrail and determine the length of need is by drawing and measuring the installation in plan view using CADD software. Designing graphically offers several advantages:

- Laying out installations along horizontal curves often requires some judgment, and it is helpful to review the design visually and to-scale; see Figure 38-6.C.
- A graphical layout allows the designer to look at various flare rates (note that non-blocked guardrail shall not be flared) while considering guardrail length and the extent to which the guardrail projects toward the ditch; see Figure 38-6.D. Greater flare rates will shorten guardrail lengths, but may increase the amount of earthwork required in order to provide the 1V:10H slopes needed in front of the guardrail. Designers will typically balance these issues based on site-specific characteristics (e.g., steepness of the front slope, width of the ditch).
- When designing graphically in plan view, the designer can look at contours and cross sections to determine if guardrail should be extended for steep slopes.
- As a quality-control measure, a graphical layout allows the designer to simply look at the design, drawn to scale, and confirm that the design is appropriate.
- Graphic layout can accurately depict all post locations, and related utility, drainage, or other conflicts.

For guardrail layout on curves, Figure 38-6.C shows an example of using the tangential runout path from the edge of traveled way to the back of the hazard or area of concern. Compare the tangential runout path and the runout length (L_R) and use the shorter of these values for design. The tangential runout path will tend to control on smaller radius curves, and the runout length on flatter curves. This procedure will help to minimize the required guardrail installation. The general relationship between flaring of guardrail and the grading required is depicted on Figure 38-6.D.

Using CADD is particularly efficient if cells are developed for the various guardrail components that make up a guardrail installation. Cells can be created for transitions to bridge ends, terminals, standard 12.5 ft (3.81 m) sections, and other components, etc., which can be efficiently placed in CADD to develop layouts and compare designs.



LON = $L_1 + L_2 - L_3$

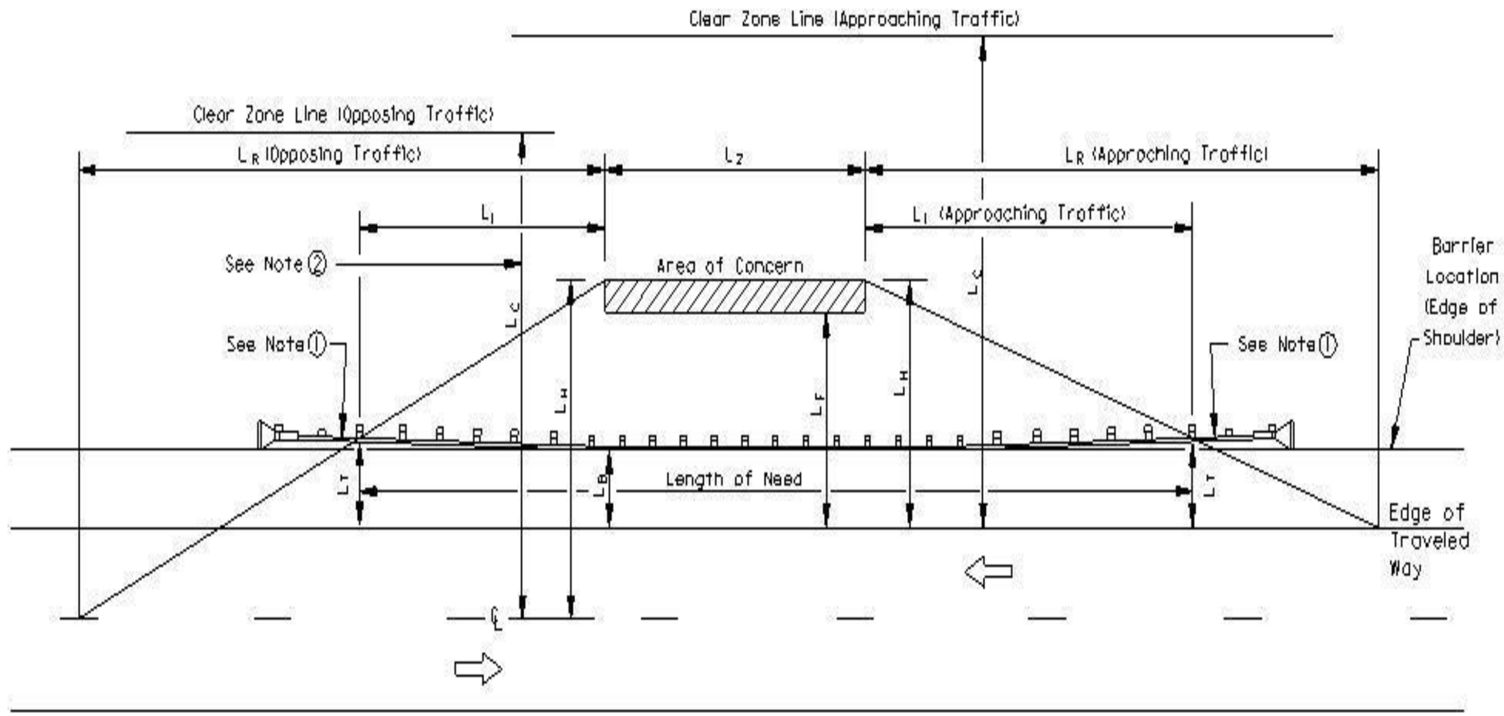
Notes:

① Use appropriate crashworthy terminal. See Section 38-6.06.
② Use a Type 2 terminal for one-way traffic. For two way traffic where L_c for opposing traffic > (L_F + 12), use an appropriate crashworthy terminal, with LON point passing through the third post of the crashworthy terminal.

L_T = Distance to the barrier at the third post of the terminal
L_B = Distance to the barrier
L_C = Distance to the clear zone
L_H = Distance to the back of the hazard
L_F = Distance to the front of the hazard
L_R = Runout length (see Figure 38-6.E)
L_1 = Length of need for the approach end
L_2 = Length of the hazard
L_3 = Distance from the downstream end of the hazard
LON = Length of Need

BARRIER LENGTH OF NEED LAYOUT
(One-Way Roadways or Two-Way Roadways Where the Hazard and Guardrail are Beyond the Clear Zone of Opposing Traffic)

Figure 38-6.A



LON = L_1 (approaching) + L_2 + L_1 (opposing)

Notes:

① Use appropriate crashworthy terminal. See Section 38-6.06.
② If L_c for opposing traffic < (L_F + 12) then refer to Figure 38-6.A.

L_T = Distance to the barrier at the third post of the terminal
L_B = Distance to the barrier
L_C = Distance to the clear zone
L_H = Distance to the back of the hazard
L_F = Distance to the front of the hazard
L_R = Runout length (see Figure 38-6.E)
L_1 = Length of need for the approach end
L_2 = Length of the hazard
LON = Length of Need

BARRIER LENGTH OF NEED LAYOUT
(Two-Way Roadways Where the Hazard and Guardrail are within the Clear Zone of Opposing Traffic)

Figure 38-6.B

38-6.01(b) Nomograph Solution

If the installation is on a tangent section of roadway, the nomograph in Figure 38-6.F can be used to determine the length of need. The procedure for using the nomograph is as follows, assuming a hazard is present requiring protection:

1. Draw a horizontal line at L_B on the y-axis (the lateral distance of the barrier from the edge of traveled way). This assumes that the barrier is not flared; i.e., it is parallel to the roadway.

   If a crashworthy terminal is provided, draw the horizontal line at L_T instead of L_B to account for the offset at the third post of the Traffic Barrier Type 1, Special (TBT T1). Normally this is an additional 2.7 ft (0.8 m) for a TBT T1 (Flared) and 0.75 ft (0.2 m) for a TBT T1 (Tangent).

   If the guardrail itself is flared, draw a line from L_B on the y-axis equal to the flare rate of the guardrail. If a flared section of guardrail connects to a tangent portion, such as a Type 6 terminal, show both the tangent and flared portions on the nomograph. For a TBT T1 attached to a flared section of guardrail, the TBT T1 will often have the same flare rate as the guardrail to which it is attached, but the flare rate must not exceed the maximum rate established through crash testing for the terminal selected. Example problem 38-6.01(5) illustrates all of these scenarios.

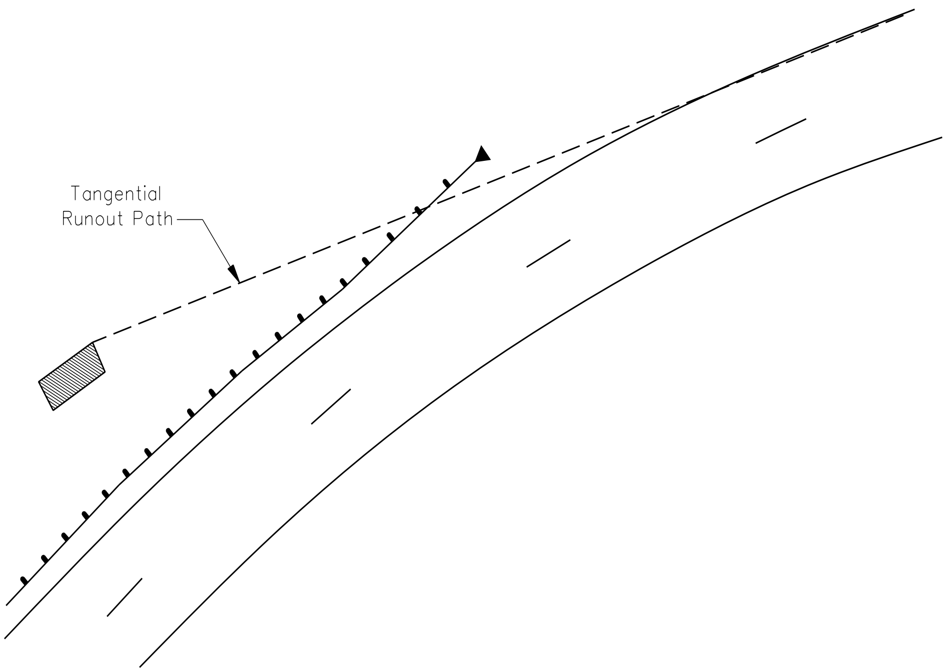
2. Locate L_H or L_C, whichever is less, on the y-axis. Check the hazard location for the opposing direction if the roadway is two-way. Also check for the need of a crashworthy terminal end section for the opposing direction of traffic. Example problem 36-6.01(3) illustrates this situation.

3. Determine L_R from Figure 38-6.E and locate L_R on the x-axis. If barrier protection is needed for only the approaching traffic, use only the “Edge of Traveled Way Scale.” If needed for both directions of travel, locate L_R on both the “Edge of Traveled Way Scale” and the “Centerline Scale.” See Step 7 to address the downstream end of the barrier where the hazard does not require shielding for the opposing traffic.

4. Connect the points in Steps 2 and 3 with a straight line(s).

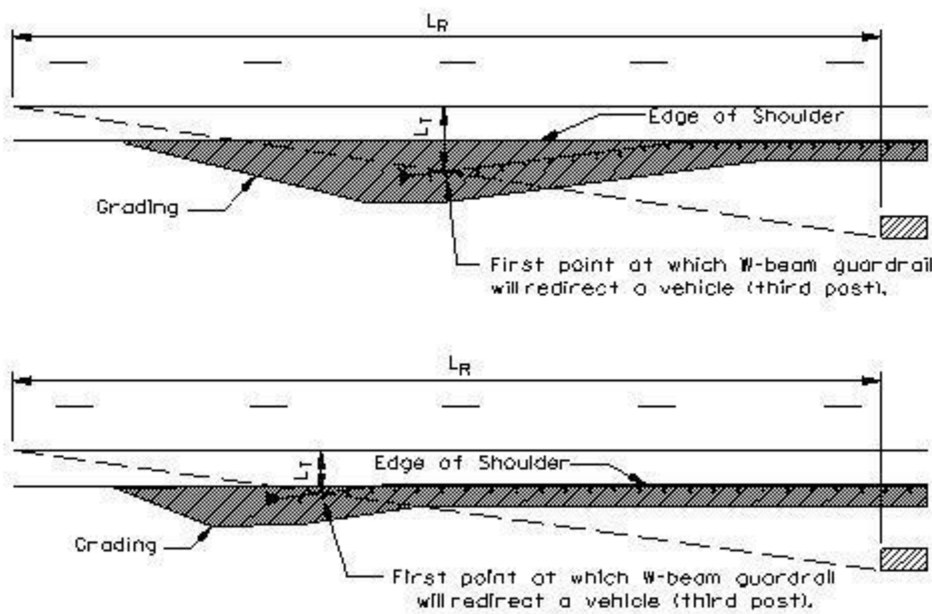
5. Locate the intersection(s) of the lines in Steps 1 and 4. From this point(s), draw a line vertically to the “Edge of Traveled Way Scale” and, if required, to the “Centerline Scale” to determine L_1.

6. Read L_1 from the “Edge of Traveled Way Scale” and, if required, from the “Centerline Scale.” As illustrated on Figures 38-6.A and 38-6.B, L_1 is measured from the lateral edge of the hazard to the third post of the terminal. The LON does not include the gating portion of the terminal.



GRAPHICAL LAYOUT OF GUARDRAIL ALONG A HORIZONTAL CURVE

Figure 38-6.C



GUARDRAIL LENGTH (AMOUNT OF FLARE) VS. AMOUNT OF GRADING

Figure 38-6.D

Design Speed		Traffic Volume (ADT)*							
		Over 10,000		5000-10,000		1000-4999		Under 1000	
		Runout Length L_R		Runout Length L_R		Runout Length L_R		Runout Length L_R	
mph	(km/hr)	ft	(m)	ft	(m)	ft	(m)	ft	(m)
75	(130)	415	(127)	380	(116)	335	(102)	290	(86)
70	(110)	360	(110)	330	(101)	290	(88)	250	(76)
60	(100)	300	(91)	250	(76)	210	(64)	200	(61)
55	(90)	265	(81)	220	(67)	185	(57)	175	(54)
50	(80)	230	(70)	190	(58)	160	(49)	150	(46)
45	(70)	195	(60)	160	(49)	135	(42)	125	(38)
40	(60)	160	(49)	130	(40)	110	(34)	100	(30)
30	(50)	110	(34)	90	(27)	80	(24)	70	(21)

**Based on a 10 year projection from the anticipated date of construction*.

RUNOUT LENGTHS (L_R) FOR BARRIER DESIGN

Figure 38-6.E

7. If barrier protection is only warranted for one direction of travel (Figure 38-6.A), use the following procedure to determine the downstream end of the length of need, otherwise proceed to Step 8:

   a. If not done in Step 1, draw a horizontal line from L_B at the y-axis to represent the lateral distance of the barrier from the edge of travel way (i.e., no adjustment for the flare of the terminal).

   b. Locate L_F on the y-axis as the distance from the hazard to the edge of traveled way, at the downstream end of the hazard.

   c. From point L_F, draw a line parallel to the 25 degree line in Figure 38-6.F until it intersects the L_B line.

   d. From the intersection between the L_B line and the L_F line, draw a line vertically to the "Edge of Traveled Way Scale" and read L_3.

8. Calculate the length of need (LON):

If barrier protection is warranted for only one direction of travel:

$$LON = L_1 + L_2 – L_3$$ Equation 38-6.1

If barrier protection is warranted for both directions of travel:

$$LON = L_1 \text{ approaching} + L_2 + L_1 \text{ opposing}$$ Equation 38-6.2

The next three steps consider the contribution of various guardrail terminals to completing the length of need.

9. Because the various proprietary TBT T1 terminals vary in the location of their beginning of length of need (BLON) point and in total length, it is not possible to provide absolute positions of the end of guardrail or the limits of the terminal. Where a TBT T1 is to be installed, specify the BLON station and offset in the plans. For design purposes, use a consistent TBT T1 available from the Qualified Products List (QPL) throughout the project, with the BLON point at post 3. Use this information to determine how much redirective barrier the TBT T1 provides toward completing the LON. While utilizing the shortest available TBT T1 will provide the most conservative value for guardrail plan quantity, consider the effects of a longer TBT T1 being used in the field and its impact on the location of proposed entrances and grading. Standard assumptions introduce an assumed gating section 12.5 ft long from post 1 to post 3 of the TBT T1.

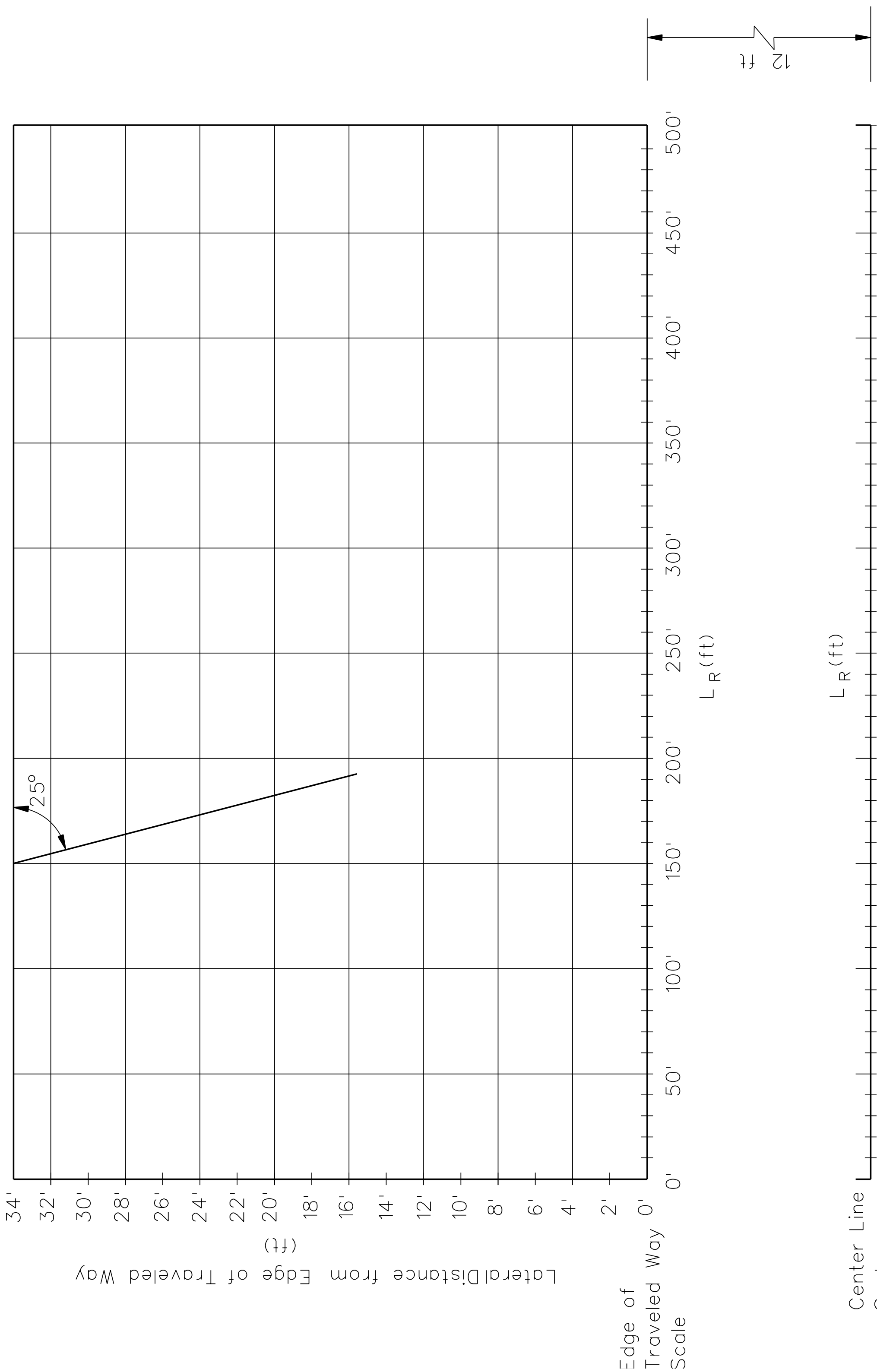
   For a TBT T2 the length of need begins at 37.5 ft (11.43 m) from the end post of the TBT T2. This means that the TBT T2 and the adjacent 25 ft (3.81 m) of guardrail do not contribute to the LON. Using a TBT T2 requires adding at least 25 ft (3.81 m) of guardrail beyond the LON when calculating the pay item quantities.

10. For connection of guardrail to other terminals from the *Illinois Highway Standards,* determine the contribution of the terminals toward completing the LON. These terminals are connections between guardrail and other barrier types. Typically their entire length contributes to the LON. For example:

    - The entire length of a TBT Type 6, 6A, or 6B counts toward the LON so that length needs to be subtracted from the LON adjusted in Step 9 (see applicable *IDOT Highway Standard* for terminal length).

11. Check that the LON and layout is adequate and does not create conflicts.

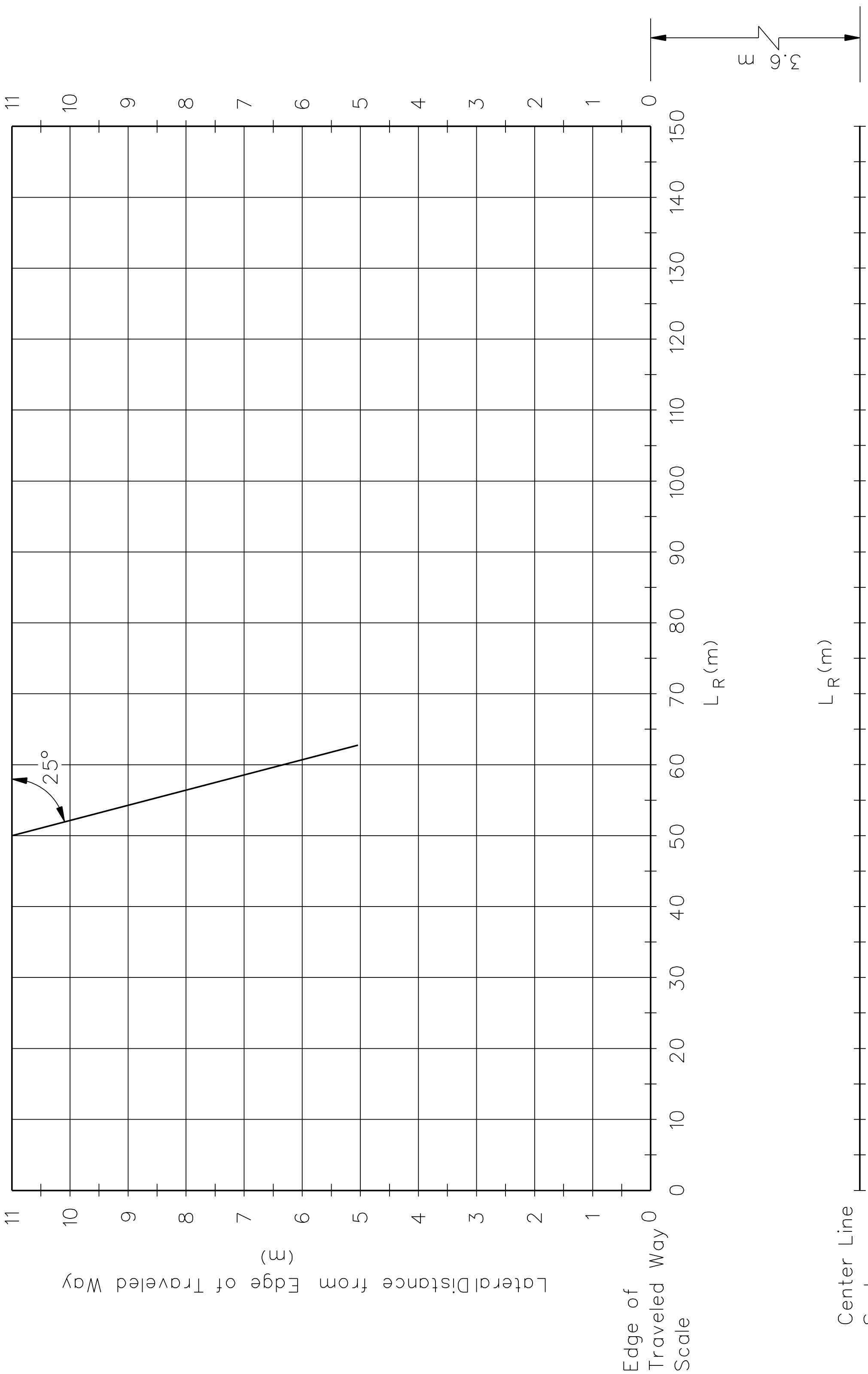
    Determine the pay item plan locations and quantities. When a TBT T1 is used in a run of guardrail, it is not necessary or possible to determine the guardrail or terminal limits with certainty. Use the nominal pay item limits based on the BLON location and assume TBT T1 parameters. As-built adjustments in construction will be necessary to determine splice locations, specific devices to be used, and final pay quantities. These adjustments are considered nominal in providing the LON.



Note: Centerline scale assumes a 12-ft lane width. For other lane widths, appropriate adjustments must be made.

BARRIER LENGTH OF NEED CALCULATION (TANGENT ROADWAYS ONLY)
(US Customary)

Figure 38-6.F



Note: Centerline scale assumes a 3.6-m lane width. For other lane widths, appropriate adjustments must be made.

BARRIER LENGTH OF NEED CALCULATIONS
(Metric)

Figure 38-6.F

Example 38-6.01(1) (One-Way Traffic)

Given: New Construction (See Figure 38-6.G)
One-way roadway
Design ADT = 7000 vpd
Design speed = 70 mph
Slope = 1V:6H front slope
Tangent roadway
Shoulder width = 10 ft
L_H = 25 ft
L_2 = 40 ft
L_F = 15 ft
Unflared barrier (steel plate beam guardrail, Type A) located at the edge of the shoulder (L_B = 10 ft).
Traffic Barrier Terminal Type 1 (TBT T1), Special (Flared)

Problem: Determine the barrier length of need (LON) and plan length of guardrail, Type A.

Solution: Use the nomograph procedure starting on page 38-6.5 (refer to the nomograph in Figure 38-6.H).

1. Since a TBT T1, Special (Flared) terminal is proposed, draw a horizontal line at L_T on the y-axis of the nomograph,

   Where: L_T = 10 + 2.7 = 12.7 ft

   The 2.7 ft is added to the shoulder width to take into account the flare of the guardrail terminal at the third post.

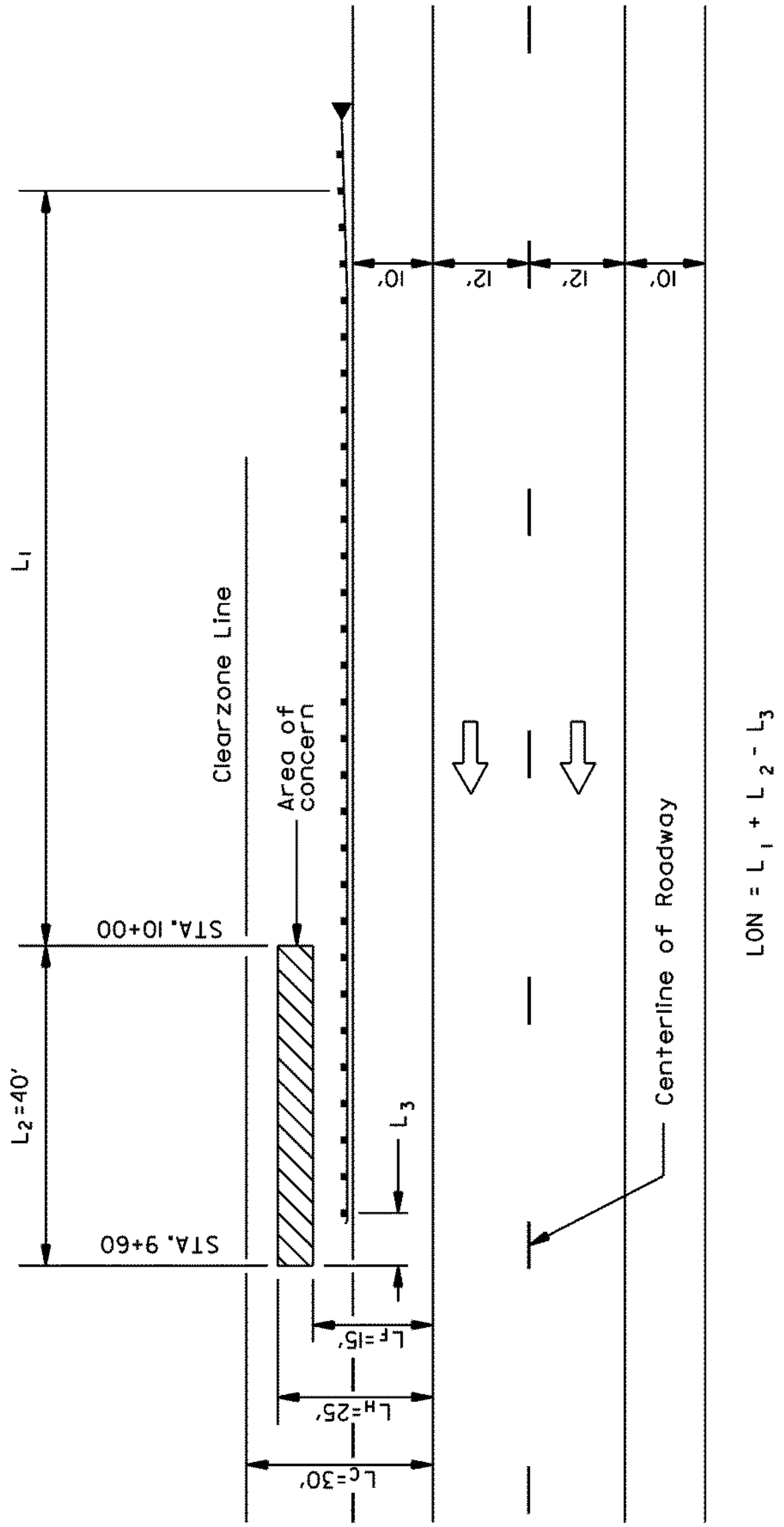
2. From Figure 38-3.A, the clear zone (L_C) is 30 ft and the hazard warrants protection since $L_F < L_C$. Locate the lesser of L_H or L_C, on the y axis. In this case locate L_H = 25 ft on the y-axis.

3. From Figure 38-6.E, L_R = 330 ft. Locate this point on the "Edge of Traveled Way Scale." Since the roadway is one-way, protection is only warranted from one direction, and therefore L_R is not located on the "Centerline Scale."

4. Connect the points in Steps 2 and 3.

5. From the intersection between the lines from Step 1 and Step 4, draw a vertical line down to the "Edge of Traveled Way Scale" to get L_1.

6. Read L_1 = 162 ft from the "Edge of Traveled Way Scale."



PLAN VIEW
EXAMPLE 38-6.01(1)

Figure 38-6.G

7. Since barrier protection is only warranted for one direction, perform the following steps to establish L_3, and thus determine the location of the downstream end of the barrier:

   a. Draw a horizontal line from L_B = 10 on the y-axis.
   b. Locate L_F = 15 ft on the y-axis.
   c. Draw a line from L_F parallel to the 25 degree line until it intersects the L_B line.
   d. From the intersection between the lines formed from Step 7a and Step 7c, draw a vertical line down to the “Edge of Traveled Way Scale” to find L_3. Read L_3 = 11 ft.

8. Calculate the length of need (LON) of guardrail. In this example barrier protection is needed only in one direction of travel. Therefore:

   LON = 162 + 40 – 11 = 191 ft   Equation 38-6.1

9. Based on the stationing shown in Figure 38-6.G, the BLON for the approach end (TBT T1) falls at, Station 11+62.00, 24.7 ft left. This is set as the face of rail location at post 3 of the TBT T1 (see QPL for specific end terminal dimensions). For this example, a 37.5 ft long TBT T1 is selected from the QPL. So the TBT T1 will provide at least (37.5 ft– 12.5 ft =) 25 ft of the length of need. As described, this TBT T1 will also include a gating section from post 1 to post 3 (12.5 ft).

10. A TBT T2 is used for the departure end of the guardrail since there is one-way traffic. The TBT T2 requires an additional 25 ft of guardrail which is added to the estimated length beyond the BLON for the TBT T2.

11. Standard terminals other than the TBT T2 are not used, so this step does not apply

12. Determine the pay item plan locations and quantities.

    The BLON for the approach end (TBT T1) is at Station 11+62.00, 24.7 ft left.

    The steel plate beam guardrail has one end at:

    (Station 11+62) – 25 ft = Station 11+37.00

    The other end of the steel plate beam guardrail is at:

    (Station 11+37) – (191 ft (LON) + 25 ft (provided by TBT T1) – 25 ft (additional needed with TBT T2) = Station 9+46.00

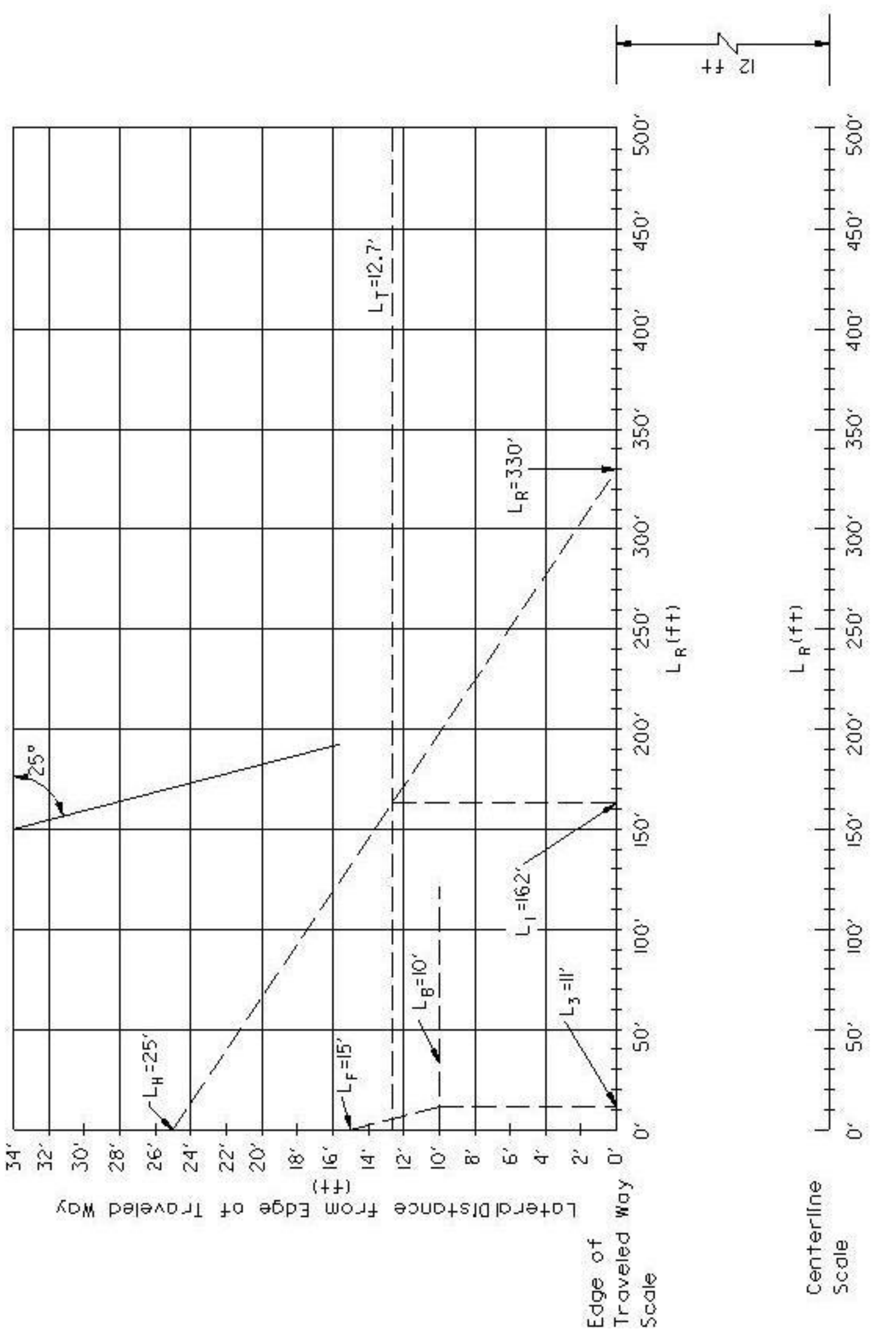
    The pay item quantity of guardrail is (Station 11+37) – Station (9+46) = 191 ft.

    The TBT T2 is from Station 9+46, 22.0 ft left to:

    (Station 9+46) – 12.5 ft = Station 9+33.50, 22.0 ft left.

13. Check that the LON and layout is adequate after all adjustments. By inspection, the design LON matches the LON from the nomograph and plan layout. For the TBT T1, the BLON is at 24.7 ft left of roadway centerline at Station 11+62.00.

    No constraints are shown that would interfere with a gating end of a TBT T1, or adjustment of +/- 12.5 ft of the Station of the TBT T1 location.



BARRIER LENGTH OF NEED CALCULATION
Example 38-6.01(1)

Figure 38-6.H

Example 38-6.01(2) (Two-Way Traffic)

Given: Reconstruction (See Figure 38-6.I)
Two-lane/two-way roadway
Design ADT = 5000 vpd
Design speed = 60 mph
Slope = 1V:4H front slope
Tangent roadway
Lane width = 12 ft
Shoulder width = 8 ft
L_H = 15 ft
L_2 = 10 ft
L_F = 10 ft
Traffic Barrier Terminal Type 1 (TBT T1), Special (Tangent)

Problem: Determine the barrier length of need and plan length of guardrail needed.

Solution: Use the nomograph procedure starting on page 38-6.5 (refer to the nomograph in Figure 38-6.J).

1. Since a TBT T1 (Tangent) terminal is proposed, draw a horizontal line at L_T on the y-axis of the nomograph,

   Where: L_T = 8 + 0.75 = 8.75 ft

   The 0.75 ft is added to the shoulder width to take into account the flare of the guardrail terminal at the third post. The offset from the centerline is thus: 12 +8 + 0.75 = 20.75 ft.

2. From Figure 38-3.A, the clear zone (L_C) is 30 ft and the hazard warrants protection for approaching traffic since $L_F < L_C$. Locate the lesser of L_C or L_H on the y-axis. In this case locate L_H = 15 ft on the y-axis for the travel lane closest to the hazard.

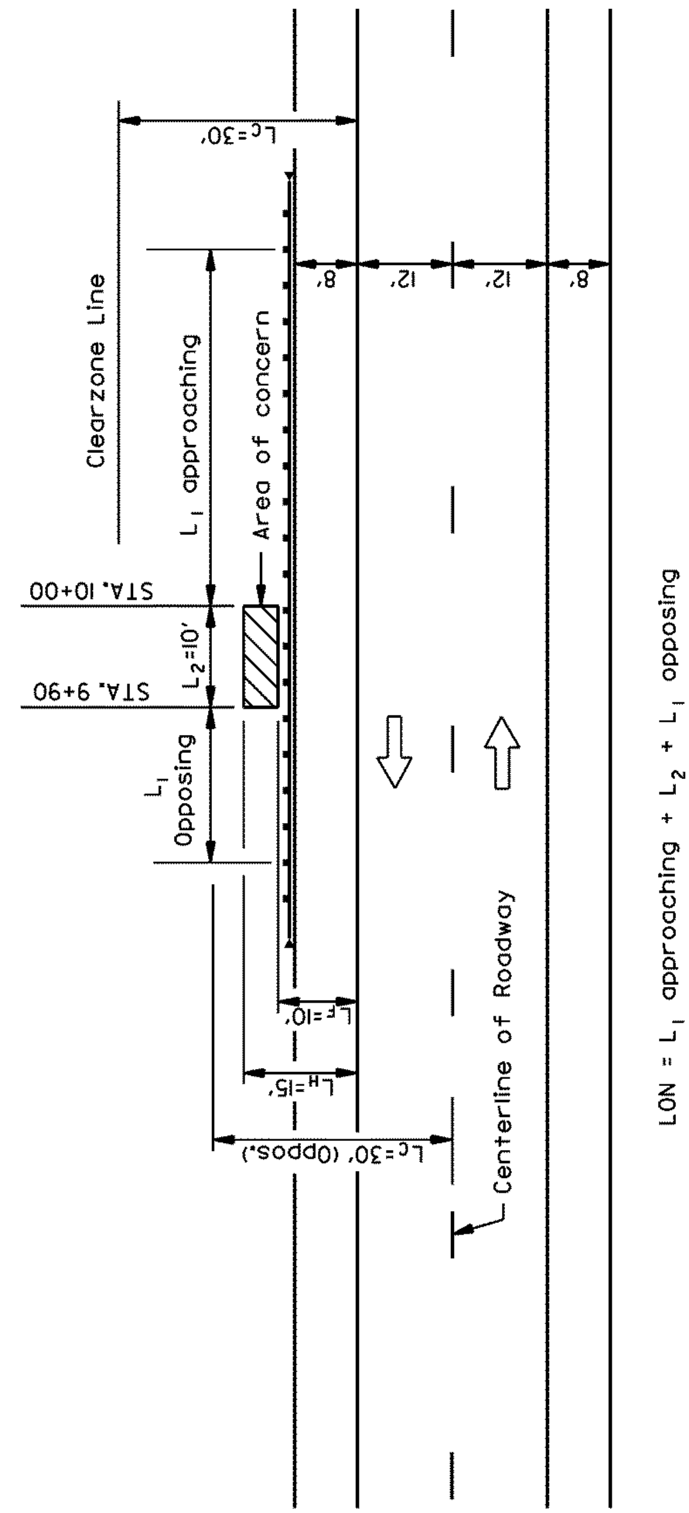
   Add 12 ft, the lane width, to L_F to determine if the hazard is within the clear zone for opposing traffic.

   Since L_F + 12 = 22 ft, and is less than the L_C, guardrail protection is also needed for the opposing direction of traffic at the face of the hazard.

   Similarly, L_H + 12 = 27 ft which is also less than L_C, therefore protection is needed for the full lateral width of the hazard.

3. From Figure 38-6.E, L_R = 250 ft Locate this point on the “Edge of Traveled Way Scale” and the “Center Line Scale”, since protection is required for both directions of travel.

4. Connect the points in Steps 2 and 3. Draw a line for the approaching traffic from the y-axis to the “Edge of Traveled Way Scale” and a line for the opposing traffic from the y-axis to the “Center Line Scale.”



PLAN VIEW
EXAMPLE 38-6.01(2)

Figure 38-6.I

5. From the intersection between the lines from Step 1 and Step 4, draw vertical lines down to the “Edge of Traveled Way Scale” and the “Centerline Scale” to get L_1 for both directions of travel.

6. Read L_1 = 103 ft from the “Edge of Traveled Way Scale” and L_1 = 57 ft from the “Centerline Scale.”

7. Skip this step, since protection is warranted from both directions of travel.

8. Calculate the length of need, LON, of guardrail. In this example, barrier protection is needed from both directions. Therefore:

   LON = 103 ft + 10 ft + 57 ft = 170 ft   Equation 38-6.2

9. Based on the stationing shown in Figure 38-6.I, the station and offset of the approach end BLON is

   (Station 10+00) + 103 ft = Station 11+03.00, 20.75 ft left.

   The station for the end of opposing traffic is:

   (Station 10+00) – 10 ft – 57 ft = Station 9+33.00, 20.75 ft left.

10. Step 10 does not require any action as no terminals from the *Illinois Highway Standards* are used.

11. Step 11 does not apply as no TBT T2 terminals are being placed.

12. Determine the pay item lengths and plan locations.

    By inspection, placement of the TBT T1 BLON points at the plan locations will satisfy the design length of need. Although some field adjustment using standard panels and specific TBT T1 products will be needed, these adjustments are considered nominal.

    The plan Stations of the TBTs T1 are:

    The selected TBT T1 for this example is 37.5 ft long, and its BLON is at post 3, 12.5 ft from its end.

    BLON is at Station 11+03.00, 20.75 ft left.

    Begin TBT T1 at (Station 11+03) – 25 ft = Station 10+78.00, 20.0 ft left.

    End TBT T1 at (Station 11+03) + 12.5 ft = Station 11+15.50 ft, 20.75 ft left.

    BLON is at Station 9+33.00, 20.75 ft left.

    Begin TBT T1 at (Station 9+33) - 12.5 ft = Station 9+20.50, 20.75 ft left.

    End TBT T1 at (Station 9+33) + 25 ft = Station 9+58.00, 20.0 ft left.

The plan stations for the guardrail pay item are thus:

Station 9+58.00, 20.0 ft left.

To

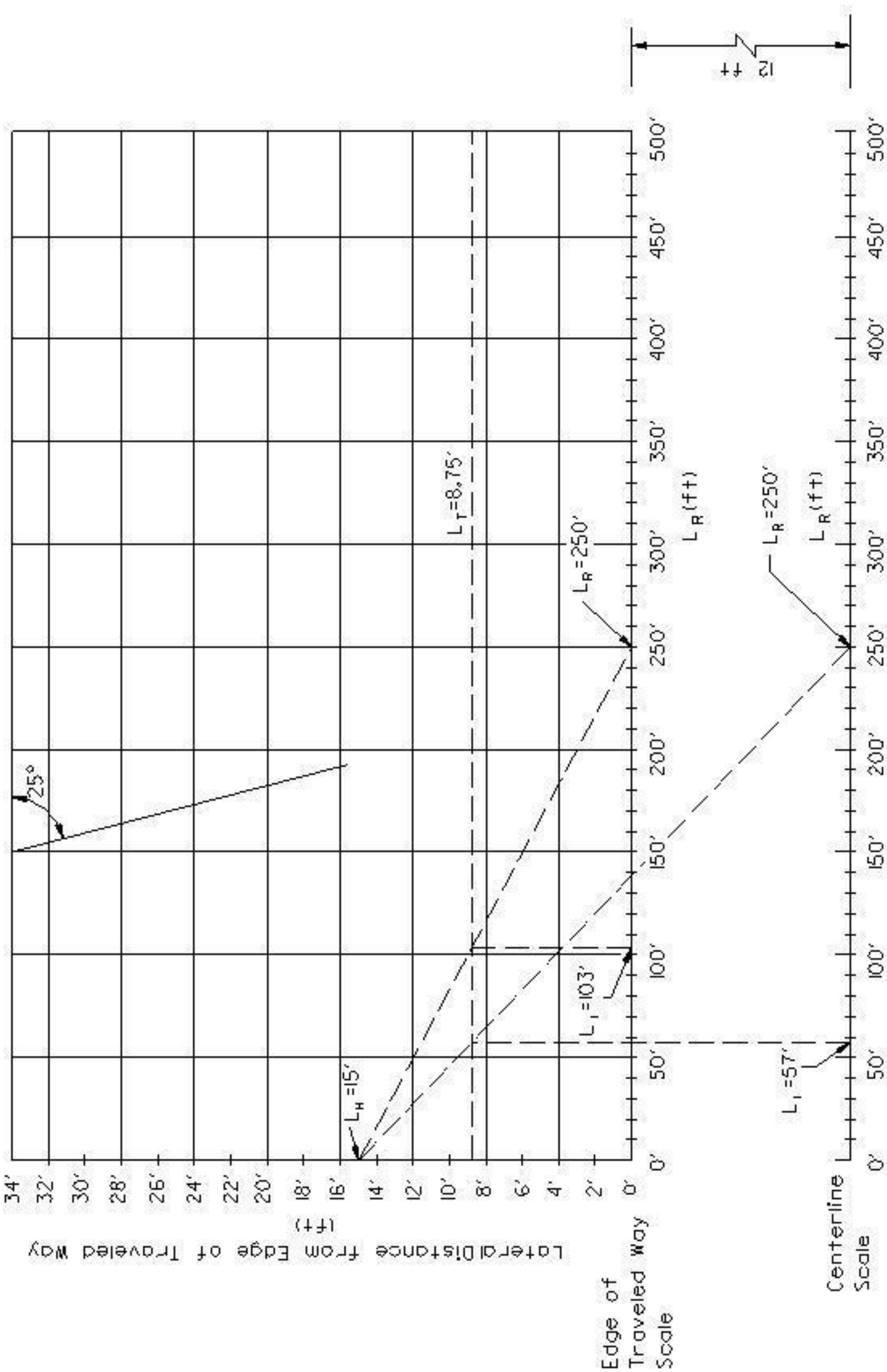
Station 10+78.00, 20.0 ft left.

Quantity of guardrail pay item = (Station 10+78) – (Station 9+58) = 120 ft.

It is not necessary to round to an even number of 12.5 ft guardrail panels because the precise location and dimensions of the TBTs T1 are not known until the contractor selects an item from the QPL.

Special design note. A special design will be needed at the hazard because the space from the face of guardrail (L_B = 8 ft) and the face of the hazard (L_F = 10 ft) is only 2 ft. Because the width of the guardrail system is 21 in., there are only 3 in. between the back of the posts and the face of the hazard for deflection of the guardrail. Per Figure 38-6.V, Type A guardrail requires 38 in. clear width for deflection between the back of the post and the face of the hazard.

Because there is not an acceptable deflection distance between the back of the guardrail posts and the area of concern (hazard), the guardrail needs to transition to a rigid barrier across the width of the hazard. If the nature of the hazard is such that guardrail may be bolted to it, using details similar to the Traffic Barrier Terminal Type 6B, transition the post spacing on both sides of the structure to minimize the consequence of "pocketing", and carry a continuous barrier across the structure. If the area of concern does not provide a suitable backup for guardrail attachment, then provide a concrete barrier and provide transitions and connections as just described. Job-specific details and special provisions will be needed.



BARRIER LENGTH OF NEED CALCULATION
Example 38-6.01(2)

Figure 38-6.J

Example 38-6.01(3) (Two-Way Traffic — Hazard Beyond Opposing Traffic's Clear Zone)

Given: Reconstruction (See Figure 38-6.K)
Two-lane/two-way roadway
Design ADT = 5000 vpd
Design speed = 60 mph
Slope = 1V:4H front slope
Tangent roadway
Shoulder width = 8 ft
L_H = 23 ft
L_2 = 2 ft (i.e., a point hazard)
L_F = 21 ft
L_B = 8 ft
Traffic Barrier Terminal Type 1, Special (Tangent) (TBT T1)

Problem: Determine the barrier length of need and plan length of guardrail, Type A.

Solution: Use the nomograph procedure starting on page 38-6.5 (refer to the nomograph in Figure 38-6.L).

1. Since a TBT T1 (Tangent) terminal is proposed, draw a horizontal line at L_T on the y-axis of the nomograph,

   Where L_T = 8 + 0.75 = 8.75 ft.

   The 0.75 ft is added to the shoulder width to take into account the flare of the guardrail terminal at the third post. The offset from the centerline is thus: 12 +8 + 0.75 = 20.75 ft.

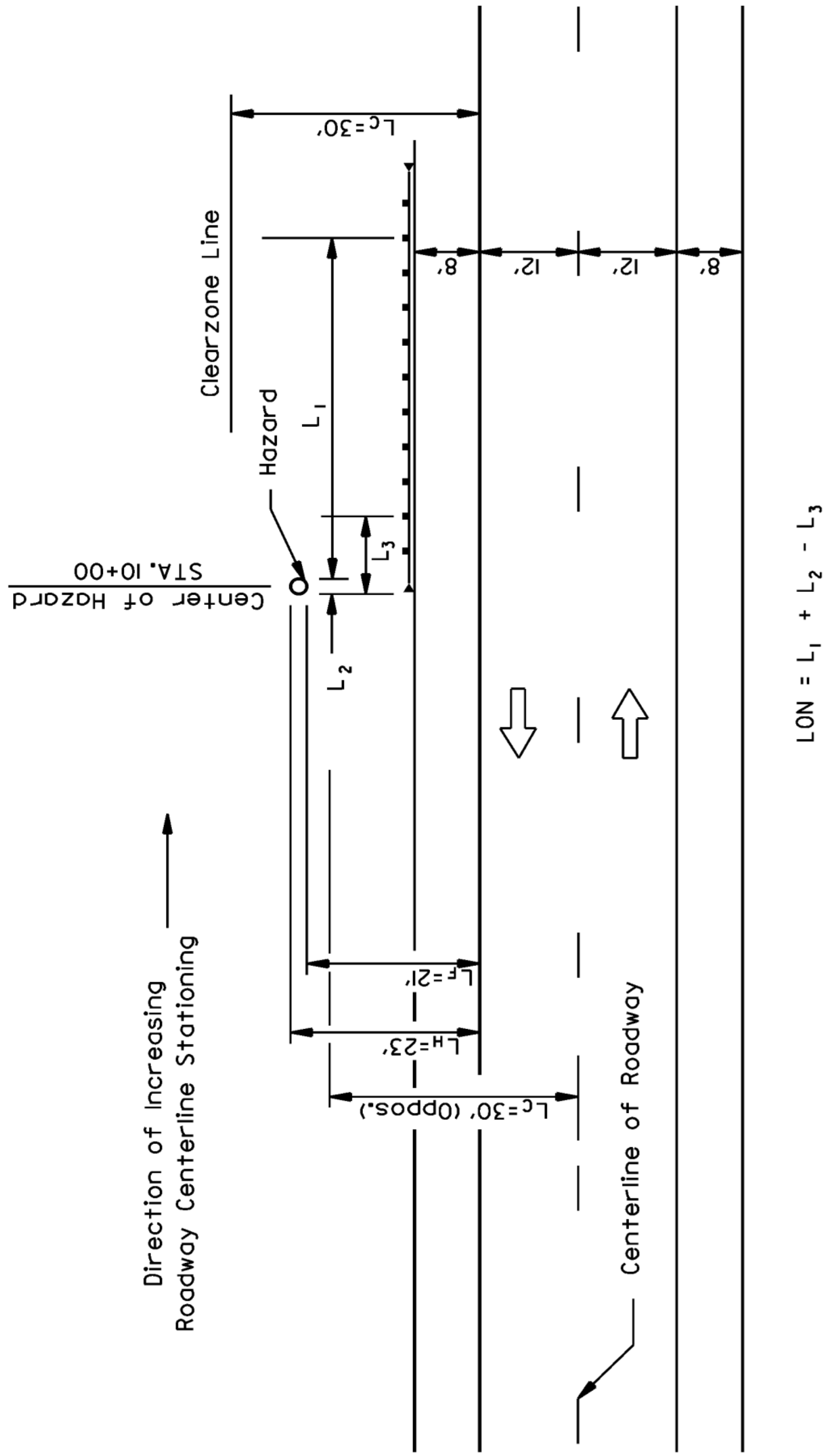
2. From Figure 38-3.A, the clear zone (L_C) is 30 ft and the hazard warrants protection for approaching traffic since $L_F < L_C$. Locate the lesser of L_C or L_H on the y-axis. In this case locate L_H = 23 ft on the y-axis.

   Add 12 ft, the lane width, to L_F to determine if the hazard is within the clear zone for opposing traffic.

   Since L_F + 12 = 33 ft, and is greater than L_C, guardrail protection may not be required for the opposing direction of traffic. Use engineering judgment or follow the guidance in Section 38-3 to determine the need for roadway protection for the opposing direction of traffic.

   Although, for this example, it is assumed guardrail protection from the point hazard for the opposing direction traffic is not required, a crashworthy terminal is needed downstream because of two-way traffic.

3. From Figure 38-6.E, L_R = 250 ft. Locate this point on "Edge of Traveled Way Scale." Since protection is warranted for approaching traffic only, there is no need to locate L_R on the "Centerline Scale."



PLAN VIEW
EXAMPLE 38-6.01(3)
Figure 38-6.K

4. Connect the points in Steps 2 and 3.

5. From the intersection between the lines from Step 1 and Step 4, draw a vertical line down to the “Edge of Traveled Way Scale” To get L_1.

6. Read L_1 = 153 ft from the “Edge of Traveled Way Scale” for approaching traffic.

7. Since barrier protection is only warranted for one direction, perform the following steps to establish L_3, and thus determine the location of the downstream end of the barrier.

   a. Draw a horizontal line L_B. L_B = 8 ft.

   b. Locate L_F = 21 ft on the y-axis.

   c. Draw a line parallel to the 25 degree line from L_F until it intersects the L_B line.

   d. From the intersection between the lines formed from Step 7a and 7c, draw a vertical line down to the “Edge of Traveled Way Scale.” Read L_3 = 29 ft.

8. Calculate the length need, LON, of guardrail. In this example barrier protection is needed in one direction of traffic. Therefore:

   LON = 153 + 2 - 29 = 126 ft Equation 38-6.1

9. Based on the stationing shown in Figure 38-6.K, the station and offset of the approach end BLON is:

   (Station 10+00)+ 1 ft + 153 ft = Station 11+54.00, 20.75 ft left.

   The stationing for the opposing traffic’s end is:

   (Station 10+00) – 1 ft + 29 ft = Station 10+28.00, 20.75 ft left.

10. Step 10 does not require any action as no terminals from the *Illinois Highway Standards* are used.

11. Step 11 does not apply as no TBT T2 terminals are being placed.

12. Determine the pay item lengths and plan locations.

    By inspection, placement of the TBT T1 BLON points at the plan locations will satisfy the design length of need. Although some field adjustment using standard panels and specific TBT T1 products will be needed, these adjustments are considered nominal.

    The plan Stations of the TBTs T1 are calculated as follows:

    The selected TBT T1 for this example is 37.5 ft long, and its BLON is at post 3, 12.5 ft from its end.

    The BLON is at Station 11+54.00, 20.75 ft left. Therefore:

    Begin TBT T1 at (Station 11+54) - 25 ft = Station 11+29.00, 20.0 ft left.

End TBT T1 at (Station 11+54) + 12.5 ft = Station 11+66.50, 20.75 ft left.

BLON at Station 10+28.00, and 20.75 ft left.

Begin TBT T1 at (10+28) - 12.5 ft = Station 10+15.50, 20.75 ft left.

End TBT T1 at (10+28) + 25 ft = Station 10+53.00, 20.0 ft left.

The plan stations for the guardrail pay item are thus:

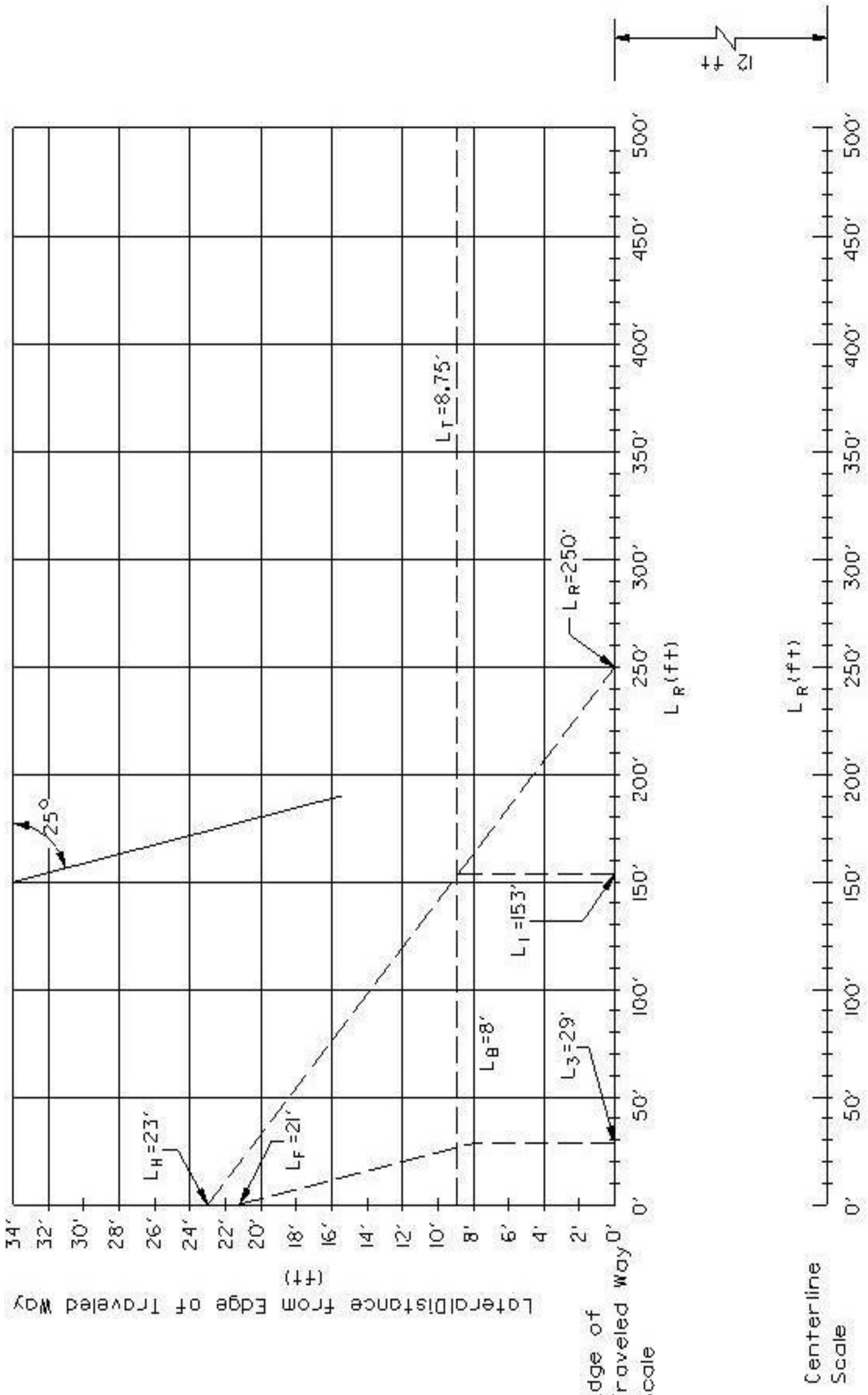
Station 10+53.00, 20.0 ft left.

To

Station 11+29.00, 20.0 ft left.

Quantity of guardrail pay item = (Station 11+29) – (Station 10+53) = 76 ft.

It is not necessary to round to an even number of 12.5 ft guardrail panels because the precise location and dimensions of the TBTs T1 are not known until the contractor selects an item from the QPL.



BARRIER LENGTH OF NEED CALCULATION
Example 38-6.01(3)

Figure 38-6.L

Example 38-6.01(4) (Bridge on Two-Way Two-Lane Highway with Recoverable Front Slope)

Given: New Construction (See Figure 38-6.M)
Two-way, two-lane highway
Design ADT = 5500 vpd
Design speed = 60 mph
Guardrail for shielding of bridge parapet ends and steep slope adjacent to the slope wall
Bridge slope wall = 1V:2H
Typical front slopes = 1V:4H (Assume a front slope of at least 1V:3H prevails to within 100 ft of the bridge, then transitions over 100 ft to match the bridge cone/slopewall).
Tangent roadway
Lane width = 12 ft
Shoulder width = 8 ft
Unflared barrier (steel plate beam guardrail, Type A) located at the edge of the shoulder (L_B = 8 ft)
Traffic Barrier Terminal Type 1 (TBT T1), Special (Flared)

Problem: Determine the location and limits of the hazard, the barrier length of need, and the pay item length of guardrail. This problem assumes a symmetrical layout with the same hazards for traffic approaching at both ends of the bridge.

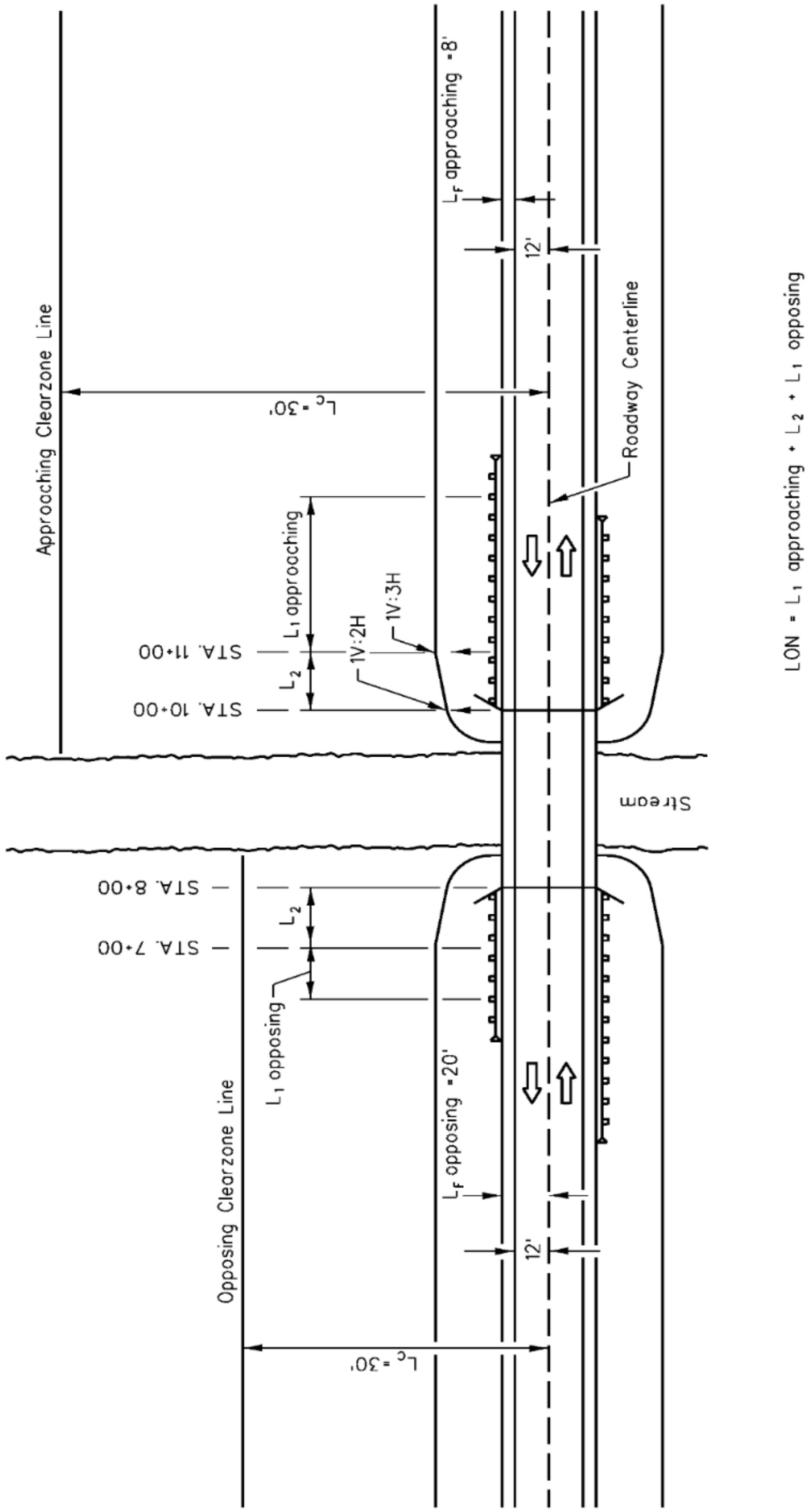
Solution: Approach Side:

The hazards are the 1V:2H slope off the end of the bridge cone, the drop-off to the stream below the bridge, and the transition slope steeper than 1V:3H. For simplicity, it has been previously determined that the location where the slope becomes steeper than 1V:3H is located 100 ft from either side of the bridge. Since the layout is symmetrical, for simplicity, the analysis will be done for one side of the bridge/one direction of travel. Use the nomograph procedure starting on page 38-6.5 (refer to the nomograph in Figure 38-6.N).

1. Since a TBT T1 (Flared) terminal is proposed, draw a horizontal line at L_T on the y-axis of the nomograph for the approach side of the roadway, where:

   L_T = 8 ft + 2.7 ft = 10.7 ft

   The 2.7 ft is added to the shoulder width to take into account the flare of the guardrail terminal at the third post. The offset from the centerline is thus: 12 + 8 + 2.7 = 22.7 ft.



PLAN VIEW
EXAMPLE 38-6.01(4)
Figure 38-6.M

2. The face of the closest hazards, L_F, the end of the parapet wall and the drop-off below the bridge, is 8 ft from the edge of the traveled way. From Figure 38-3.A, the clear zone (L_C) is 30 ft, thus the hazard warrants protection for the approach side since $L_F < L_C$. Locate the lesser of L_H or L_C on the y-axis. The L_H, defined by the drop-off below the bridge and the end of the bridge embankment cone, extends to the flood plain beyond the clear zone, so plot L_C = 30 ft on the y-axis. This represents the largest offset that is of concern for shielding.

3. From Figure 38-6.E, L_R = 250 ft. Locate this point on the "Edge of Traveled Way Scale."

4. Connect the points in Steps 2 and 3. Draw a line for the right side of traffic from the y-axis to the "Edge of Traveled Way Scale."

5. From the intersection between the lines from Step 1 and Step 4, draw vertical lines down to the "Edge of Traveled Way Scale."

6. Read L_1 = 161 ft from the "Edge of Traveled Way Scale." Note that assuming the layout is symmetrical, this need be calculated only once, and then mirrored for the other direction of travel.

7. This is a two-way, two-lane roadway and the guardrail is within the clear zone for both directions, so Step 7 does not apply.

8. Calculate the length of need, LON, of guardrail for the approach side.

   Guardrail upstream from the bridge, L_1 protects vehicles from the transition side slope to the bridge cone. Because this is the widest area protected and because the parapet wall and bridge cone are located further downstream for traffic, they are also protected at least to the clear zone. The parapet wall protects vehicles from the bridge drop-off. Thus for analyzing the approach sides, L_2 starts 100 ft from the end of the parapet wall. The parapet wall is not part of the guardrail LON, thus:

   L_2 = 100 ft

   So, L_1 for the approaching direction on the right side is 161 ft.

   LON = 100 ft + 161 ft = 261 ft   Equation 38-6.2

9. Based on the stationing shown in Figure 38-6.M, the stations and offsets of the BLON points are:

   (Station 10+00) + 261 ft = Station 12+61.00, 22.7 ft left.

   Selecting a 37.5 ft TBT T1 from the QPL for this example, and applying the BLON at post 3 (12.5 ft from the end), the plan Stations of the TBT T1 are:

   (Station 12+61) - 25 ft = Station 12+36.00, 20.0 ft left

   To

   (Station 12+61) + 12.5 ft = Station 12+73.50, 22.7 ft left.

10. At each corner of the bridge a TBT T6 will connect to the bridge parapet. As noted from *Highway Standard* 631031, the length of the pay item for the TBT T6 is 37.5 ft and this overlaps the end of the bridge parapet by 7.25 in. (0.6 ft) The distance from the end of the parapet to the end of the TBT T6 pay item is then 36.9 ft.

    The pay item limits for the TBT T6 are:

    (Station 10+00) – 0.6 = Station 9+99.40, 20.0 ft left

    To Station 10+36.90, 20.0 ft left.

11. Step 11 does not apply as no TBTs T2 are being used.

12. Based on the information provided, and by inspection, the BLON points are set to provide adequate length of need for all hazards. The designer should also check the locations of the TBTs T1 to determine if the sites are suitable for the required grading at these terminals and that the typical cross sections stated still prevail at these locations.

13. Determine the plan lengths and stationing for guardrail. Use the stations for the TBTs T1 and TBTs T6 from above to determine the plan quantities and stationing.

    Station 10+36.90, 20.0 ft left to Station 12+36.00, 20.0 ft left = 199.1 ft.

<u>Opposing Side</u>:

The hazards are the 1V:2H slope off the end of the bridge cone, the drop-off to the stream below the bridge, and the transition slope steeper than 1V:3H. For simplicity, it has been previously determined that the location where the slope becomes steeper than 1V:3H is located 100 ft from either side of the bridge. Since the layout is symmetrical, and for simplicity, the analysis will be done for one side of the bridge/one direction of travel. Use the nomograph procedure starting on page 38-6.5 (refer to the nomograph in Figure 38-6.N).

1. Since a TBT T1 (Flared) terminal is proposed, draw a horizontal line at L_T on the y-axis of the nomograph for the opposing side of the structure, where:

    L_T = 8 ft + 2.7 ft = 10.7 ft

    The 2.7 ft is added to the shoulder width to take into account the flare of the guardrail terminal at the third post. The offset from the centerline is thus: 12 +8 + 2.7 = 22.7 ft.

2. Add 12 ft, the lane width to L_F to determine if the hazard is within the clear zone for an opposing departure. Since L_F + Lane width = 12 + 8 = 20 ft, is less than L_C, protection is also needed from hazards on the left side of the roadway. L_C is less than L_H, so plot L_C = 30 ft from the centerline scale on the y-axis for the left side of the roadway. In this case a distance 30 ft from the road centerline scale falls at 18 ft from the edge of travelled way scale.

3. From Figure 38-6.E, L_R = 250 ft. Locate this point on the “Center Line Scale.”

4. Connect the points in Steps 2 and 3. Draw a line for the left side departure of traffic from the y-axis to the "Center Line Scale."

5. From the intersection between the lines from Step 1 and Step 4, draw a vertical line down to the "Center Line Scale."

6. Read L_1 = 61 ft from the "Center Line Scale" Note that assuming the layout is symmetrical, this need be calculated only once, and then mirrored for the other side of the bridge.

7. This is a two-lane, two-way roadway and the guardrail is within the clear zone for both directions, so Step 7 does not apply.

8. Calculate the length of need, LON, of guardrail for the opposing side.

   Guardrail upstream from the bridge, L_1 protects vehicles from the transition side slope and bridge cone. Because this is the widest area protected and because the parapet wall and bridge cone are located further upstream, they are also protected to at least the clear zone. The parapet wall protects vehicles from the bridge drop-off. Thus for analyzing the right side, L_1 starts 100 ft from the end of the parapet wall. The parapet wall is not part of the guardrail LON, thus:

   L_2 = 100 ft

   And, L_1 for the opposing direction is 61 ft.

   So, LON = 100 ft + 61 ft = 161 ft. Equation 38-6.2

9. Based on the stationing shown in Figure 38-6.M, the stations and offsets of the BLON points are:

   (Station 8+00) - 161 ft = Station 6+39.00, 22.7 ft left.

   Using a 37.5 ft TBT T1 from the QPL ,for this example, and applying the BLON at post 3 (12.5 ft from the end), the plan Stations of the TBT T1 are:

   (Station 6+39) – 12.5 ft = Station 6+26.50, 22.7 ft left.

   To

   (Station 6+39) + 25 ft = Station 6+64.00, 20.0 ft left.

10. At each corner of the bridge a TBT T6 will connect to the bridge parapet. The length of the pay item for the TBT T6 is 37.5 ft and this overlaps the end of the bridge parapet by 7.25 in. (0.6 ft). The distance from the end of the parapet to the end of the TBT T6 pay item is then 36.9 ft.

    The pay item limits of the TBT T6 for the opposing approach to the bridge are:

    Station 8+00.60, 20.0 ft left.

    To

Station 7+63.10, 20.0 ft left.

11. Step 11 does not apply as no TBTs T2 are being used.

12. Based on the information provided and by inspection the BLON points are set to provide adequate length of need for all hazards. The designer should also check the locations of the TBT T1s to determine if the sites are suitable for the required grading at these terminals and that the typical cross sections stated still prevail at these locations.

13. Determine the plan lengths and stationing for guardrail. Use the stations for the TBTs T1 and TBTs T6 from above to determine the plan quantities and stationing.

Station 6+64.00, 20.0 ft left to Station 7+63.10, 20.0 ft left = 99.1 ft.

Discussion: This example illustrates compliance with nominal clear zone requirements. However, engineering judgment may apply for application of clear zones. Suppose the vertical drop of the bridge cones to the flood plain is 20 ft. Also note that the discussion of clear zones in Section 38-3.01(2) states: "If a formidable obstacle lies just beyond the clear zone, it may be appropriate to remove or shield the obstacle if costs are reasonable."

The guardrail as designed protects against vehicles traversing it as far as the 30 ft clear zone. However, this leaves another 5 ft vertically (10 ft horizontally) unshielded. Note also that except for the transition slope in the last 100 ft approaching the bridge, the roadside slopes are traversable and a vehicle running out behind the guardrail might reach the transition area with some speed remaining and still some drop to the flood plain.

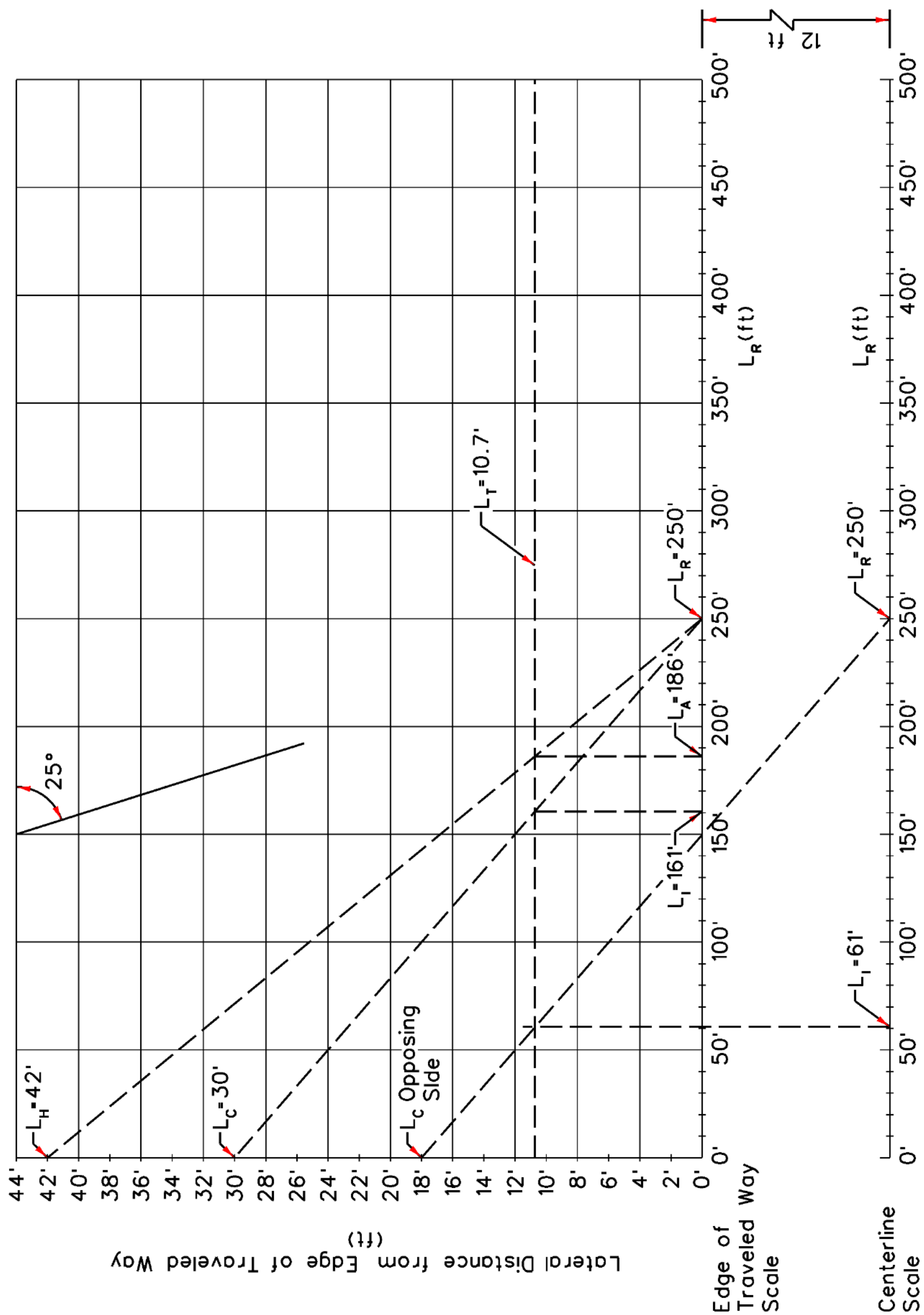
How much additional guardrail would be needed to shield against roadway departures to the toe of the bridge cones?

The bridge cone begins about 2 ft beyond the shoulder and then extends horizontally about 40 ft to the flood plain. For the approach side roadway departure, extend the vertical axis and plot a point at 42 ft, the total width of the bridge cone hazard, L_H. See Figure 38-6.N.

Connect this point to the runout length point (250 ft) on the "Edge of Traveled Way Scale."

Connect these two points and draw a vertical line where they cross L_T = 10.7 ft and find that this intersects the "Edge of Traveled Way Scale" at 186 ft.

Therefore, in this case, the length of need in advance of the bridge (L_A), 186 ft, needed to shield the full bridge cone is less than the total length of need to shield the slope transition area (261 ft) and this concern is resolved.



BARRIER LENGTH OF NEED CALCULATION
Example 38-6.01(4)

Figure 38-6.N

Example 38-6.01(5) (Bridge on Two-Way Two-Lane Highway with Non-recoverable Front Slope)

Given:
New Construction (See Figure 38-6.O)
Two-way, two-lane highway
Design ADT = 7000 vpd
Design speed = 60 mph
Guardrail for shielding of bridge parapet ends and steep slope adjacent to the slope wall
Bridge slope wall = 1V:2H
Typical front slopes = 1V:3H
Tangent roadway
Lane width = 12 ft
Shoulder width = 8 ft
Unflared barrier (steel plate beam guardrail, Type A) located at the edge of the shoulder (L_B = 8 ft)
Traffic Barrier Terminal Type 1 (TBT T1), Special (Flared)

Problem: Determine the location and limits of the hazard, the barrier length of need, and the pay item length of guardrail. This problem assumes a symmetrical layout with the same hazards for traffic approaching at both ends of the bridge.

Solution: Approach Side:

The hazards are the 1V:2H slope off the end of the bridge cone, the drop-off below the bridge, and the transition slope steeper than 1V:3H. For simplicity, it has been previously determined that the location where the slope becomes steeper than 1V:3H is located 100 ft from either side of the bridge. Since the layout is symmetrical, and for simplicity, the analysis will be done for one side of the bridge. First, complete the non-recoverable front slope procedure. See Section 38-3.03(b) to determine the recommended clear zone distance. Then use the nomograph procedure starting on page 38-6.5 (refer to the nomograph in Figure 38-6.P).

Non-Recoverable Front Slope Procedure

1. Determine the clear zone for a 1V:6H or flatter slope for the design speed and traffic volume given above. From Figure 38-3.A, the standard clear zone value for this case is 30 ft to 32 ft.

2. To determine the clear runout area beyond the toe of the front slope, subtract the shoulder width or the distance from the edge of the travelled way to the shoulder hinge point from the distance in Step 1. For this example, the shoulder width is 8 ft and the bridge cone begins about 2 ft beyond the shoulder and then extends horizontally about 40 ft to the flood plain. At minimum, the recommended clear distance beyond the toe of the non-recoverable slope (1V:3H) is:

30 ft minus 22 ft, which yields 8 ft.

3. The clear runout area beyond the toe of the front slope is the greater distance of the value determined in Step 2 (8 ft) or 10 ft. Thus for this example the clear zone, L_c, extends 10 ft beyond the toe of the front slope, which is 40 ft from the hinge point. Utilizing this more conservative value of 10 ft yields a recommended clear zone for approaching traffic of 8 ft + 2 ft + 40 ft + 10 ft = 60 ft.

<u>Length of Need Procedure</u>

1. Since a TBT T1 (Flared) terminal is proposed, draw a horizontal line at L_T on the y-axis of the nomograph for the approach side of the roadway, where:

   L_T = 8 ft + 2.7 ft = 10.7 ft

   The 2.7 ft is added to the shoulder width to take into account the flare of the guardrail terminal at the third post. The offset from the centerline is thus: 12 + 8 + 2.7 = 22.7 ft.

2. The face of the closest hazards, L_F, the end of the parapet wall and the drop-off below the bridge, is 8 ft from the edge of the traveled way. From the discussion above, the clear zone (L_C) is 60 ft, thus the hazard warrants protection for the approach side since $L_F < L_C$.

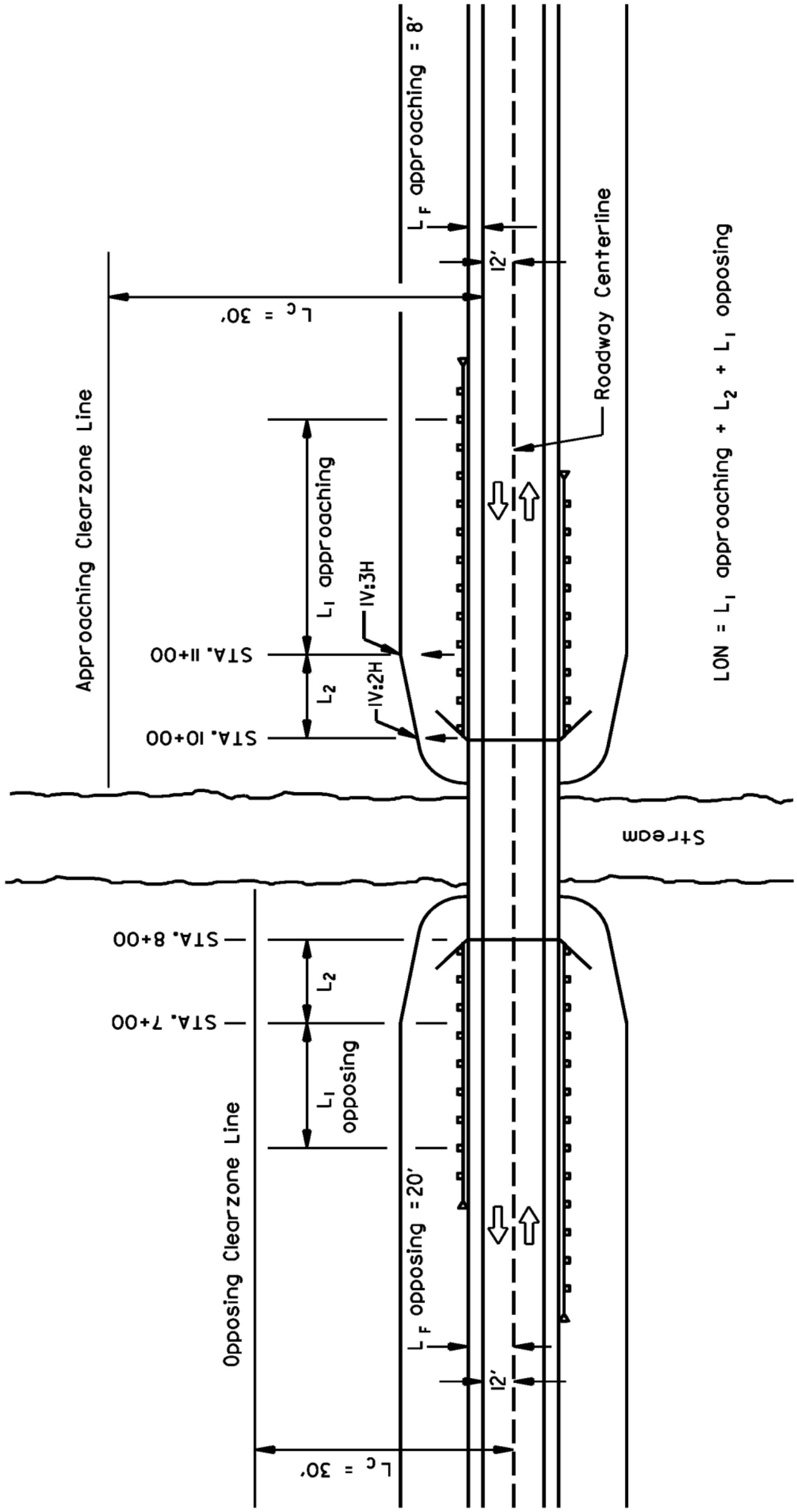
3. Locate the lesser of L_H or L_C on the y-axis. The L_H, defined by the drop-off below the bridge and the end of the bridge embankment cone, extends to the flood plain beyond the clear zone, so plot L_C = 60 ft on the y-axis. This represents the largest offset that is of concern for shielding. From Figure 38-6.E, L_R = 250 ft. Locate this point on the “Edge of Traveled Way Scale.”

4. Connect the points in Steps 2 and 3. Draw a line for the right side of traffic from the y-axis to the “Edge of Traveled Way Scale.”

5. From the intersection between the lines from Step 1 and Step 4, draw vertical lines down to the “Edge of Traveled Way Scale.”

6. Read L_1 = 205 ft from the “Edge of Traveled Way Scale.” Note that assuming the layout is symmetrical, this need be calculated only once, and then mirrored for the other direction of travel.

7. This is a two-way, two-lane roadway and the guardrail is within the clear zone for both directions, so Step 7 does not apply.



PLAN VIEW
EXAMPLE 38-6.01(5)

Figure 38-6.O

8. Calculate the length of need, LON, of guardrail for the approach side.

Guardrail upstream from the bridge, L_1, protects vehicles from the transition side slope to the bridge cone. Because this is the widest area protected and because the parapet wall and bridge cone are located further downstream for traffic, they are also protected

at least to the clear zone. The parapet wall protects vehicles from the bridge drop-off. Thus for analyzing the approach sides, L_2 starts 100 ft from the end of the parapet wall. The parapet wall is not part of the guardrail LON, thus:

L_2 = 100 ft

So, L_1 for the approaching direction on the right side is 205 ft.

LON = 100 ft + 205 ft = 305 ft Equation 38-6.2

9. Based on the stationing shown in Figure 38-6.O, the stations and offsets of the BLON points are:

(Station 10+00) + 305 ft = Station 13+05.00, 22.7 ft left.

Selecting a 37.5 ft TBT T1 from the QPL for this example, and applying the BLON at post 3 (12.5 ft from the end), the plan Stations of the TBT T1 are:

(Station 13+05) - 25 ft = Station 12+80.00, 20.0 ft left

To

(Station 13+05) + 12.5 ft = Station 13+17.50, 22.7 ft left.

10. At each corner of the bridge a TBT T6 will connect to the bridge parapet. As noted from *Highway Standard* 631031, the length of the pay item for the TBT T6 is 37.5 ft and this overlaps the end of the bridge parapet by 7.25 in. (0.6 ft). The distance from the end of the parapet to the end of the TBT T6 pay item is then 36.9 ft.

The pay item limits for the TBT T6 are:

(Station 10+00) – 0.6 = Station 9+99.40, 20.0 ft left

To Station 10+36.90, 20.0 ft left.

11. Step 11 does not apply as no TBTs T2 are being used.

12. Based on the information provided, and by inspection, the BLON points are set to provide adequate length of need for all hazards. The designer should also check the locations of the TBTs T1 to determine if the sites are suitable for the required grading at these terminals and that the typical cross sections stated still prevail at these locations.

13. Determine the plan lengths and stationing for guardrail. Use the stations for the TBTs T1 and TBTs T6 from above to determine the plan quantities and stationing.

Station 10+36.90, 20.0 ft left to Station 12+80.00, 20.0 ft left = 243.1 ft.

Opposing Side:

The hazards are the 1V:2H slope off the end of the bridge cone, the drop-off below the bridge, and the transition slope steeper than 1V:3H. For simplicity, it has been previously determined that the location where the slope becomes steeper than 1V:3H is located 100 ft from either side of the bridge. Since the layout is symmetrical, and for simplicity, the analysis will be done for one side of the bridge/one direction of travel. Use the nomograph procedure starting on page 38-6.5 (refer to the nomograph in Figure 38-6.P).

1. Since a TBT T1 (Flared) terminal is proposed, draw a horizontal line at L_T on the y-axis of the nomograph for the opposing side of the roadway, where:

   L_T = 8 ft + 2.7 ft = 10.7 ft

   The 2.7 ft is added to the shoulder width to take into account the flare of the guardrail terminal at the third post. The offset from the centerline is thus: 12 + 8 + 2.7 = 22.7 ft.

2. Add 12 ft, the lane width to L_F to determine if the hazard is within the clear zone for an opposing departure. Since L_F + Lane width = 12 + 8 + 2 = 22 ft, is less than L_C, protection is also needed from hazards on the left side of the roadway, opposing side. L_C is less than L_H, so plot the enhanced L_C = 60 ft on the y-axis and note that this falls 72 ft from the centerline scale.

3. From Figure 38-6.E, L_R = 250 ft. Locate this point on the "Center Line Scale".

4. Connect the points in Steps 2 and 3. Draw a line for the left side departure of traffic from the y-axis to the "Center Line Scale."

5. From the intersection between the lines from Step 1 and Step 4, draw a vertical line down to the "Center Line Scale."

6. Read L_1 = 171 ft from the "Center Line Scale" Note that assuming the layout is symmetrical, this need be calculated only once, and then mirrored for the other side of the bridge.

7. This is a two-lane, two-way roadway and the guardrail is within the clear zone for both directions, so Step 7 does not apply.

8. Calculate the length of need, LON, of guardrail for the opposing side.

   Guardrail upstream from the bridge, L_1 protects vehicles from the transition side slope and bridge cone. Because this is the widest area protected and because the parapet wall and bridge cone are located further upstream, they are also protected to at least the clear zone. The parapet wall protects vehicles from the bridge drop-off. Thus for analyzing the right side, L_1 starts 100 ft from the end of the parapet wall. The parapet wall is not part of the guardrail LON, thus:

L_2 = 100 ft

And, L_1 for the opposing direction is 171 ft.

So, LON = 100 ft + 171 ft = 271 ft Equation 38-6.2

9. Based on the stationing shown in Figure 38-6.O, the stations and offsets of the BLON points are:

   (Station 8+00) - 271 ft = Station 5+29.00, 22.7 ft left.

   Using a 37.5 ft TBT T1 from the QPL, for this example, and applying the BLON at post 3 (12.5 ft from the end), the plan Stations of the TBT T1 are:

   (Station 5+29) – 12.5 ft = Station 5+16.50, 22.7 ft left.

   To

   (Station 5+29) + 25 ft = Station 5+54.00, 20.0 ft left.

10. At each corner of the bridge a TBT T6 will connect to the bridge parapet. The length of the pay item for the TBT T6 is 37.5 ft and this overlaps the end of the bridge parapet by 7.25 in. (0.6 ft). The distance from the end of the parapet to the end of the TBT T6 pay item is then 36.9 ft.

    The pay item limits of the TBT T6 for the opposing departure approaching the bridge are:

    Station 8+00.60, 20.0 ft left.

    To

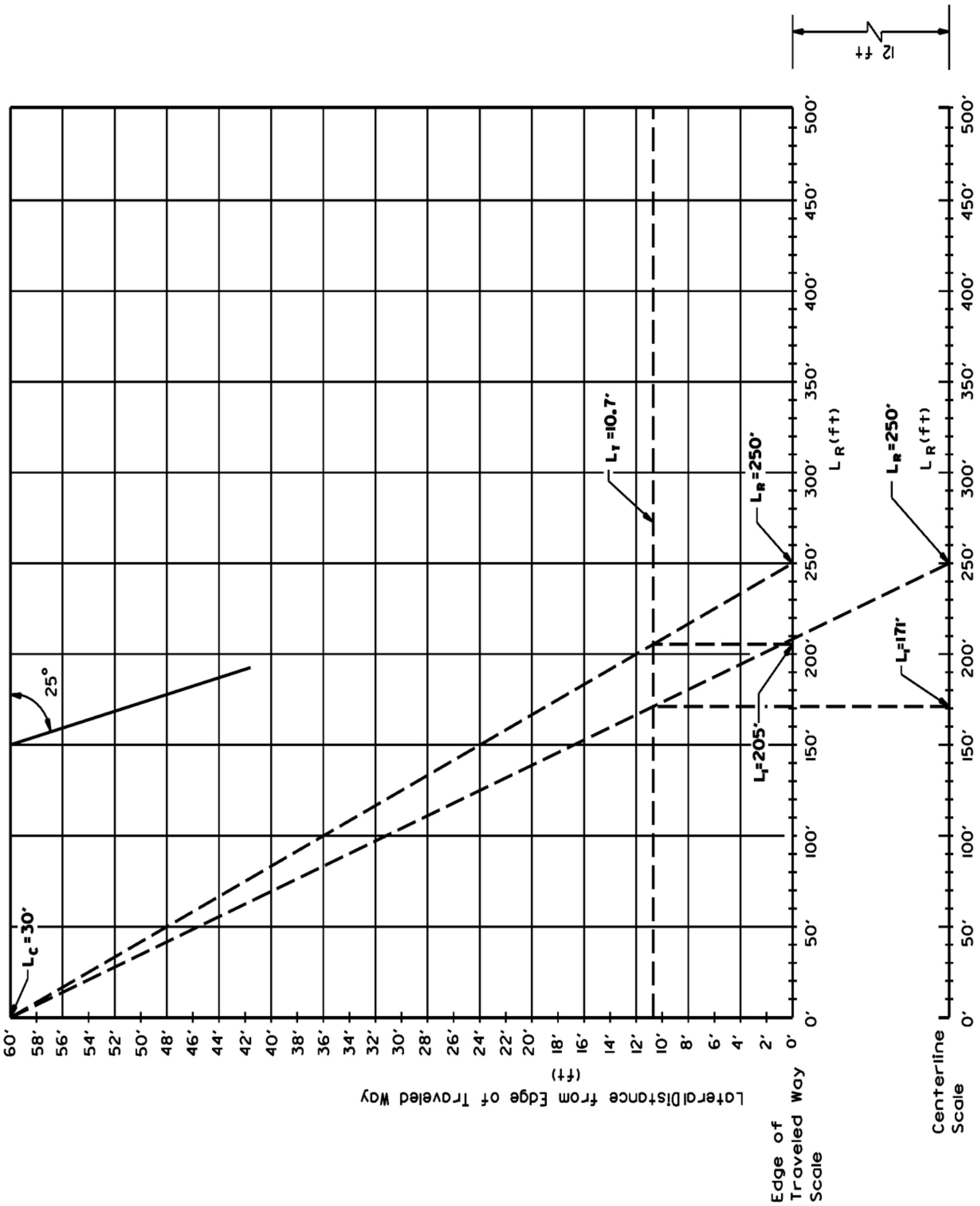
    Station 7+63.10, 20.0 ft left.

11. Step 11 does not apply as no TBTs T2 are being used.

12. Based on the information provided and by inspection the BLON points are set to provide adequate length of need for all hazards. The designer should also check the locations of the TBT T1s to determine if the sites are suitable for the required grading at these terminals and that the typical cross sections stated still prevail at these locations.

13. Determine the plan lengths and stationing for guardrail. Use the stations for the TBTs T1 and TBTs T6 from above to determine the plan quantities and stationing.

    Station 5+54.00, 20.0 ft left to Station 7+63.10, 20.0 ft left = 209.1 ft.



BARRIER LENTGH OF NEED CALCULATION EXAMPLE 38-6.01(5)

Figure 38-6.P

Example 38-6.01(6) (Divided Four-lane Freeway with 64 ft Median between Dual Structures)

Given: Reconstruction (See Figure 38-6.Q)
Divided four-lane freeway with 64 ft median between dual structures
Design ADT = 20,000 vpd
Design speed = 75 mph
Tangent roadway
Lane width = 12 ft
Shoulder width (right) = 10 ft
Shoulder width (left) = 6 ft
Unflared barrier (steel plate beam guardrail, Type A) located along the right edge of the shoulder (L_B = 10 ft).
Traffic Barrier Terminal Type 1, Special (Flared) (TBT T1) on right side of the shoulder
Traffic Barrier Type 6 at each bridge parapet end
Flared (1:20) barrier (steel plate beam guardrail, Type A) with a Traffic Barrier Terminal Type 1, Special on the median side of the roadway

Side slopes on the right edge of roadway:

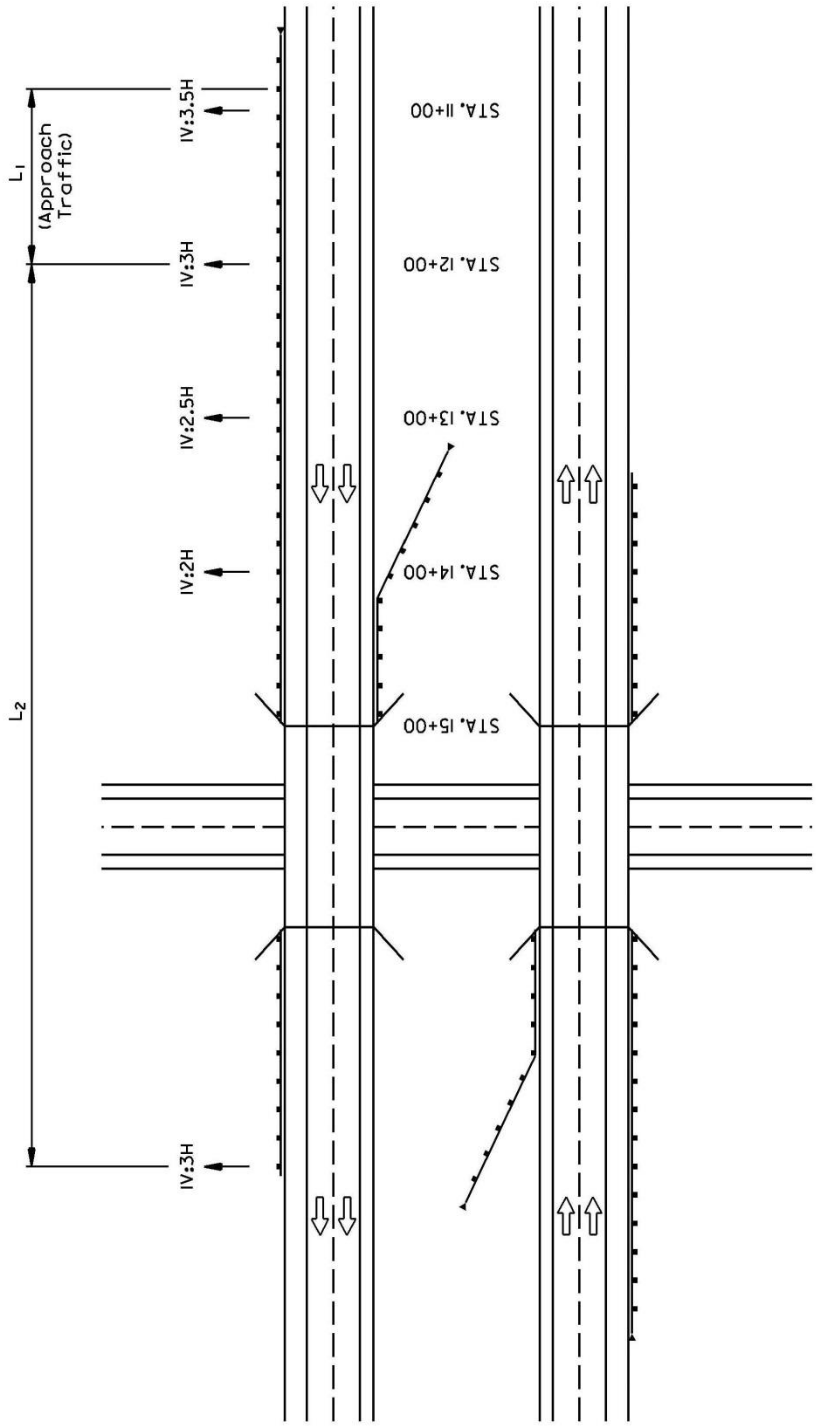
Station	Front Slope*	Height
Project limit to 11+00	1V:4H	10 ft
11+00 to 12+00	1V:3.5H	12 ft
12+00 to 13+00	1V:3H	15 ft
13+00 to 14+00	1V:2.5H	18 ft
14+00 to 15+00	1V:2H	20 ft

Beginning of bridge parapet at Station 15+00.

*Front slope begins at 14 ft from the edge of pavement to allow for 2 ft of embankment behind the guardrail posts. (10 ft shoulder, 2 ft guardrail width, and 2 ft additional embankment width for guardrail post support.)

Problem: Determine the barrier length of need and length of guardrail pay item for the roadside guardrail on the right side and on the median side.

Solution: Guardrail is needed on the approach of the right side of the roadway for shielding from the front slope steeper than 1V:3H,and the bridge cone, on the approach for the median side of the roadway for the gap between the dual structures in the median, and on the approach for both sides of the roadway due to the highway beneath. Each side of the roadway must be analyzed independently. This problem will only analyze the roadway approaching the bridge and not any of the roadway past the bridge. Use the nomograph procedure starting on page 38-6.5 (refer to the nomographs in Figure 38-6.R and Figure 38-6.S).



PLAN VIEWW
EXAMPLE 38-6.01(6)
Figure 38-6.Q

Length of Need – Right Side

1. Since a TBT T1 (Flared) terminal is proposed on the right side, draw a horizontal line at L_T on the nomograph for the right side of the roadway, where:

   L_T = 10 ft + 2.7 ft = 12.7 ft

   The 2.7 ft is added to the shoulder width to take into account the flare of the guardrail terminal at the third post. The offset from the centerline is thus: ½(64) + 24 + 10 + 2.7 = 68.7 ft.

2. From Figure 38-3.A, the clear zone (L_C) is 30 ft and the hazard warrants protection for traffic on the right side approach since L_F (10 ft) < L_C. Locate the lesser of L_C or L_H on the y-axis. L_H, defined by front slope and bridge embankment cones, begins longitudinally at the station of the critical slope (Sta. 12+00) and extends laterally to the flood plain beyond the clear zone, so plot L_C = 30 ft on the y-axis.

3. From Figure 38-6.E, L_R = 360 ft. Locate this point on the "Edge of Traveled Way Scale." The two directions of travel are separated by a 64 ft median, so the separate roadways can be analyzed independently for roadside hazards as two one-way roadways. There is no need to locate L_R on the "Centerline Scale." Protection is needed on the left side of the roadway for traffic approaching the bridge, however. This is addressed below.

4. Connect the points in Steps 2 and 3. Draw a line for the traffic on the right from the y-axis to the "Edge of Traveled Way Scale."

5. From the intersection between the lines from Step 1 and Step 4, draw vertical lines down to the "Edge of Traveled Way Scale" to get L_1.

6. Read L_1 = 207 ft from the "Edge of Traveled Way Scale."

7. This step determines L_3, for situations where barrier protection is only warranted for one direction of traffic. L_3 determines the amount of barrier protection that may be deducted due to the lateral location of the hazard. Although this design would result in an L_3 analysis, L_3 is on the downstream end of the bridge, thus an analysis is beyond the scope of this problem and therefore not needed.

8. Calculate the length of need, LON, of guardrail. The length of need due to the critical side slope, or L_1, is 207 ft upstream of Station 12+00. The L_2 distance is made up of a combination of lengths. L_2 is the length of guardrail from Sta. 12+00 to the parapet wall end at Sta. 15+00, includes the parapet wall across the bridge, and includes the guardrail downstream of the bridge end, therefore:

   LON = 207 + 300 + 0 + 0 = 507 ft   Equation 38-6.2

   Since the scope of this problem is only to calculate the amount of Steel Plate Beam Guardrail upstream from the bridge end, and not the guardrail downstream from the bridge or length of the concrete parapet wall representing part of L_2, the length of the parapet wall and guardrail downstream from the bridge end are both set equal to 0.

9. Based on the stationing shown in Figure 38-6.Q, the station and offset of the approach end BLON is:

   (Station 15+00) -507 ft = Station 9+93, 68.7 ft right.

   Limits of the TBT T1, using a length of 37.5 ft and the BLON point at post 3,

   12.5 ft from the end of the TBT T1.

   (Station 9+93) + 25 ft = Station 10+18.00, 66.0 ft right.

   To

   (Station 9+93) – 12.5 ft = Station 9+80.50, 68.7 ft right.

10. At each corner of the bridges a TBT T6 will connect to the bridge parapet. The length of the pay item for the TBT T6 is 37.5 ft and this overlaps the end of the bridge parapet by 7.25 in. (0.6 ft). The distance from the end of the parapet to the end of the TBT T6 pay item is then 36.9 ft.

    The pay item limits for the TBT T6 are:

    (Station 15+00) + 0.6 ft = Station 15+00.60, 66.0 ft right.

    To

    (Station 15+00.6) - 37.5 ft = Station 14+63.10, 66.0 ft right.

11. Step 11 does not apply, as no TBT T2s are being used.

12. Determine the pay item quantity and stations for the remaining item(s).

    The guardrail run will connect the TBT T6 and the TBT T1.

    From

    End of TBT T6 = Station 14+63.10, 66.0 ft right.

    To

    End of TBT T1 = Station 10+18.00, 66.0 ft right.

    Length of guardrail plan quantity = 445.1 ft.

13. Check that LON is adequate and check for conflicts.

    Sum the redirective portion of the TBT T1, the TBT T6, and the guardrail.

    25 ft + 36.9 ft + 445.1 ft = 507 ft.

    This is as expected because the nominal BLON point has been used without adjustment. Because the actual dimensions of the TBT T1 are not known until construction, use this information for plan locations and quantities. Field adjustments to accommodate a specific proprietary device and common guardrail panel lengths are considered nominal.

    The designer should also check the location of the TBTs T1 to assure that they can be installed with proper grading and that design assumptions for the front slopes or other roadside obstacles are valid.

Length of Need – Median (left) side (Use a new nomograph for the median side of the roadway from that used for the right side of the roadway)

1. With the left side having a flared barrier and a TBT Type 6, which offers protection from the bridge parapet end, multiple considerations are required for the guardrail run. The TBT Type 6 is not designed to be flared, therefore it is located at the back of shoulder. Draw a horizontal line at L_B, equal to 36.9 ft long, for the length of the TBT Type 6 on the nomograph for the left side of the roadway, where:

   L_B = 6 ft on the y-axis

   From 36.9 ft the steel plate beam guardrail, Type A flares at a ratio of 1 lateral: 20 longitudinal. Draw a line on the nomograph with a 1:20 flare starting at 36.9 feet. The TBT T1, Special is to be placed in line with the guardrail flare, therefore do not show any additional offset or flaring for the TBT T1, Special.

2. From Figure 38-3.A, the clear zone (L_C) is 30 ft. The hazards are the bridge parapet end at 6 feet and the gap between the dual structures that can lead onto the highway below. The left side of the roadway warrants protection for approaching traffic since $L_F < L_C$. Locate the lesser of L_C or L_H on the y-axis, so plot L_C = 30 ft on the y-axis.

3. From Figure 38-6.E, L_R = 360 ft. Locate this point on “Edge of Traveled Way Scale.” Since the approaching and opposing roadways are on separate alignment, this problem resembles a one-way alignment, and there is no need to locate L_R on the “Centerline Scale.”

4. Draw a line connecting the points plotted in steps 2 and 3.

5. From the intersection between the lines from Step 1 and Step 4, draw vertical line down to the “Edge of Traveled Way Scale” to get L_1.

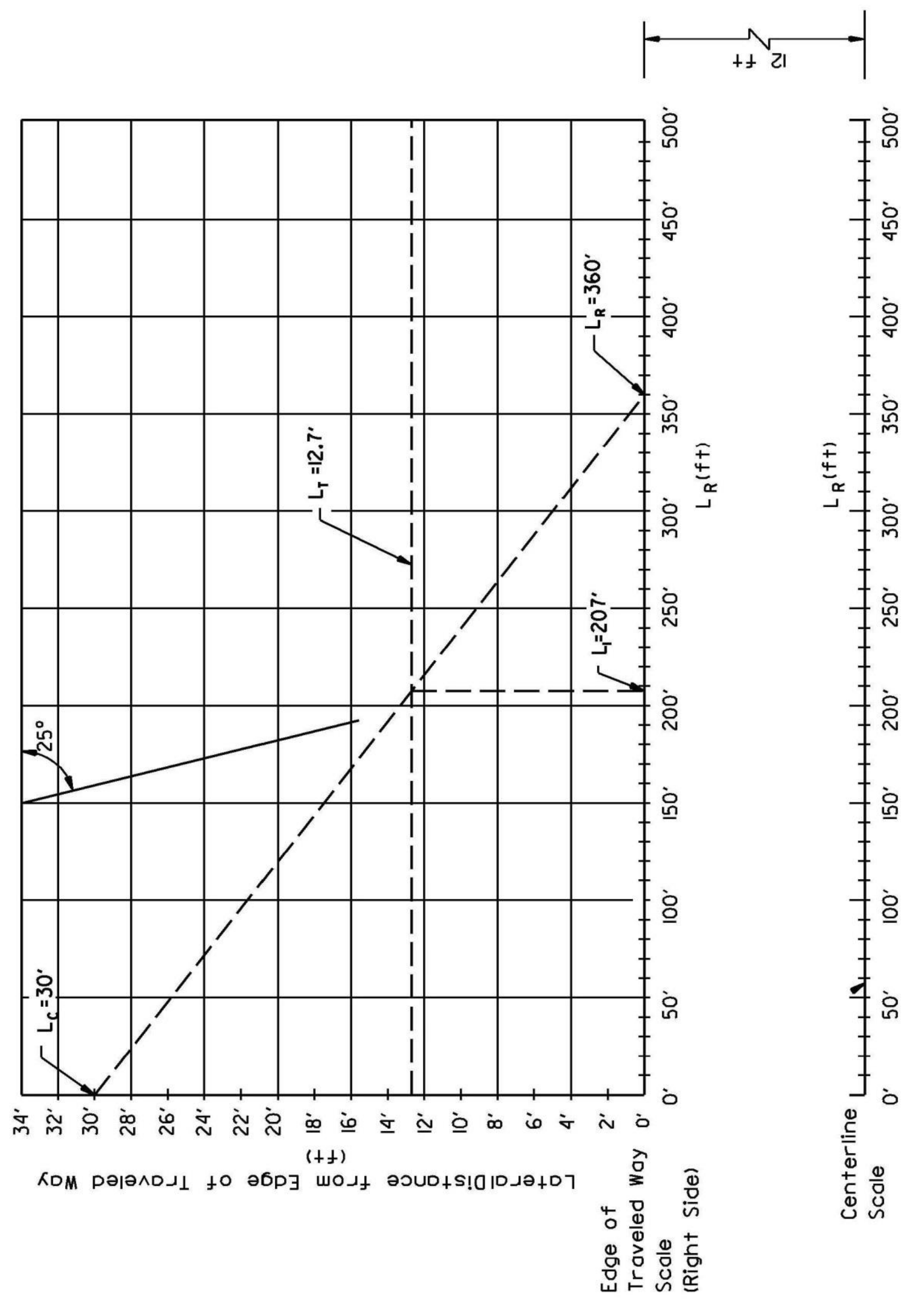
6. Read L_1 = 194 ft from the “Edge of Traveled Way Scale”

7. This step determines L_3, for situations where barrier protection is only warranted for one direction of traffic. L_3 determines the amount of barrier protection that may be deducted due to the lateral location of the hazard. Although this design would result in an L_3 analysis, L_3 is on the downstream end of the bridge, thus an analysis is beyond the scope of this problem and not needed.

8. Calculate the length need, LON, of guardrail.

   LON = 194 + (length of the concrete parapet wall) - 0 = 194 ft Equation 38-6.1

   Since the scope of this problem is only to calculate the amount of Steel Plate Beam Guardrail upstream from the bridge end, and not the guardrail downstream from the



BARRIER LENGTH OF NEED CALCULATION
Example 38-6.01(6)

Figure 38-6.R

bridge or length of the concrete parapet wall representing part of L_2, the length of the parapet wall and guardrail downstream from the bridge end is set equal to 0.

9. Based on the stationing shown in Figure 38-6.Q, the station and offset of the BLON for the median side barrier is:

    (Station 15+00) – 194 ft = Station 13+06.00.

    The guardrail is flared at 1:20 beyond (Station 15+00)-36.9 ft = Station 14+63.10

    The additional offset is [(Station 14+63.1) - Station 13+06)]/20 = 7.9 ft.

    The total offset from the edge of pavement is 7.9 ft taper + 6 ft shoulder = 13.9 ft.

    The edge of pavement is located at 32.0 ft right.

    The BLON is located at Station 13+06.00, 18.1 ft right.

    No length corrections are made for the 1:20 flare because field adjustments of pay item lengths will be needed, and the adjustment factor would be only 1.00125.

    The pay item limits for the TBT T1, assuming a 37.5 ft long device from the QPL and assuming that the BLON of the device is at post 3, 12.5 ft from its end:

    (Station 13+06) + 25 ft = Station 13+31.00, 19.35 ft right.

    To

    (Station 13+06 – 12.5 ft = Station 12+93.50, 17.48 ft right.

    With 18.1 ft + (25/20) = 19.35 ft, and

    19.35 ft - (37.5/20) = 17.48 ft.

10. At each corner of the bridges a TBT T6 will connect to the bridge parapet. The length of the pay item for the TBT T6 is 37.5 ft and this overlaps the end of the bridge parapet by 7.25 in. (0.6 ft). The distance from the end of the parapet to the end of the TBT T6 pay item is then 36.9 ft.

    The pay item limits for the TBT T6 are:

    (Station 15+00) + 0.6 ft = Station 15+00.60, 32.0 ft right.

    To

    (Station 15+00.6) - 37.5 ft = Station 14+63.10, 32.0 ft right.

11. Step 11 does not apply, as no TBTs T2 are being used.

12. Determine the pay item limits and quantities for the remaining items.

    Guardrail will connect from the TBT T6 to the TBT T1.

    Station 14+63.10, 32.0 ft right

    To

    Station 13+31.00, 19.35 ft right

    Length of guardrail = 132.1 ft

13. Check that the LON is adequate.

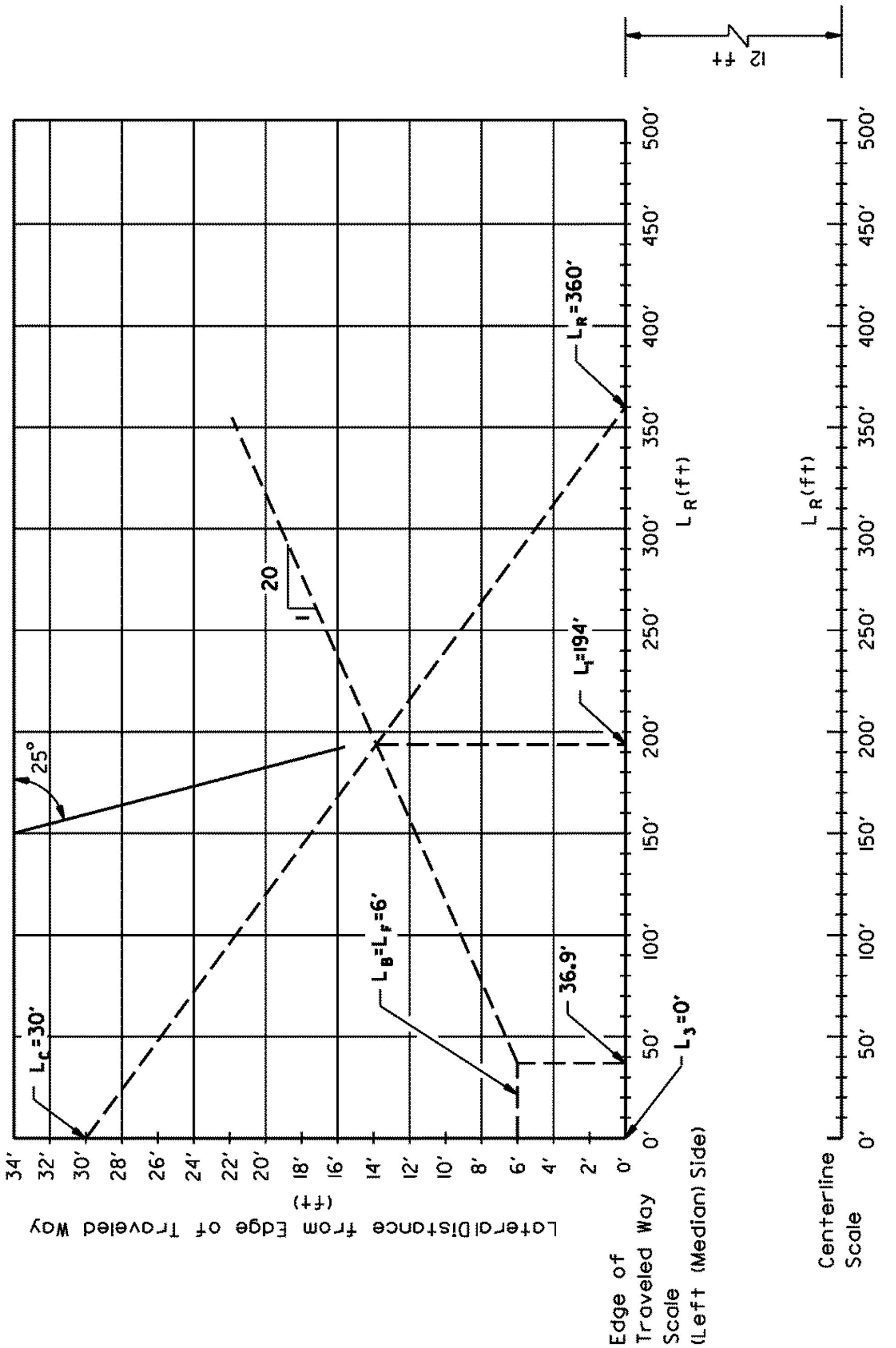
    TBT T6 = 36.9 ft

    Guardrail = 132.1 ft

    TBT T1 = 25 ft

    Total = 194 ft

    As expected, placing the BLON at the design length of need point results in a design that exactly matches the calculated length of need. Minor field adjustments will account for the specific proprietary device selected for the TBT T1 and for use of common guardrail panel lengths and splice locations.



BARRIER LENGTH OF NEED CALCULATION
Example 38-6.01(6)

Figure 38-6.S

38-6.02 Guardrail Post Foundations

Design and testing of strong post guardrail are generally done using strong soils. The systems allow the posts to rotate in the soil such that vehicle impact loads are distributed through the post into the soil material, avoiding bending or breaking of the posts. With the Midwest Guardrail System, this movement of the post along with the 12 in. (300 mm) blockout also keeps the rail near its design height until the rail releases from the blockout. If posts bend or break due to excessive foundation strength, they can provide excessive resistance to movement of the rail, resulting in failure of the rail. Also, the bent posts can become launching ramps to an errant vehicle.

The following are general guidance on use of guardrail with a full range of foundation types:

1. Guardrail Posts in Soil. *Highway Standard* 630001 shows the application of guardrail posts in soil. Where the front slope falls within 2 ft (600 mm) behind the guardrail posts and is steeper than 1V:3H use 9 ft (2.74 m) posts. Otherwise use the 6 ft (1.83 m) posts.

2. Guardrail Posts in Mow Strips [≤ 8 in. (200 mm) thick]. *Highway Standard* 630001 shows the provisions needed to allow guardrail posts to function when placed in a stabilized surface no thicker than 8 in. (200 mm). The “leave out” or backfilled cored hole for the post is designed to allow the post to deflect and absorb a portion of the impact energy before the rail releases from the deflected post. Also, allowing the post to rotate in the soil is critical to avoid both over-stressing of the rail element and excessive vehicle uplift along a bending post. The capping material for the post deflection space is intended as a weed suppression layer, and is intentionally weak to allow the post to break through when hit. Although the minimum dimensions for the deflection space are shown, wider “leave outs” may be used if this reduces crash damage to the shoulder or mow strip.

3. Guardrail Posts in Rock or in Paved Areas >8 in. (200 mm) Thick. Where rock is encountered, or where the depth of a paved area exceeds 8 in. (200 mm), the detail “Footing for Post When Impervious Material is Encountered” (from *Highway Standard* 630001) should be applied. For paved locations, the “V” value shown is the thickness of the paved material at the post location. Where no rock or other impervious material is encountered below the paved area, the post should not be shortened.

38-6.03 Barrier Offset and Grading

Generally, roadside hardware should be placed as far as practical from the edge of traveled way consistent with proper operation and performance of the barrier system. Such placement gives an errant motorist a greater chance to regain control and avoid a crash. It also provides for increased sight distance. Consider the following when determining barrier lateral placement:

1. Driver Expectations. It is generally desirable to have consistent clearance between traffic and roadside features such as bridge railings, parapets, retaining walls, and roadside barriers, particularly in urban areas where there is a preponderance of these elements. Uniform development enhances highway safety by providing the driver with a level of

expectation, thus reducing driver concern, and perceived need for altering their driving path within the lane.

2. Shoulder. Typically, the roadside barrier is located with the face of barrier at the edge of the shoulder unless flared away from the shoulder. In areas with SPBG this will result in the hinge point for the front slope being located approximately 4 ft (1.2 m) from the outside edge of shoulder to provide proper backfilling to the posts. Refer to Standard 630001.

3. Shy Line. The distance from the edge of the traveled way beyond which a roadside object will not be perceived as an obstacle and result in a motorist's reducing speed or changing vehicle position on the roadway is called the shy-line offset. (See Figure 38-6.T). Where possible, barriers should be placed beyond the shy line. This is more important for short, isolated instances. For long, continuous runs of barrier this is less important, especially if the barrier is introduced outside the shy line and gradually tapered in toward the traveled way.

4. Embankment. Where possible, provide 2 ft (600 mm) of embankment at a 1:10 or flatter slope between the back of guardrail barrier posts to the hinge point with the front slope. See *Highway Standard* 630001 for options.

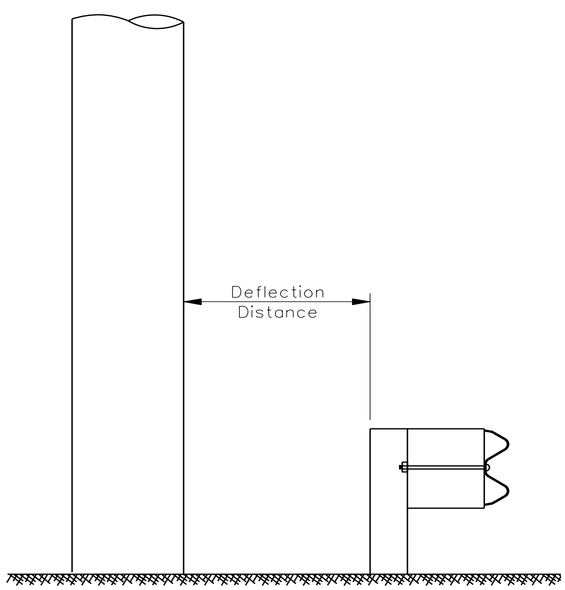
5. Deflection Distance. Most roadside barriers will deflect when impacted. Adequate deflection space should be provided so that guardrail can deflect without contacting fixed objects behind the barrier as displayed in Figure 38-6.U. Figure 38-6.V provides the deflection distances for the types of guardrail typically used by IDOT. Refer to Section 38-7.03(b)3 for a discussion on the deflection distance of high-tension cable.

6. Zone of Intrusion. The Zone of Intrusion (ZOI) is the region measured above and behind the face of a barrier system where an impacting vehicle or any major part of the system may extend during an impact. The amount of intrusion behind the barrier is related to the barrier height and profile as well as the vehicle size, speed, and angle of impact. For TL-2, TL-3 and TL-4 where practical, the designer should try to accommodate this additional distance behind the barrier as part of new construction or reconstruction projects. Figure 38-6.W shows the ZOI for TL-2, TL-3 and TL-4 for a typical concrete barrier wall section. No ZOI is currently available for TL-5. Narrowing of the roadway is not preferred on high-speed facilities to accommodate additional clearance for ZOI. For example, at an existing overpass structure where the pavement underneath is being reconstructed, it is usually not recommended to reduce shoulder width in order to gain additional clearance behind the barrier to provide ZOI clearance.

Customary		Metric	
Design Speed (mph)	Shy Line Offset, S (ft)	Design Speed (km/hr)	Shy Line Offset, S (m)
75	10	120	3.2
70	9	110	2.8
60	8	100	2.4
55	7	90	2.2
50	6.5	80	2.0
45	6	70	1.7
40	5	60	1.4
30	4	50	1.1

SUGGESTED SHY LINE OFFSET

Figure 38-6.T



DEFLECTION DISTANCE FOR W-BEAM GUARDRAIL

Figure 38-6.U

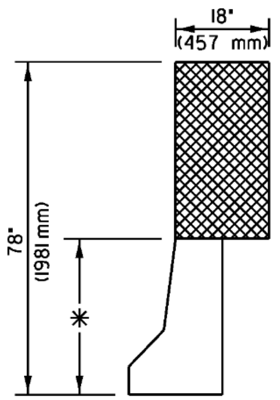
Guardrail Type	Deflection Distance					
	Condition					
	Tangent	**1:13 flare**	**1:7 flare**	**0 in. to 6 in. behind 6 in. curb (0 mm to 150 mm behind 150 mm curb)**	***4 ft to 12 ft behind 6 in. curb *(1.2 m to 3.6 m behind 150 mm curb)**	****Long span**
Type A W-Beam Guardrail @ 6'-3" (1905 mm) post spacing	38 in. (965 mm)	63 in. (1.60 m)	83 in. (2.11 m)	47 in. (1.19 m)	25 in. (635 mm)	73 in. (1.85 m)
Type B W-Beam Guardrail @ 3' 1 ½" (953 mm) post spacing	30 in. (762 mm)	Do not flare Type B	Do not flare Type B	Do not use Type B	Do not use Type B	Do not use Type B
W-Beam Guardrail @ 1' 6 ¾" (476 mm) post spacing	22 in. (559 mm)	Do not flare	Do not flare	Do not use	Do not use	Do not use
Weak Post SPBGR Attached to Culverts	38 in. (965 mm)	Do not flare	Do not flare	Do not use	Do not use	Do not flare
Non-Blocked SPBGR	34 in. (864 mm)	Do not flare	Do not flare	Do not use	Do not use	34 in. (864 mm) (Use only beyond required CRT posts)

**Test Level 2 only. Face of the guardrail located from >6 in. to <4 ft (>150 mm to < 1.2 m) behind the face of curb has not been approved for TL-2 or TL-3 and is not included above.*

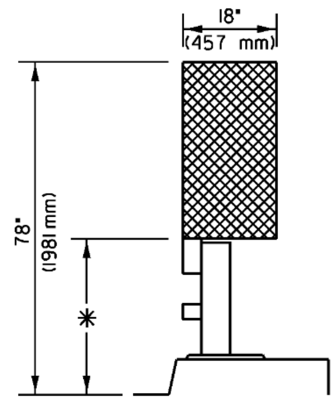
***Culvert headwalls may be placed at lesser distances than the deflection. Refer to Highway Standard 630106.*

Check allowable flare rate based on speed in Figure 38-6.X.

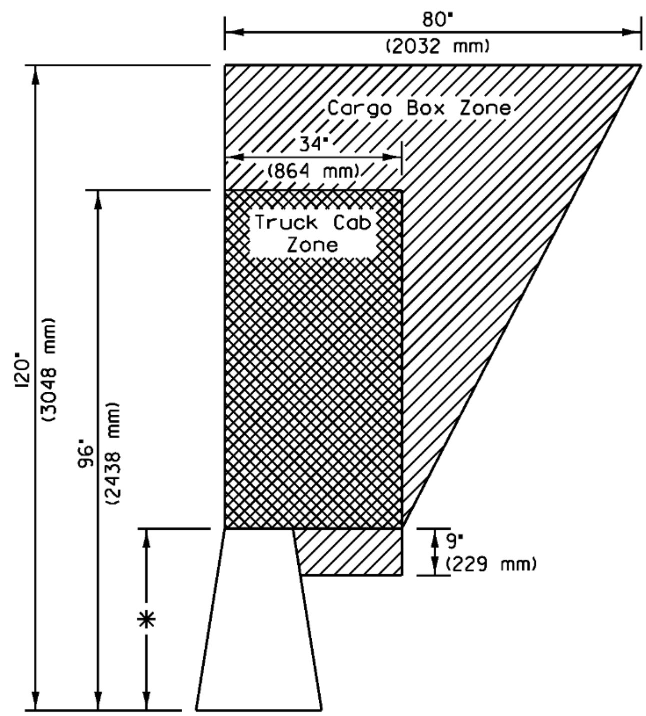
DYNAMIC DEFLECTION OF GUARDRAIL
Figure 38-6.V



* Reviewed TL-3 sloped-faced concrete barrier heights fell in a range of 30 in. (762 mm) to 32 in. (813 mm)



* Reviewed TL-3 steel tubular barrier on curb (curb greater than 6") heights fell in a range of to 32 in. (813 mm) to 34 in. (846 mm)



* Reviewed TL-3 sloped-faced concrete barrier heights fell in a range of 30 in. (762 mm) to 32 in. (813 mm)

SELECTED ZONE of INTRUSION VALUES

Figure 38-6.W

38-6.04 Barrier Flare

A roadside barrier is considered flared when it is not parallel to the edge of the traveled way. Barrier flare has advantages and disadvantages. Flaring moves the barrier further from the traveled way where it is less likely to be hit, it helps to reduce the length of need and amount of barrier needed, it can improve sight distance, and it can serve to introduce a barrier from outside the shy zone into the shy zone. However, flared barrier increases the quantities of earthwork, and results in increased angles of impact.

At the point where tangent guardrail meets flared guardrail, a 12.5 ft (3.81 m) section of guardrail is normally installed on a slight curve by adjusting the posts back a small distance at the transition. This creates a smoother transition and makes the guardrail easier to construct at this point.

Cable barrier for shielding roadside hazards is normally installed parallel to the roadway, with no flare. In special situations where flare is needed with cable barrier, use a 1:50 flare rate.

Figure 38-6.X presents the maximum recommended flare rates as a function of roadside safety, design speed, and barrier type. Flatter flare rates may be used, and can still be very effective in reducing length. Where a barrier approaches or crosses the shy line with approaching traffic, flatter flare rates based on “inside shy line” values should be considered.

38-6.05 Terrain

Crash testing and acceptance of roadside safety hardware is based on test conditions with the impacting vehicle rolling on all four wheels, and at normal ride height when it impacts the device or feature. Vehicles traversing curbs, slopes, or changes in slopes may arrive at a roadside device sliding, spinning, or above or below normal ride height. This can result in unfavorable crash results. Roadside terrain needs to be considered in roadside safety design to achieve a more forgiving roadside.

1. Curbs. When practical, avoid combining a curb and guardrail when using the Midwest Guardrail System (MGS) and blockouts. Where a curb up to 6 in. (150 mm) and guardrail combination is needed, two applications, as noted below, have been crash tested and accepted using the Midwest Guardrail System .

   a. Test Level 3 (TL 3). MGS Type A guardrail may be placed with the face of guardrail located zero to 6 in. (150 mm) behind the face of curb. Figure 38-6.Y shows this configuration. Note that the height of this installation is referenced from the edge of pavement in front of the guardrail face.

   b. Test Level 2 (TL 2). At locations where the roadside safety design speed is 45 mph (70 km/hr) or less, MGS Type A guardrail may be placed at offsets from 4 ft (1.2 m) to 12 ft (3.6 m) from the face of curb. This is useful for placement behind sidewalks in urban areas, including approaches to bridges. Note that the height of this installation is referenced from the ground surface at the guardrail. The terminal section may be tangent or flared, provided it is within the 4 ft to 12 ft (1.2 m to 3.6 m) zone; see Figure 38-6.Z.

Designers should consider options for avoiding placement of curb in advance and adjacent to a Traffic Barrier Terminal Type 1 or Type 2 guardrail terminal. Neither of these terminals has been tested with a curb. As a first choice, extend the guardrail beyond the limits of the curbing, tapering out the curb height appropriately. It may also be possible to shift the curb laterally behind the terminal and apply the same shift on the approach. If a terminal end is needed along the section with curb, provide a tangent terminal with a 50:1 flare so that the impact head of the terminal does not protrude on the roadway. Whenever curbs and guardrail terminals will be in close proximity review the design to confirm that the terminal will operate properly at the proposed height. Vertical transitions may be necessary in some cases.

2. Slopes. Slopes in front of a W-beam guardrail system should be 1V:10H or flatter. This also applies to the embankment between the back of the guardrail posts and the hinge point, the areas in front of the flared section of guardrail, the area approaching the terminal ends, and the area behind the terminal ends as shown on *Highway Standard* 630301.

   Some high tension cable barriers may be used on approach slopes of 1V:4H or flatter; see Section 38-7.03(b).

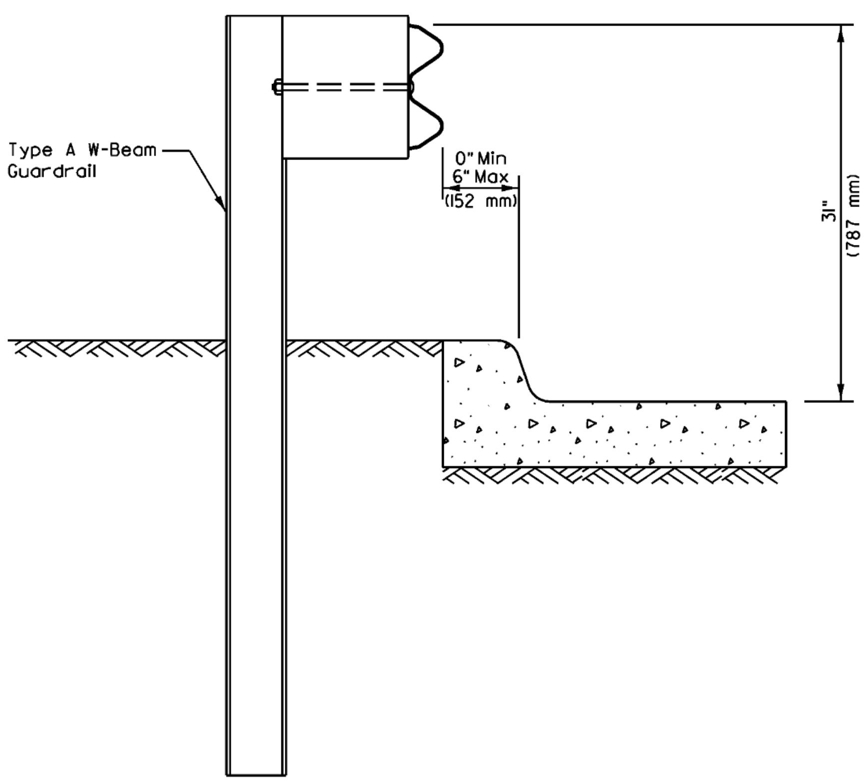
Design Speed		Flare Rate for Barrier Inside Shy Line*	Flare Rate for Barrier Beyond Shy Line*		
(mph)	(km/hr)		Rigid (Concrete)	Semi-Rigid (W-Beam)	Flexible (Cable)
70	110	1:30	1:20	1:15	1:50
60	100	1:26	1:18	1:14	1:50
55	90	1:24	1:16	1:12	1:50
50	80	1:21	1:14	1:11	1:50
45	70	1:18	1:12	1:10	1:50
40	60	1:16	1:10	1:8	1:50
30	50	1:13	1:8	1:7	1:50

**See Figure 38-6.T for shy line distances.*

Note: Non-blocked guardrail is not to be flared.

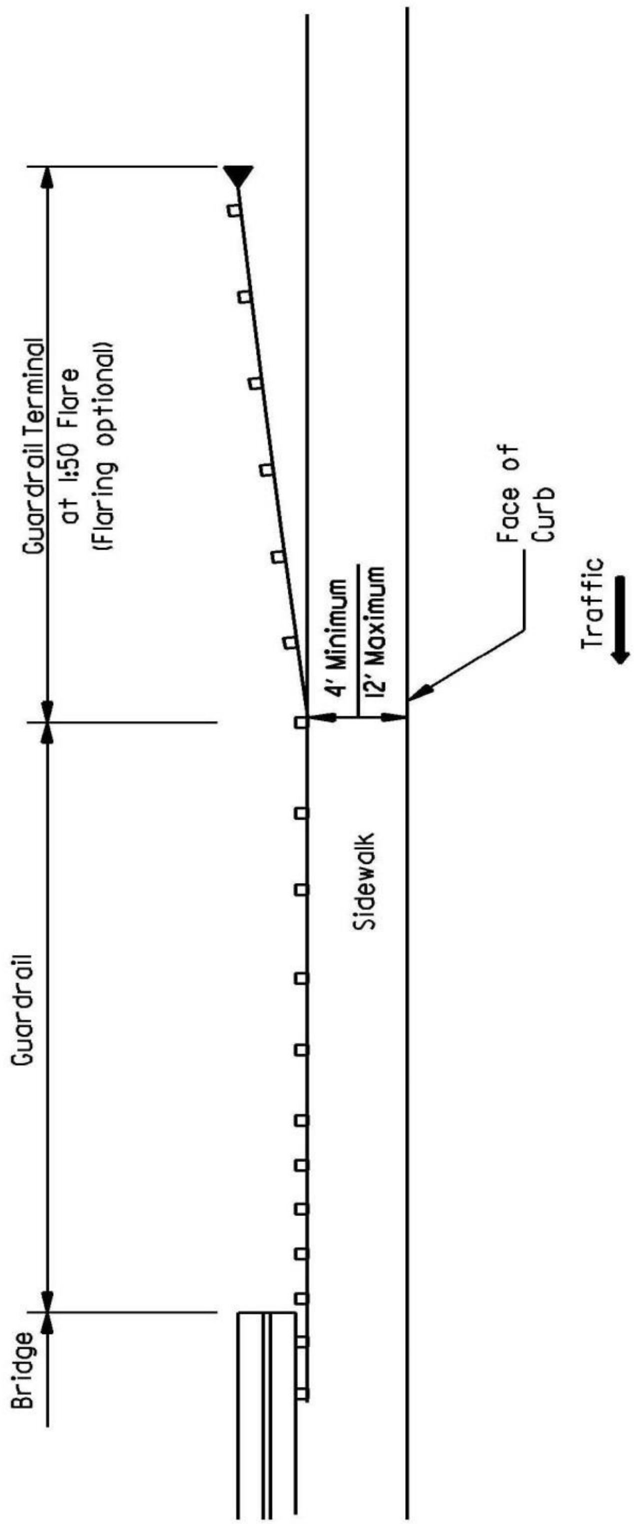
MAXIMUM FLARE RATES FOR BARRIER DESIGN

Figure 38-6.X



PLACEMENT OF W-BEAM GUARDRAIL WITH CURB

Figure 38-6.Y



W-BEAM GUARDRAIL WITH SIDEWALK AND CURB
(45 mph (70 km/hr) or less)

Figure 38-6.Z

38-6.06 Terminal Treatments

Barrier terminal sections present potential roadside hazards for run-off-the-road vehicles; however, they are also critical to the proper structural performance of the barrier system. Therefore, the designer must carefully consider the selection and placement of the terminal end.

The *Illinois Highway Standards* present the design details for several end treatments used by the Department. Other proprietary terminal treatments are allowed under various Specifications and Special Provisions. The particular proprietary items routinely allowed for use on IDOT projects are included in the Department's Qualified Products List (QPL) that is published in the Material Approvals section of the "Doing Business" page of the IDOT internet site. The process of approving MASH-tested devices, replacing NCHRP Report 350 devices, is continuing for several of these systems. The QPL lists both the products and the current requirements during this transition period. The following sections briefly describe each system and, where applicable, discuss typical uses of the system.

38-6.06(a) Guardrail End Terminals

The following terminals are applicable to the steel plate beam guardrail:

1. Type 1, Special (Flared). This terminal section is for use with steel plate beam guardrail. The designer should choose a flared terminal where practical, if no additional right-of-way must be purchased for installation and the grading needed to provide a 1V:10H approach slope to the terminal is reasonable. Each device has a maximum flare rate measured versus normal traffic flow. Note that this flare rate can potentially be flatter than a flare rate proposed for a guardrail run.

   Note that both the beginning of length of need (BLON) location point and the length of the Traffic Barrier Terminal Type 1, Special (TBT T1 SPL), will vary depending on which proprietary item the contractor chooses for termination of the guardrail. Refer to the QPL for drawings showing detailed dimensions of, and maximum flare rates for, the currently-approved devices.

   For design purposes, using the shortest TBT T1 SPL will provide the most conservative guardrail plan quantity; however, the effects of the contractor's potential selection of a longer TBT T1 SPL than assumed in design must be evaluated in the design phase for its impact on the location of proposed entrances and grading.

   The ends of some TBT T1 SPL devices have redirective properties beginning at the first post, however the first 12.5 ft (3.81 m) of most TBT T1 SPL terminals is called the gating portion and is not included in the length of need. The purpose of the non-redirective, or gating portion of the TBT's, is to provide anchorage for the adjacent redirective guardrail run. A steel cable, with ends attached to the first rail and the first post, provides tension that stiffens the adjacent redirective rail pieces. Therefore, when designing a TBT T1 SPL end terminal, assume the length of need begins at the third post, 12.5 ft (3.81 m) from the free end. This conservative assumption will ensure sufficient guardrail quantities are present in the plans and will prevent conflicts with driveways, etc., during construction.

Based on crash testing, the area behind and beyond the terminal should be traversable and free of fixed objects. The minimum recommended distance is a rectangular area approximately 75 ft (23 m) beyond the terminal parallel to the rail and 20 ft (6.0 m) behind and perpendicular to the rail, where right-of-way, environmental concerns, and other resources allow.

2. Type 1, Special (Tangent). This terminal section is for use with steel plate beam guardrail. Tangent terminals should typically be chosen in areas where the cross section or drainage requirements would require additional right-of-way to accommodate the Type 1 Special (Flared) terminal. Each device has a maximum flare rate measured versus normal traffic flow. Note that this flare rate can potentially be flatter than a flare rate proposed for a guardrail run.

   Note that both the beginning of length of need (BLON) location point and the length of the Traffic Barrier Terminal Type 1, Special (TBT T1 SPL), will vary depending on which proprietary item the contractor chooses for termination of the guardrail. Refer to the QPL for drawings showing detailed dimensions of, and maximum flare rates for, the currently-approved devices.

   For design purposes, using the shortest TBT T1 SPL will provide the most conservative guardrail plan quantity; however, the effects of the contractor's potential selection of a longer TBT T1 SPL than assumed in design must be evaluated in the design phase for its impact on the location of proposed entrances and grading.

   The ends of some TBT T1 SPL devices have redirective abilities beginning at the first post, however the first 12.5 ft (3.81 m) of most TBT T1 SPL terminals is called the gating portion and is not included in the length of need. The purpose of the non-redirective, or gating portion of the TBT's, is to provide anchorage for the adjacent redirective guardrail run. A steel cable, with ends attached to the first rail and the first post, provides tension that stiffens the adjacent redirective rail pieces. Therefore, when designing a TBT T1 SPL end terminal, assume the length of need begins at the third post, 12.5 ft (3.81 m) from the free end. This conservative assumption will ensure sufficient guardrail quantities are present in the plans and will prevent conflicts with driveways, etc. during construction.

   Based on crash testing, the area behind and beyond the terminal should be traversable and free of fixed objects. The minimum recommended distance is a rectangular area approximately 75 ft (23 m) beyond the terminal parallel to the rail and 20 ft (6.0 m) behind and perpendicular to the rail where right-of-way, environmental concerns, and other resources allow.

3. Type 1B. In areas of cut sections on the roadway, or where the road is transitioning from cut to fill, it is sometimes possible to terminate a guardrail installation by burying the end in the natural or typically-graded back slope. When properly designed and located, this generic system provides full shielding of the identified hazard, eliminates the possibility of

any end-on impact with the terminal, and minimizes the likelihood of the vehicle passing behind the rail. The length of need point for this terminal begins at the transition from cut to fill, and the guardrail and terminal extend more than 75 ft (23 m) beyond this point.

Currently, the Type 1B end terminal meets NCHRP Report 350 criteria. Through research there is potential for approval of a MASH Type 1B terminal; in the meantime Highway Standard 631006 can be applied in the specific circumstances described here. Use of the Type 1B terminal shall meet all of the following criteria:

a. The steepness of the slope into which the barrier is buried should be as nearly vertical as possible, so the slope effectively becomes part of the barrier. This slope should be at least 1V:3H or steeper, with steeper slopes preferred.

b. The length of need for the roadside barrier begins where the guardrail crosses the ditch flowline.

c. The beginning of the length of need for the roadside barrier (where it crosses the ditch flowline) is positioned about 75 ft (23 m) upstream of the transition from cut to fill. This provides a buffer area for any vehicles that might get behind or over the buried terminal.

d. Front slopes must be 1V:4H or flatter.

e. The height of the rail must be held constant with respect to the edge of the roadway shoulder.

f. The maximum height of the top of the rail where it crosses the ditch bottom is 45 in. (1143 mm).

g. Depending on site conditions, the terminal may be anchored by driven posts or a poured concrete block, or may be anchored to sound rock.

Careful site review, along with design of profiles and cross slopes, is necessary to satisfy the criteria listed above. If all of these criteria cannot be met, another terminal type should be considered.

4. Type 2. This is an unflared terminal with a cable anchor. The Traffic Barrier Terminal, Type 2 (TBT T2), should be used on the departing end of W-beam guardrail where end-on impacts are not a consideration; i.e., on one-way roadways. The full length of a TBT T2 plus the adjacent 25 ft (7.62 m) will not redirect an impacting vehicle and is therefore not to be considered as part of the length of need required to shield the hazard. Therefore the BLON for a guardrail run with a TBT T2, is at 37.5 ft (11.43 m) from the end post of the TBT T2.

When providing the additional 25 ft of steel plate beam guardrail as shown in Figure 38-6.A, the Type 2 end terminal is considered crashworthy for departing impacts only.

38-6.06(b) Median Barriers

See Section 38-7.04(d) for guidance on Department-approved end terminals (impact attenuators) for median barriers. These also apply to the ends of the concrete barrier where it is used as a roadside barrier.

38-6.06(c) Bridge Rail Connections

Roadside barriers are often terminated with a transition into a bridge rail. When length of need is met by placing two concurrent end terminals back to back, e.g. a Type 1 (Special) connected to a Type 6, best practice is to place an additional segment of Type A guardrail between the two end terminals to ensure proper connection and redirective properties.

Terminals used as bridge rail connections are discussed below and shown on the Highway Standards.

1. Type 5. This is a connector terminal which should be used to connect steel plate beam guardrail to the concrete bridge parapet or end post at the departing end of a new one-way bridge.

2. Type 5A. This is a connector terminal that should be used only for repair of existing installations on the State system, and for Local Roads projects, if specified by the Local Agency. It is used to connect steel plate beam guardrail to a steel bridge rail at either the approaching end or departing end of the bridge. For applications on the State highway system, or other locations where compliance with *NCHRP Report 350* or *MASH* is required, see Type 6A.

3. Type 6. This is a connector terminal that includes a transition section, special posts, blockouts, and end shoe. It also requires the use of a curb. Use Type 6 to attach steel plate beam guardrail to the end(s) of bridges with concrete parapet or to a permanent concrete barrier. It may also be used to connect the steel plate beam guardrail to the face of other concrete structures where the required curb can be installed.

4. Type 6A. This transition is similar to the Type 6, except it is used for attachment of steel plate beam guardrail to either curb-mounted steel bridge rail or to side-mounted steel bridge rail (two element rail systems approved under *NCHRP Report 350*). When used with a bridge rail system that includes a curb, a curb must be used with the Type 6A, similar to the Type 6. If there is no curb used on the bridge, do not use a curb with the Type 6A.

5. Type 6B. This transition is used when connecting steel plate beam guardrail to the face of a concrete structure (e.g., a pier) and where the installation of a curb is either not possible or not desirable. It requires blocking out the thrie beam rail of the transition by 8 in. (200 mm) at the connection point. The designer must carefully weigh the relative merits of this potential loss of horizontal clearance against the complications of adding a curb when selecting between the Type 6B terminal and the Type 6 for attachment to a structure.

6. Type 10. This is a connector terminal that may be used to connect steel plate beam guardrail to the departing end of concrete parapets or concrete bridge rails of one-way bridges, except for bridges or culverts with concrete post and beam rails. Existing concrete post and beam rails should be removed and retrofitted with a steel bridge rail or a structurally designed concrete parapet and connected using an appropriate connector.

7. Type 11. This is a connector terminal that should be used to connect temporary bridge railing to temporary concrete barrier. Specifications for the temporary concrete barrier require that the last segment of barrier be fixed in place by anchor pins. These pins are critical to the performance of this terminal to avoid a potential “pocketing” location for impacting vehicles. This terminal, as shown on *Highway Standard* 631051, is considered adequate for *NCHRP Report 350* Test Level 2; for design speeds up to 45 mph (70 km/hr). Where speeds are higher, the post spacing for the temporary bridge railing shall be no more than 3′ -1½″ (953 mm). With the reduced post spacing for the temporary bridge rail, this transition is considered adequate for *NCHRP Report 350* Test Level 3.

38-6.07 Minimum Length/Gaps

The minimum length of guardrail should include 75 ft (23 m) of length of need (redirective) guardrail. Common configurations meeting this minimum requirement include a pair of Traffic Barrier Terminals Type 1, Special, a Traffic Barrier Terminal Type 1, Special, connected to a Traffic Barrier Terminal Type 6 (or 6A, or 6B); or a Traffic Barrier Terminal Type 1, Special, plus 50 ft (15.24 m) of guardrail connected to a Traffic Barrier Terminal Type 2.

Where gaps exist in the need for a roadside barrier, it is typically economically justified to provide continuous runs of guardrail, rather than to leave gaps of 200 ft (60 m) or less. This is because the pair of Traffic Barrier Terminals Type 1, Special, that would be required to form a gap cost about the same as a run of guardrail 200 ft (60 m) long. It may also be safer by reducing exposure to additional terminal ends. Shorter gaps may be necessary and prudent where the guardrail is warranted, as access needs, sight distance, or other reasons dictate the need for a gap.

38-6.08 Typical Applications

Figures 38-6.AA through 38-6.CC illustrate typical applications of roadside barrier installations. See Figure 38-6.DD for the minimum length of Type A or Type B guardrail that must be installed between non-blocked guardrail and a traffic barrier terminal (TBT).

38-6.09 Short Radius Guardrail

There are currently no short radius (radius = 150 ft (45 m) or less) guardrail systems that the Department has identified and adopted as a standard design element. A side road or entrance within the length of need of a guardrail installation poses a severe challenge to the design of a safe roadside. Although installing a short radius Type A guardrail around one or both of the roadway radius returns is possible, a vehicle impacting the radius at a high angle and speed may penetrate the barrier, or vault over the barrier after the posts lean back, creating a ramping effect. Where penetration or vaulting does not occur, the vehicle may be decelerated at an excessive rate.

Recognizing that it is often not practical to change the site conditions by relocating the roadway or entrance to allow for the proper length of need of guardrail, the 2011 edition of the AASHTO *Roadside Design Guide* (*RDG*) acknowledges that some compromise will be necessary. Where a short radius guardrail is appropriate for addressing roadside safety the RDG recommends that the installation should be made as forgiving as practical. However, prior to choosing this solution, alternatives should be assessed as summarized in this section.

38-6.09(a) Design Alternatives

1. Relocate or Close the Intersecting Roadway/Entrance. This is the preferred solution and should be considered during project scoping or Phase I preliminary engineering. Proceeding with a relocation or closure will involve consideration of expected crash risk, barrier maintenance costs, project scope, cost, and impacts to adjacent properties and the environment. This action generally provides the most positive solution for roadside safety. If it is undertaken, give additional consideration to flattening side slopes, widening embankments, etc., to reduce the need for any barrier.

2. Terminate the Guardrail in Advance of the Intersecting Roadway. When relocating or closing the roadway/entrance is not feasible and where the nominal length of need falls near the intersecting roadway the designer may choose to truncate the standard guardrail with an approved terminal section or impact attenuator in advance of the intersection. Flaring the guardrail away from the roadway can be combined with guardrail truncation to improve length of need coverage. Truncating a guardrail run and exposing a hazard such as a slope or dropoff should be compared to the hazard posed by a short radius guardrail installation.

   Termination of guardrail short of the length of need is considered a design exception and shall be discussed at a coordination meeting with the reason(s) for the short length documented in the meeting minutes; see Section 31-7.

3. Short Radius Guardrail. If relocating a roadway/entrance cannot be accomplished and terminating the guardrail short of its length of need is undesirable, the designer may consider a short radius guardrail installation. Considerations in application include how close it can be installed to a bridge, what radius can be used, and how far it must run along the intersecting side road.

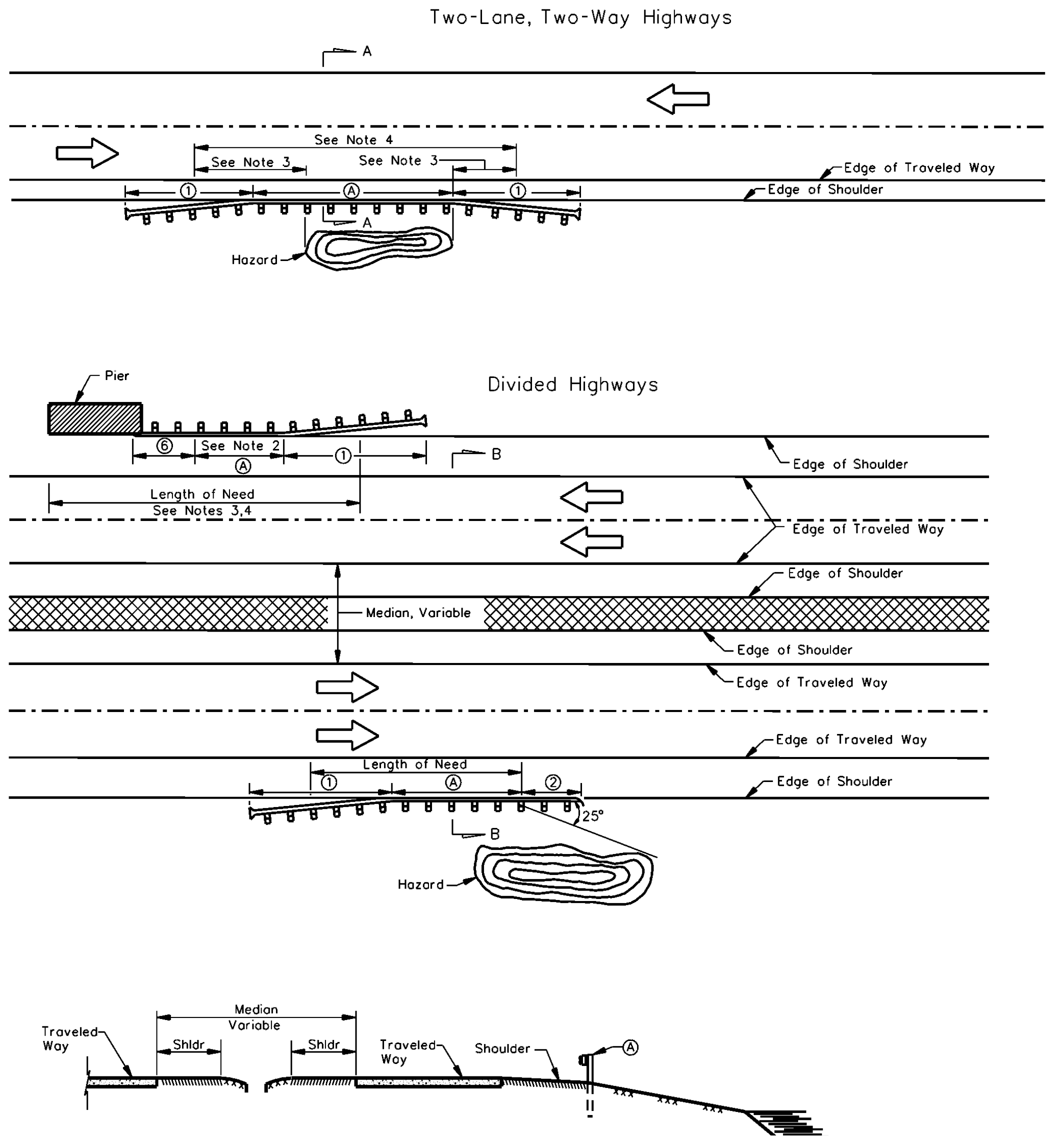
   Steel Plate Beam Guardrail, Type A is the only current system usable for a short radius installation. The design should introduce strong posts likely to rotate out of a vehicle's path and minimize vaulting, blockouts to minimize snagging, and mounting height to minimize override. This system has not met any crash testing criteria, but when a short radius guardrail installation is required, it represents an effort to provide a forgiving installation.

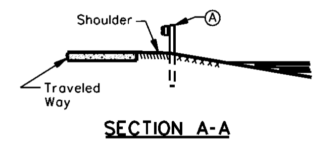
When terminating the radius guardrail system, the guardrail on the intersecting roadway should be completed to any required length of need and terminated with an appropriate end treatment. On a very low speed roadway (e.g., private driveway), this may be a Type 2 terminal. On most public roadways, or other roadways where higher speeds are possible, provide a Traffic Barrier Terminal Type 1, Special. These terminals are important to provide adequate anchoring of the radius system, and safety for the traffic on the intersecting roadway.

Given that the preferred method is to relocate or close the intersecting roadway or entrance, and that the short radius guardrail does not meet *MASH* or *NCHRP Report 350* criteria, the decision to use the strong post design (current standard) for a short radius installation is considered a design exception. The design shall be discussed at a coordination meeting and documented in the meeting minutes. The strong post design is the Department's current Standard Type A guardrail installed on the necessary radius. Do not use Type B guardrail in radius applications, as it increases the likelihood that posts will only deflect partially and launch a vehicle.

Because the strong post radius guardrail system represents some compromise in roadside design, consider an attempt to shadow it from impacts. This can be done by applying a tangent run of guardrail on the approach side of the intersecting roadway. Radius guardrail is available in five foot increments of radius from 5 ft (1.52 m) to 150 ft (45.72 m). For radii longer than 150 ft (45.72 m), the straight sections can be deflected in the field to match curves.

4. Other Solutions. Other solutions may be possible on a case-by-case basis. For example, in some locations it may be feasible to locate an impact attenuator system in the radius area. Another idea is to flare the guardrail approaching the short radius and provide guardrail on the other side of the entrance to "shadow" the radius installation. If desired, coordinate with BSPE for specific situations that may present multiple design options.





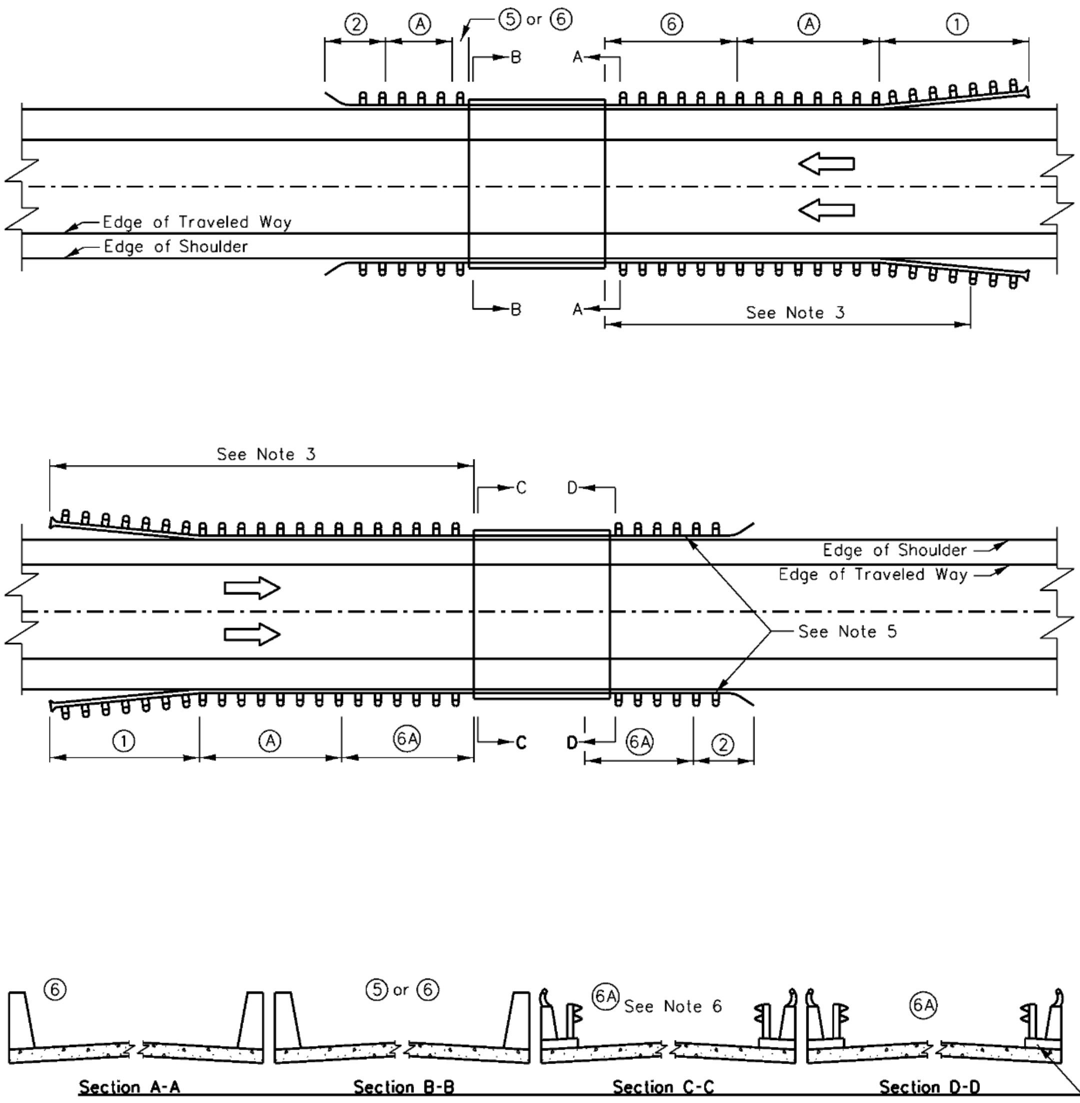
Notes:

1. Traffic Barrier Terminal Types:
   ① Type 1, Special (Tangent or Flared)
   ② Type 2
   ⑥ Type 6 (Type 6B may also be considered)
2. Steel Plate Beam Guardrail Types:
   Ⓐ Type A (Type B may be used if needed)
3. Length of need in advance of the hazard should be determined using Figure 38-6F.
4. Total length of need includes length of need at each end of the hazard plus the length required immediatley adjacent to the hazard. See Section 38-6.01.
5. When Traffic Barrier Terminal Type 1, Special is used, a portion is applied to the length of need.
6. Flare of terminals must not exceed maximum rate for device type selected as measured versus normal traffic flow.

Not to scale.

TYPICAL APPLICATION OF GUARDRAIL AND TRAFFIC BARRIER TERMINALS

Figure 38-6.AA



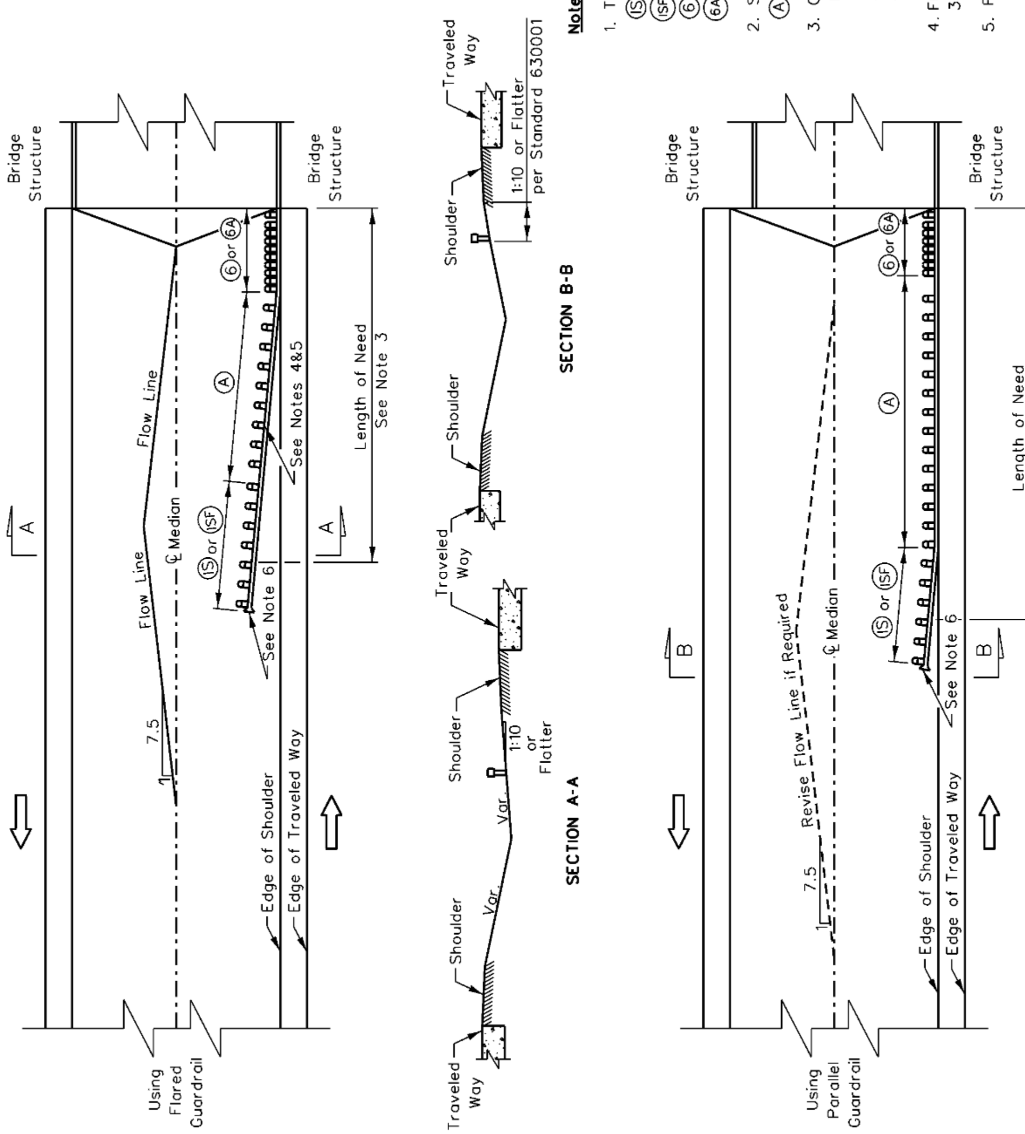
Notes:

1. Traffic Barrier Terminal Types
   - (1) Type 1, Special (Tangent or Flared)
   - (2) Type 2
   - (5) Type 5
   - (6) Type 6
   - (6A) Type 6A
2. Steel Plate Beam Guardrail Types
   - (A) Type A
3. Guardrail length of need should be determined using Figure 38-6.F. Designer may consider shielding wider for median hazards. See section 38-6.01.
4. When Traffic Barrier Terminal Type 1, Special is used, a portion of terminal is applied to the length of need.
5. Guardrail is to be placed at the departing end of one-way bridges only when guardrail is needed for some other uncorrectable hazard length of need as per Note 3 above.
6. Safety walk greater than 9 in (225 mm) high must be removed or retrofitted.
7. Flare of terminals must not exceed maximum rate for device type selected, as measured versus normal traffic flow.

Not to scale

TYPICAL APPLICATION OF GUARDRAIL AND TRAFFIC BARRIER TERMINALS
(Median Widths Less Than 64 ft (19.5 m) at Dual Structures)

Figure 38-6.BB



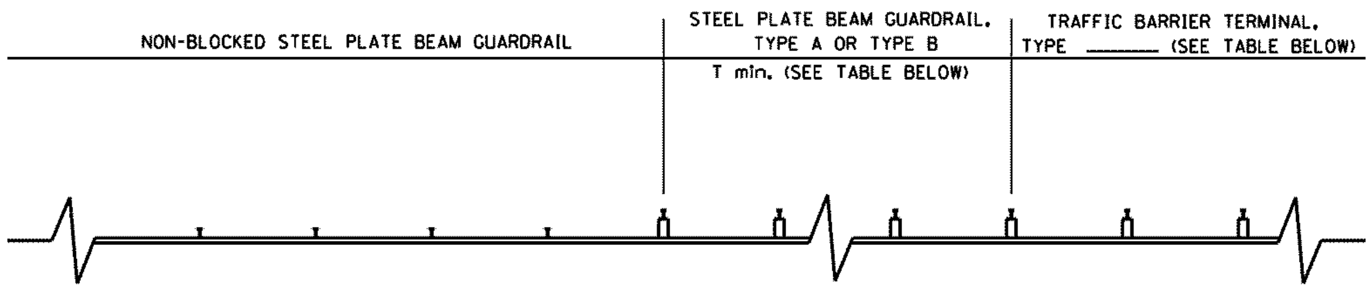
Notes:

1. Traffic Barrier Terminal Types
   (1S) Type 1 (Special)
   (1SF) Type 1 (Special) Flared
   (6) Type 6
   (6A) Type 6A
2. Steel Plate Beam Guardrail Types
   (A) Type A
3. Guardrail length of need in advance of hazard should be determined using Figure 38-6.F. Designer may consider shielding wider clear zone for median hazards. See section 38-6.01.
4. Flare rate inside shy line (Figure 38-6.X)
5. Flare rate beyond shy line (Figure 38-6.X)
6. Flare of terminals must not exceed maximum rate for device type selected, as measured versus normal traffic flow.

TYPICAL APPLICATION OF GUARDRAIL AND TRAFFIC BARRIER TERMINALS
(For Median Widths at Dual Structures)

Figure 38-6.CC

MINIMUM LENGTH TYPE A OR TYPE B GUARDRAIL BETWEEN NON-BLOCKED GUARDRAIL AND A TRAFFIC BARRIER TERMINAL



TRAFFIC BARRIER TERMINAL, TYPE ______	T min. ft (m)
2	50 (15.24)
6, 6A, OR 6B	25 (7.62)
5	25 (7.62)
1, SPECIAL (TANGENT)	12.5 (3.81)
1, SPECIAL (FLARED)	12.5 (3.81)

NON –BLOCKED GUARDRAIL/END-TERMINAL DETAIL
Figure 38-6.DD

38-7 MEDIAN BARRIERS

Median barriers prevent errant vehicles from crossing the median of a divided highway and colliding with vehicles in the opposing direction of travel. The decision to use a median barrier, as well as the selection of barrier type should be identified in the Phase I engineering report for the project. This decision is especially important for early and accurate coordination with bridge cross section details.

38-7.01 Median Barrier Warrants

38-7.01(a) Freeways

For freeways with a posted speed of 55 mph or greater, use Figure 38-7.B to determine if a median barrier may be warranted. The figure uses the inputs of median width and traffic volume, along with Illinois-specific cross-median crash data, to determine the benefit/cost (B/C) ratio of installing a barrier using the procedure shown in Section 38-7.01(c).

In the “Median Barrier Recommended” area of the Figure 38-7.B, the B/C ratio is expected to be at least 2.00 and the barrier is warranted. In the “Evaluate Cost Effectiveness” area of the figure, the B/C ratio is less definitive and additional analysis should be performed to determine if the barrier is warranted.

For existing freeways, the additional analysis involves determining a project specific B/C ratio using existing crash data for the section and other factors such as: route continuity of the median barrier, a progressive and logical “build out” of the barriers, area development trends, future programming for the location, and proximity to interchanges. A study of Illinois’ fatal cross-median crashes has shown that almost 70% happen within one mile (1.6 km) of an interchange.

For proposed freeways, the additional analysis is similar to that above for existing freeways, except for the need to use the Enhanced Interchange Safety Analysis Tool (ISATe) to predict crash frequency and severity in determining a more project-specific B/C ratio for installation of median barrier. Alternatively, the ISATe and cost-effectiveness study can be used to determine if the use of a wider median, which will eliminate the need for median barrier on a new facility, is a preferable alternative to the initial construction of the barrier. Contact BSPE regarding the use of ISATe.

38-7.01(b) Highways with a Flush/Depressed Median and Partial Access Control

For highways with both a flush/depressed median and partial access control, the decision to use a median barrier should consider the B/C ratio. As the median barrier must terminate at each at-grade intersection, give special consideration to sight distance and the need to provide a safety treatment at each end of the barrier, as well as right-of-way constraints, property access needs, number of intersections and driveway openings, and adjacent commercial development.

38-7.01(c) Benefit/Cost (B/C) Ratio Procedure

To determine the B/C ratio of a median barrier, use the following procedure. This procedure assumes a 15-year life for the median barrier and a 3% discount rate:

1. Determine the Benefit.

   - Determine the annual number of fatal (K), severe injury (A), and moderate injury (B) cross-median crashes. Cross median crashes shall be determined from reading the narrative portions of crash reports. For existing roadways, use an average of at least five years of crash data.
   - Determine the annual cost of K, A, and B cross-median crashes. Apply the cost per crash method (not per fatality or injury) according to Figure 38-7.A to determine the annual cost.
   - Determine the annual benefit (AB) for installing the median barrier. The AB is estimated as the current year KAB crash cost multiplied by 0.92.

     AB = Current year KAB crash cost X 0.92.

   - Determine the total benefit (B) of the median barrier.

     B = AB x 11.94

     where: 11.94 = present worth factor (for current year)

2. Determine the Cost.

   - Select the most appropriate median barrier according to Sections 38-7.02 and 38-7.03.
   - Determine the installation cost (IC) of the median barrier. Include in the cost any additional items that are required for the selected barrier (e.g., grading, drainage, paving, mow strips).
   - Estimate the number of crashes (encroachments) into the median barrier per year using the Roadside Safety Analysis Program (RSAP).
   - Determine the annual repair cost (ARC) of the median barrier. Multiply the estimated number of crashes per year (from the RSAP) by the following:

     + $0 for rigid median barrier,
     + $1200 x $(1.03)^{(\text{Construction Year - 2012})}$ for semi-rigid median barrier, and
     + $800 x $(1.03)^{(\text{Construction Year - 2012})}$ for flexible median barrier.

     Documented repair costs in the area may be used in place of these.

   - Determine the total cost (C) of the median barrier.

     C = IC + (ARC x 11.94)

     where: 11.94 = present worth factor (for current year)

3. Determine the Benefit/Cost Ratio.

B/C ratio = B/C

A minimum B/C ratio of 2.00 warrants installation of a median barrier. When the B/C ratio is between 1.00 and 2.00, other factors should be considered. Other factors include route continuity of median barrier, a progressive and logical "build out" of the barriers, area development trends, future programming for the location, and proximity to interchanges. A study of Illinois' fatal, cross-median crashes has shown that almost 70% happen within one mile (1.6 km) of an interchange.

Crash Severity*	2018 Cost Per Crash
Fatal Crash (K)	$ 6,626,000
Severe Injury Crash (A)	$ 357,000
Moderate Injury Crash (B)	$ 131,000

* Crash severity is determined by the most severe injury in a given crash.

Use the following procedures to determine the cost (losses) over a study period due to cross median crashes.

1. Cross median crashes are those in which a vehicle traveling in the correct direction on one side of a divided freeway crosses the median into opposing traffic and has a collision with a vehicle traveling in its correct direction in the opposing traffic lanes.

   #K cross median crashes x ($ 6,626,000)
   + #A cross median crashes x ($ 357,000)
   + #B cross median crashes x ($ 131,000)

   Total KAB crash cost for the study period (2018 dollars)

2. Annual KAB crash cost for the study period

   = (Total KAB crash cost for the study period) / N

   where N = Length of study period

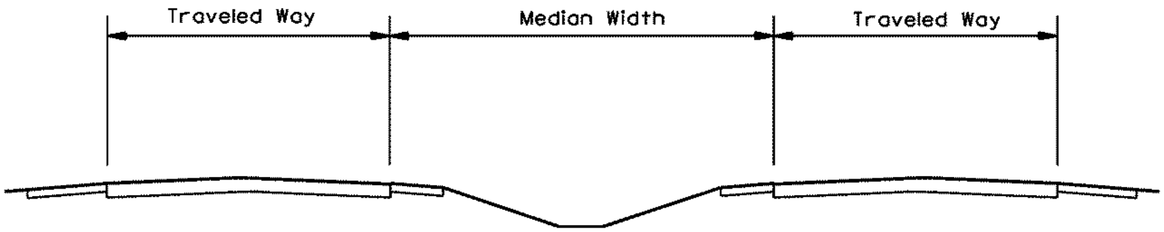
3. The designer must update this dollar figure to the current year using a 3% discount rate.

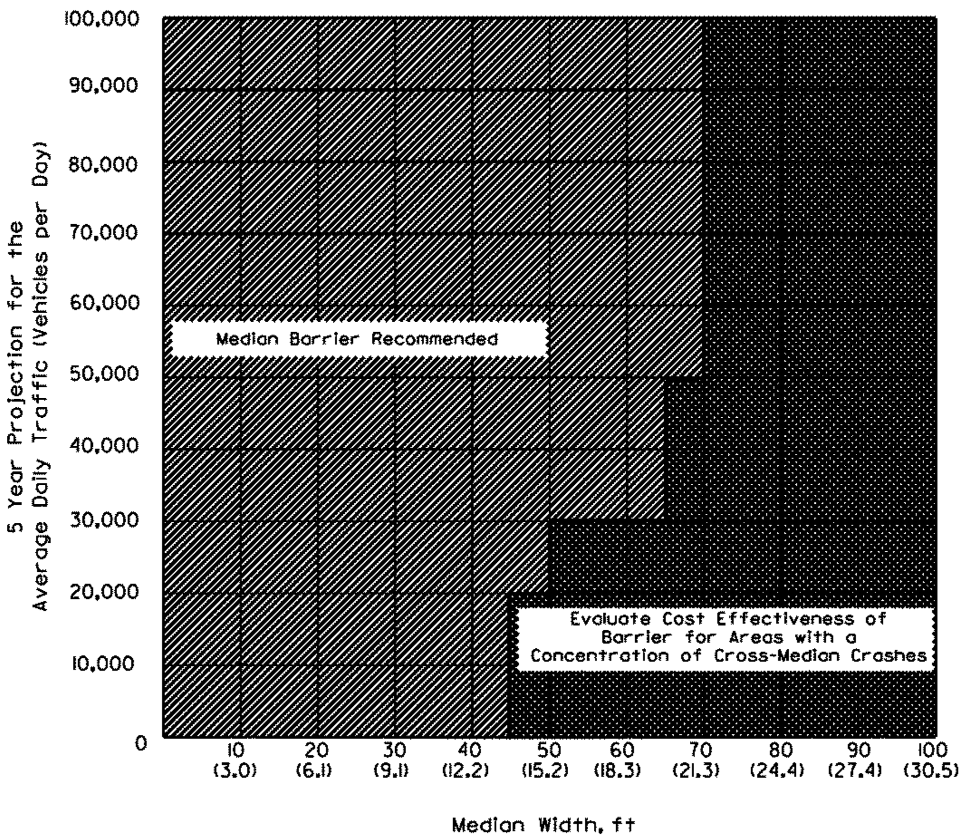
   Current year annual KAB crash cost

   = Annual KAB crash cost x $1.03^{\text{(current year - 2018)}}$

ANNUAL KAB CRASH COST FOR A STUDY PERIOD

Figure 38-7.A





WARRANTS FOR MEDIAN BARRIERS ON FREEWAYS

Figure 38-7.B

38-7.02 Median Barrier Types

As with roadside barriers, median barriers can be categorized as rigid, semi-rigid, and flexible.

38-7.02(a) Rigid Median Barriers

The rigid median barrier currently used by the Department is a single slope concrete barrier with a 44 in. (1120 mm) height. See *Highway Standard* 637006. This design has been certified as meeting MASH (Test Level 5). The minimum height required for Test Level 5 is 42 in. (1065 mm) but the additional height of the current design allows for a future 2 in. (50 mm) overlay and matches the height of the Test Level 5 parapet design used by the Bureau of Bridges and Structures.

In the median, the concrete barrier it typically double faced but a single-faced design may be used to go around a fixed object in the median (e.g., bridge piers) or where twin separated structures are encountered. Single-faced barriers must be designed on a case-by-case basis, require structural reinforcement, and are normally tied to the supporting pavement/shoulder.

Prior to the current single slope design, the Department used two different heights of F-Shape concrete barrier and they are allowed to remain in service until a project scope involves barrier replacement. The 32 in (815 mm) height F-Shape design was an NCHRP Report 350 Test Level 4 barrier. The 42 in (1065 mm) height design was an NCHRP Report 350 Test Level 5 barrier.

38-7.02(b) Semi-Rigid Median Barriers

The semi-rigid median barrier used by the Department is steel plate beam guardrail, Type D (double rail). See *Highway Standard* 630001. This median barrier meets Test Level 3 and is most applicable to medians with intermediate widths of 20 ft to 30 ft (6.0 m to 9.0 m) and/or low-to-moderate truck traffic volumes (< 5000 MU per day). Another application is for the separation of adjacent on/off ramps at interchanges.

38-7.02(c) Flexible Median Barriers

The flexible median barriers used by the Department are high-tension cable (HTC) median barriers. HTC median barriers consist of cables under high tension, suspended on lightweight posts, with an anchorage foundation at each end to hold the tension on the cables.

The tension present in the cables of an HTC system allow the cable to remain at an effective height after the removal of several supporting posts. This is valuable after a moderate crash, as some level of protection remains until repairs can be completed. However, the weak post component of these systems usually results in some damage, even from minor or nuisance hits. The repair of the weak posts is straightforward, and with socketed systems may not require any specialized equipment.

The HTC median barriers approved for use on slopes of 1V:6H or flatter meet *Test Level 4*. The barriers approved for use on slopes steeper than 1V:6H, but not steeper than 1V:4H, meet *Test Level 3*. The terminals for HTC median barriers meet *Test Level 3*. For each of these systems slope, placement, and other criteria limit where and how they may be used.

38-7.03 Median Barrier Selection

38-7.03(a) Selection Guidelines

The selection of a median barrier type starts with the median width and slopes. These two median conditions will have the greatest impact on the barrier's performance. Figure 38-7.C provides selection guidelines based upon these conditions and also provides the recommended placement for that barrier within the median.

Where more than one type of median barrier is recommended, consider the following factors:

1. Traffic Volumes. Higher traffic volumes generate more impacts on a median barrier. Also, closing lanes to work on median barriers causes more traffic complications where traffic volumes are high. In high-traffic volume locations, rigid barriers are generally preferred because they usually provide continuous, crashworthy service without generating maintenance and repair.

   As a guide, a rigid barrier is likely to be more cost-effective where the peak hour level of service is LOS C or worse and the distance to the median barrier from the traveled way is 12 ft (3.6 m) or less.

2. Heavy Vehicle Traffic. Where there is a high volume of heavy vehicles, or a history of heavy vehicle, cross-median crashes, a rigid barrier would be preferred as it is more likely to contain and redirect heavy vehicles. Maintenance and repairs are not usually required after a hit.

3. Median Appurtenances. A roadway with a median barrier may also warrant other appurtenances in the median (e.g., highway lighting, signs, glare screens). This favors the use of the concrete barrier, which can more readily accommodate these appurtenances.

4. Maintenance Operations. Two factors are important:

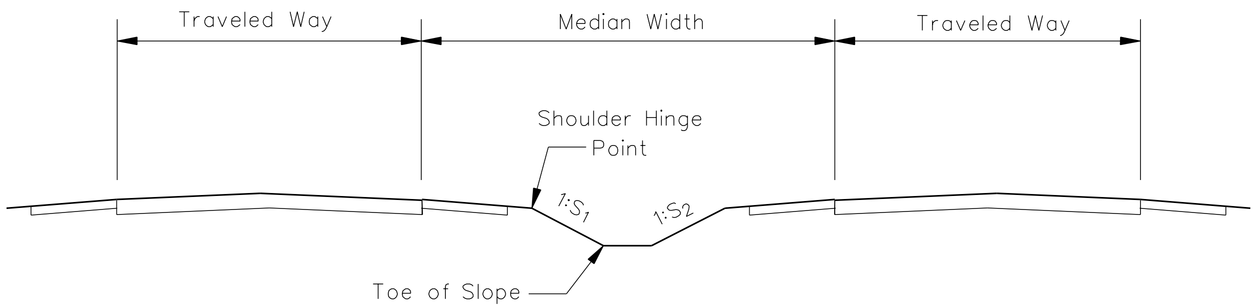
   a. First, maintenance response time will influence safety. The longer a damaged section of median barrier is present, the greater the likelihood of a second impact with a damaged barrier. A damaged semi-rigid barrier may remain at operational height after some impacts and may still provide protection in the event of a second impact. However, if substantially damaged it can itself become a greater hazard close to traffic until it is fully repaired and operational. This consideration favors the use of a rigid barrier which normally sustains little or no damage when impacted..

b. Second, the maintenance operations for repairing a median barrier can be disruptive to traffic. It is important to consider worker safety and traffic safety when developing a traffic control scheme for barrier repair. Lane closures are typically necessary where working room is limited. This consideration favors the use of a rigid barrier in narrow medians and/or high-traffic volume areas, or a flexible barrier where sufficient space is available adjacent to or behind the barrier to accommodate the smaller equipment needed to repair it.

5. Benefit/Cost Ratio. The B/C ratio is important but does not consider additional crash or user delay costs due to traffic backups for repair. Consider the safety consequences based on the other factors listed above to make sure the system is acceptable for the specific site.

Figure 38-7.D compares the advantages and disadvantages of the different types of median barriers used by the Department and their typical usage.

Median barriers may also be used in locations other than medians. This would typically occur where a barrier is needed to separate lanes of traffic moving in the same direction or beginning to diverge.



Median Conditions		Recommended Median Barrier Type	Recommended Placement
Width	**Slopes**		
W < 25 ft (7.6 m)	S_1 and S_2 ≥ 10	Rigid or Semi-Rigid	Near center of median
	S_1 or S_2 < 10 and S_1 and S_2 ≥ 8	Semi-Rigid	Near center of median
	S_1 or S_2 < 8	N/A – Consider a roadside barrier along each shoulder.	
W ≥ 25 ft (7.6 m)	S_1 and S_2 ≥ 10	Rigid, Semi-Rigid, or Flexible	Near center of median
	S_1 or S_2 < 10 and S_1 and S_2 ≥ 8	Semi-Rigid or Flexible	Near center of median
	S_1 or S_2 < 8 and S_1 and S_2 ≥ 6	Flexible	2 ft (600 mm) or more from shoulder hinge point and more than 8 ft (2.4 m) from the ditch line bottom
	S_1 or S_2 < 6 and S_1 and S_2 ≥ 4	Flexible	Within 4 ft (1.2 m) of shoulder hinge point and more than 8 ft (2.4 m) from the toe of any front slope
	S_1 or S_2 < 4	N/A – Consider a roadside barrier along each shoulder.	
Other median conditions (e.g., stepped, bermed)		Contact the Bureau of Safety Programs and Engineering.	

GUIDELINES FOR MEDIAN BARRIER SELECTION/PLACEMENT

Figure 38-7.C

38-7.03(b) Design Considerations

Each type of median barrier involves design elements that must be considered in the selection process. Consider the following:

1. Rigid Median Barriers. As noted earlier, the IDOT 44 in. (1120 mm) Double Face Concrete Barrier has been certified as meeting MASH criteria (Test Level 5). As a double-face concrete barrier nears the median pier of an overhead structure or twin separated structures, it may be necessary to split the barrier into two single-face barriers; this requires detailed design. There may also be a need to design details for a transition from the current single-sloped barrier into one of the older F-shape or New Jersey shaped barriers. The Bureau of Bridges and Structures and Bureau of Safety Programs and Engineering should be asked to provide guidance when such treatment is necessary.

2. Semi-Rigid Median Barriers. See Section 38-7.02(b) as it applies to Type D guardrail.

3. Flexible Median Barriers.

    a. Line Post Foundations. The line posts of High Tension Cable (HTC) median barriers may be driven directly into the ground or through a mow strip or may be set into socket-type concrete foundations. Consider the depth of frost penetration. As a rule of thumb, the foundations should be at least 30 in. (762 mm) deep south of I-72, 36 in. (915 m) deep along, and north of, I-72 to I-80, and 42 in. (1065 mm) deep along I-80 and north to the state border.

    b. End Anchorages. HTC median barriers use significant anchorages (foundations) at each end of a run of cables to hold the high tension. The HTC specifications set design requirements and require shop drawings from the contractor for the end anchorages. Where it is necessary to change from a flexible median barrier to another roadside barrier or median barrier, provide an appropriate longitudinal overlap so that each system can operate and the entire median has adequate protection. Leave at least a 10 ft (3.0 m) transverse gap between the systems to provide access and ensure operational integrity. Another option for avoiding conflicts between different barrier types is to begin runs of flexible barrier at the departure ends of bridges; see Figure 38-7.E.

    c. Mow Strips. Mow strips provide a paved area under and immediately adjacent to the barrier. They are provided as a maintenance consideration to ease mowing and minimize nuisance hits. A typical design is a 4 ft (1.2 m) wide, 4 in. (100 mm) thick mat of hot-mix asphalt. If within the shoulder limits, mow strips need to conform to the shoulder slope. Beyond the shoulder limits, mow strips need to conform to the front slope. Avoid drop-offs along the edge of a mow strip. Provide grading, if necessary, to smoothly match the mow strips to the slopes.

    d. Length of Need. The length of an HTC median barrier that can be used to satisfy the length of need (see Section 38-6.01) will vary among the manufacturers.

Because the brand of HTC will not be known during the design, define the length of need point for all types as 50 ft (15.2 m) from the end of the terminal section.

Type	Advantages	Disadvantages	Typical Usage
Rigid	1. Can accommodate most vehicular impacts without penetration 2. Little or no deflection distance required behind the barrier. 3. Little or no damage sustained for most vehicular impacts; therefore, least need for maintenance. 4. Minimum potential for vehicle underride/override or snags. 5. Light supports, sign supports, glare screens, etc., may be mounted on top.	1. Highest initial cost. 2. Can induce vehicular rollover. 3. For some conditions, it has highest occupant decelerations (i.e., it is the least forgiving barrier type). 4. Reduced performance where offset between the barrier and the traveled way exceeds 12 ft (3.6 m). 5. Snow drifting.	1. Urban freeways. 2. For high traffic volumes. 3. For high volumes of heavy vehicles. 4. Where maintenance of a median barrier would result in lane closures with significant impacts to traffic. 5. Works well for moderate to narrow medians.
Semi-Rigid	1. Lower initial cost. 2. High level of familiarity by maintenance personnel. 3. Can safely accommodate wide range of impact conditions for passenger vehicles. 4. Relatively easy installation.	1. Performance for vehicles above 5000 lb (2270 kg) (PU) is not assured. 2. At high-impact locations, will require frequent maintenance. 3. Snow drifting. 4. Hazard until repaired.	1. Moderate median widths, 25 ft to 40 ft (7.6 m to 12.2 m). 2. Low to mid-range of traffic volumes.
Flexible	1. Lowest initial cost. 2. Can be installed in medians where slopes are as steep as 1V:4H. 3. Repairs usually do not require specialized or heavy equipment. 4. Repairs can be quick. 5. Minimizes snow drifting. 6. Can safely accommodate wide range of impact conditions for passenger vehicles and, on 1V:6H or flatter slopes, single-unit trucks. 7. Remains at height and provides some protection after moderate hits.	1. Performance for heavy vehicles (above 18000 lb (8000 kg) (SU) is not assured where slopes are 1:6 or flatter. 2. Performance for vehicles above 5000 lb (2270 kg) (PU) is not assured where slopes are 1:4 to 1:6. 3. Virtually every impact will require some repair. 4. Susceptible to snowplow damage. 5. Learning curve for maintenance forces when introduced to a new area. 6. Deflection space required behind the barrier is 12 ft (3.6 m) unless special designs are developed.	1. Medians wider than 25 ft (7.6 m). 2. For low to moderate traffic volumes where repairs can be made without significant traffic impacts.

COMPARISON OF MEDIAN BARRIER TYPES

Figure 38-7.D

e. Deflection. Flexible median barriers will deflect more than the other median barrier types. When laying out a flexible barrier, allow for 12 ft (3.6 m) of deflection.

If designs for reduced deflection are needed, refer to Figure 38-7.F. This figure allows for reduced deflection based on 10 ft (3.0 m) or 15 ft (4.6 m) post spacing and limited space between end anchors from 300 ft (90 m) and 3000 ft (915 m). If reduced post spacing and/or reduced anchor spacing are required, these must be shown in the contract documents. Deflection values may be interpolated between these two curves, but may not be extrapolated. These curves are not to be used where the convex side of a curved flexible barrier installation is between traffic and a hazard. Contact BSPE for this case.

It is desirable to locate flexible median barriers so that an impacting vehicle will not be allowed to encroach into the traveled way beyond the barrier. However, in some applications, the deflection distance of a median barrier will encroach into the opposing lane. This is permissible when the barrier placement requirements dictate because not all hits will develop the full deflection, the encroachments will be momentary, and the limited encroachment is preferable to allowing a vehicle to enter the opposing traffic unchecked. In addition, many cases may occur where the cable is an interim safety measure until more extensive reconstruction can be accomplished.

f. Length of Installation. Very long installations (more than 3 miles (5.0 km)) of HTC may be possible; review manufacturer's recommendations. However, the designer should remember that an impact at the terminal will release tension throughout the entire run of cable. The designer should weigh the advantages and disadvantages of long runs of barrier versus the loss of performance during the time between a terminal hit and its repair.

Very long runs of HTC will also inhibit turnarounds by police and emergency first responders.

g. Alignment. HTC will not accommodate abrupt changes in vertical alignment. Crossing of abrupt sags will leave the cable too high and cause posts to be pulled upwards or cables to be lifted above correct mounting heights. Crossing of abrupt crests will place severe downward stress on cable supports and will result in low cable height after one impact. Mainline freeway alignments are unlikely to experience this problem, but cable profiles along median surfaces may vary due to drainage features, crossovers, pier locations, and other median details. These issues are minimized with an installation along or near a shoulder and usually must be addressed for locations closer to the median center. Breaking and overlapping the runs of HTC at crest or sag vertical curves is a strategy to minimize this effect, and may also be coordinated with changes in the preferred side of installation; see Figure 38-7.E.

If the radius of horizontal curvature is 1200 ft (366 m) or less, check the manufacturers' recommendations to confirm which systems may be used.

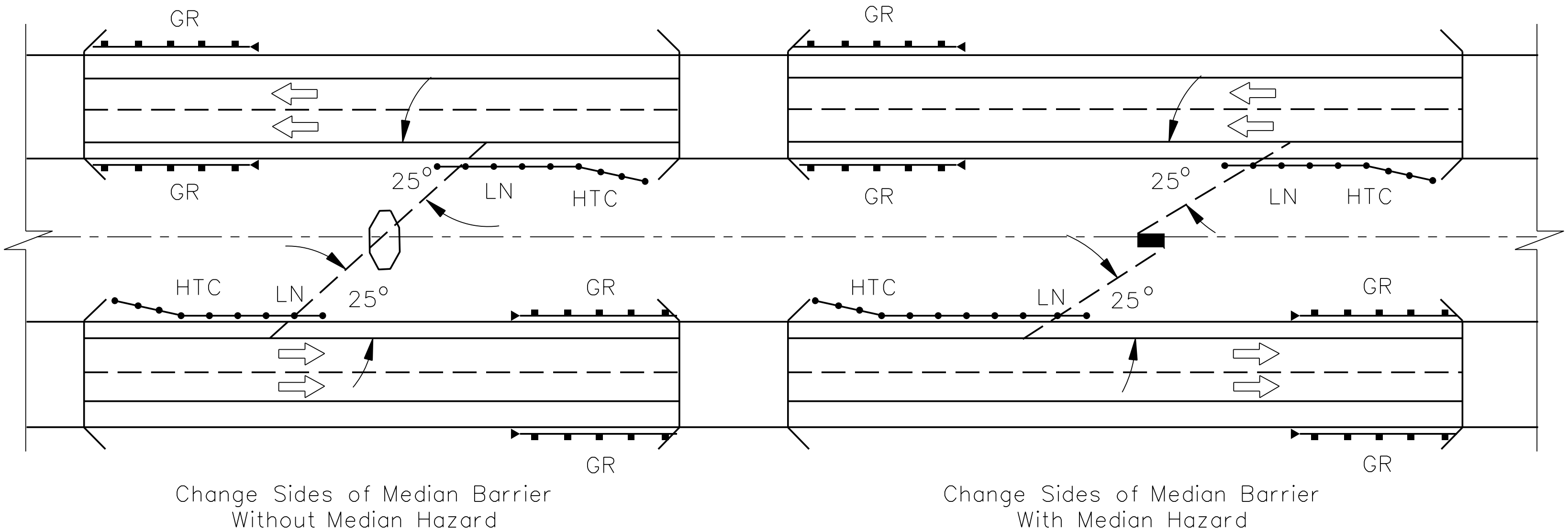
When placing HTC near a shoulder around a curve, it should ideally be located where the near traffic is making the left-hand curve (inside of curve relative to near traffic). This may reduce nuisance hits and allow more vehicles leaving the opposing roadway to come to a stop in the median before reaching the barrier. Also, traffic impacting the barrier on its convex side will result in increased deflection that can better be tolerated in the median.

If the barrier must be placed on the outside of a curve with superelevation of 3% or greater, it must be within 2 ft (0.600 m) of the edge of shoulder.

h. Elevation Differences. Where each roadway is on independent profile, especially if one is significantly higher than the other, it is generally preferred to place the median barrier along the higher roadway. This consideration should be balanced along with the alignment considerations; see Item g. above.

i. Delineation. Where the HTC is placed along a shoulder, apply reflective caps, reflective tape, or reflectors to the posts of the system at spacing and offsets similar to those used for guardrail reflectors.

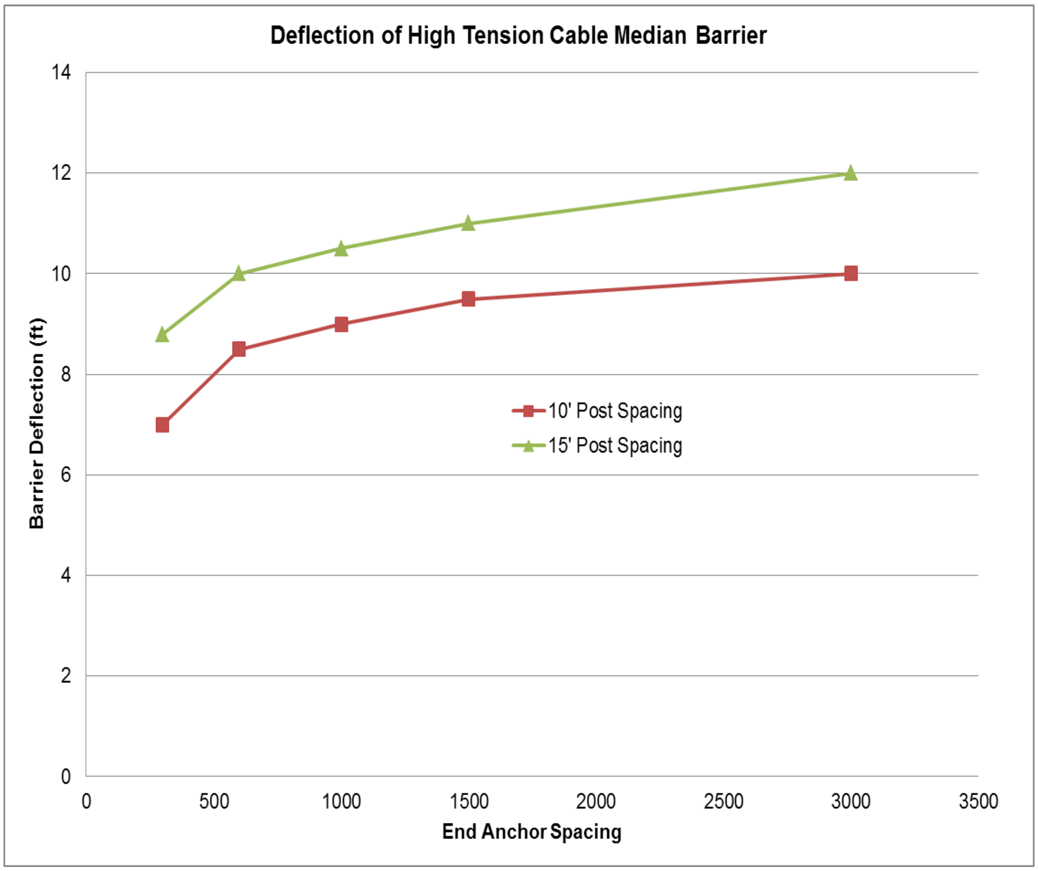
j. Coordination. It is important to involve local emergency responders during Phase I development, at the preconstruction meeting, and during any hands-on demonstrations provided by the HTC manufacturer. Cutting of cables should be discouraged. Replacement/splicing of cut cables is much more expensive and time consuming than resetting of intact cables. Contractor and manufacturer personnel can instruct emergency responders about alternatives to cutting cables and methods to disengage vehicles. Also, coordinate with emergency responders to ensure safe median and shoulder access is provided.



LN = Length of Need Point
GR = Guardrail
HTC = High Tension Cable

COORDINATION OF HIGH TENSION CABLE WITH STRUCTURES AND CROSSOVERS

Figure 38-7.E



Cable Median Barrier Deflection vs Post Spacing and End Anchor Spacing

Figure 38-7.F

38-7.04 Median Barrier Layout

Much of the information presented in Section 38-6 on roadside barrier layout also applies to median barriers (e.g., placement behind curbs). The following sections present criteria specifically for the design of median barriers.

38-7.04(a) Sloped Medians

Slopes in the median affect the performance of a barrier. A vehicle traversing a slope, or transitioning between two slopes, prior to impact may not impact the barrier with all four tires on the ground, may have its suspension compressed, or may have a tendency to roll. Where the impact is made under these types of conditions, the crash results may be undesirable. The recommendations for median barrier type and placement considering slopes are shown in Figure 38-7.C.

38-7.04(b) Flared/Divided Median Barriers

It may be necessary to flare a median barrier to a different offset from the traffic lane. Also, a sloped median, a fixed object in the median, or twin separate bridges may require that a median barrier be divided. The median barrier may be divided by one of the following methods:

1. Rigid Median Barriers. A fixed object may be encased within a concrete barrier or a single-faced concrete barrier may be placed on both sides of a fixed object, see Figure 38-7.G.
2. Semi-Rigid Median Barriers. Steel plate beam guardrail, Type D, may be divided into two separate runs of guardrail passing on each side of the median hazard (fixed object or slope), see Figure 38-7.H.
3. Flexible Median Barriers. HTC barriers may be placed on either or both sides of a median hazard, provided adequate deflection distance is available. If the HTC runs on only one side of the hazard, a roadside barrier or impact attenuator should be used as needed to protect traffic in the opposing direction.

Flare rates for rigid or semi-rigid systems should be according to the guidelines for roadside barriers. Flexible barrier may be flared at a rate of 1:50.

38-7.04(c) Barrier-Mounted Features

Luminaire supports are often mounted on top of concrete barriers, and the top height is typically able to accommodate them. However, the designer should recognize that a zone of intrusion [see Section 38-6.03(6)] is a relevant concern when a concrete barrier divides to pass on either side of an obstacle or when features are mounted on top of a concrete barrier. If trucks or buses impact the concrete barrier, their high center of gravity may result in a vehicular roll angle which possibly will allow the truck or bus to impact the features on top of or immediately adjacent to the concrete barrier. The 44 in. (1120 mm) Double Face Concrete Barrier provides sufficient height to substantially reduce past concerns (with lower-height barriers) regarding the zone of intrusion. However, a designer should consider whether there are opportunities to split a standard barrier into two separate single-face barriers while providing a 2 ft (600 mm) to 3 ft (900 mm) offset distance between the barrier face and obstacle (e.g., bridge piers or poles).

38-7.04(d) Terminal Treatments

As with roadside barrier terminals, median barrier terminals present a potential roadside hazard for run-off-the-road vehicles. Therefore, the designer must carefully consider the selection and placement of the terminal end. Where practical, the median barrier should be extended into a wider median area so that the terminal is further from traffic. The following *NCHRP Report 350* or MASH terminals are used by the Department for median barriers:

1. Rigid Median Barriers. The end of a concrete barrier is typically shielded with an impact attenuator. The Department maintains a Qualified Products List (QPL) on its website. *NCHRP Report 350* or *MASH* passed devices are required as noted on the QPL, which is regularly updated to list the approved devices, noting their MASH testing status and associated Test Level.

2. Semi-Rigid Median Barriers. Steel plate beam guardrail, Type D, is typically shielded with an impact attenuator. Refer to the discussion on rigid median barriers above.

3. Flexible Median Barriers. For HTC barriers each system has its own proprietary terminals. The terminals included in the QPL meet the requirements of *NCHRP Report 350* or MASH, and testing status is noted.

38-7.04(e) Superelevation

Chapter 32 discusses superelevation development for multilane divided facilities. Where a median barrier is present, the axis of rotation is typically about the two median edges. This will allow the median (and the barrier) to remain in a horizontal plane through the curve. See Chapter 32 for more information.

38-7.04(f) Median Crossovers Locations

1. Permanent Locations. Chapter 44 provides guidance and further reference for the location and design of permanent median crossovers. Proper installation of median barriers must take permanent median crossovers into account as there will be a break in the barrier. Where a break is exposed to approaching traffic, it will require treatment according to Section 38-7.04(d). Consider the following:

    a. The most common method for providing an opening in a median barrier for a permanent crossover is to establish a gap in the barrier.

b. For rigid or semi-rigid barriers, the gap should fit the geometry of the permanent crossover and provide the required throat width for the crossover, plus allowance for any radii or flares.

c. For flexible barriers, keep the end anchorage location about an additional 30 ft (9.0 m) away from the completion of the radii or flares. This will help to prevent damage to the terminals by vehicles using the median crossovers that would release tension on the entire run of barrier. Also, for HTC consider changing sides of the median at median crossovers. This will provide slightly better length of need coverage and also provide an opportunity to introduce the change of sides for reasons discussed in Section 38-7.03(b) and as shown in Figure 38-7.I.

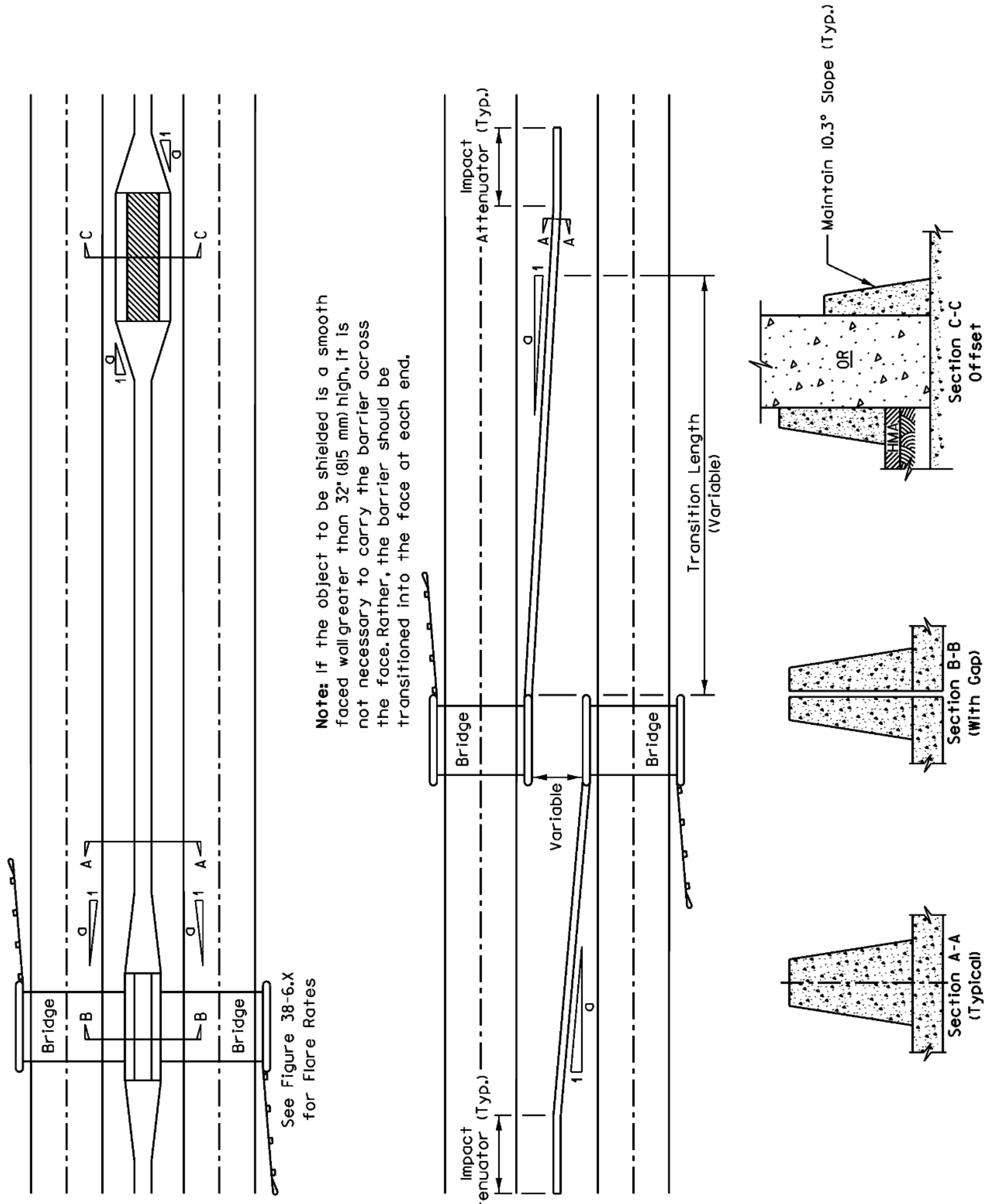
d. Another way to create an emergency location for crossing the median is to leave a gap while at the same time changing the side of the median for the barrier. In this application, the length of need points for the barriers should be connected by a line departing the traveled way at a 25 degree angle. This will provide continuous protection of the median for most departing vehicles; see Figure 38-7.E.

e. Proprietary barrier gates are available for concrete median barriers. These gates are opened by manual means or by electric motors depending on the brand and options selected. These gates should only be used on a case-by-case basis and when supported by a decision according to Section 66-1.04(b).

2. Temporary Locations. For HTC barriers it is possible to create or anticipate temporary locations for emergency use.

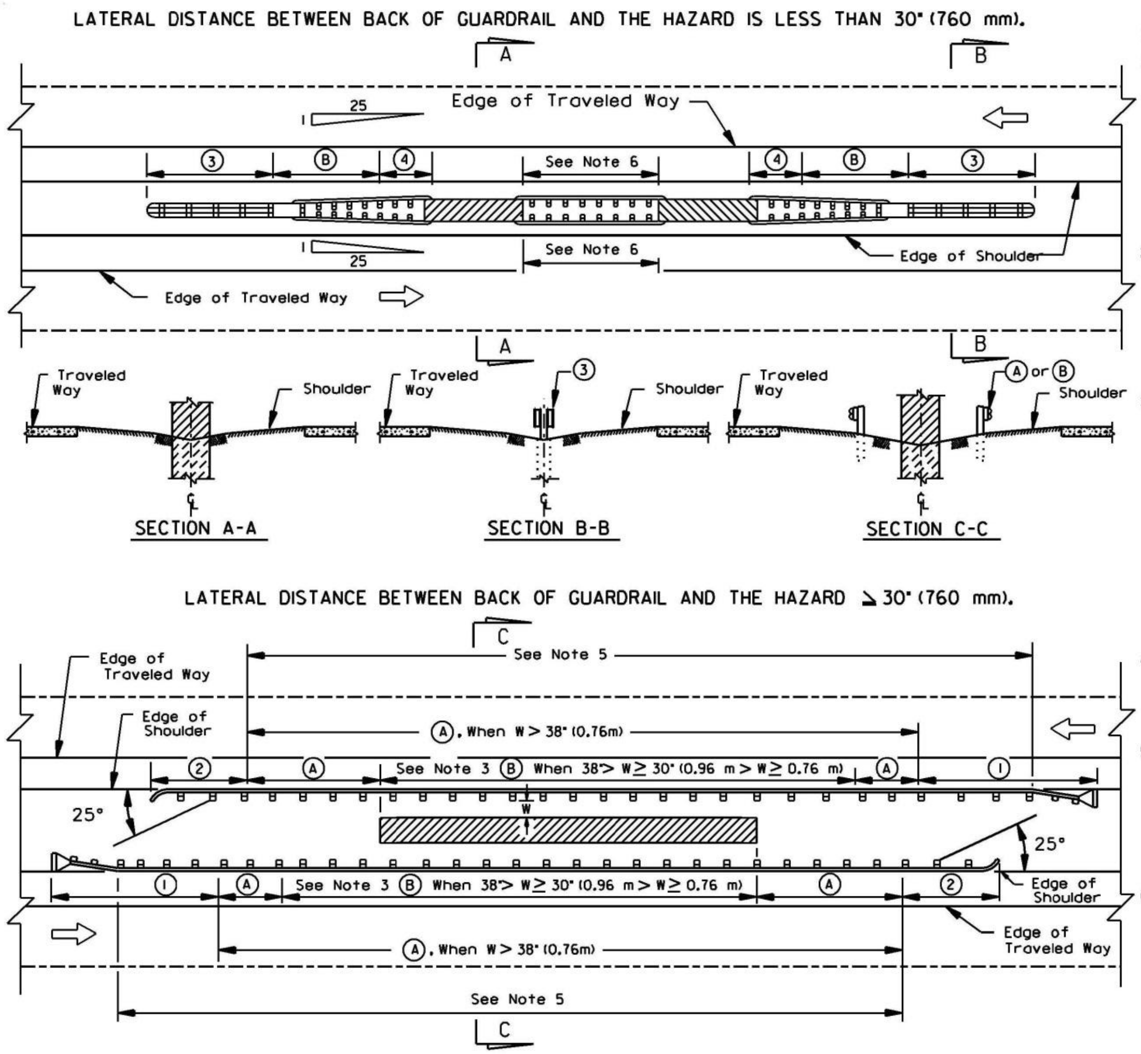
a. Where socketed posts are used, it is possible to remove the cables from a sufficient number of posts, or disconnect the cables at the turnbuckles, and create slack. Once cable slack is present, sufficient posts may be removed to create temporary crossover locations.

b. Careful selection of well-drained locations for changing sides for HTC can allow emergency vehicles to make serpentine moves across the median were soil conditions are sufficiently stable. For example, this may indicate ditch check locations or pier locations.



FLARING/DIVIDING CONCRETE BARRIER

Figure 38-7.G



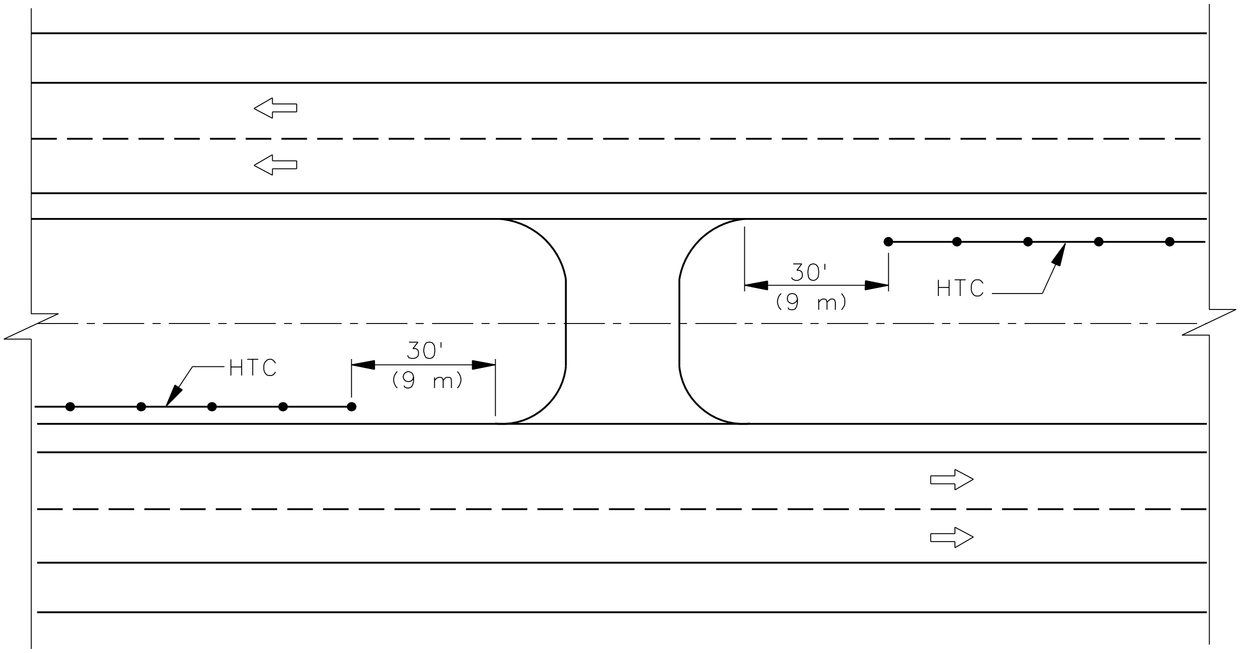
Notes:

1. Traffic Barrier Terminal Types:
   - (1) Type I (Special)
   - (2) Type 2
   - (3) Impact Attenuator
   - (4) Type 6 or 6B
2. Steel Plate Beam Guardrail Types:
   - (A) Type A
   - (B) Type B
3. Provide min. 25' (7.62 m) of Type B guardrail in advance of hazard. Provide Type A guardrail as needed to meet length of need. If Type A guardrail is not required, Type B guardrail may be connected directly to traffic barrier terminal Type I, special.
4. Where the foreslope is 1V:10H or steeper, locate guardrail at shoulder edge.
5. Total length of barrier includes length of need on each end of the hazard plus the length required immediately adjacent to the hazard. See Section 38-6.01.
6. Close gap between piers with concrete barrier, or connect Type 6 or 6B terminals to each, and maintain 18.5" (470 mm) post spacing and nested thrie beam from pier to pier.

Drawing not to scale.

DIVIDING STEEL PLATE BEAM GUARDRAIL

Figure 38-7.H



HIGH TENSION CABLE AT MEDIAN CROSSOVERS

Figure 38-7.I

38-7.05 Glare Screens

38-7.05(a) General

Headlight glare may be defined as a sensation experienced when a person's vision is interrupted by a light source which has a much higher intensity than the surrounding area. It is frequently cited as a major contributing factor in nighttime crashes that occur on unlighted highways The magnitude and severity of headlight glare depends on various combinations of a wide variety of factors, including:

- headlight systems, which include the headlight configuration, mounting height, and output intensity;
- roadway features, which include the roadway alignment, geometrics, and pavement reflectivity;
- transmission media, which includes the atmosphere and physical features through which the light must pass, such as windshields and eyeglasses; and
- human variables, which include driver's age, visual ability, and fatigue.

Depending on the severity and effect glare has on a driver, it may be classified as discomfort or disability glare, defined as follows:

1. Discomfort. Discomfort glare does not necessarily impair the vision. However, it frequently causes drivers to become tense and apprehensive, which increases the level of fatigue and may lead to driver error. This type of glare is common and usually occurs where median or outer separator widths are greater than approximately 30 ft (10 m).

2. Disability. Disability glare definitively impairs a driver's vision, frequently causing temporary blindness; consequently, it should be addressed whenever practical. Disability glare occurs usually where median or outer separator widths are less than approximately 30 ft (10 m) in width, on horizontal curves, where the opposing traveled ways are at different elevations, and/or where transitions alter the highway horizontal alignments of the directional roadways.

38-7.05(b) Design Considerations

As indicated, headlight glare from opposing traffic can be bothersome and distracting. Glare screens can be used with or without median barriers to greatly reduce the problem and should be used when no other practical alternative exists to eliminate disability glare (e.g., wider median, outer separation, highway lighting, landscaping). The designer should consider if the following conditions exist when determining the need for a glare screen:

- unlighted divided highways where design speeds are 50 mph (80 km/hr) or greater and medians 30 ft (9.0 m) or less in width;
- horizontal curves on divided highways;
- points where the separation between a mainline and frontage road is minimal and alignment is such that mainline traffic is affected by the lights of vehicles using the frontage road;
- points of transition which create critical glare angles between opposing vehicles;
- locations where nighttime crash rates are unusually high; and
- any location where conflicting light sources cause a distorted or confusing view of the driver's field of vision.

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 and the narrow separation may make headlight glare especially bothersome. The designer should consider the use of glare screens at these sites. A key element warranting their use is the number of public complaints received for a highway section.

38-7.05(c) Glare Screen Types

The following describes the glare screens used by the Department:

1. Concrete Glare Screen. . The current single slope double face concrete barrier has a height that lessens the frequency of glare concerns compared to older lower barriers, but these concerns persist under certain conditions. Where a glare screen is warranted for a section of roadway with concrete barrier, the designer may specify a concrete glare screen. See the *Illinois Highway Standards* for details. This type of glare screen is advantageous on high-volume routes due to its low maintenance.

2. Glare Screen Blades. As an alternative to the concrete glare screen, a series of thin vertical blades may be mounted on top of the concrete barrier. The designer must specify the spacing, height, and longitudinal spacing of the blades on the plans. Please contact the Central Bureau of Materials when considering the use of glare screen blades.

3. Fence Glare Screen. A fence glare screen usually consists of fabric lined fence or a fence with slats woven into the fence material. This type of glare screen is typically used in controlling glare between the mainline and adjacent frontage roads where an access control fence is usually required. In addition to alleviating glare, the fence will restrict potential unpermitted access between two closely spaced facilities.

38-7.05(d) Glare Screen Design

The following applies to the design of a glare screen:

1. General. Glare screens must not be used as a wind or snow shield nor should they detract from the aesthetics of the highway. However, they should be durable and easy to maintain.

2. Cutoff Angle. Glare screens should be designed for a cutoff angle of 22 degrees. This is the angle between the median centerline and the line of sight between two vehicles traveling in opposite directions; see Figure 38-7.J. The glare screen should be designed to block the headlights of oncoming vehicles up to the 22 degree cutoff angle. On horizontal curves, the design cutoff angle should be increased to allow for the effect of curvature on headlight direction:

   $$\text{Cutoff Angle (in degrees)} = 22 + \frac{5729.6}{R} \quad \text{(US Customary)}$$

   $$\text{Cutoff Angle (in degrees)} = 22 + \frac{1746.8}{R} \quad \text{(Metric)}$$

   Where:

   R = radius of horizontal curve in feet (meters)

3. Horizontal Sight Distance. Glare screens may reduce the available horizontal sight distance. For curves to the left, the designer will need to check the middle ordinate to determine if adequate stopping sight distance will be available; see Section 32-4.

4. Sag Vertical Curves. When determining the necessary glare screen height, the designer may ignore the effect of sag vertical curvature.

5. Height of Eye. The average driver's eye height is 3.5 ft (1065 mm) for passenger vehicles and 7.6 ft (2.3 m) for large trucks. These heights are averages and must be adjusted when considering outlying conditions.

6. Glare Screen Height. The upper and lower elevations of the glare screen must be such that light does not shine over or under the barrier. The height of glare screens may be established by examining the following factors:

   a. height of driver's eye in relation to the pavement,

   b. height of the headlights of various size vehicles in relation to the pavement, and

   c. changes in elevation across the entire roadway width including the median.

7. Coordination of Glare Screen with Concrete Barrier. The preceding steps cover design of glare screen. However, calculation of detailed height requirements does not imply that the height of glare screen should vary repeatedly from location to location along a job. Select the height to bracket the needs of the section or logical segments. In addition, the height to the top of glare screen should be determined using standard devices and the following steps:

   For locations where the 44 in. (1120 mm) concrete barrier is used, the concrete glare screen may be added to reach a height of 63 in. (1600 mm). If heights greater than 63 in. (1600 mm) are required, then glare screen blades or special designs using concrete may be considered. The addition of taller concrete barrier or concrete glare screen raises issues regarding control of debris scatter from a collision, as well as the necessary shape and slopes for the taller sections. Contact BDE to coordinate any designs using concrete glare screens above a height of 63 in. (1600 mm).

* * * * * * * * * *

Example 38-7.05(1)

Given: Six-lane divided highway
12 ft travel lanes
2% pavement cross slope
5 ft median width

Problem: Determine the upper and lower elevations of the glare screen.

Solution: First, determine the lower elevation based on the following factors:

1. The most severe condition is two sport cars traveling in opposite directions each using the right-hand lane.

2. The eye level of the drivers is 3 ft above the pavement.

3. The lower edge of the sport car's headlights is 1.75 ft above the pavement.

4. The driver's eyes are approximately 8.75 ft from the outer edge of the traveled way.

5. Figure 38-7.K presents the determination of the lower edge of the glare screen.

Next, determine the upper elevation based on the following factors:

1. The most severe condition is two large trucks traveling in opposite directions, one using the right-hand lane and the other using the left-hand lane.

2. The eye level of the drivers is approximately 7.6 ft above the pavement.

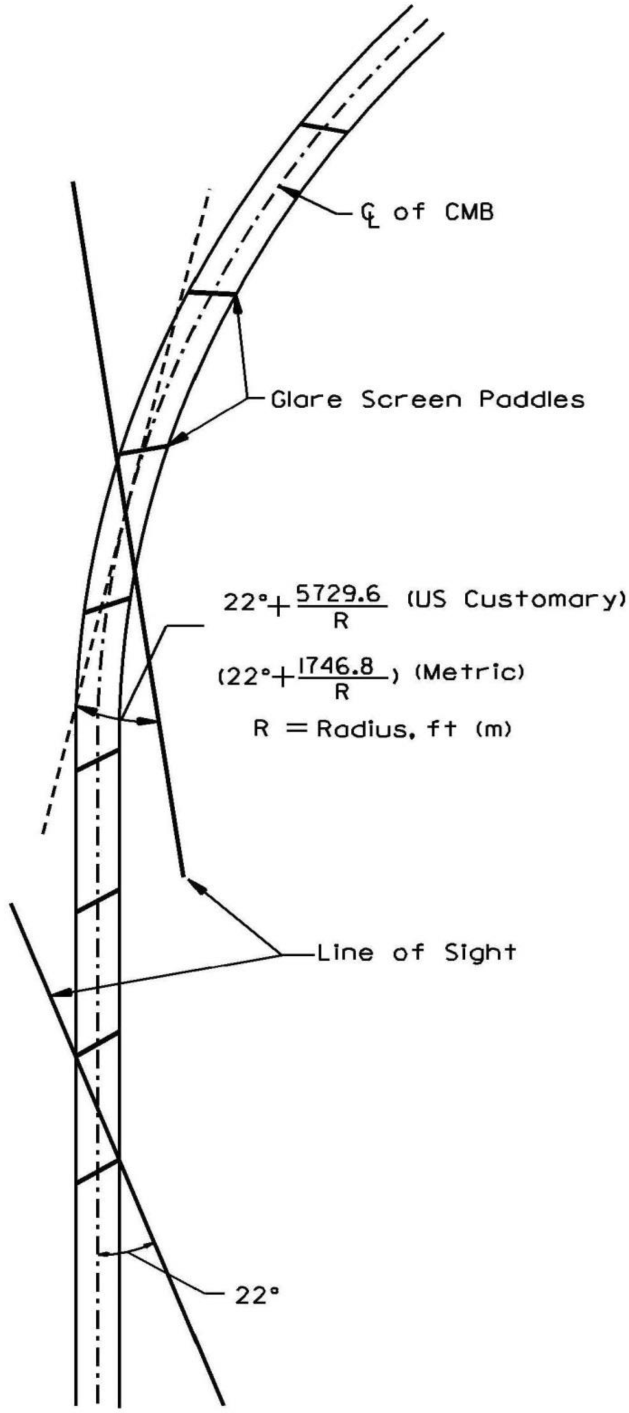
3. The lower edge of the truck headlights is 3.75 ft above the pavement.

4. The eye of the driver using the left-hand lane is approximately 5.75 ft from the median centerline.

5. The left headlight of the truck using the right-hand lane is approximately 4.5 ft from the outer edge of the traveled way.

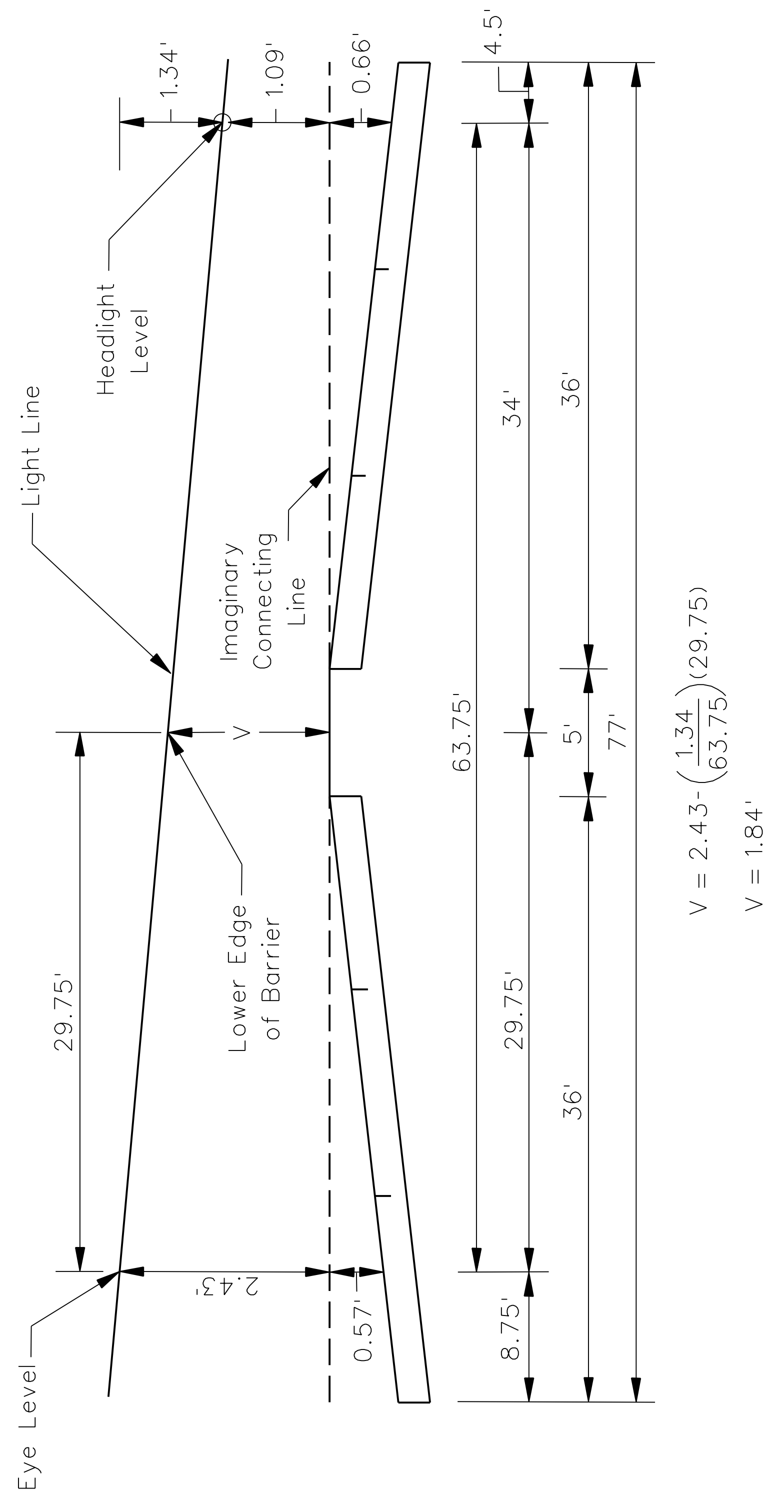
6. Figure 38-7.L presents the determination of the upper edge of the glare screen.

For most locations, it is not necessary to use this upper level; see Section 38-7.05(c).



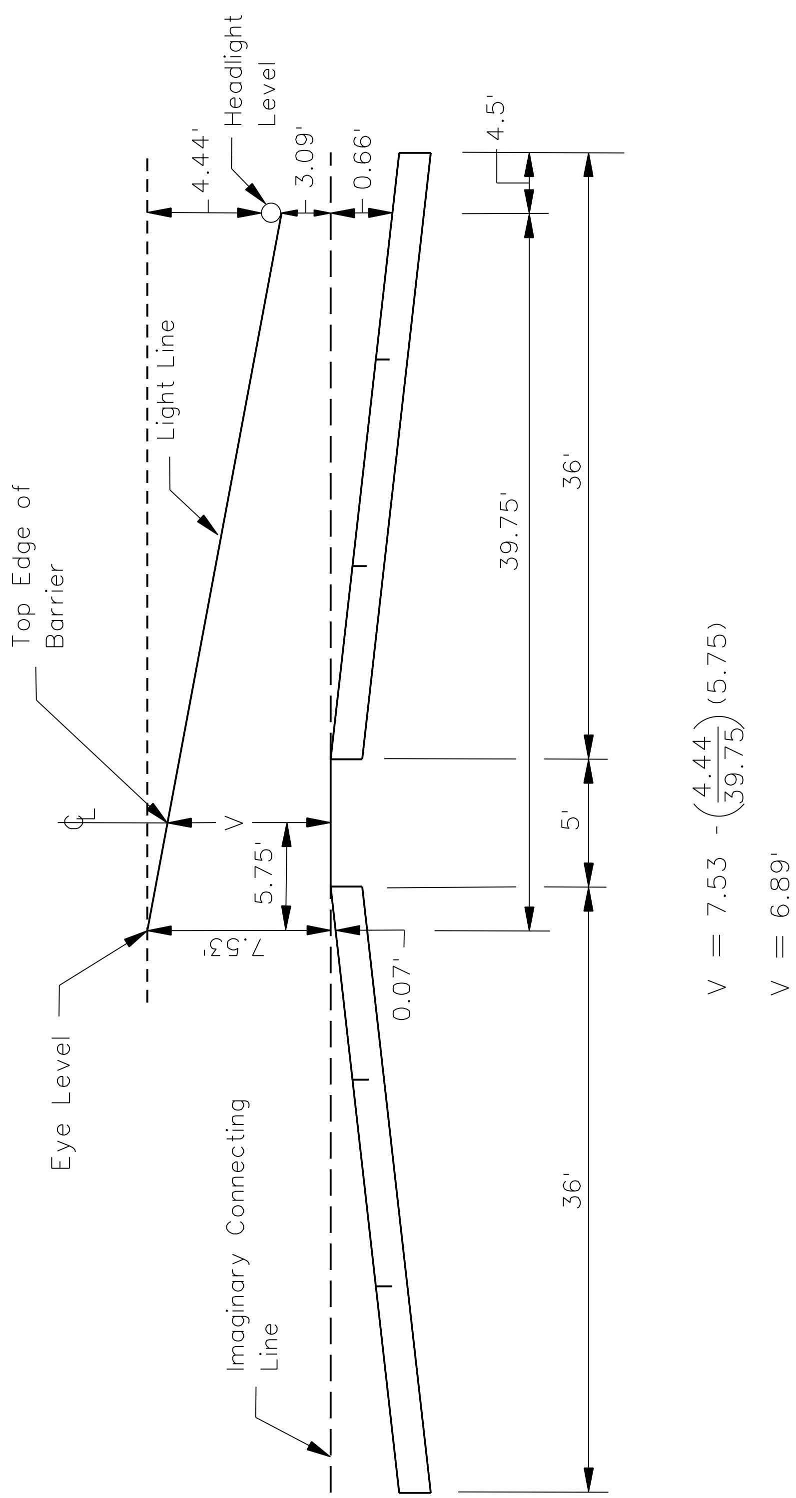
CUTOFF ANGLE FOR GLARE SCREENS

Figure 38-7.J



LOWER ELEVATION OF GLARE SCREENS
(Example 38-7.05(1))

FIGURE 38-7.K



UPPER ELEVATION OF GLARE SCREENS
(Example 38-7.05(1))

Figure 38-7.L

38-8 IMPACT ATTENUATORS (Crash Cushions)

38-8.01 General

Impact attenuators (crash cushions) are protective systems that prevent errant vehicles from impacting hazards by decelerating them to a stop after a frontal impact, by redirecting them away from the hazard, or by decelerating them after a side impact. They operate on the basis of either energy absorption or momentum transfer. Impact attenuators are adaptable to many roadside hazard locations where longitudinal barriers cannot practically be used. Selection of the appropriate device or system must consider the corridor design speed and required test level as described earlier in this chapter.

Impact attenuators have two primary applications. They may be installed as stand-alone devices to shield point hazards (e.g., bridge piers, sign foundations) or they may be used as terminal treatments for roadside or median barrier systems. Where used to shield a point hazard, the impact attenuator is placed very near or in contact with the hazard; therefore, no length of need applies, and no additional barrier is required. This application may be appropriate only where the shoulder and/or front slope in the runout area is 1V:10H or flatter and other requirements of the impact attenuator layout (e.g., pad or base, physical room for the system) can be accommodated. Otherwise, a roadside barrier or median barrier, as appropriate should be used.

38-8.02 Warrants

Impact attenuator warrants are the same as barrier warrants. Once a hazard is identified, the designer should first attempt to remove, relocate, or make the hazard break away. If these options are impractical an impact attenuator should be considered.

For median widths of 84 ft (26 m) or less, all piers, sign foundations, and similar hazards in medians of divided highways warrant shielding. For median widths greater than 84 ft (26 m), the need should be considered on a case-by-case basis.

38-8.03 Impact Attenuator Types

38-8.03(a) Overview

Selection of the most appropriate impact attenuator type depends on a variety of factors:

1. Redirective Properties. The impact attenuator devices have various properties related to the path of a vehicle after impact.

2. Operational Principles. The systems have varied means to deal with the energy or momentum impacted by an impact.

3. Maintenance and Repair Issues. Some systems retain residual capacity to absorb additional frontal impacts during the time between an initial crash and full repair of the system. Systems vary in the cost and effort required for repair of crash and nuisance hits.

4. Approved Devices. To be considered for use on Illinois highways, a given device must be included on the Department's QPL.

5. Physical Placement Requirements. The size, layout and anchorage requirements may dictate or eliminate various systems depending on the type of location where protection is required.

6. Costs. Given the wide variation in the approaches to the above considerations, the systems vary in cost of installation and repair. Life cycle cost analysis using the Roadside Safety Analysis Program (RSAP) may be a useful tool.

7. Pedestrians/Bicyclists. In some installations, impact attenuators may be introduced into the pedestrian/bicyclist environment. This will require consideration of various factors to evaluate the relative risks to the vehicular traffic and pedestrian/bicyclist traffic.

All of these factors, taken together, guide impact attenuator selection. The selection process for both permanent and temporary devices, is covered in this section. Impact attenuators are moving toward compliance with MASH testing criteria. The QPL is regularly updated to note the testing status of each proprietary device as well as the approved test levels.

38-8.03(b) Redirective Properties

Impact attenuators are further categorized by how they redirect impacting vehicles.

1. Fully Redirective Devices. A fully redirective device will safely redirect a vehicle that impacts at any location along the face of the device.

2. Partially Redirective Devices. A partially redirective device will safely redirect a vehicle that impacts downstream of a given length of need point along the length of the device. This type of device will allow a vehicle impacting between the length of need point and the free end of the impact attenuator to pass through to the area behind the device.

3. Non-Redirective Devices. A non-redirective device will either capture an impacting vehicle or allow it to pass through when hit along the face of the device.

38-8.03(c) Operational Principles

1. Energy Absorbing Devices. This type of impact attenuator operates on the principle of absorbing the energy of the vehicle by various means, including crushing or deformation of engineered modules, friction of moving parts, or by compression of a hydraulic cylinder. Some energy is also absorbed by the impacting vehicle as the front end of the vehicle is crushed on impact. Energy absorbing attenuators require rigid back-up support or connection to another barrier system to contain the forces created by the deformation of the device. This support may be supplied as part of the impact attenuator or may be derived from its connection to the barrier or hazard (e.g., concrete structure). This distinction may preclude the use of some systems for shielding point hazards that will not

provide this support. In these cases, a special provision limiting the selection to no less than two alternatives may be required. This type of device also requires vertical and lateral anchoring. This is accomplished by attachment to a bituminous or concrete base or by placement of posts. Devices of this type capture or rebound the vehicle in a frontal impact. For side impacts, the devices work either as fully redirective or partially redirective.

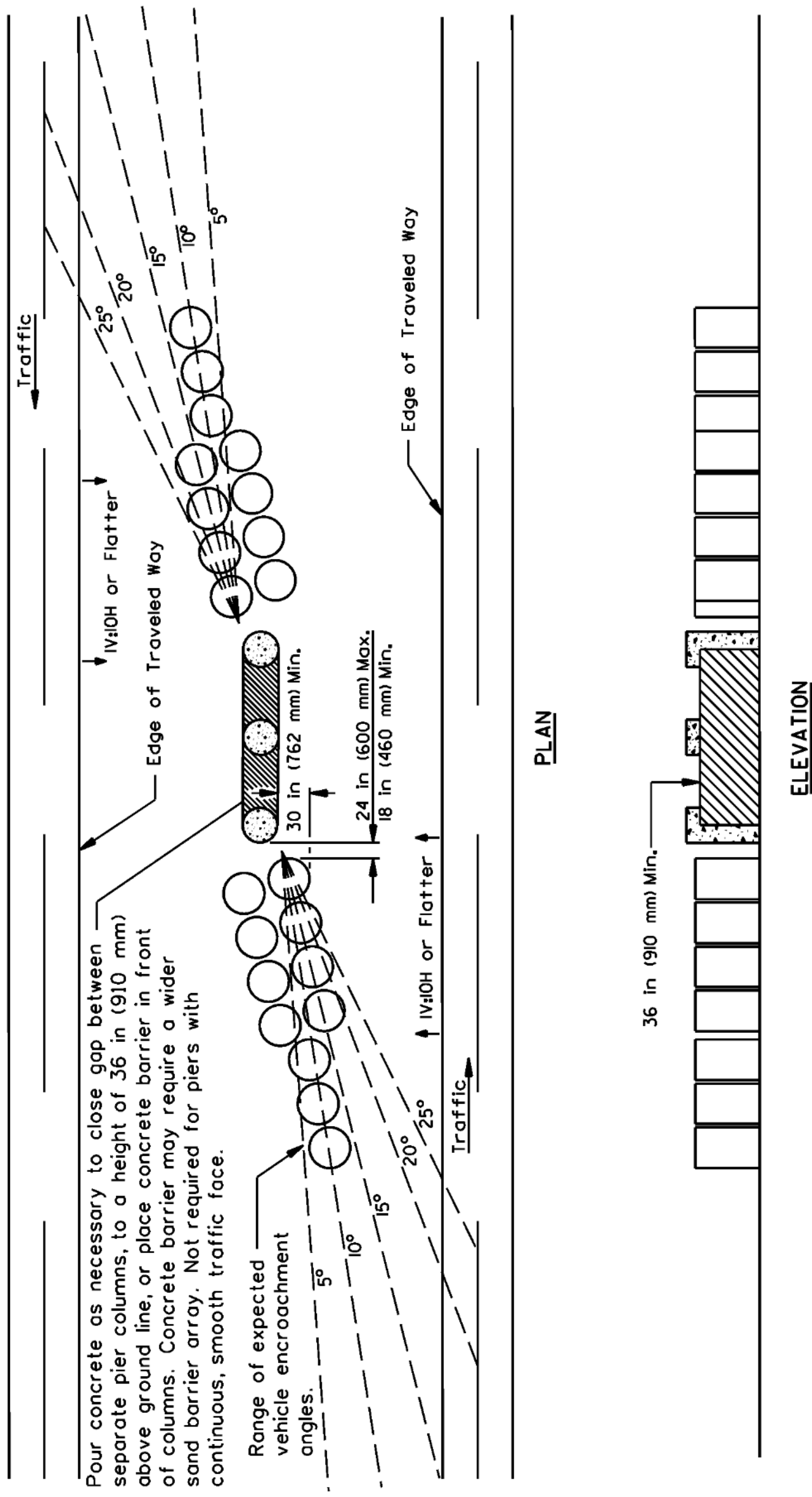
2. Momentum Transfer Devices. This type of system operates by transferring the momentum of an impacting vehicle to an expendable mass of material contained in the device.

   a. Sand Modules. A typical momentum transfer device is an array of sand-filled plastic modules. The Department has developed standard arrays for both Test Level 2 and Test Level 3 (see *Highway Standard* 643001). Once the Test Level is selected for a project (TL-2 or TL-3), the number of modules used in the standard sand module array need not be altered, except to provide lateral protection as discussed immediately below:

   The sand module impact attenuator design should allow for safe side impacts. Figures 38-8.A and 38-8.B illustrate two methods to modify the sand module design to accommodate angle impacts. Figure 38-8.A illustrates how the modules may be shifted to afford attenuation at the end points and direction along the sides of the hazard by closing or covering the gap between pier columns. Figure 38-8.B illustrates where the side of the hazard and available space are such that full protection, through attenuation only, can be provided by the use of additional modules to widen the standard array. Although the entire area of the hazard must be shielded from angle impacts either by attenuation or redirection, the permissible attenuation may be varied to optimize space and economy.

   The sand module systems require no back-up support or connection to another system. However, they do require a firm and stable base. For permanent systems, an HMA or PCC base is required. For temporary installations not to be placed over a winter, an aggregate base may be used. Sand modules have no redirective capability and generate considerable debris upon impact. On the approaching traffic corner, the exterior modules must be laterally offset at least 2.5 ft (750 mm) from the corner of the hazard; see Figure 38-8.A.

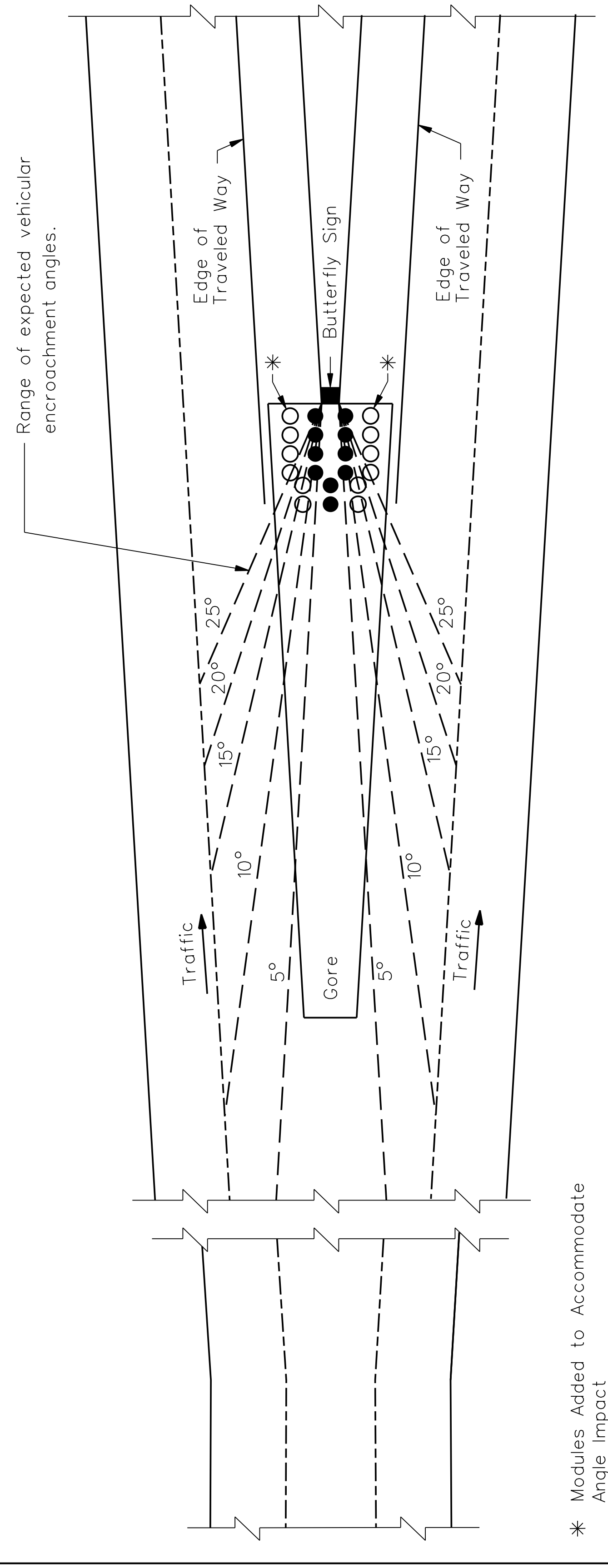
   Show the layout of sand modules, including positioning relative to the hazard, in the plans. Note the Test Level (TL-2 or TL-3) for which the array is designed.



Typical installation of a freestanding, sand-filled container type impact attenuator in median.

ANGLE IMPACT AND POSITIONING DESIGN FOR SAND BARRELS

Figure 38-8.A



TYPICAL INSTALLATION OF A FREESTANDING, SAND-FILLED, CONTAINER-TYPE IMPACT ATTENUATOR SYSTEM IN A MAJOR FORK

ANGLE IMPACT DESIGN FOR SAND BARRELS

Figure 38-8.B

b. Water Filled Impact Attenuator. The water-filled barrier dissipates energy both by energy transfer (crushing of modules) and by momentum transfer to the system's mass. Water filled impact attenuators also have no redirective capability and may spread water in the area of an impact. These impact attenuators are used with temporary barriers only when freezing is not a concern, and must be attached to the barrier system. They do not require anchorage to the pavement or base. Water filled impact attenuators require less width for placement than do sand module impact attenuators.

Figure 38-8.C gives comparisons of systems based on their operational principles.

38-8.04 Maintenance and Repair Considerations

Some systems require extensive repairs or replacement after a full speed impact, while some others may only require minor adjustments and/or replacement of drop-in modules or simply resetting with minimal repair parts. Additionally, some systems retain partial capability to shield a hazard after an initial impact and before repair.

Sand modules are particularly vulnerable to nuisance hits from mowers or wide vehicles. Such occurrences may puncture the plastic modules and cause loss of sand, thereby rendering the devices less effective. Care should be taken to provide some buffer space on the pad for sand modules to allow for mower overhang. A minimum suggested buffer is 12 in. (300 mm) along the sides and front of the array.

Impact attenuators that incorporate tracks or guides anchored to a base may be subject to accumulation of road debris (e.g., sand and silt). In extreme cases and conditions these may interfere with the operation of the attenuator. Generally, attenuator locations should be kept out of depressed locations or other sites that encourage deposition of debris. Where this is unavoidable, the designer may "write out," by special provision, any specific impact attenuators that have critical moving parts (e.g., tracks, guides, rollers, cables) near the ground line.

38-8.04(a) Resettable Devices

Resettable devices are those that do not usually require significant repair parts but may require some work to return the system to a crashworthy configuration ready for the next impact. The initial cost for these systems is intermediate between severe use (see Section 38-8.04(b)) and other fully-redirective devices. These devices are cost-effective where significant impacts may occur one or more times in a three-year period. Spreadsheets are available for more detailed analysis. Contact the Bureau of Safety Programs and Engineering for more information.

Operational Principal	Advantages	Disadvantages
Energy Absorbing Devices	• Little or no debris after a hit. • Ease of maintenance after a hit. • Some systems retain partial attenuation capacity after a hit. • Protection from pocketing at transition from impact attenuator to hazard. • Adaptable to very narrow hazards.	• Possible high initial cost. • Considerable site preparation (e.g., pad, back-up structure, mounting bolts or anchors). • IDOT pay items and specifications will cover hazards up to only 90 in. (2.25 m) wide. See Section 38-8.06. • Not suitable for spanning structural expansion joints. Special details required in plans. Contact BSPE if this application is required.
Momentum Transfer Devices (Sand Modules)	• Relatively low initial cost. • Ease of installation. • Versatile; can be used to cover a large area.	• Considerable debris after a unit is hit. • Generally, no residual attenuation capacity after a major hit. • No side redirection and little or no protection at transition for impact attenuator to hazard. • Considerable inventory of parts and space for replacements required. • Modules may “walk” when placed on structures. Contact BDE if this application is required.
Momentum Transfer Devices (Water Filled)	• Relatively low initial cost. • Ease of installation. • Little or no site preparation. • Does not require anchorage to a paved base. • Adaptable to very narrow hazards. • After impact, can be restored quickly by two laborers and a water supply/tank.	• Water on ground or pavement immediately after a hit. • Require environmentally friendly antifreeze for cold weather application. • Attaches only to concrete barrier, although the barrier may transition then to other systems. • Generally, no residual attenuation capacity after a major hit. • No side redirection. Must be placed beyond the length of need point. • Modules may “walk” when place on cross-sloped structures. Contact BDE if this application is required.

COMPARISON BY OPERATIONAL PRINCIPLE

Figure 38-8.C

There is no specification for wide impact attenuators in the resettable category. This is because the available systems vary in their treatment of this issue. Where a wide hazard is to be shielded with a resettable attenuator, the designer may prepare a special barrier transition from the hazard to the attenuator connection. See the manufacturer's specifications and drawings as well as Section 38-6.05.

38-8.04(b) Severe Use

Severe use applies to installations where the crash cushion should retain some residual capacity to absorb additional frontal impacts while awaiting repairs. The crash cushion should also require minimum cost and time for repairs after an impact. These installations are those where repeated or frequent hits are known or anticipated, and where lane closures to repair the crash cushion need to be kept to a minimum time window.

The residual frontal impact capacity available in the severe use items may be offset by some reduction in redirective capability. The residual capacity is not a substitute for proper inspection and repair after each impact. Also, the elastic components will deteriorate with time and repeated impacts and will require replacement. Some current indications are that about 13 to 15 impacts may warrant replacement.

38-8.05 Approved Devices

1. Approved Devices. For routine use by the Department, a system must be on the Department's QPL for Impact Attenuators. Unless otherwise noted, all items on the QPL are crash tested and accepted at Test Level 3. This level of safety is adequate for facilities with design speeds greater than 45 mph. For facilities with normal roadside design speeds of 45 mph or less, the designer may specify the use of devices accepted at Test Level 2. Information relative to Test Level 2 devices is included in Figure 38-8.G and the list of approved devices. Also, see Figure 38-8.G for a partial review and comparison of attributes of various approved systems.

2. Other Devices. There are some crashworthy devices that are not listed on the Department's QPL. For information about these devices, see the FHWA website, the AASHTO *Roadside Design Guide*, and the various manufacturers' brochures and Internet sites. A proposed use of these devices must be coordinated with BDE and BSPE.

Figure 38-8.H correlates the various systems relative to contract pay items.

38-8.06 Physical Placement Requirements

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

1. Level Terrain. All impact attenuators have been designed and tested for level conditions. Vehicular impacts on devices placed on an excessively sloped site could result in an impact at an improper height, which could produce undesirable vehicular behavior. Therefore, the attenuator should be placed on a base or pavement slightly sloped to

facilitate drainage, but the cross slope should not to exceed 5%, or as allowed by the proprietary specifications. Impact attenuators that require anchorage to the base should not be placed over a break in slope as this can misalign necessary guide rails and other components.

2. Curbs. No curbs higher than 2 in. (50 mm) should be constructed at impact attenuator installations. On existing highways, all curbs higher than 4 in. (100 mm) should be removed at proposed installations, if feasible.

3. Surface. Many impact attenuator systems require a paved, bituminous or concrete pad. To minimize nuisance hits, especially for sand module impact attenuators, the total base width should be 2 ft (600 mm) wider than the array.

4. Elevated Structures. The unanchored sand modules or water-filled impact attenuators may "walk" due to the vibration of an elevated structure with a cross-sloped surface. This could adversely affect its performance. If it is necessary to place sand modules or water-filled impact attenuators on elevated structures, contact BDE for assistance.

5. Orientation. The impact attenuator should be oriented to accommodate the probable impact angle of an encroaching vehicle. See Figures 38-8.A and 38-8.B for sand modules. This will maximize the likelihood of a head-on impact. However, this is not as important for impact attenuators with redirective capability. The proper orientation angle will depend upon the design speed, roadway alignment, and lateral offset distance to the attenuator. A maximum angle of approximately 15° toward oncoming traffic, as measured between the highway and impact attenuator longitudinal centerlines, is considered appropriate.

6. Location. The system must not infringe on the traveled way. There should be a minimum of 2 ft (600 mm) behind sand module systems and in front of the hazard to allow access to the system. The space or transition behind other impact attenuator systems should be according to the manufacturer's specifications.

7. Bridge Joints. Avoid the placement of fully or partially redirective impact attenuators over bridge expansion joints or deflection joints in deep superstructures because movement in these joints could create destructive strains on the system's anchor cables or other continuous parts.

8. Transitions. If required, transitions between systems and backwalls, bridge rails, or other objects are detailed in various proprietary systems. Review the acceptance information and Figure 38-8.G to ensure that systems are approved for bidirectional applications where necessary.

   Many impact attenuators can connect to guardrail or to concrete barrier. In these cases, and where the available length allows, width transitions may be designed using a barrier extended back from the impact attenuator to a connection to or protective position in front of the wide hazard. The barrier design and flare rates should be according to Section 38-6 and the *IDOT Highway Standards*. Any flared barrier or impact attenuator may somewhat increase the redirection angle for impacting vehicles.

38-8.07 Cost

The designer should investigate relative costs for items under consideration. In some cases, a premium for fully redirective properties, for a resettable system, or for items for severe use installations will be offset by the maintenance or repair benefits provided. However, the designer should be careful not to apply premium systems where crashes are rare (1 or less expected impact per 10 years). In these cases, consider using simpler, lower priced systems.

Conversely, use of a low-cost, sacrificial system in an area with occasional (up to 1 crash per 3 years) to frequent impacts (2 or more impacts per year) will lead to high costs for repeated replacement of the attenuator.

38-8.08 Pedestrian/Bicyclist Environment

Impact attenuators are designed to contribute to a forgiving roadside for errant vehicles. The crash testing takes place at 60 mph (100 km/hr) (nominal) and angles up to 25° for Test Level 3 and at 45 mph (70 km/hr) (nominal) and similar angles for Test Level 2 devices. The impact attenuators developed to buffer such crashes are often constructed of steel panels and frames, cables, and steel or wood posts. Also, during an impact, these parts are designed to move, crush, or break in a controlled manner. As result, the impacting vehicle may rotate, rebound, or glance off the impact attenuator.

Placing an impact attenuator in a pedestrian environment imposes compromises and tradeoffs between vehicle occupant safety and pedestrian/bicyclist safety. Consider the following:

- As much as practical, impact attenuators should be placed away from pedestrian/bicyclist facilities. For example, where an impact attenuator must be located at the end of a parapet or wall crossing a bridge, if space permits, extend the wall or parapet beyond the bridge and separate the pedestrian/bicyclist pathway from the wall and roadway before introducing the impact attenuator.
- Evaluation of the tradeoffs between vehicular and pedestrian/safety should include factors contributing to the relative risk for each user class. These include exposure of individuals, quality of the design/design constraints, and expected severity of each crash category.
- Exposure measures include ADT for vehicular traffic, pedestrian volumes, and bicycles.
- Measuring the quality of the design includes mainly the offset between the impact attenuator and the roadway and/or pedestrian/bicyclist way along with any constraints on developing the offset.
- To evaluate the expected severity of any crashes, consider the operating speed of the roadway facility, the treatment under consideration (e.g., impact attenuator, blunt end, sloped end), and the nature of any particular impact attenuators.
- Figure 38-8.D offers guidance regarding pedestrian/bicyclist considerations for particular impact attenuators.

Impact Attenuator System or Family	Pedestrian/Bicyclist Considerations
QuadGuard	• Side panels face pedestrians/bicyclists from opposing direction. • Gaps should be installed as tight as possible on pedestrian side. • Top edge exposed similar to guardrail.
SCI-100GM	• Side panels face pedestrians/bicyclists from opposing direction. • Exposed edges are beveled and should minimize snagging. • Side panels remain nested upon head on impact. • Gaps should be installed as tight as possible on pedestrian side. • Top edge exposed similar to guardrail.
TRACC	• Side panels face pedestrians/bicyclists from opposing direction. • Gaps should be installed as tight as possible on pedestrian side. • Top edge exposed similar to guardrail.
TAU-II	• Same as TRACC.
QUEST	• Same as TRACC.
REACT 350	• Heavy plastic drums connected/restrained by steel cables. • Steel cables are main hazard to pedestrians/bicyclists on the face. • Tops are 4.5 ft (1.4 m) off the ground and should not be hazardous to pedestrians/bicyclists.
CAT-350	• Similar to guardrail terminal.
Brakemaster 350	• Similar to guardrail terminal.
FLEAT-MT	• Similar to guardrail terminal.
Sand Modules	• Plastic drums weighted with sand. Any spilled sand may affect walking/cycling surface.
ABSORB 350	• Plastic barrier shape filled with water. • Temporary use only. • Any spilled water may freeze or otherwise wet the walking/cycling surface.
Compressor	• Steel side panels with exposed ends edges and connectors. • Varying height, including heavy plastic energy absorbing panels.
HEART	• Heavy plastic side panels surround and overhang steel diaphragms, posts, and base. • Bolted external steel retainers hold plastic panels to diaphragms.
SLED	• Water filled plastic modules. • External steel framing on first module.

PEDESTRIAN/BICYCLIST CONSIDERATIONS FOR IMPACT ATTENUATORS

Figure 38-8.D

38-8.09 Impact Attenuator Selection

The selected impact attenuator must be compatible with the specific site characteristics. For each category of device, more than one approved system must be allowed for competitive bidding, unless specific approval is made according to Section 66-1.04(b). Selection of the correct category (pay item) will require comparison and analysis of possible solutions. Factors to consider include:

- type and width of hazard (see Section 38-8.06 on transitions);
- space, or reserve area, available for installation of the system. The reserve area allows for placement of the barrier and any necessary clearances; see Figure 38-8.E;
- whether the hazard to be shielded is located in a high- or low-risk impact area;
- initial, maintenance, and restoration costs;
- ease or difficulty of restoration of the system after impact. The importance of this factor will be related to the traffic and hazard levels at a site. More traffic and higher hazards will make speedy repair or replacement a higher priority; and
- presence and direction of travel of traffic on each side of the impact attenuator.

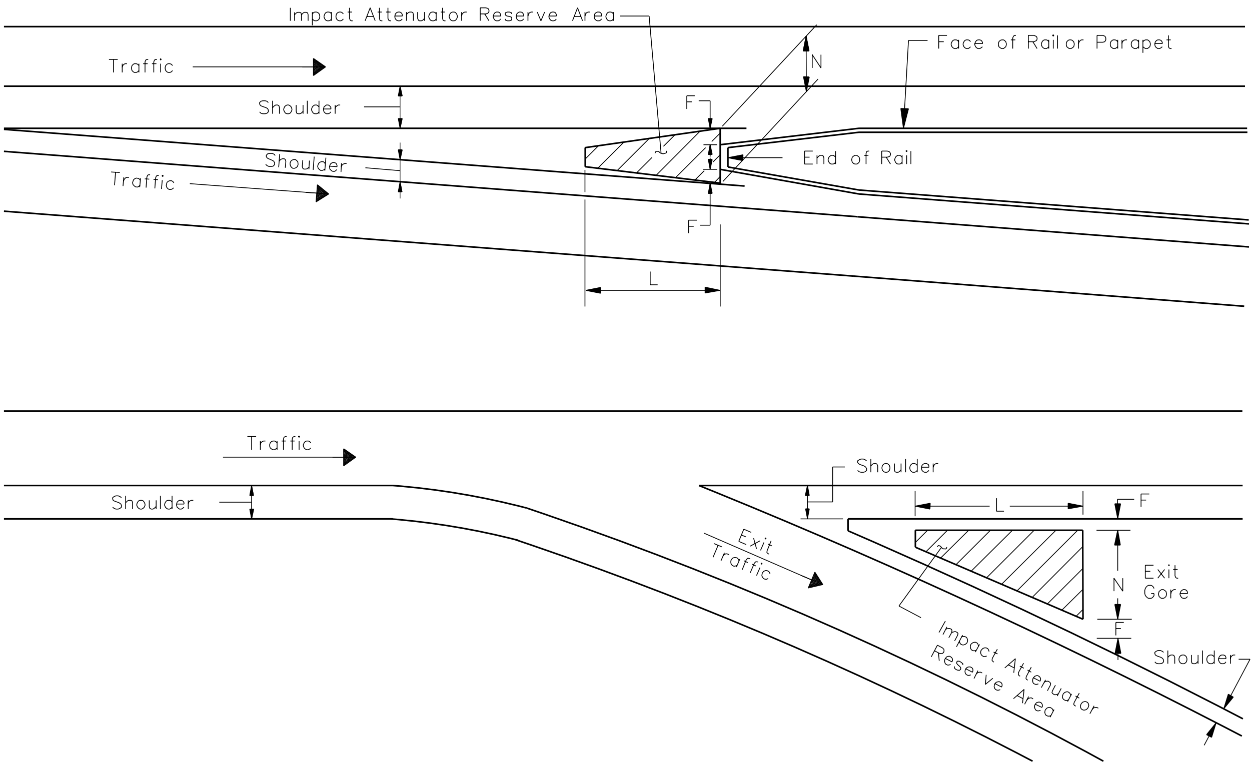
Figure 38-8.F summarizes the advantages and disadvantages of the impact attenuator principles and categories provided in Department specifications. There are many other factors that will influence the selection of an impact attenuator for a given site. Therefore, the designer should only use this figure as a starting point in the comparison and analysis process for selection of the best category.

38-8.10 Temporary Installations

Access to the work site becomes an additional consideration for temporary installations, especially where temporary concrete barriers are used to close a lane or to channel traffic.

Also, in some cases (e.g., stage construction of two-lane bridges) it may be desirable for the impact attenuator to block the closed lane, reducing the likelihood that an errant vehicle could reach the construction area. These competing needs, access and physical closure of the lane, may be mutually exclusive at some sites where shoulders and right of way are restrictive.

Where construction access can be provided on the shoulders or by other available means (e.g., temporary widening, easement), the preferred layout would include concrete barriers and an impact attenuator placed to effectively block the closed lane. The designer should provide necessary plan details to show the positioning of the concrete barrier and impact attenuator devices. If sand module impact attenuators are allowed, appropriate configuration from *Highway Standard* 643001 should be noted in the plans. Width restrictions may not allow for angling the array toward traffic. In this case, the array should be installed parallel to the roadway.



Design Speed (DS) On Mainline (mph)	Dimensions for Impact Attenuator Reserve Area (feet)								
	Minimum						Preferred		
	Restricted Conditions			Unrestricted Conditions					
	N	L	F	N	L	F	N	L	F
DS ≤ 30	6	8	2	8	11	3	12	17	4
30< DS ≤ 50	6	17	2	8	25	3	12	33	4
50 < DS ≤ 70	6	26	2	8	45	3	12	55	4
70< DS ≤80	6	35	2	8	55	3	12	70	4

Design Speed (DS) On Mainline (km/hr)	Dimensions for Impact Attenuator Reserve Area (meters)								
	Minimum						Preferred		
	Restricted Conditions			Unrestricted Conditions					
	N	L	F	N	L	F	N	L	F
DS ≤50	2.0	2.5	0.5	2.5	3.5	1.0	3.5	5.0	1.5
50< DS ≤ 80	2.0	11.6	0.6	2.8	12.2	1.0	3.5	10.0	1.5
80 < DS ≤ 110	2.0	8.5	0.5	2.5	13.5	1.0	3.5	17.0	1.5
110 < DS ≤ 130	2.0	11.0	0.5	2.5	17.0	1.0	3.5	21.0	1.5

RESERVE AREA FOR IMPACT ATTENUATORS

Figure 38-8.E

Operational Principle (Pay Item)	Advantages	Disadvantages	Typical Uses*
Energy Absorbing	See Figure 38-8.C.	See Figure 38-8.C.	
Impact Attenuators (fully redirective, narrow) and Impact Attenuators, Temporary (fully redirective, narrow)	• Prevents encroaching vehicle from traveling behind the impact attenuator. • Space efficient. • Can fit narrow hazards. • Where space permits, connection to a barrier system may allow shielding of wider hazards.	• Residual capacity after an impact varies among items. • Requires anchoring to a slab or pavement. • Not suited to wide hazards.	• Ends of concrete barrier beyond full shoulder width where impacts are expected to be rare. • Intermediate width medians, piers. • Type D guardrail.
Impact Attenuators (fully redirective, wide), and Impact Attenuators, Temporary (fully redirective, wide)	• Prevents encroaching vehicle from traveling behind the impact attenuator. • IDOT pay items and specifications will cover hazards up to only 90 in (2.25 m) wide. See Section 38-8.06 • Space efficient.	• Residual capacity after an impact varies among items in this category. • Requires anchoring to a slab or pavement.	• As above, but for wide hazards (e.g., wide piers) or gore hazards.
Impact Attenuators (severe use, narrow) and Impact Attenuators, Temporary (severe use, narrow)	• Prevents encroaching vehicle from traveling behind the impact attenuator. • May retain significant useful impact capacity after some hits. • Space efficient. • Can fit narrow hazard.	• Higher cost than items not requiring severe use characteristics. • Requires anchoring to a slab or pavement. • Not suited to wide hazards. • May rebound a vehicle as the system restores after a frontal hit. This may create secondary collisions with traffic. • Requires post impact monitoring to ensure that reusable modules are replaced at the end of their service life.	• Ends of concrete barrier separating opposing traffic where repeated or frequent hits are expected and/or where it is necessary to keep repair visits and times to a minimum. • Narrow medians. • Type D guardrail. • Roadside concrete barrier or bridge parapet in a temporary application. • Other narrow point hazards. This may require limiting the list of devices to those that are free-standing with respect to the hazard.

** See Figures 38-8H and 38-8.I for additional information.*

COMPARISON BY PAY ITEM
Figure 38-8.F

Operational Principle (Pay Item)	**Advantages**	**Disadvantages**	**Typical Uses***
Energy Absorbing	See Figure 38-8.C.	See Figure 38-8.C.	
Impact Attenuators (fully redirective, resettable)	• Requires minimal parts and labor for repairs. Low life-cycle cost where there are occasional to frequent impacts. • Prevents encroaching vehicle from getting behind the impact attenuator. • Space efficient. • Can fit narrow hazard.	• Initial cost higher than non-premium system. • Not required to self-restore after impact. • May require a special barrier detail to transition to a wide hazard.	• As above, but where impacts are expected on an occasional basis. (At least 1 per 3 years, up to 2 per year, depending on accessibility for repairs and impacts to traffic.)
Impact Attenuators (severe use, wide) and Impact Attenuators, Temporary (severe use, wide)	• May retain significant useful frontal impact capacity after some hits. • Space efficient. • Can cover a hazard width up to about 90 in (2.25 m).	• Higher cost than items not requiring severe use characteristics. • Requires anchoring to a slab or pavement. • May rebound a vehicle as the system restores after a frontal hit. This may create secondary collisions with traffic.	• Piers or gore areas separating opposing traffic where repeated or frequent hits are expected and/or where it is necessary to keep repair visits and times to a minimum. • Narrow medians.
Impact Attenuators (partially redirective)	• Lower cost than fully redirective systems. • Suited for direct attachment to Type D guardrail.	• For narrow hazards. • Requires posts to be driven. • Lack of reserve impact capacity after a hit.	• Ends of Type D guardrail separating traffic lanes moving in the same direction, and where impacts are expected to be infrequent. • Wide medians, gore areas. • Concrete barrier on right side shoulders, or at gores.
Impact Attenuators (non-redirective)	See Figure 38-8.C for Sand Modules.	See Figure 38-8.C for Sand Modules.	Point hazards (e.g., piers or sign foundations) not near a travel lane.

**See Figures 38-8.H and 38-8.I for additional information.*

COMPARISON BY PAY ITEM

Figure 38-8.F
(Continued**)**

Operational Principle (Pay Item)	Advantages	Disadvantages	Typical Uses*
Momentum Transfer	See Figure 38-8.C.	See Figure 38-8.C.	
Impact Attenuators Temporary (non-redirective)	See Figure 38-8.C.	• Area for application must have enough room to accommodate either the sand modules or the water filled impact attenuator (ABSORB 350). • Applies principally where it will shield end of a temporary concrete barrier.	• Ends of concrete barriers or other hazards well off the traffic lane, and where it is acceptable to allow a vehicle to encroach behind the device. • See *Highway Standards* 701321 and 701402.

**See Figures 38-8.H and 38-8.I for additional information.*

COMPARISON BY PAY ITEM

Figure 38-8.F
(Continued)

Where shoulders of sufficient width or other means of access are not available, the designer can arrange the concrete barriers according to the minimums shown on the *Illinois Highway Standards* and choose among the various pay items for temporary impact attenuators, as appropriate for the site and traffic. This will allow the contractor a range of options to weigh for access, cost and maintenance factors.

38-8.11 Additional Guidance

Figure 38-8.G provides a partial review and comparisons of the attributes for the various Department approved systems. Figures 38-8.H and 38-8.I correlate the operational principles to the specific systems and typical applications; refer to the QPL regarding any questions regarding these systems and their MASH testing status.

Specific dimensions, installation requirements, and other details are best documented by the various manufacturers. Refer to the Department's lists of approved devices for manufacturer names, contact information and web page links.

System	Non-Redirective	Partially Redirective	Fully Redirective	Resettable	Residual Capacity	Width	Connects To:	Bidirectional? (Y/N)	Length** (Test Level 3)	Length** (Test Level 2)	Min width (Out to Out)*	Max Width*	Notes
Quadguard			X			Up to 120"	Generic	Y	23'-11"	12'-9"	2'-7"	120"	Requires paved pad.
Quadguard II			X			Up to 120"	Generic	Y	19'-2"	10'-2"	2'-7"	120"	Requires paved pad.
Quadguard Elite			X		X	Up to 120"	Generic	Y	35'-8"	23'-11"	2'-7"	120"	Requires paved pad.
Quadguard LMC			X		X	Up to 120"	Generic	Y	35'-8"	23'-11"	2'-7"	120"	Requires paved pad.
CAT-350		X				Narrow	Type D Guardrail or Concrete Barrier	Y	31'-3"	N/A	2'-7"	2'-7"	Installs on driven posts
REACT 350			X	X	X	Up to 120"	Generic	Y	31'-1"	23'-1"	3'	120"	Requires paved pad.
Brakemaster 350		X				Narrow	Type D Guardrail or Concrete Barrier	Y	31'-8"	N/A	2'-1"	2'-1"	Installs on driven posts
Universal TAU-II			X			Up to 96"	Generic	Y	28'-11"	16'-5"	2'-11"	8'-8"	Requires paved pad.
FLEAT MT		X				Narrow	Type D Guardrail or Concrete Barrier	Yes, but intended for wide median	37'-6"	25'	Match Type D Guardrail	Match Type D Guardrail	Installs on driven posts
TRACC			X			Narrow	Generic	Y	21"	14'	2'-7"	4'-10" (See Note)	Requires paved pad.
QUEST			X			Narrow	Type D Guardrail or Concrete Barrier	Y	16'-10"	N/A	2'	2'	Requires paved pad.
SAND MODULES	X					As needed	Generic	Case-by-case design issue	30'-7"	23'-7"	6'-6"	As needed	Requires paved pad For permanent installation. Requires aggregate pad for temporary installation
ABSORB 350	X					Narrow	Temporary Concrete Barrier	Y	28'-9"	19'-1/4"	2'	2'	Does not require paved surface. Temporary use only.
SCI 100-GM			X	X		Narrow	Generic	Y	21'-6"	N/A	3'-1 7/8"	3'-1 7/8"	Requires paved pad.
SCI 75-GM			X	X		Narrow	Generic	Y	N/A	13'-6"	3'-1 7/8"	3'-1 7/8"	Requires paved pad.
Compressor			X		X	Narrow	Generic	Y	21'-3"	N/A	4'-1"	4'-1"	Requires paved pad.
HEART			X		X	Narrow	Generic	Y	26'-3"	N/A	2'-4"	2'-4"	Requires paved pad.
Sentry Longitudinal Energy Dissipator (SLED)	X					Narrow	Traffic water-filled Barrier or generic concrete safety shape	Y	26'	N/A	22 1/2"	22 1/2"	Does not require paved surface. Temporary use only.

Notes:

The TRACC may be widened. At its nominal length and at Test Level 3, the maximum width is 58 in. (1.47 m). Additional width may be gained in approximately 6½ in. (165.1 mm) increments by the addition of 28 in. (711 mm) extension wings.

* *The minimum widths shown are nominal out-to-out of the impact attenuator. The various backup systems, transition pieces, etc., are considered part of the impact attenuator, and are to be considered part of the pay item.*

ATTRIBUTES OF IMPACT ATTENUATORS

Figure 38-8.G

Systems and Allowable Products to Fit Needs	Typical Applications
Impact Attenuators (fully redirective, narrow) QuadGuard QuadGuard Elite QuadGuard LMC QuadGuard II REACT 350 Universal TAU-II Universal TAU-II-R TRACC family SCI-100GM (Test Level 3) SCI-70GM (Test Level 2) QUEST Compressor HEART	• Where the expected rate of crashes involving the system are rare to infrequent (less than 1 crash per 3 years). • *Narrow median (< 40 ft (12 m)). • Narrow hazard, concrete barrier, narrow pier. • End of median barrier or Type D rail. • Alignment or traffic operations do not contribute to added likelihood of run off the road incidents.
Impact Attenuators (fully redirective, wide) QuadGuard QuadGuard Elite QuadGuard II React 350 TRACC family Universal TAU-II Universal TAU-II-R SCI-100GM (Test Level 3) SCI-70GM (Test Level 2)	• *Narrow median (< 40 ft (12 m)). • Up to 90 in. (2.25 m) wide hazard, sign base, pier, etc. • Narrow gap between bridges. • Alignment or traffic operations do not contribute to added likelihood of run off the road incidents. • Hazards where space does not allow development of width transitions from other impact attenuators.
Impact Attenuators (fully redirective, resettable) REACT 350 SCI-100GM (Test Level 3) SCI-70GM (Test Level 2) Universal TAU-II Universal TAU-II-R Compressor HEART	• Where crashes are expected to be more than 1 per 3 years. • Similar locations to fully redirective, narrow.
Impact Attenuators (severe use, narrow) QuadGuard Elite REACT 350 Universal TAU-II-R SCI-100GM (Test Level 3) SCI-70GM (Test Level 2)	• *Narrow median (< 40 ft (12 m)). • Expect repeated impacts (> 2/yr). • Narrow hazard, concrete barrier, narrow pier. • End of median barrier or Type D rail. • Outside of curves, areas near weaving, lane drops. • Near entrances/exits on freeways/ expressways. • Also appropriate on outside shoulder hazards where repeated impacts and traffic levels make continued capability and ease of repairs critical.

IMPACT ATTENUATORS – PERMANENT INSTALLATIONS

Figure 38-8.H

Systems and Allowable Products to Fit Needs	Typical Applications
Impact Attenuators (severe use, wide) QuadGuard Elite REACT 350 Universal TAU-II-R	• *Narrow median (< 40 ft (12 m)) • Expect repeated impacts. • Up to 90 in. (2.25 m) wide hazard, sign base, pier, etc. • Narrow gap between bridges. • Outside of curves, areas near weaving, lane drops. • Near entrances/exits on freeways/ expressways. • Also appropriate on outside shoulder hazards where repeated impacts and traffic levels make continued capability and ease of repairs critical. • Hazards where space does not allow development of width transitions from other impact attenuators.
Impact Attenuators (partially redirective) *CAT 350 *FLEAT MT	• Outside shoulder, gore area. • Narrow hazard, pier, barrier wall, D rail. • Separation of lanes moving in same direction. • Expected low frequency of hits.
Impact Attenuators (non-redirective) Energite III Big Sandy Sand Barrels CrashGard Sand Barrel System	• Outside shoulder, gore area, wide median. • Sign support, etc. • Separation of lanes moving in same direction, or where there is a wide separation.

Notes:

The TRACC may be widened. At its nominal length, the maximum width is 58 in. (1.47 m). Additional width may be gained in approximately 6½ in. (165.1 mm) increments by the addition of 28 in. (711 mm) extension wings.

**See Figure 38-7.B. Warrants for median barriers may be considered also as an estimate of when to begin consideration of fully-redirective crash cushions in a median area.*

Use of standard barrier sections and approved flare rates may allow installation of narrow impact attenuators in advance of wide hazards, depending on space available.

IMPACT ATTENUATORS – PERMANENT INSTALLATIONS

Figure 38-8.H
(Continued)

Systems and Allowable Products to Fit Needs	Typical Applications
Impact Attenuators (temporary) (fully redirective, narrow) QuadGuard CZ QuadGuard LMC QuadGuard Elite REACT 350 TRACC Family Universal TAU-II Universal TAU-II-R SCI-100GM (Test Level 3) SCI-70GM (Test Level 2) HEART QUEST Compressor	• Locations where the rate of crashes is expected to be less than 1 per 3 years, and first costs control.** • *Narrow median locations. • Temporary locations where errant vehicles must not encroach behind the device. • Head to head traffic. • Severe hazards beyond the device.
Impact Attenuators (temporary) (fully redirective, wide) QuadGuard Elite QuadGuard LMC REACT 350 TRACC Family Universal TAU-II Universal TAU-II-R SCI-100GM (Test Level 3) SCI-70GM (Test Level 2)	• Similar to locations for fully redirective, narrow, but where the hazard is wide.
Impact Attenuators (temporary) (fully redirective, resettable) REACT 350 SCI-100GM(Test Level 3) SCI-70GM (Test Level 2) Universal TAU-II-R Compressor HEART	• Where crashes are expected to be more than 1 per 3 years and life cycle costs control.** • Similar to locations for fully redirective, narrow.
Impact Attenuators (temporary) (non-redirective) Fitch Universal Module System Energite III Big Sandy Sand Barrels CrashGard Sand Barrel System Sentry Longitudinal Energy Dissipater (SLED) Absorb 350	• Temporary locations where errant vehicle may continue behind the crash cushion. • See *Highway Standards* 701321 and 701402 as site conditions permit.

IMPACT ATTENUATORS – TEMPORARY INSTALLATIONS

Figure 38-8.I

Systems and Allowable Products to Fit Needs	Typical Applications
Impact Attenuators, Temporary (non-redirective, narrow) ABSORB 350 Sentry Longitudinal Energy Dissipater (SLED) *ACZ 350 System*	Space limitations preclude sand barrel arrays.
Impact Attenuators, Temporary (severe use, narrow) QuadGuard LMC QuadGuard Elite REACT 350 Compressor	• *Narrow median locations. • Temporary locations where frequent impacts are expected and/or where access for repairs would create unacceptable traffic control or operational problems. These systems are fully redirective. This must be acceptable at the site.
Impact Attenuators, Temporary (severe use, wide) QuadGuard Elite REACT 350 Universal TAU-II-R	• Similar to locations for Severe Use, Narrow, but where the hazard is wide.

Notes:

**See Figure 38-7.B. Warrants for median barriers may be considered also as an estimate of when to begin consideration of fully-redirective crash cushions in a median area.*

***Generally, life cycle costs are the responsibility of the contractor for temporary installations.*

IMPACT ATTENUATORS – TEMPORARY INSTALLATIONS

Figure 38-8.I
(Continued)

38-9 ROADSIDE SAFETY IN URBAN OR RESTRICTED ENVIRONMENTS

This section applies to roadways characterized by built-up locations with curbed sections, frequent stops, off-peak operating speeds of 45 mph (70 km/hr) and lower, frequent traffic conflicts with driveways and side streets, multiple fixed objects in the roadside, restricted right of way, and closed drainage.

Within such areas, the application of open road clear zones may not be practical. This guidance will balance the need for a clear zone with practicality and demonstrated safety benefits in urban and restricted environments.

38-9.01 Safety Performance – Evaluation of Urban and Restricted Locations

Although a clear roadside concept is still preferred, it is more practical and most cost-beneficial to identify critical locations and features with a history of over-representation for roadside crash mitigation in urban/restricted locations.

The general hierarchy of treatments, as shown in Section 38-4.02, applies also in urban/restricted environments.

38-9.02 Operational Offset, Clear Zone, and Enhanced Lateral Offset

The lateral offset procedures in this section should be applied to any urban facility where feasible. However, lower speed facilities (posted speed limit below 30 mph), central business districts, locations with 24 hour on-street parking, and locations with limited right of way and competing uses for roadside space may minimize the application of this section.

Lateral offset concepts should be applied to built-up locations with curbed sections, frequent stops, off-peak operating speeds 45 mph (70 km/hr) and lower, frequent traffic conflicts with driveways and side streets, multiple fixed objects in the roadside, restricted right of way, and closed drainage. Lateral offset concepts and other focused roadside safety treatments should be emphasized at locations of safety performance problems related to roadside safety, and systematically to types of locations representing roadside safety issues.

1. Operational Offset. At a minimum, provide an operational offset from the face of curb to fixed objects of 1.5 ft (0.5 m) on tangents and 3 ft (0.9 m) along the radii of the curb return at intersections. These values are intended only to ease traffic operations, preserve sight distance, keep truck mirrors from striking objects, and do not represent a criterion for roadside safety design.

2. Clear Zone. Section 38-3 or applicable portions of Chapter 49 or 50 provide the appropriate clear zone values for roads, including urban and restricted locations. However, achieving full clear zones in urban or restricted environments is often not practical due to limited right of way and the many competing transportation uses and other uses in the corridor.

3. Enhanced Lateral Offset. An enhanced lateral offset of 4 ft (1.2 m) from the face of curb to any fixed object should be provided on tangent sections, and an enhanced lateral offset of 6 ft (1.8 m) should be provided on the outside of curves. For built up urban locations with no curb, the greater of these offsets doubled, or the clear zone, should be applied and measured from the edge of the traveled way.

   Additional lateral offset (wider than the enhanced lateral offset) should be provided at some specific locations.

   a. Inside of Curves. In addition to creating a wider lateral offset on the outside of curves, attention should be paid to (stopping) sight distance at the inside of sharp horizontal curves to assure that the roadway is not obstructed by roadside objects or embankments; see Figure 38-9.A.

   b. Lane Merge Locations. At the taper point where the lane drop is complete, a lateral offset of 12 ft (3.6 m) should be considered. This offset should be extended at least 10 ft (3.0 m) in both directions from the taper point, and desirably along the taper to where it will intersect the extension of the lateral offset of the roadway prior to the beginning of the lane drop. Breakaway objects should have lateral offsets of at least 4 ft to 6 ft (1.2 m to 1.8 m) at these locations. A wider lateral offset at taper points on urban roadways will reduce roadside crashes at these locations and allow the driver to focus solely on merging into the traffic stream; see Figure 38-9.B.

   c. Driveway locations. A lateral offset of 10 ft to 15 ft (3.0 m to 4.6 m) should be considered for a distance of 10 ft to 15 ft (3.0 m to 4.6 m) beyond the far edge of driveways to account for driver error and times of poor visibility. Sight triangles should also be maintained; see Figure 38-9.C.

   d. Intersections. Roadside crashes at intersections are a significant concern. Particular configurations related to roadside crashes include channelization islands, objects in the curb/radius return, and objects aligned opposite pedestrian curb ramps.

      - Channelizing islands and median noses should be designed according to Chapter 36. Rigid objects at either the corner island or the median nose should be avoided where practical.

      - Object placement on the inside edge of intersection turning movements should be as far as practical from the curb face or lane edge. A target lateral offset value of the intersection return should be 6 ft (1.8 m) for curbed facilities with a minimum value of 3 ft (0.9 m). Similarly, for locations without curbs, these values should be as far as possible from the edge of the traveled way because drivers will not have a curb to help them realize their vehicles have strayed from the designated turning path.

- Rigid objects should not be positioned such that errant vehicles are directed toward them along the path of a curb ramp. It is preferable that the pedestrian pushbutton be placed on a breakaway pedestal pole adjacent to the curb ramp rather than on a rigid traffic signal pole when possible. This may also enable the traffic signal pole placement to occur further away from the curb return region.

38-9.03 Roadside Features in Urban and Restricted Areas

1. Curbs. Curbs do not typically redirect errant vehicles. Vehicles impacting barrier curbs are likely to lose contact with the ground and become uncontrollable for some distance.

   When a vehicle strikes a curb, the trajectory depends on several variables including the size and suspension characteristics of the vehicle, its impact speed and angle, and the height and shape of the curb. Details of guardrail placement behind curbs are shown in *Highway Standard* 630001. Guardrail placed from 4 ft to 12 ft (1.2 m to 3.6 m) behind a curb, as shown on the standard has been crash tested to comply with *MASH* at Test Level 2.

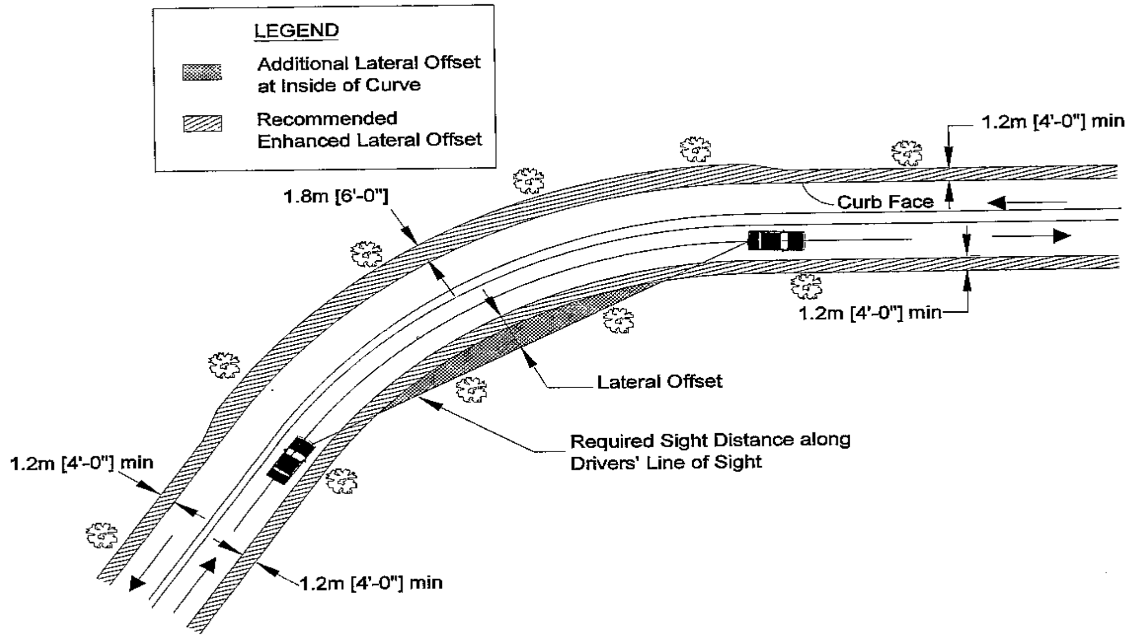
2. Roadside Development. If objects must be placed within the enhanced lateral offset, these should be frangible or breakaway objects that do not trigger further remediation.

3. Utility Poles. Utility poles are the second most common object hit in fatal fixed object crashes and are predominately represented in urban locations.

   Some practical suggestions for mitigating utility pole crashes include:

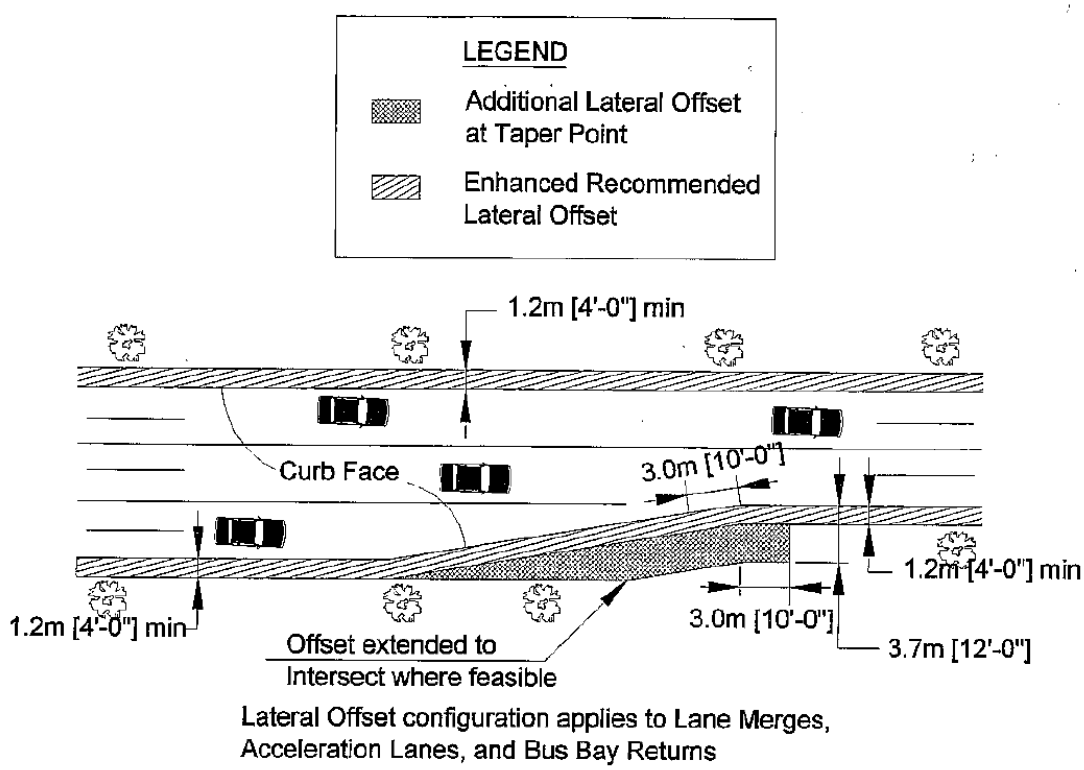
   - Place utility poles as far as possible from the active travel lanes.
   - Place utility poles away from access points where poles may restrict sight distance and be more likely to be struck.
   - Place utility poles on the inside of sharp horizontal curves.
   - Place utility poles only on one side of the road.

4. Lighting. Refer to 38-4.11 for recommendations regarding rigid versus breakaway light supports.



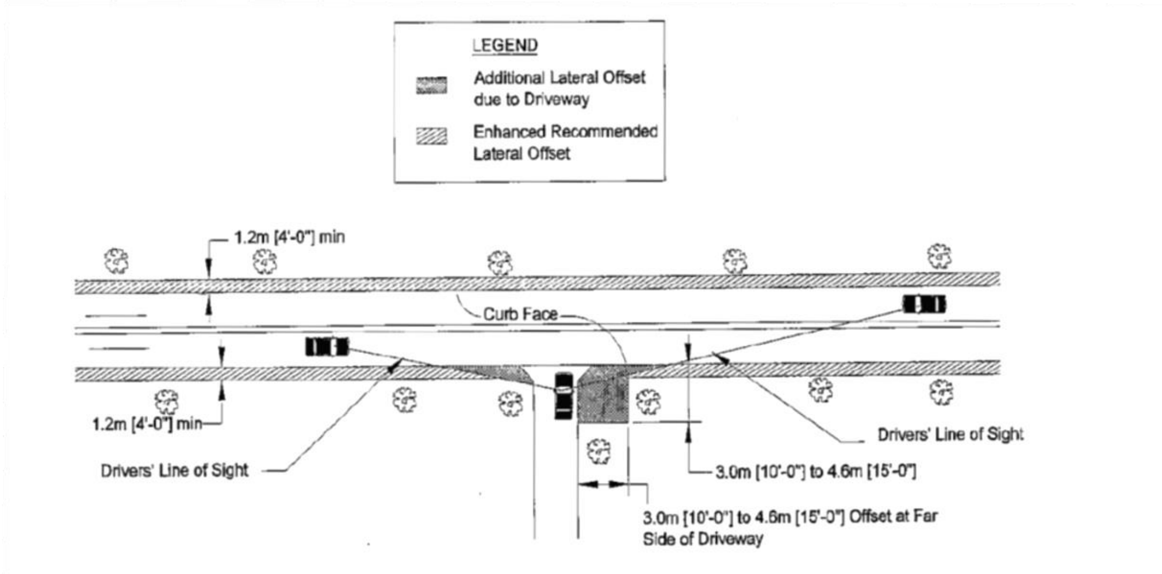
ENHANCED LATERAL OFFSET FOR CURVES IN URBAN OR RESTRICTED LOCATIONS

FIGURE 38-9.A



LATERAL OFFSET AT MERGE POINTS

FIGURE 38-9.B



ENHANCED LATERAL OFFSET AT DRIVEWAYS

FIGURE 38-9.C

38-9.04 Use of Roadside Barriers in Urban or Restricted Environments

Barriers and their end treatments within the clear zone shall be crashworthy and approved by the Department. The use of curbs with these devices may alter details of application or rule out certain systems. The selection of the appropriate test level shall be based upon the design speed of the roadway.

Many uses and competing concerns that define the urban or restricted environment also complicate selection and application of roadside barriers in these locations. When a roadside barrier is to be used, consider all of the following to evaluate the suitability of various barrier options, and placement:

- Lateral offset from the edge of pavement or curb,
- Deflection distance of the barrier,
- Terrain effects,
- Flare rate,
- Length of need,
- Corner sight distance,
- Pedestrian activity, including the needs of persons with disabilities, and
- Bicycle activity.

Generally, a barrier should be placed as far from the traveled way as possible, but it is also desirable that a uniform clearance to items such as bridge railings, retaining walls, and roadside barriers be presented to motorists.

38-9.05 Barrier Warrants

Remediation guidelines, including barrier warrants, are presented in Section 38-4.03. However, for urban or restricted environments these warrants may be less applicable due to the variety of needs addressed by these roadways. The Roadside Safety Analysis Program (discussed in Section 38-4.01) may be used to model these environments and arrive at specific warrants where questions arise. The major premise should remain that a traffic barrier should be installed only if it is expected to reduce the likelihood of severe crashes.

Innocent Bystander and Adjacent Land Use Protection. There are no set warrants or guidelines for these situations. Design judgment should be used. Consider crash history and site-specific factors.

38-9.06 Common Urban Barrier Treatments

1. Roadside and Median Barriers. Generally, median barriers will not be warranted or recommended in urban areas with street intersections, curbs, and design speeds of 45 mph (70 km/hr) or less. The use of roadside barriers will be tempered by the considerations of Section 38-9.05.

2. Crash Cushions. Crash cushions, especially those that are fully-redirective, take less space than standard roadside barrier installations. They may be more practical in many cases, especially for shielding fixed objects.

38-10 REFERENCES

1. *Roadside Design Guide*, AASHTO, 2011.

2. *A Supplement to "A Guide for Selecting, Locating, and Designing Traffic Barriers*," Texas Transportation Institute, March 1980.

3. *Safety Design and Operational Practices for Streets and Highways*, FHWA, March 1980.

4. "A Roadside Design Procedure," James Hatton, Federal Highway Administration, January 1974.

5. NCHRP Synthesis 66, *Glare Screen Guidelines*, Transportation Research Board, December 1979.

6. NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, Transportation Research Board, 1993.

7. *Illinois Highway Standards*, current edition.

8. *Manual for Assessing Safety Hardware*, AASHTO, 2016.

9. NCHRP Report 638, *Guidelines for Guardrail Implementation,* Transportation Research Board, 2009.

10. NCHRP Report 711, *Guidelines for Selection, Use, and Maintenance of Cable Barrier Systems*, Transportation Research Board, 2012.

11. "Report on The Advisability of Expanding the Use of Cable Median Barrier in Illinois", Prepared for Illinois Legislature by CH2M Hill for the Illinois Department of Transportation, 2009.