Chapter Thirty-five

ROADSIDE SAFETY

BUREAU OF LOCAL ROADS AND STREETS MANUAL

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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 35 presents clear zone distances that are intended to provide an adequate clear recovery area for errant vehicles that run off the road, as well as providing criteria for the selection, layout, and design of roadside barriers for all new construction/ reconstruction projects. Roadside hazards on 3R projects are addressed in Section 33-3.07.

35-1 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 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 in height between 6 in and 10 in (150 mm and 250 mm) with a face steeper than 3 vertical to 1 horizontal (3V:1H).

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

4. Barrier Warrant. A criterion that identifies an area of concern that should be shielded by a traffic barrier, if judged to be practical. The warrant may be based on IDOT/AASHTO guidelines, on a “cost-effective” assessment, or on engineering judgment.

5. Critical Parallel Slope. Fill sections with front slopes steeper than 1V:3H that are not considered to be traversable by a run-off-the-road vehicle. Depending on the encroachment conditions, a vehicle on a critical slope may overturn.

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

7. Front Slope. 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.

8. Impact Angle. For a longitudinal barrier, the angle between a tangent to the face of the barrier and a tangent to the vehicular path at impact.

9. Length of Need. 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 is measured to the last point of full-strength rail.

10. Mountable Curb. 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°.

11. Non-Recoverable Parallel Slope. Slopes that can be safely traversed, but upon which an errant vehicle is unlikely to recover before reaching the bottom of the slope. 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.

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

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

14. Roadside Barrier. A longitudinal barrier (e.g., guardrail, concrete barrier) used to shield roadside hazards.

15. Roadside Clear Zone. The distance beyond the edge of traveled way that should be clear of any non-traversable hazards or fixed objects.

16. 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).

17. 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.

18. 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).

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

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

21. Transverse Slope. 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.

35-2 ROADSIDE CLEAR ZONES

35-2.01 Background

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

1. Project Scope of Work. The clear zone distances in Section 35-2 apply to all new construction/reconstruction projects. Chapter 33 presents the clear zone criteria for 3R projects.

2. Context. The clear zone widths presented in this *Manual* are based on limited empirical data which has 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 basis for making decisions on providing a safe roadside area for new construction/reconstruction projects. The use of an appropriate clear zone distance is a compromise between providing maximum safety and minimizing construction costs. Each application of the clear zone distance must be evaluated individually, and the designer must exercise good judgment.

3. Boundaries. The designer should not use the clear zone distances as boundaries for introducing roadside objects (e.g., bridge piers, non-breakaway sign supports, utility poles, landscaping features). These should be placed as far from the traveled way as practical. If an obstacle lies just beyond the clear zone, it may be appropriate to remove or shield the obstacle if costs are reasonable. Conversely, the clear zone should not be achieved at all costs.

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 is not required. If, on the other hand, the right-of-way width exceeds the design clear zone, this offers an opportunity to increase safety by removing all hazards within the right-of-way. Specifically for reconstruction projects, BLRS policy is that the clear zone will be the values from Section 35-2 or the right-of-way line, whichever is less.

5. Level of Protection. A 30 ft clear zone is predicated on achieving a clear recovery area that will provide approximately 80% to 85% of all run-off-the-road vehicles the opportunity to recover where the design speed is 60 mph (100 km/h). For lower design speeds (but traffic volumes of over 6000 ADT), the clear zones are reduced but still provide a (theoretical) 80% to 85% level of protection. However, on facilities with ADTs less than 6000, Figure 35-2A and the AASHTO *Roadside Design Guide* present reduced clear zone values that provide a lower level of protection based on subjective cost-effective considerations. For example, with a design speed of 50 mph (80 km/h) and a flat side slope, an 18 ft (6 m) clear zone will provide the approximate 80% to 85% level of protection. A 12 ft (4 m) clear zone (as recommended for ADTs of 750-1500) will provide approximately a 65% level of protection. Therefore, the AASHTO clear zone values, which have been adopted by BLRS for use on non-State highway facilities for

new construction/reconstruction projects, inherently provide reduced protection for facilities with ADTs less than 6000.

35-2.02 Clear Zone Values

Figure 35-2A presents clear zone distances for recoverable front slopes (1V:4H or flatter) and for back slopes 1V:3H or flatter to be used in the design of new construction/reconstruction projects. The following discusses the use of the figure to determine the applicable clear zone.

35-2.02(a) Speed

The designer will use the design speed for the project determined from Chapter 32 to determine the applicable clear zone.

35-2.02(b) Traffic Volumes

For all new construction/reconstruction projects, the design traffic volume will typically be the projected traffic volume 20 years from the anticipated date of construction. For low-volume roadways with ADTs of 400 or less, current traffic volumes may be used.

Figure 35-2A is divided into ranges of traffic volumes for different design speeds. As indicated in the figure, ADT influences the clear zone value. In general, the wider clear zones apply to the higher traffic volumes.

35-2.02(c) Side Slopes

The roadway side slope will influence the recommended clear zone distance. Figure 35-2B presents a schematic of the general side slope configurations, which may include:

- a straight front slope,
- 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 35-2A for "back slopes" only apply to a section as illustrated in Figure 35-2B; 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 35-2.03 to 35-2.05 discuss side slopes in detail.

Design Speed	Design Year ADT(1)	Front Slopes(2)		Back Slopes(3)		
		1V:6H or Flatter	1V:5H to 1V:4H	1V:3H	1V:5H to 1V:4H	1V:6H or Flatter
40 mph or less	Under 750	7(7)	7(7)	7(7)	7(7)	7(7)
	750 or Over	10	10	10	10	10
45 – 50 mph	Under 750	10(7)	12(7)	10(7)	10(7)	10(7)
	750 – 1500	12	16	10	12	14
	1500 – 6000	16	20	12	14	16
	Over 6000	18	24	14	18	20
55 mph	Under 750	12(7)	14(7)	10(7)	10(7)	10(7)
	750 – 1500	16	20	10	14	16
	1500 – 6000	20	24	14	16	20
	Over 6000	22	26	16	20	22
60 mph	Under 750	16(7)	20(7)	10(7)	12(7)	14(7)
	750 – 1500	20	26	12	16	20
	1500 – 6000	26	30	14	18	24
	Over 6000	30	30	20	24	26

Notes:

1. *The "Design Year ADT" will be the total ADT for both directions of travel for the design year. Traffic volumes will normally be based on a 20-year projection from the anticipated date of construction unless current ADT < 400. This applies to both divided and undivided facilities.*
2. *For 1V:3H and 1V:2H front slopes, see Sections 35-2.03(b) and 35-2.03(c). For roads functionally classified as local with an ADT ≤ 400, see Section 35-2.02(d).*
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 35-2B(c)). For sections with roadside ditches, see Section 35-2.05.*
4. *All distances are measured from the edge of the traveled way.*
5. *The values in the figure apply to tangent sections of highway. See the discussion in Section 35-2.02(e) for possible adjustments on horizontal curves.*
6. *The values in the figure apply to all uncurbed sections and to curbed sections in rural areas. See Section 35-2.02(f) for curbed sections in urban areas.*
7. For roads functionally classified as local with an ADT ≤ 400, see Section 35-2.02(d).

MINIMUM CLEAR ZONE DISTANCES (ft)
(New Construction/Reconstruction)

Figure 35-2A (US Customary)

Design Speed	Design Year ADT[1]	Front Slopes[2]		Back Slopes[3]		
		1V:6H or Flatter	1V:5H to 1V:4H	1V:3H	1V:5H to 1V:4H	1V:6H or Flatter
60 km/h or less	Under 750 750 or Over	2.0 3.0	2.0 3.0	2.0 3.0	2.0 3.0	2.0 3.0
70-80 km/h	Under 750 750-1500 1500-6000 Over 6000	3.0[7] 4.5 5.0 6.0	3.5[7] 5.0 6.0 7.5	3.0[7] 3.0 3.5 4.5	3.0[7] 3.5 4.5 5.5	3.0[7] 4.5 5.0 6.0
90 km/h	Under 750 750-1500 1500-6000 Over 6000	3.5[7] 5.0 6.0 6.5	4.5[7] 6.0 7.5 8.0	3.0[7] 3.0 4.5 5.0	3.0[7] 4.5 5.0 6.0	3.0[7] 5.0 6.0 6.5
100 km/h	Under 750 750-1500 1500-6000 Over 6000	5.0[7] 6.0 8.0 9.0	6.0[7] 8.0 9.0 9.0	3.0[7] 3.5 4.5 6.0	3.5[7] 5.0 5.5 7.5	4.5[7] 6.0 7.5 8.0

Notes:

1. *The "Design Year ADT" will be the total ADT for both directions of travel for the design year. Traffic volumes will normally be based on a 20-year projection from the anticipated date of construction unless current ADT < 400. This applies to both divided and undivided facilities.*

2. *For 1V:3H and 1V:2H front slopes, see Sections 35-2.03(b) and 35-2.03(c).). For roads functionally classified as local with an ADT ≤ 400, see Section 35-2.02(d).*

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 35-2B(c)). For sections with roadside ditches, see Section 35-2.05.*

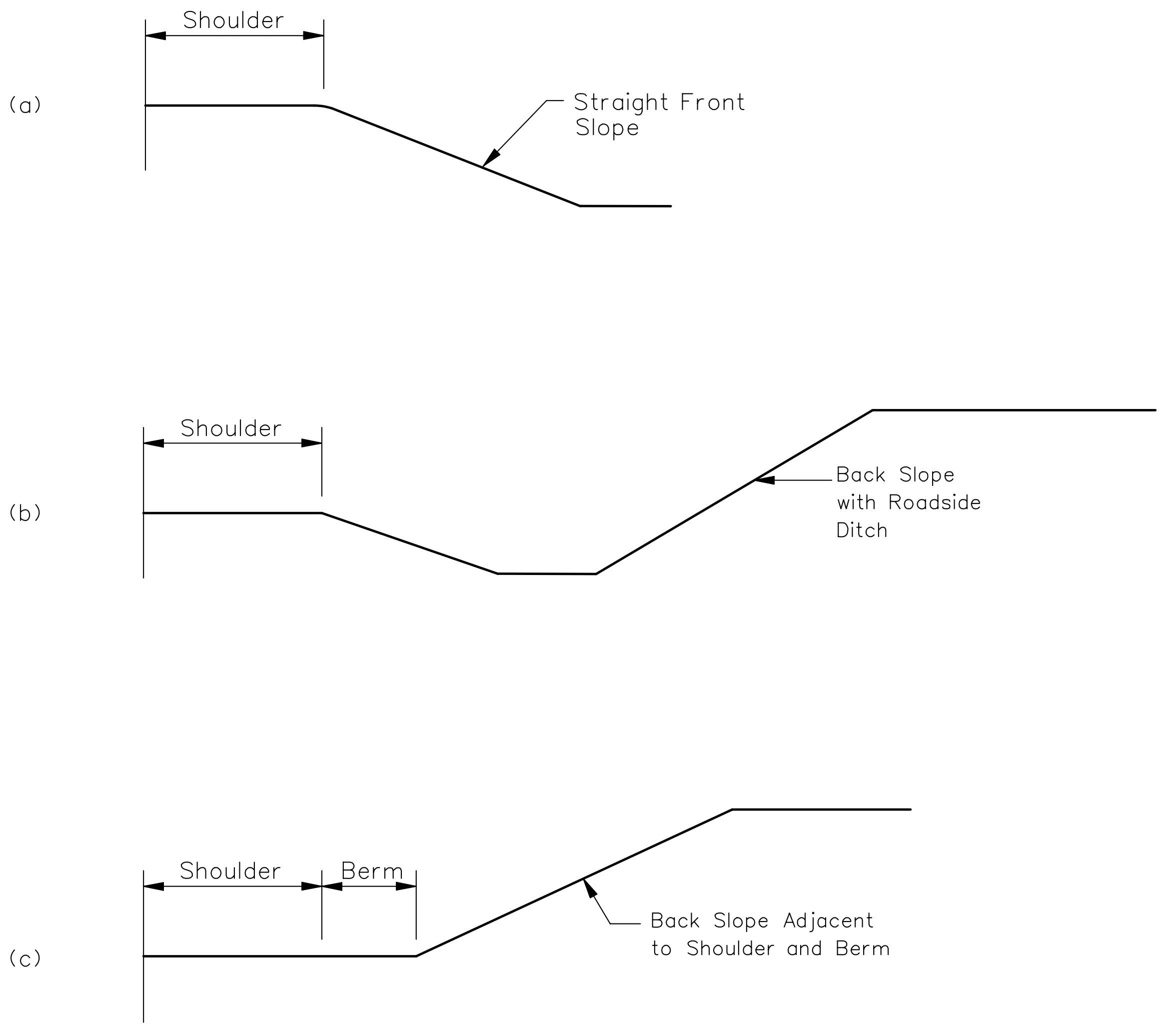
4. *All distances are measured from the edge of the traveled way.*

5. *The values in the figure apply to tangent sections of highway. See the discussion in Section 35-2.02(e) for possible adjustments on horizontal curves.*

6. *The values in the figure apply to all uncurbed sections and to curbed sections in rural areas. See Section 35-2.02(f) for curbed sections in urban areas.*

7. For roads functionally classified as local with an ADT ≤ 400, see Section 35-2.02(d).

RECOMMENDED CLEAR ZONE DISTANCES (m)
(New Construction/Reconstruction)
Figure 35-2A (Metric)



SIDE SLOPE CONFIGURATIONS

Figure 35-2B

35-2.02(d) Low-Volume Local Roads

The clear zone for uncurbed roads functionally classified as local with an ADT ≤ 400 may be reduced to 6 ft (1.8 m).

35-2.02(e) Horizontal Curve Adjustment

The clear zone values in Figure 35-2A 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. The designer should consider adjusting the tangent values to provide wider clear zones on the outside of horizontal curves on high speed roadways with significant traffic volumes where there is a significant crash potential, and the increased clear zones are cost effective and do not require additional right-of-way. Where the Horizontal Curve Adjustment is considered, see Section 38-3 of the *BDE Manual* for the adjustment factor to be used.

35-2.02(f) Curbed Sections

The values in Figure 35-2A apply to uncurbed sections of highway. Where curbs are present, the following will apply:

1. Urban/Suburban Facilities. A minimum horizontal, obstruction-free clearance of 1.5 ft (450 mm) should be provided as measured from the gutter line of the curb. This applies to both barrier and mountable curbs, except that M2 (M5) curb will be treated as an uncurbed section. Because curbs are not considered to have re-directional capabilities, it is desirable to provide obstruction-free clearances beyond the curb for a distance of at least 1.5 ft (450 mm). Hazards behind curbs preferably should be located outside of the clear zone shown for uncurbed roadways (see Figure 35-2A).

   As further discussed in Section 35-3, general IDOT policy is that roadside barriers are typically not warranted to shield hazards outside of the minimum required clear zone. This also applies to hazards outside of the obstruction-free area behind curbs. However, special conditions may indicate the need for a barrier where obstacles are present outside of the obstruction-free zone.

2. Rural Facilities. For specific field conditions, it may be acceptable to use mountable curbs on rural facilities; see Chapter 31. However, the clear zone will be determined assuming that the facility is uncurbed (i.e., the clear zone criteria presented in this Chapter will apply to all rural facilities whether curbed or uncurbed).

35-2.02(g) 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, 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 measured from the edge of the through lane 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). Where the intersection is curbed, the criteria in Section 35-2.02(f) will apply (i.e., the minimum obstruction-free zone is 1.5 ft (450 mm) from the gutter line).

2. Auxiliary Lanes Adjacent to Mainline. 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 farther will apply.

35-2.03 Front Slopes

Figure 35-2B illustrates the basic configurations for front slopes. Section 35-1 presents definitions of parallel front slopes that apply to clear zone determinations. Figure 35-2C presents schematics for these definitions, and the following discusses the clear zone application in conjunction with Figure 35-2A.

35-2.03(a) Recoverable Front Slopes

For parallel front slopes 1V:4H and flatter (Figure 35-2C(a)), the recommended clear zone distance can be determined directly from Figure 35-2A.

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Example 35-2.03(1) (Recoverable Front Slope)

Given: Front Slope = 1V:4H
Design Speed = 50 mph
Design ADT = 3000

Problem: Determine the recommended clear zone distance.

Solution: From Figure 35-2A, the clear zone distance should be 20 ft.

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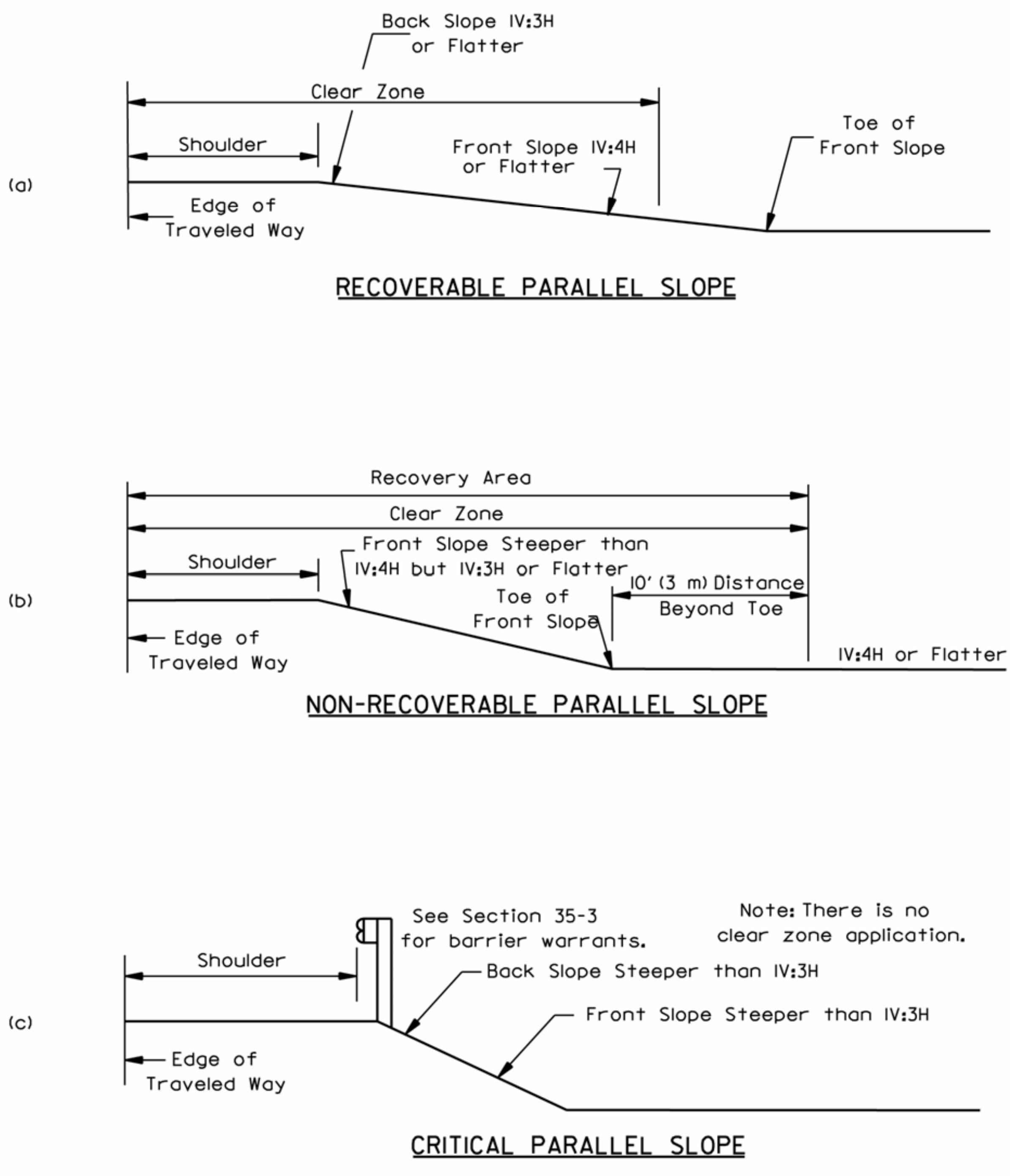

CLEAR ZONE APPLICATION FOR SLOPES
(Uncurbed)

Figure 35-2C

35-2.03(b) Non-Recoverable Front Slopes

For parallel front slopes steeper than 1V:4H but 1V:3H or flatter (Figure 35-2C(b)), the recommended clear zone includes a distance beyond the toe of the slope. Use the following procedure to determine the clear zone:

1. Determine the clear zone for a 1V:6H or flatter slope from Figure 35-2A for the applicable design speed and traffic volume.

2. If the clear zone extends beyond the break for the 1V:3H slope, provide a 10 ft (3 m) clear recovery area beyond the toe of the slope if sufficient right-of-way exists. It is not necessary to acquire additional right-of-way to provide the 10 ft (3 m) recovery area.

* * * * * * * * * *

Example 35-2.03(2) (Non-Recoverable Front Slope)

Given: Front Slope = 1V:3H
Shoulder Width = 6 ft
Break in slope is at the edge of shoulder
Design Speed = 50 mph
Design ADT = 3000

Problem: Determine the recommended clear zone distance.

Solution: The procedure in Section 35-2.03(b) for non-recoverable front slopes is used as follows:

1. From Figure 35-2A, the clear zone for a front slope 1V:6H or flatter is 16 ft.

2. Because the clear zone (16 ft) exceeds the shoulder width (6 ft), the recommended clear zone distance beyond the toe of the non-recoverable slope (1V:3H) is 10 ft.

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35-2.03(c) Critical Front Slope

A critical front slope is one on which a vehicle is likely to overturn. Front slopes steeper than 1V:3H are critical (Figure 35-2C(c)). If a front slope steeper than 1V:3H begins closer to the through traveled way than the suggested clear-zone distance for that specific roadway, a barrier might be warranted if the slope cannot readily be flattened. See Section 35-3.

35-2.04 Back Slopes

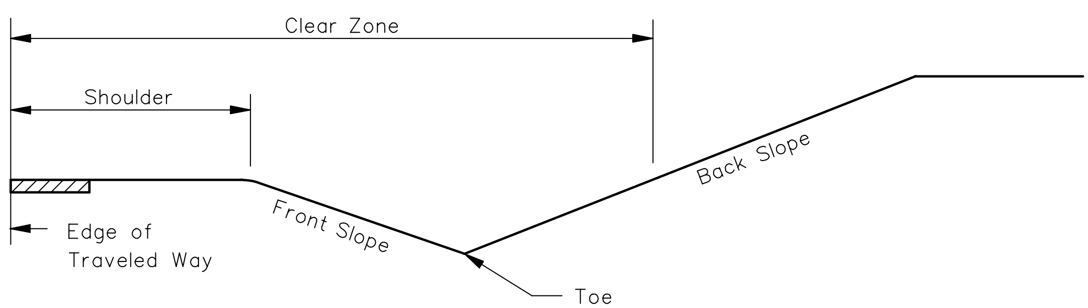
For back slopes without the presence of a roadside ditch (Figure 35-2C), the recommended clear zone distance for back slopes 1V:3H or flatter can be determined directly from Figure 35-2A. Back slopes steeper than 1V:3H are critical and Section 35-2.03(c) should be used.

Example 35-2.03(1) (Back Slopes)

Given: Back Slope = 1V:3H
No Roadside Ditch
Design Speed = 50 mph
Design ADT = 3000

Problem: Determine the recommended clear zone distance.

Solution: From Figure 35-2A, the clear zone distance should be 12 ft.



CLEAR ZONE APPLICATION FOR ROADSIDE DITCHES

Figure 35-2D

35-2.05 Roadside Ditches

Ditch sections as illustrated in Figure 35-2D are typically constructed in roadside cut sections without curbs. The applicable clear zone across a ditch section will depend upon the front slope, the type of ditch, the horizontal location of the toe of the back slope, and various highway factors. The designer will use the following procedure to determine the recommended clear zone distance:

1. Check Front Slope. Use Figure 35-2A to determine the clear zone based on the front slope if the front slope is 1V:4H or flatter. For slopes steeper than 1V:4H but 1V:3H or flatter, the clear zone is beyond the toe of the front slope.

2. Check Location of the Toe of Back Slope. Based on the distance from Step 1, determine 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 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. If the toe is within the clear zone, Step 3 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 from Step 1 above, a clear zone should be provided on the back slope. This clear zone will be the lesser of the following distances beyond the toe of the backslope:

   - 5 ft (1.5 m) beyond the toe of the back slope, or
   - the clear zone distance from Figure 35-2A measured from the edge of the traveled lane.

4. Clear Zones (Rock Cuts). In rock cuts with steep back slopes, no clear zone is required beyond the toe of back slope. 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.

* * * * * * * * * *

Example 35-2.05(1) (Ditch Section)

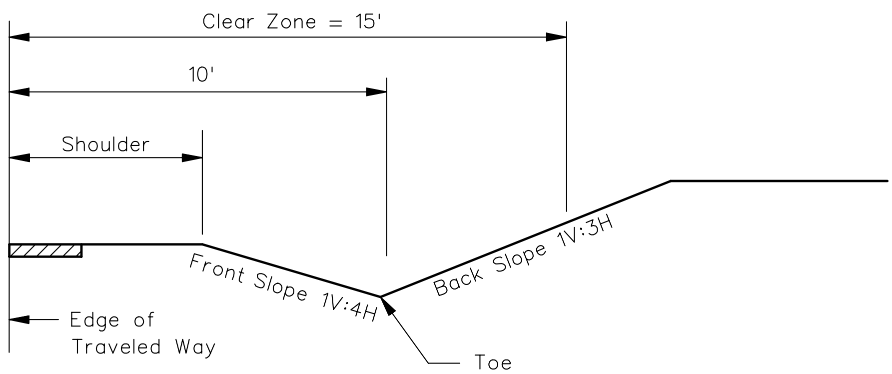
Given: Design ADT = 3000
V = 50 mph
Front Slope = 1V:4H
Ditch Width = 0 ft
Back Slope = 1V:3H
Toe of back slope is 10 ft from edge of traveled way.
See Figure 35-2E.

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

Solution: Using the procedure in Section 35-2.05:

1. Check Front Slope. Figure 35-2A yields a clear zone of 20 ft for a 1V:4H front slope.

2. Check Location of the Toe of Back Slope. The toe of back slope is within the clear zone. Therefore, Step 3 applies.



CLEAR ZONE AT DITCH SECTIONS
(Example 35-2.05(1))

Figure 35-2E

3. Determine Clear Zone on Back Slope (Earth Cuts). Providing a clear zone for a distance 5 ft up the 1V:3H back slope yields a clear zone 15 ft from the edge of the traveled way. This is less than the 20 ft clear zone required for the front slope. Therefore, the 15 ft clear zone applies.

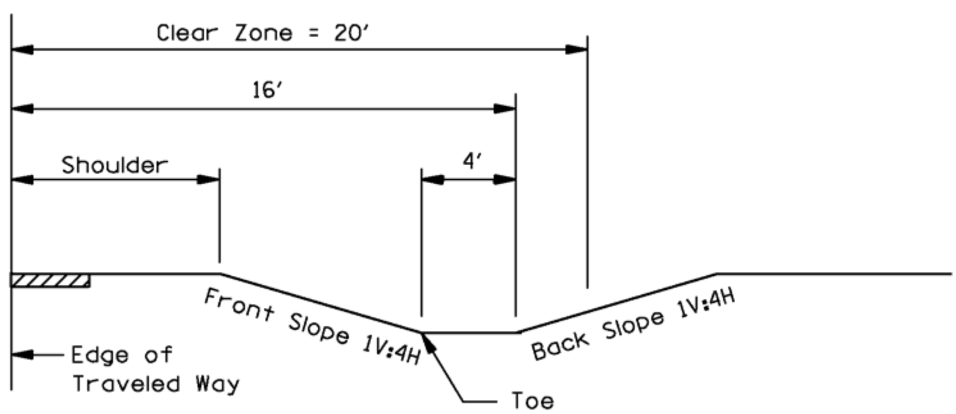
Example 35-2.05(2) (Ditch Section)

Given: Design ADT = 3000
V = 50 mph
Front Slope = 1V:4H
Ditch Width = 4 ft
Back Slope = 1V:4H
Toe of back slope is 16 ft from edge of traveled way.
See Figure 35-2F.

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

Solution: Using the procedure in Section 35-2.05:

1. Check Front Slope. Figure 35-2A yields a clear zone of 20 ft for a 1V:4H front slope.



CLEAR ZONE AT DITCH SECTIONS
(Example 35-2.05(2))

Figure 35-2F

2. Check Location of the Toe of Back Slope. The toe of back slope is within the clear zone. Therefore, step #3 applies.

3. Determine Clear Zone on Back Slope (Earth Cuts). Providing a clear zone for a distance 5 ft up the 1V:4H back slope yields a clear zone of 21 ft from the edge of the travel way. This is more than the 20 ft clear zone required for the front slope. Therefore, the 20 ft clear zone applies.

35-3 TREATMENT OF ROADSIDE HAZARDS

35-3.01 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, etc., extending more than 4 in (100 mm) above the ground;
- bridge piers and abutments at underpasses and bridge parapet ends;
- culverts and 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 normal depth of water ≥ 2 ft (600 mm));
- non-traversable ditches;
- utility poles or towers;
- drainage appurtenances; and
- steep transverse slopes.

35-3.02 Range of Treatments

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

- eliminate the hazard (flatten embankment, etc.);
- relocate the hazard;
- where applicable, make the hazard breakaway (e.g., sign posts, luminaire supports);
- shield the hazard with a roadside barrier;
- delineate the hazard; or
- do nothing.

35-3.03 Methodologies

35-3.03(a) General

The goal of any roadway project should be to eliminate all roadside hazards within the clear zone. When the hazard cannot be eliminated, efforts should be made to provide a treatment to minimize the impact of the hazard to the motorist or to provide a barrier to protect the motorist from the hazard. 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, installation costs and, where applicable, crash experience. The following briefly discusses the decision-making methods for the treatment of roadside hazards.

35-3.03(b) BLRS Policy

For specific applications, the BLRS has adopted policies on the treatment of roadside hazards including the placement of roadside barriers or, in some cases, elimination of the requirement for a barrier.

For roads functionally classified as local with design ADT ≤ 400, it is not necessary to install a roadside barrier even if it is not practical or cost effective to remove a roadside hazard from the clear zone. However, all hazards must be removed from the shoulder and protection must be provided at bridge rails in accordance with Section 35-3.08.

Roadside barriers also do not need to be provided on urban streets functionally classified as local. However, roadside hazards need to be removed from the shoulder or for a distance of 1.5 ft (450 mm) from the gutter line of the curb where provided at the edge of pavement.

35-3.03(c) Cost-Effective Method

Where practical, the designer should use an approved cost-effective methodology to analyze site-specific alternative safety treatments of a roadside hazard. This will provide an objective means to analyze the many factors that impact roadside safety, and will in theory allow the local agency to allocate its resources to maximize the safety benefit to the traveling public. It will also promote uniformity of decision-making for roadside safety throughout the local agency. IDOT generally uses the cost-effective methodology Roadside Safety Analysis Program (RSAP) presented in Appendix A of the AASHTO *Roadside Design Guide*.

35-3.03(d) Engineering Judgment Method

Based on engineering judgment, the designer should analyze the site to determine if the hazard can be eliminated or properly treated. By a “relative severity” assessment, the designer decides 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 should be installed; if not, 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., a large power pole) 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 if a roadside barrier should be installed under one of the following conditions:

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

2. If extenuating circumstances exist, the designer may override BLRS policies for barrier installation or the results of a cost-effective method and not install a roadside barrier. In this case, designers must document the reasons for their decision. This documentation should include crash histories for the section of roadway, traffic volumes, posted speed, and roadway geometry, if available. Send a copy of the documentation to the district for their concurrence in the decision not to provide a barrier.

35-3.04 Embankments

A roadside barrier is not required when the roadway embankment has a parallel front slope of 1V:3H or flatter. A barrier is also not required if the ADT is under 400. However, a roadside barrier may be needed because of other hazards located on the slope. A barrier will be provided when the fill heights exceed the values in Figure 35-3A for slopes steeper than 1V:3H.

Embankment Slope	Design ADT 400-1500	Design ADT Over 1500
1V:2H	10 ft (3 m)	6 ft (1.8 m)
1V:2.5H	20 ft (6 m)	9 ft (2.7 m)

EMBANKMENT FILL HEIGHTS REQUIRING ROADSIDE BARRIERS

Figure 35-3A

35-3.05 Roadside Ditches

Roadside barriers are not required solely to shield roadside ditches. However, barriers may be warranted to shield other hazards within the clear zone.

35-3.06 Transverse Slopes

Where a road or street intersects a side road or an entrance, a slope transverse to the road will be present. See Figure 35-3B. In general, transverse slopes should be as flat as practical. Figure 35-3C presents BLRS criteria for transverse slopes within the clear zone based on the type of facility and design speed. Figure 35-3C 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 35-3.07),
- construction costs, and
- right-of-way and environmental impacts.

Although the 1V:10H or 1V:6H transverse slopes 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.

If the "acceptable" criteria in Figure 35-3C cannot be met, the designer should consider the installation of a roadside barrier.

35-3.07 Roadside Drainage Features

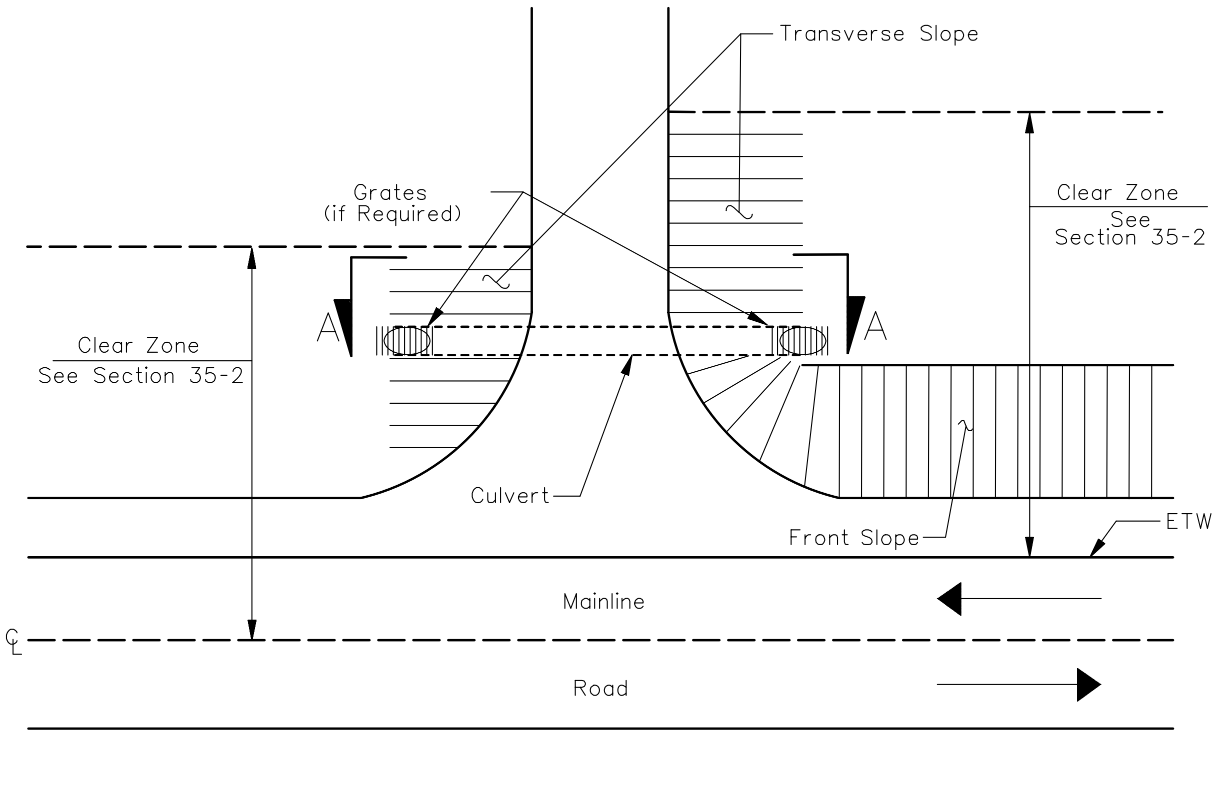
Effective drainage is one of the most critical elements in the design of a highway or street. However, drainage features should be designed and constructed considering their consequences to run-off-the-road vehicles. Ditches, curbs, culverts, and drop inlets are common drainage system elements that should be designed, constructed, and maintained considering both hydraulic efficiency and roadside safety.

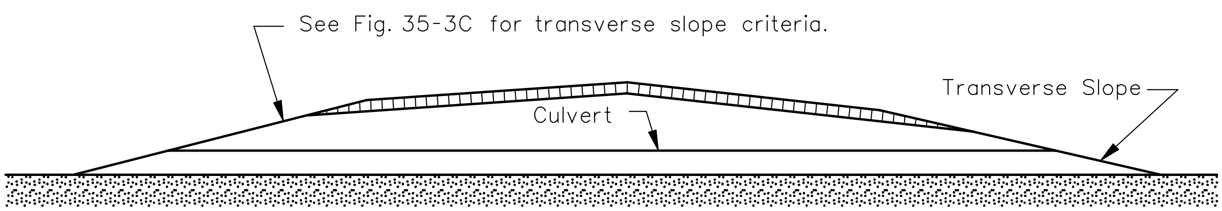
In general, the following options, listed in order of preference, are applicable to all drainage features:

1. Design or modify drainage structures so that they are traversable or present a minimal hazard to an errant vehicle.

2. If a major drainage feature cannot effectively be redesigned or relocated, shielding by a roadside barrier should be considered.

The *Illinois Drainage Manual* discusses IDOT's practices for hydrology and hydraulics and for the physical design of roadside drainage structures. Sections 35-3.07(b) and (c) discuss the safety design of these structures.





SECTION A-A

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

Figure 35-3B

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

Note: A specific maximum acceptable transverse slope has not been included for low-speed facilities. This will be determined on a case-by-case basis based on the factors listed in Section 35-3.06.

RECOMMENDED TRANSVERSE SLOPES

Figure 35-3C

35-3.07(a) Curbs

Curbs are typically used to control drainage or to protect erodible soils. Chapter 31 and the *IDOT Highway Standards* provide detailed information on the warrants and types of curbs used by IDOT. 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. Facilities with a design speed greater than 45 mph (70 km/h) should be designed without curbs. However, if necessary, a mountable curb may be used at the edge of the shoulder. Facilities with a design speed of 45 mph (70 km/h) or less may use either a mountable or barrier 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. It is acceptable to use the 2 in (50 mm) high M2 (M5) curb in conjunction with a roadside barrier. See Section 35-4.04.

3. Redirection. Curbs offer no safety benefits on high-speed roadways and should not be used to redirect errant vehicles.

35-3.07(b) Cross Drainage Structures

Cross drainage structures convey water beneath the roadway. However, if not properly designed, they may present a hazard to run-off-the-road vehicles. The available roadside safety treatments for cross culverts are:

- extend the culvert opening beyond the clear zone,
- provide a traversable end section,
- shield the culvert with a roadside barrier, or
- do nothing.

The following summarizes BLRS practices on the roadside safety treatment of cross drainage structures within the clear zone that are not shielded with a roadside barrier:

1. Pipe Diameter ≤ 36 in (915 mm). For these pipe sizes, provide a pipe end treatment that matches the parallel slope.

2. Pipe Diameter > 36 in (915 mm) to ≤ 54 in (1400 mm). For these pipe sizes, provide a precast pipe end section with grate.

3. Pipe Diameter > 54 in (1400 mm). For these pipe sizes, provide a special end section with a grate designed in accordance with the AASHTO *Roadside Design Guide*, or provide a roadside barrier.

For pipe arches and elliptical pipes, the pipe rise should be used, rather than the equivalent round diameter, to determine the safety treatment. For box culverts, special designs for the end treatment will be required depending on the rise and span of the culvert. The type of treatment should be similar to that discussed above for pipe culverts.

When it is not feasible to provide grates for a culvert terminating within the clear zone, consider extending the culvert beyond the clear zone. It may be possible to flatten the front slopes for a distance through the culvert area to decrease the required clear zone. In any case, the culvert must be extended as much as feasible within right-of-way and drainage constraints, or a roadside barrier must be provided. The end of any culvert terminating within the clear zone should be delineated. Each culvert location should be analyzed individually, and the treatment selected should be based on cost effectiveness, as well as right-of-way and environmental constraints and maintenance issues.

35-3.07(c) Parallel Drainage Structures

Parallel drainage culverts are those that are oriented parallel to the main flow of traffic. They are typically used under intersecting side roads, driveways, and field entrances. Because an errant vehicle will impact the structure at approximately 90°, parallel drainage structures represent a potential hazard. Therefore, the designer must coordinate their design with that of the surrounding transverse slope (Section 35-3.06) to minimize the hazard.

The following summarizes BLRS practices on the roadside safety treatment of parallel drainage structures within the clear zone that are not shielded with a roadside barrier:

1. Pipe Diameter ≤ 24 in (450 mm). For these pipe sizes, a projecting end is acceptable.

2. Pipe Diameter > 24 in (600 mm). For these pipe sizes, the safety treatment will depend upon the ADT and pipe diameter. See Figure 35-3D for general guidelines; the final treatment will be based on the site-specific conditions. Figure 35-3E presents a schematic of a design for grate protection of a parallel drainage structure. The bottom bar or pipe of the grate should be 4 to 8 inches (100 mm to 200 mm) above the culvert invert. This will reduce wheel snagging if an errant vehicle impacts the pipe end. Grates are only required on the approach end to the nearest lane of traffic. Grates are desirable on the departure end and near or within curves.

3. Pipe Arches and Elliptical Pipes. The pipe rise should be used rather than the equivalent round diameter to determine the appropriate end treatment in accordance with the above practices.

4. Box Culverts. The distance from the flow line of the culvert to the top of the headwall will be used in place of the pipe diameter to determine the appropriate treatment from Figure 35-3D. If the span of the box culvert is > 5 ft (1.5 m), a special end treatment must be developed regardless of the height.

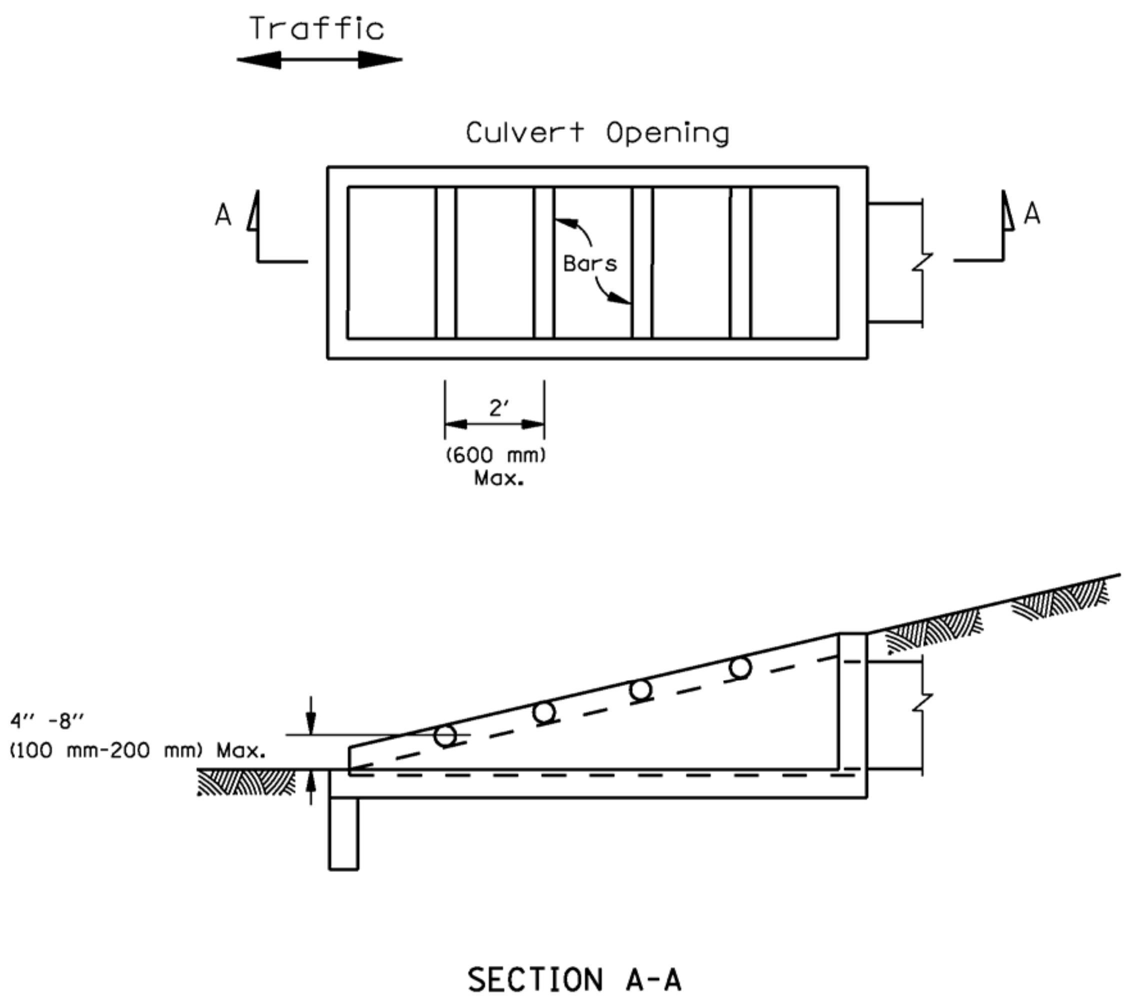
ADT	Pipe Size	Treatment
ADT ≤ 1000	> 24 in (600 mm)	End of pipe should match surrounding transverse slope; pipe opening can remain.
1000 < ADT ≤ 13,000	30 in (750 mm)	End of pipe should match surrounding transverse slope; pipe opening can remain.
	≥ 36 in (915 mm)	End of pipe should match surrounding transverse slope; provide end section with grates. See Note (1)
ADT > 13,000	≥ 30 in (750 mm)	End of pipe should match surrounding transverse slope; provide end section with grates.

Notes:

(1) Grates may be omitted on tangent sections in locations where debris clogging requires substantial maintenance attention to retain the required waterway opening. Justification shall be documented and retained in the project file.

SAFETY TREATMENT FOR PARALLEL DRAINAGE STRUCTURES

Figure 35-3D



GRATE PROTECTION FOR PARALLEL DRAINAGE STRUCTURES

Figure 35-3E

5. Eliminate Exposed Ends. Parallel drainage structures may be closely spaced because of frequent driveways and intersecting roads. In these locations, it may be practical 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.

6. Barrier. When the structure is too large to be safety treated effectively, it may be necessary to shield the obstacle with a traffic barrier.

35-3.08 Bridge Rails

An approaching roadside barrier (or approved terminal section) is required for all bridge rail ends closest to the flow of traffic, unless at least one of the following applies:

- The posted speed limit is less than 25 mph on an urban curbed section.
- The ADT is less than 150; the bridge is approach roadway width; and the bridge is on tangent alignment.
- A township or road district bridge is wider than the approaching roadway and the bridge is on tangent alignment.

The above exceptions do not apply if a design speed is chosen which exceeds the design speed shown in Figures 32.2A, 32-2A, 33-3A, or 33-3B.

For bridge rail ends on the opposite side (i.e., departure ends of two-way roadways), the need for shielding the end of the bridge will be determined by whether or not the bridge end is within the clear zone (as measured from the centerline of the traveled way) for the opposing flow of traffic.

35-3.09 Other Hazards

35-3.09(a) Roadside Sign Supports

Roadside sign supports located within the clear zone should be made breakaway. See Chapter 39 for more information.

35-3.09(b) Mailbox Supports

Mailbox supports are discussed in Chapter 41.

35-3.09(c) Utility Poles

Every effort should be made to eliminate or relocate all utility poles within the clear zone. When poles cannot be moved outside of the clear zone, consider shielding selected poles.

35-3.09(d) Trees

Trees with an expected mature size greater than 4 in (100 mm) are considered fixed objects. Consider the removal of an individual tree where it is determined that the tree is both an obstruction and to be in a location where they are likely to be hit. Because tree removal can be expensive and often has adverse environmental impacts, it is important that this countermeasure be used only when it is an effective solution. When a tree is in a vulnerable location and cannot be moved, consider a traffic barrier to shield the tree. However, a roadside barrier should only be used when the severity of impacting the tree is greater than impacting the barrier.

35-4 ROADSIDE BARRIERS

35-4.01 <u>Types</u>

The following Sections briefly describe allowable types and usages of roadside barriers commonly used on local agency projects. Barrier terminal and end sections used in conjunction with these barriers are also described. The *IDOT Highway Standards* presents the details on each system. Chapter 35 does not discuss median barriers and impact attenuators because of their infrequent use on local agency projects. They are discussed in Chapter 38 of the *BDE Manual*.

35-4.01(a) Steel Plate Beam Guardrail

The steel plate beam guardrail, commonly known as the “W”-beam system, will normally be used by a local agency for a roadside barrier. The steel plate beam guardrail with strong posts is a semi-rigid system. A major objective of the strong post system is to prevent a vehicle from “snagging” on the posts. This is achieved by using blockouts to offset the posts from the longitudinal beam and by establishing 6′-3″ (1905 mm) as the maximum allowable post spacing.

IDOT has developed several variations of the steel plate beam guardrail for various applications:

1. <u>Type A</u>. The Type A guardrail uses the typical 6′-3″ (1905 mm) post spacing, and is the most commonly used barrier system in Illinois. Type A guardrail has a deflection distance of 3 ft (920 mm).

2. <u>Type B</u>. The Type B guardrail uses a post spacing of 3′-1½″ (953 mm) and has a deflection distance of 2 ft (600 mm). It is used where the deflection distance for the Type A system is unavailable. Type B guardrail may be installed when the distance from the back of guardrail posts to the embankment hinge point is 0 to 2 ft (0 to 0.6 m). The reduction in support from the embankment will increase the potential deflection of the system, and allowance for 3 ft (920 mm) deflection should be made when this design is used.

3. <u>Type C</u>. The Type C guardrail is a single rail that is attached directly to rigid objects where a 2 ft (600 mm) deflection distance cannot be provided and where it is necessary or desirable to carry the guardrail across the face of a structure. Limited applications of this type are expected. Normally, guardrail will be attached to concrete structures (e.g., piers) in a manner similar to that described in Section 35-4.02(b) for attachments at bridges.

4. <u>Attached to Headwalls</u>. IDOT has developed an adaptation of the steel plate beam guardrail specifically for attachment to concrete headwalls near the edge of the shoulder.

The height of all guardrail should be 27 in (685 mm) from the finished ground line to the top of the guardrail.

35-4.01(b) Cable Road Guard

Cable road guard is only used where the designer needs to inhibit unwanted vehicular encroachments. It should not be used as a roadside barrier.

35-4.01(c) Other Systems

Many other roadside barrier systems are available that may have application at specific sites (e.g., the thrie beam). The designer should reference the AASHTO *Roadside Design Guide* for information on these systems. IDOT must approve the use of any system not included in the *IDOT Highway Standards*.

35-4.02 Barrier Terminal Treatments

Barrier terminal sections present a potential roadside hazard 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.

On NHS routes, existing safety features should at a minimum meet NCHRP 230 standards. However, it is desirable that the bridge railings, transitions, approach guardrail, and guardrail terminals meet NCHRP Report 350 criteria. Unique designs should be compared to accepted designs and will be approved on a case-by-case basis. For acceptable bridge railings and barriers, see the FHWA safety hardware website at www.fhwa.dot.gov/bridge/bridgerail/index.cfm under Bridge Railings or under Longitudinal Barriers (keyword: bridge railings). New designs shall meet NCHRP Report 350 criteria.

Transitions may be considered acceptable if the approach rail is nested (double rail element at the connection), the post spacing is reduced, and a rubrail or curb is present to minimize wheel snagging. Acceptable Report 230 transitions are identified in two FHWA Technical Advisories (1986 and 1993), and Report 350 transitions are on the FHWA website at www.fhwa.dot.gov/bridge/bridgerail/index.cfm under Longitudinal Barriers (keyword: bridge rail transitions). Unacceptable guardrail terminals on the NHS are blunt ends, turned-down ends and breakaway cable terminals (BCTs). Others meeting NCHRP Report 230 or 350 criteria should be acceptable.

For non - NHS routes, at a minimum bridge rail should be crashworthy, the approach rail should be adequately connected to the bridge rail, and the rail post spacing should be reduced to limit deflection. Nested railing is preferred, but not required. Terminals should be crashworthy with no blunt ends. Crashworthy terminals are preferred, and existing turn-downed ends and BCTs should be eliminated when practical. However, cost-effectiveness of replacement should be considered on low volume, low speed roads.

The *IDOT Highway Standards* present the design details for several end treatments allowed by the Central BLRS. Other proprietary terminal treatments are allowed under various specifications. The following Sections briefly describe each system and, where applicable, discuss typical uses of the system.

35-4.02(a) Guardrail Ends

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

1. Type 1. This terminal section may be used on local agency highways, except locations on the National Highway System or locations where the traffic volumes exceed 6000 ADT and design speeds are in excess of 50 mph (80 km/h). The approach end of the terminal has a 4 ft (1.2 m) flare. The shoulder in the area of the terminal must be widened. See Standard BLR 23 for details.

2. Type 1, Special (Flared). This terminal section is intended for use with steel plate beam guardrail. All approved terminals meet NCHRP 350 criteria. The designer should choose a flared terminal where practical, if no additional right-of-way must be purchased for installation. The leading portion of the terminal is normally a gating design. Because of the gating function, the area behind and beyond the terminal should be relatively free of significant fixed objects. See the *IDOT Highway Standards* for a detail of the shoulder widening at the terminal.

3. Type 1, Special (Tangent). This is a terminal section intended for use with steel plate beam guardrail. All approved terminals meet NCHRP 350 criteria. Tangent terminals should be chosen in areas where the cross section or drainage structure would require additional right-of-way to accommodate the Type 1 Special (Flared) terminal. The leading portion of the terminal is normally a gating design. Because of the gating function, the area behind and beyond the terminal should be relatively free of significant fixed objects. See the *IDOT Highway Standards* for a detail of the shoulder widening at the terminal.

4. Type 1B. This terminal should be used at the approaching or departing (where practical) end of roadside barriers where appropriate cut or artificial mound conditions exist or can reasonably be constructed.

5. Type 2. This is an unflared terminal with a cable anchor. The Type 2 terminal should be used on the departing end of steel plate beam guardrail where end-on impacts are not a consideration.

35-4.02(b) Bridge Rail Connections

Roadside barriers are often terminated with a transition into a bridge rail. The connector terminal sections should be compatible with the bridge rail. Railing for locations on NHS routes must meet the requirements of NCHRP 230 or 350 as discussed in Section 35-4.02. For other locations, selection should be based on consideration of cost and safety. Reference information on bridge railing is contained in the IDOT Bridge Manual, Section 3.2.14. The following terminals are used as bridge rail connections, and do not comply with NCHRP 350 unless noted herein:

1. Type 5. This connector terminal should be used to connect steel plate beam guardrail to the concrete bridge parapet or end post at the departing end of a new bridge, where this end is not within the clear zone of the opposing traffic.

2. Type 5A. This connector terminal is used to connect steel plate beam guardrail to a steel bridge rail at either the approach end or departing end of the bridge. For applications where compliance with NCHRP 350 is required, use Type 6A.

3. Type 5R. This connector terminal should only be used to connect steel plate beam guardrail to the concrete bridge parapet or end post at either the approach end or departing end of an existing bridge where the clear width of the bridge cannot be reduced.

4. Type 6. This connector terminal includes a transition section, special posts, blockouts, and an end shoe. It also requires the use of a curb on the approach. Use Type 6 to attach steel plate beam guardrail to the end(s) of bridges with concrete parapet. It may also be used to connect the steel plate beam guardrail to the face of the other concrete structures where the curb can be installed. Recent modifications to the design of this terminal have achieved compliance with NCHRP 350.

5. Type 6A. This connector terminal 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 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.

6. Type 6B. This connector terminal 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 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.

7. Type 8. This connector terminal includes a transition section, special posts, blockouts, and a turned-down connection to the top of the safety curb. Only use Type 8 on existing installations.

8. Type 10. This connector terminal should be used to connect steel plate beam guardrail to the departing end of existing bridges where this end is not within the clear zone of the opposing traffic.

35-4.03 Lateral Placement

Roadside barriers should be placed as far as practical from the edge of traveled way. This placement provides an errant motorist the best chance of regaining control of the vehicle without impacting the barrier. It also provides better sight distance, particularly at nearby intersections. The following factors should be considered when determining barrier lateral placement:

1. Shoulder. Typically, the roadside barrier is located at the edge of the shoulder such that the face of the barrier is flush with the shoulder hinge point.

2. Deflection. The dynamic deflection distance of the barrier, as measured from the back of the post, should not be violated. Section 35-4.01(a) provides the deflection distances for the types of roadside barriers typically used.

3. Shoulder Stabilization. Where a barrier is placed on high fills or highly erodible soils, it may be desirable to provide shoulder stabilization in accordance with the *IDOT Highway Standards*. IDOT's District Geotechnical Engineer should be consulted for guidance.

4. Slopes. Where a barrier is placed in front of slopes, the design should provide a minimum 2 ft (600 mm) width behind the guardrail to the slope break. This provides for post support, reduces erosion, and reduces maintenance needs. If a minimum 2 ft (600 mm) width cannot be provided, Type B guardrail may be used. See Section 35-4.01(a).

5. Shy Distance. Drivers tend to "shy" away from continuous longitudinal obstacles along the roadside (e.g., guardrail). Therefore, the lateral barrier offset should desirably be based on the criteria in Figure 35-4A.

US Customary		Metric	
Design Speed (mph)	Shy Line Offset (ft)	Design Speed (km/h)	Shy Line Offset (m)
60	7.9	100	2.4
55	7.2	90	2.2
50	6.6	80	2.0
45	5.6	70	1.7
40	4.6	60	1.4
35	4.1	50	1.1
30	3.6		

SUGGESTED SHY LINE OFFSET

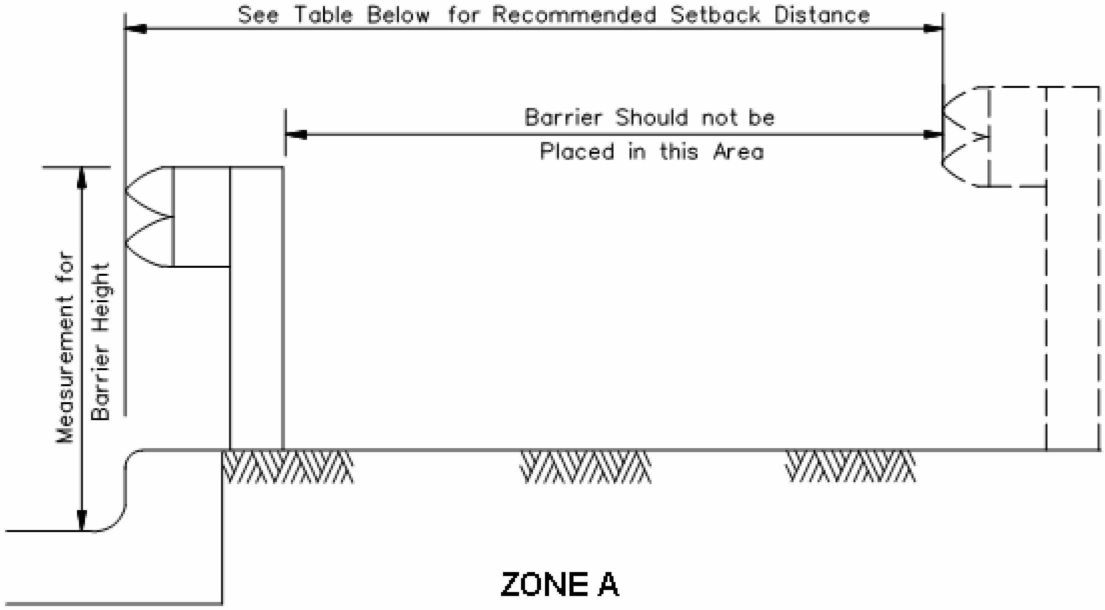
Figure 35-4A

35-4.04 Placement Behind Curbs

If practical, roadside barriers should not be placed in conjunction with either barrier or mountable curbs. Where this is necessary, the following will apply (see Figure 35-4B):

1. Roadside Barrier/Curb Orientation. Ideally, the face of the barrier should be in line with the face of the curb (i.e., at the gutter line). However, this is not always practical. At a maximum, the barrier face should be no more than 1 ft (300 mm) from the face of curb. The height of the guardrail must be measured from the pavement or paved shoulder surface. In addition, the designer should consider reducing the curb height to 4 in (100 mm) and stiffening the rail to reduce vaulting potential. Rail stiffening may be accomplished by using Type B guardrail, by using a double nested Type A rail, or by bolting a W-beam to the back of the posts.

2. Lateral Placement. Figure 35-4B presents criteria to determine proper barrier placement behind curbs. If a barrier must be located in the zone not recommended, the designer must use the M2 (M5) mountable curb for design speeds greater than 30 mph (50 km/h). The 2 in (50 mm) height will introduce little or no vehicular vaulting, and therefore will not interfere with the proper vehicular/barrier interaction. The M2 (M5) curb will extend upstream from the end of the roadside barrier by a distance determined as indicated in Figure 35-4C.



US Customary		Metric	
Design Speed (mph)	Curb-to-Barrier (Zone A) Distance* (ft)	Design Speed (km/h)	Curb-to-Barrier (Zone A) Distance* (m)
≤ 30	NA	≤ 50	NA
35 – 40	8	60	2.5
45	10	70	3.0
≥ 50	See Note (1)	≥ 80	See Note (1)

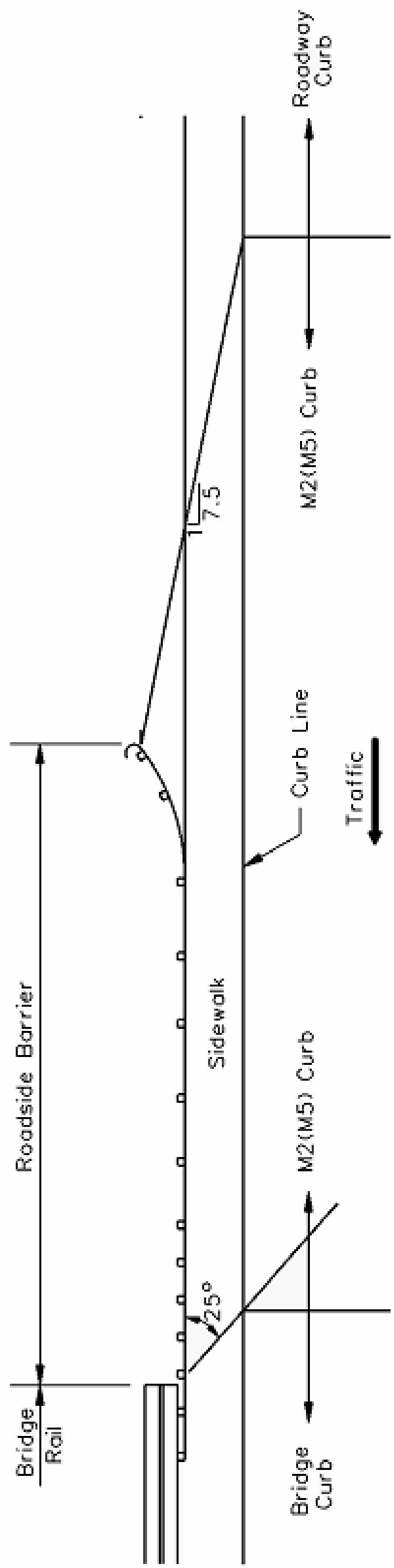
**Values in table represent distance beyond which it is acceptable to place a barrier.*

Notes:

1. *For design speeds ≥ 50 mph (80 km/h), curbs should not be used with a barrier.*
2. *Barrier should be flush with curb as shown. At a maximum, the barrier face may be placed up to 1 ft (300 mm) behind curb. When placed behind the face of the curb, reductions in curb height and rail stiffening should be considered.*
3. *If barrier must be placed in Zone A above, use the M2 (M5) curb. See Figure 35-4K.*

PLACEMENT OF BARRIER RELATIVE TO CURBS

Figure 35-4B



USE OF ROADSIDE BARRIER WITH M2 (M5) CURB

Figure 35-4C

35-4.05 Placement on Slopes

Slopes in front of a barrier should be 1V:10H or flatter. This also applies to the areas in front of the flared section of guardrail and to the area approaching the terminal ends.

35-4.06 Barrier Flare

Flaring a roadside barrier away from the roadway has two benefits:

- the necessary length of need is reduced, and
- the barrier is less likely to be impacted.

The disadvantage is that a flare will increase the vehicular angle of impact. Figure 35-4D presents suggested flare rates for roadside barriers, which are intended to balance the advantages and disadvantages of flares.

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

**See Figure 35-4A for shy line distances.*

SUGGESTED FLARE RATES FOR BARRIER DESIGN

Figure 35-4D

35-4.07 Length of Need

A roadside barrier must be extended a sufficient distance upstream and/or downstream from the hazard to safely protect a run-off-the-road vehicle. Otherwise, the vehicle could travel behind the barrier and impact the hazard.

Many factors combine to determine the appropriate length of need for a given roadside condition. These include:

- the distance to the outside limit of the hazard (L_H) or the clear zone (L_C), whichever is less;

- the distance between the edge of traveled way and the barrier (L_B);
- the runout length (L_R), which is based on the design speed (V) and the traffic volume on the facility;
- the length of hazard (L_2), as measured parallel to the roadway;
- whether or not the barrier is on a flare (see Figure 35-4D); and
- on two-way facilities, whether or not the barrier needs to be extended to provide protection for the traffic in the opposing direction.

Figures 35-4E and 35-4F illustrate the variables that will determine the barrier length of need. Figure 35-4E applies to a two-way roadway where the hazard is not within the clear zone of the opposing direction of travel. Figure 35-4F applies to a two-way facility where the roadside hazard is within the clear zone of the opposing direction of traffic.

To determine the length of need, use the nomograph in Figure 35-4H and the following procedure:

1. Construct 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).

2. Locate L_H or L_C, whichever is less, on the y-axis.

3. Determine L_R from Figure 35-4G and locate L_R on the x-axis. If barrier protection is needed for only the approaching traffic, only use the scale marked "Edge of Traveled Way Scale." If needed for both directions of travel, locate L_R on both scales marked "Edge of Traveled Way Scale" and "Centerline Scale." See Step 7 to determine the downstream end of the barrier where the hazard does not require shielding for the opposing traffic.

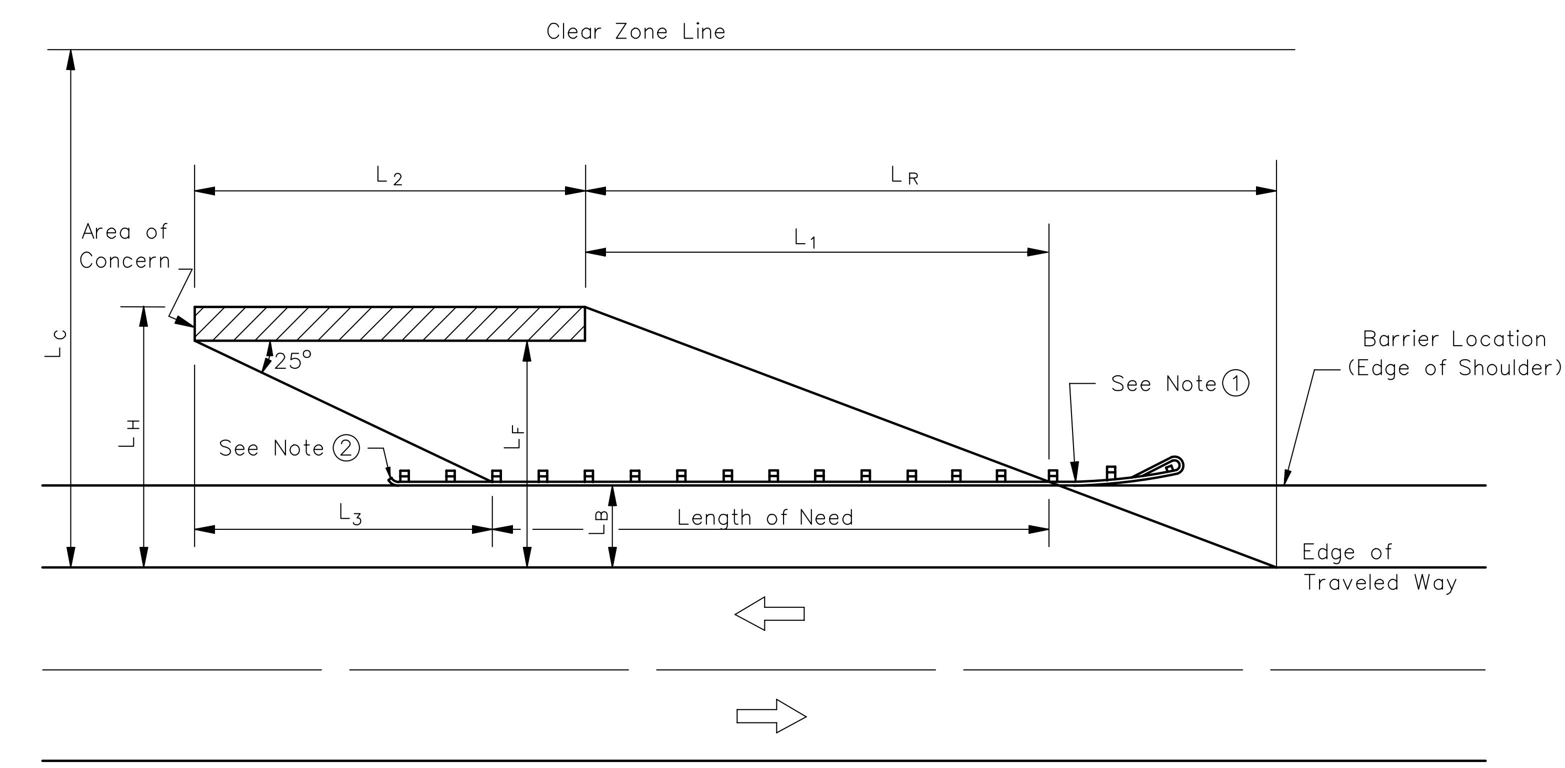
4. Connect the points in Steps 2 and 3 with a straight line or two straight lines.

5. Locate the intersection(s) of the lines in Steps 1 and 4. From this point(s), draw a line vertically to the L_R Scale(s).

6. Read L_1 from the L_R Scale(s). As illustrated on Figures 35-4E and 35-4F, L_1 is measured from the lateral edge of hazard to the beginning of the end terminal (i.e., it does not include the terminal).

7. If barrier protection is only warranted for one direction of travel (Figure 35-4E), use the following procedure to determine the downstream end of the length of need:

    a. Locate the distance (L_F) from the front of the hazard to the edge of traveled way on the y-axis.



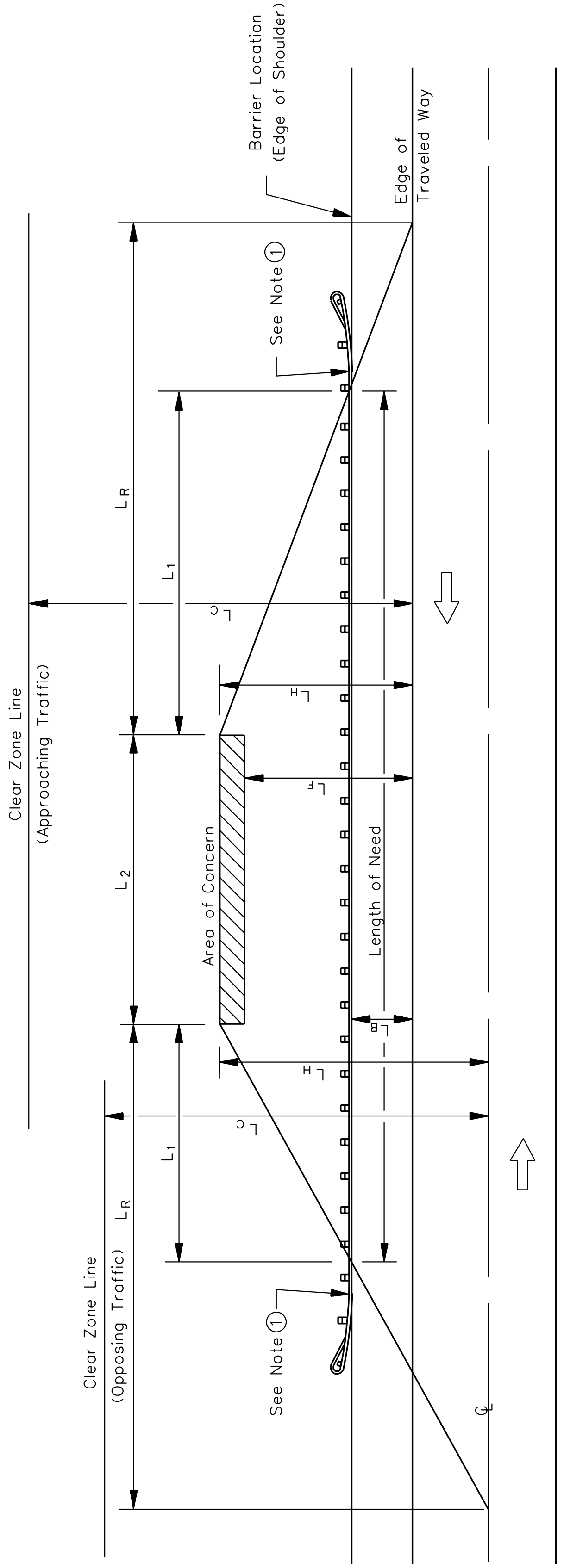
Notes:

① *Use appropriate crashworthy terminal; see Section 35-4.02.*
② *Use acceptable anchorage terminal: see Section3 5-4.02.*

L_B = Distance to barrier
L_C = Clear zone
L_H = Distance to back of hazard
L_F = Distance to front of hazard
L_R = Runout length (see Figure 35-4G)
L_1 = Length needed for approach end
L_2 = Length of hazard
L_3 = Length to be omitted from length of need

BARRIER LENGTH OF NEED LAYOUT
(Hazard Not Within Clear Zone of Opposing Traffic)

Figure 35-4E



L_B = Distance to barrier
L_C = Clear zone
L_H = Distance to back of hazard
L_F = Distance to front of hazard
L_R = Runout length (see Figure 35-4G)
L_1 = Length needed for approach end
L_2 = Length of hazard

Note:

① Use appropriate crashworthy terminal. See Section 35-4.02.

BARRIER LENGTH OF NEED LAYOUT
(Hazard Within Clear Zone of Opposing Traffic)

Figure 35-4F

Design Speed		Traffic Volume (ADT)*							
		Over 6000		2000-6000		800-2000		Under 800	
		Runout Length L_R		Runout Length L_R		Runout Length L_R		Runout Length L_R	
Mph	(km/h)	ft	(m)	ft	(m)	ft	(m)	ft	(m)
60	(100)	425	(130)	400	(120)	345	(105)	330	(100)
55	(90)	360	(110)	345	(105)	315	(95)	280	(85)
50	(80)	330	(100)	300	(90)	260	(80)	245	(75)
45	(70)	260	(80)	245	(75)	215	(65)	200	(60)
40	(60)	230	(70)	200	(60)	180	(55)	165	(50)
35		200		185		165		150	
30	(50)	165	(50)	165	(50)	150	(45)	130	(40)

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

RUNOUT LENGTHS FOR BARRIER DESIGN

Figure 35-4G

b. From this point, draw a line parallel to the 25° line in Figure 35-4H until it intersects the L_B line (Step 1).

c. Move down vertically to the L_R "Edge of Traveled Way Scale" and read L_3.

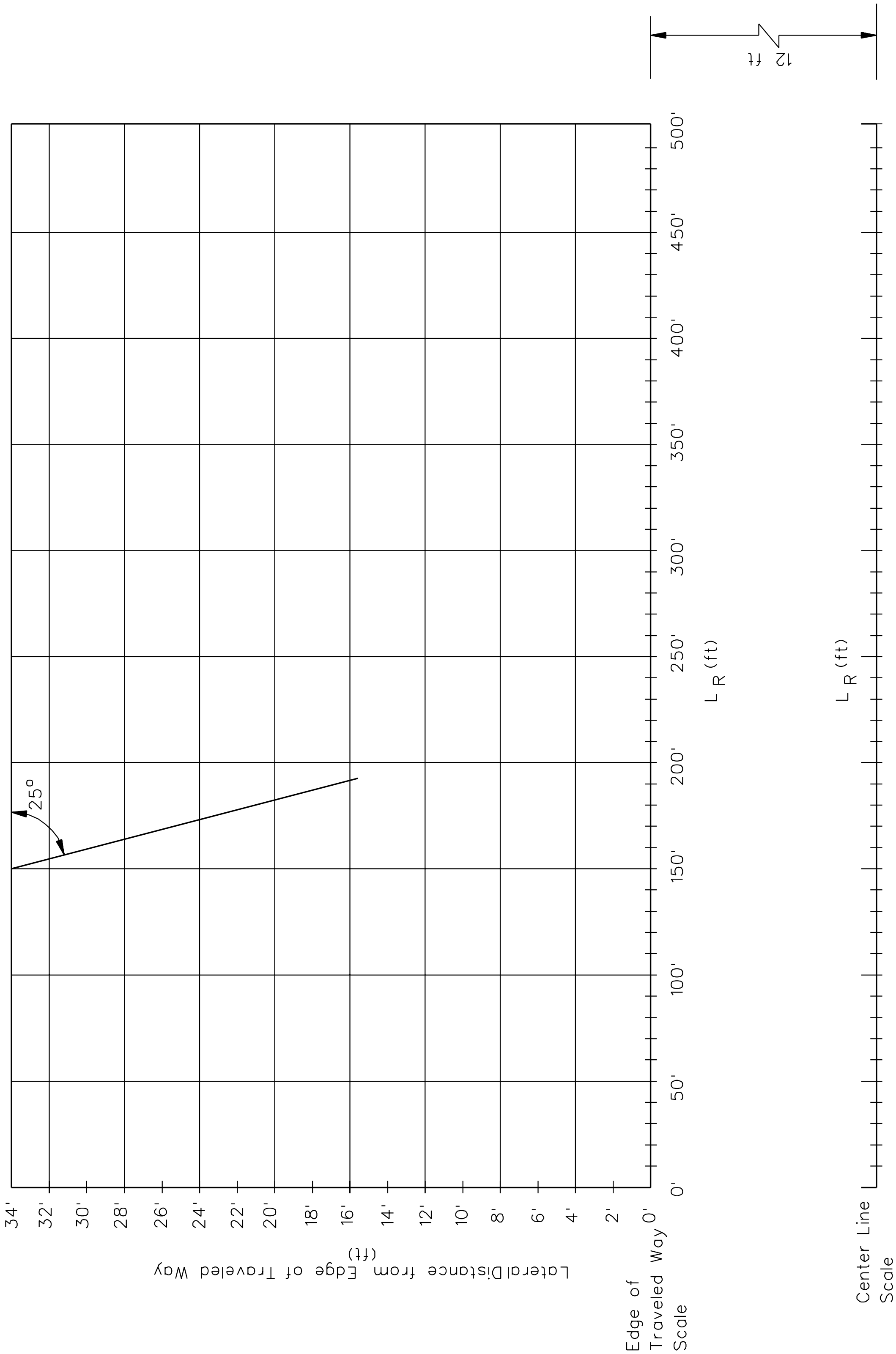
d. As illustrated on Figure 35-4E, the L_3 distance is omitted from the length of need.

8. A barrier flare may be used to reduce the barrier length of need. Example 35-4.07(3) illustrates how to use Figure 35-4B to determine L_1 when the barrier is flared.

9. The length of need determined in the above steps must be adjusted to provide full 12′-6″ (3.81 m) panels of guardrail. The length of guardrail required in advance of the hazard as determined in Steps 1 through 6 is always rounded up. The length to be omitted as determined in Step 7 is always rounded down.

The various traffic terminal end treatments may allow a portion of the terminal to be included in the length of need. Include any applicable portion when determining the location of the terminal.

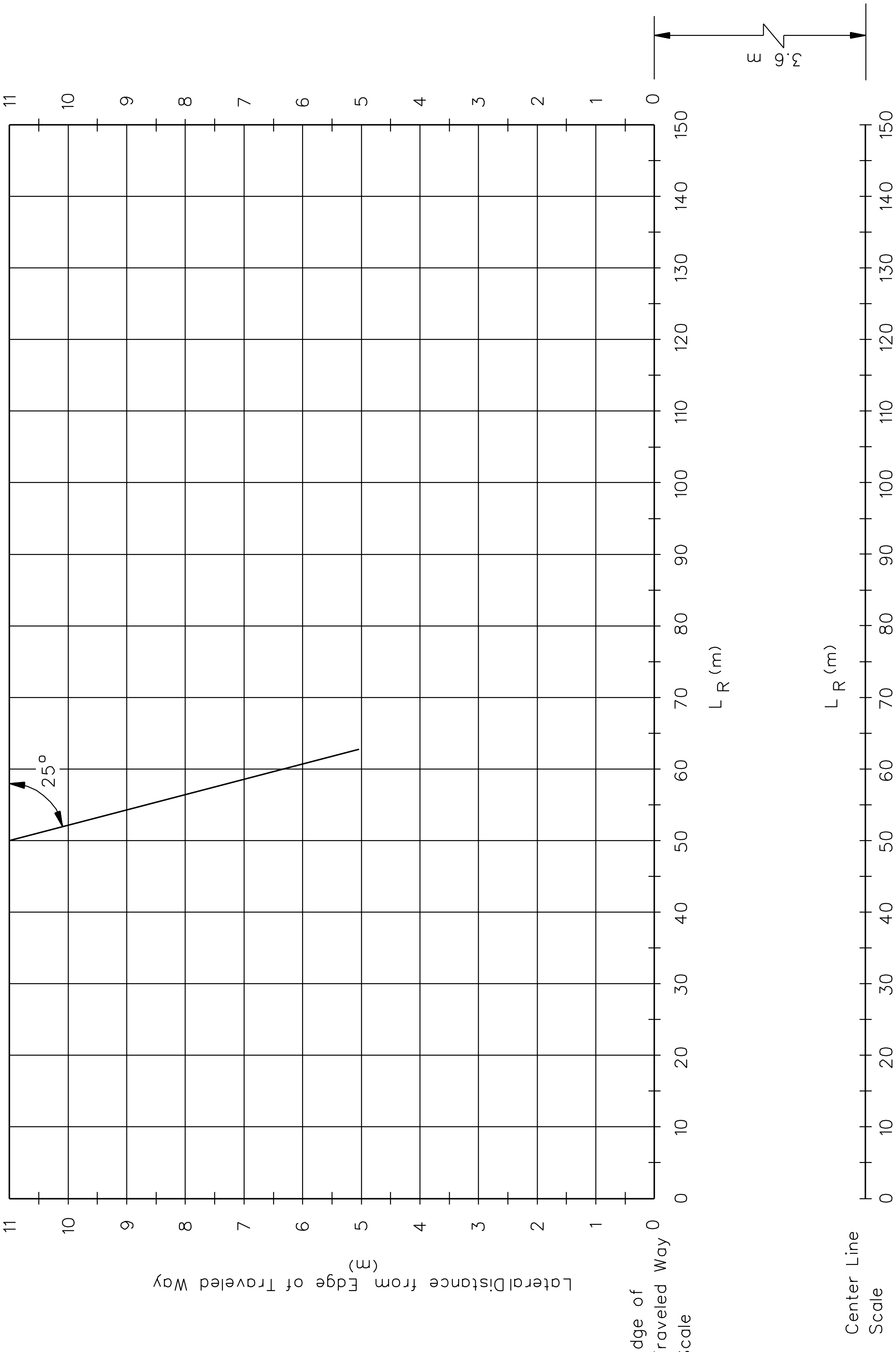
* * * * * * * * * *



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

BARRIER LENGTH OF NEED CALCULATION
(US Customary)

Figure 35-4H



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

BARRIER LENGTH OF NEED CALCULATION
(Metric)

Figure 35-4H

Example 35-4.07(1) (Approach Rail Only)

Given: Design ADT = 7000
V = 60 mph
Slope = 1V:4H front slope
Tangent roadway
Shoulder width = 8 ft = L_B
L_H = 25 ft
Two-way roadway
L_F = 15 ft
Unflared barrier (steel plate beam guardrail, Type A) located at edge of shoulder

Problem: Determine the barrier length of need.

Solution: Using the procedure in Section 35-4.07, the following steps apply (see solution in Figure 35-4I):

1. L_B = 8 ft. Figure 35-4I illustrates the horizontal line.

2. From Figure 35-2A, L_C = 30 ft. Therefore, because $L_H < L_C$, locate L_H = 25 ft on the y-axis.

3. From Figure 35-4G, L_R = 425 ft. Locate point on "Edge of Traveled Way Scale."

4. Connect the points in Steps 2 and 3.

5. Draw the vertical line down to the L_R scale.

6. Read L_1 = 285 ft.

7. Use the procedure to locate the downstream end of the barrier length of need:

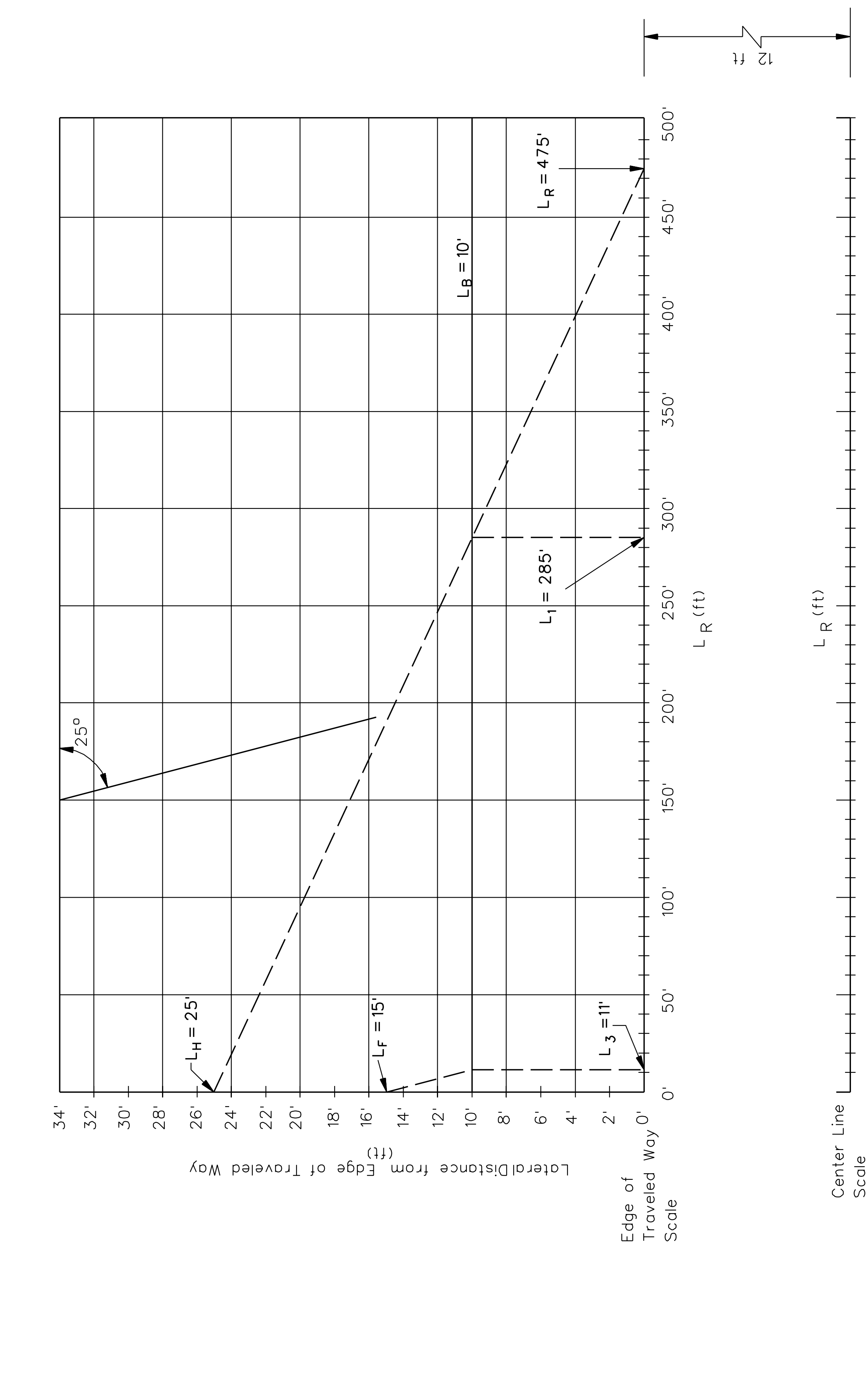
   a. Locate L_F = 15 ft on the y-axis.
   b. Draw a line parallel to the 25° line (see Figure 35-4I).
   c. Draw a vertical line down to the L_R scale. Read L_3 = 18 ft.

8. Not applicable (i.e., no flare).

9. Round L_1 and L_3 as discussed to ensure only full-length panels of guardrail are used.

Example 35-4.07(2) (Approach and Departure Rail Needed)

Given: Design ADT = 5000
V = 60 mph
Slope = 1V:4H front slope
Tangent roadway



BARRIER LENGTH OF NEED CALCULATION
(Example 35-4.07(1))

Figure 35-4I

Shoulder width = 8 ft = L_B
L_H = 15 ft
Two-way roadway
L_F = 10 ft
Unflared barrier (use steel plate beam guardrail, Type B, due to lack of deflection distance) located at edge of shoulder

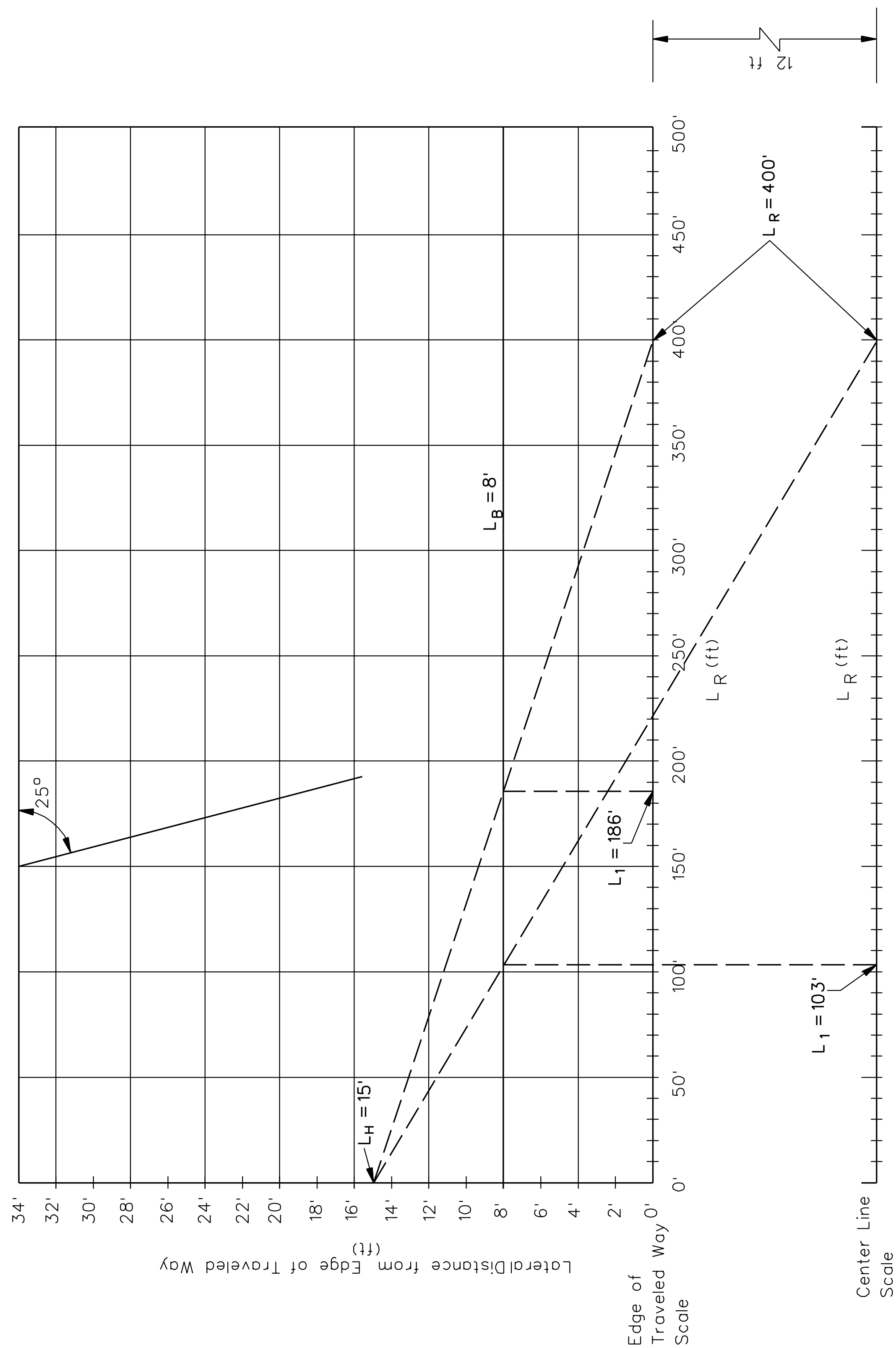
Problem: Determine the barrier length of need.

Solution: Using the procedure in Section 35-4.07, the following steps apply (see solution in Figure 35-4J):

1. L_B = 8 ft. Figure 35-4J illustrates the horizontal line.
2. From Figure 35-2A, L_C = 20 ft. Therefore, because $L_H < L_C$, locate L_H = 15 ft on the y-axis.
3. From Figure 35-4G, L_R = 400 ft. Locate point on "Edge of Traveled Way Scale" and "Center Line Scale."
4. Connect the points in Steps 2 and 3.
5. Draw the vertical line down to the L_R scales.
6. Read L_1 = 186 ft upstream from the hazard and L_1 = 103 ft downstream from the hazard.
7. Not applicable.
8. Not applicable (i.e., no flare).
9. Round L_1 upstream and downstream as discussed to ensure only full-length panels of guardrail are used.

Example 35-4.07(3) (Flared Barrier)

Given: Design ADT = 7000
V = 60 mph
Slope = 1V:4H front slope
Tangent roadway
Shoulder width = 8 ft = L_B
L_H = 25 ft
Two-way roadway
L_F = 15 ft
Barrier (steel plate beam guardrail, Type A) with 1:20 flare



BARRIER LENGTH OF NEED CALCULATION
(Example 35-4.07(2))

Figure 35-4J

Problem: Determine the barrier length of need.

Solution: Using the procedure in Section 35-4.07 (adjusted for flare), the following steps apply (see solution in Figure 35-4K):

1. Figure 35-4K illustrates the location of barrier with 1:20 flare.

2. From Figure 35-2A, L_C = 30 ft. Therefore, because $L_H < L_C$, locate L_H = 25 ft on the y-axis.

3. From Figure 35-4G, L_R = 425 ft. Locate point on "Edge of Traveled Way Scale."

4. Connect the points in Steps 2 and 3.

5. Draw the vertical line down to the L_R scale. Read L_1 = 135 ft. *Note that, for the unflared barrier in Example 35-4.07(1), L_1 = 285 ft.*

6. Use the procedure to locate the downstream end of the barrier length of need:

   a. Locate L_F = 15 ft on the x-axis.
   b. Draw a line parallel to the 25° line (see Figure 35-4K).
   c. Draw a vertical line down to the L_R scale. Read L_3 = 18 ft.

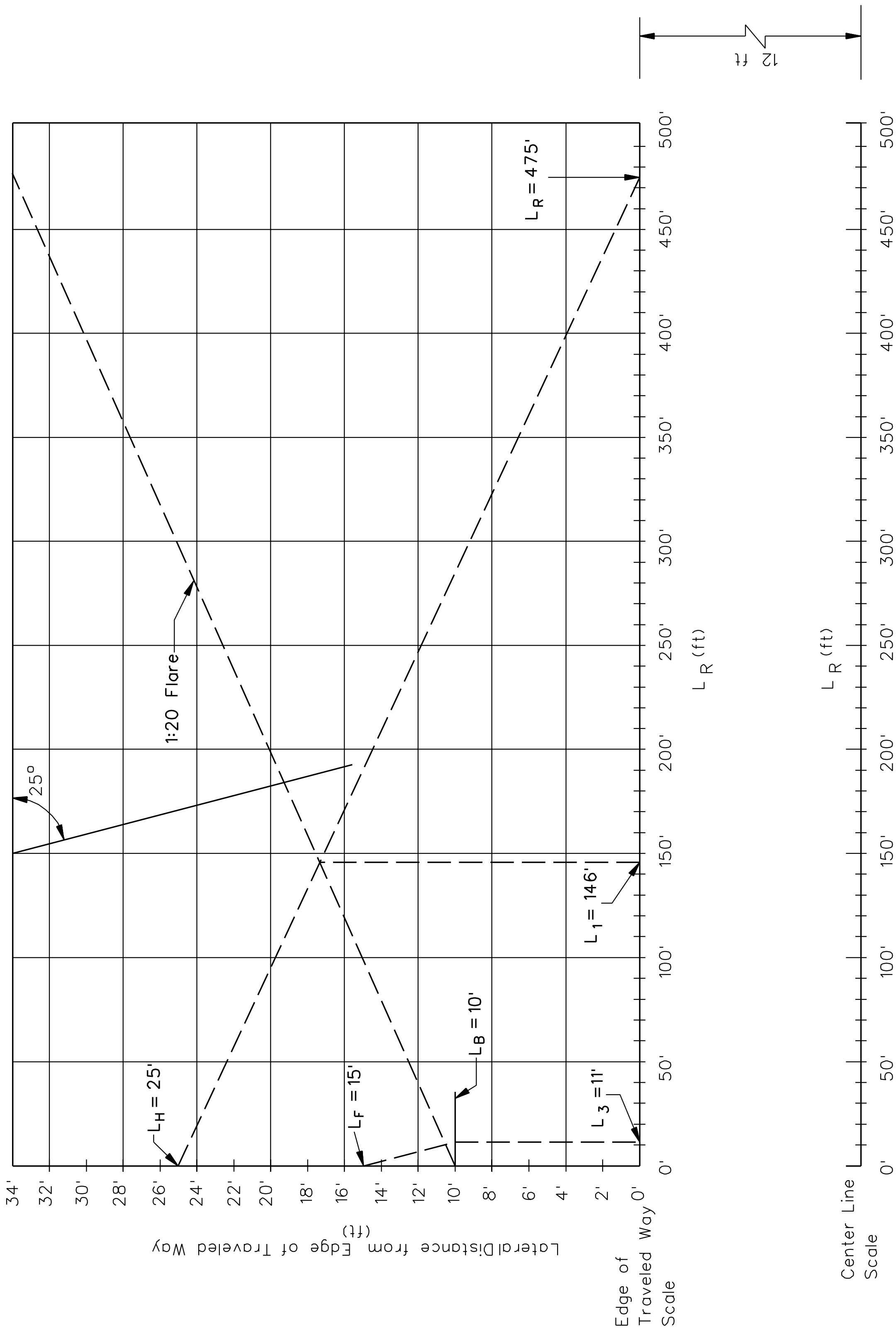
7. Flare rate has been used.

8. Round L_1 and L_3 as discussed to ensure only full-length panels of guardrail are used.

* * * * * * * * *

35-4.08 Minimum Length/Gaps

Short runs of barrier have limited value and should be avoided unless designed especially to shield a point hazard. Generally, a barrier should have at least 100 ft (30 m) of standard guardrail section exclusive of terminal sections and/or transition sections. Likewise, short gaps between runs of barrier are undesirable. Therefore, gaps of less than 200 ft (60 m) between barrier termini should be connected into a single run. Exceptions may be necessary for access.



BARRIER LENGTH OF NEED CALCULATION
(Example 35-4.07(3))

Figure 35-4K

35-4.09 <u>Short-Radius Guardrail</u>

A side road or entrance within the length of need of a guardrail installation poses a challenge to the design of a safe roadside. The most common approach to this situation has been to install a short-radius Type A guardrail around one or both of the roadway radius returns. However, a vehicle impacting the Type A guardrail at a high angle and speed may penetrate the barrier, or vault over the barrier as the posts lean back, creating a ramping effect. When penetration or vaulting does not occur, the vehicle will likely decelerate rapidly.

The designer should evaluate the following alternatives to installing a Type A guardrail on a short radius at intersections or entrances.

35-4.09(a) Relocate or Close the Intersecting Roadway/Entrance

Relocation or closure of the side road or entrance is the preferred solution over short radius guardrail, and should be considered during project scoping or during the Phase I preliminary engineering. This decision will involve consideration of project scope, cost, and impacts to adjacent properties and the environment. This alternative will not always be practical, but it will provide the most positive solution to the roadside safety issue. If this alternative is selected, additional consideration should be given to flattening side slopes, widening embankments, etc., to reduce the need for the barrier.

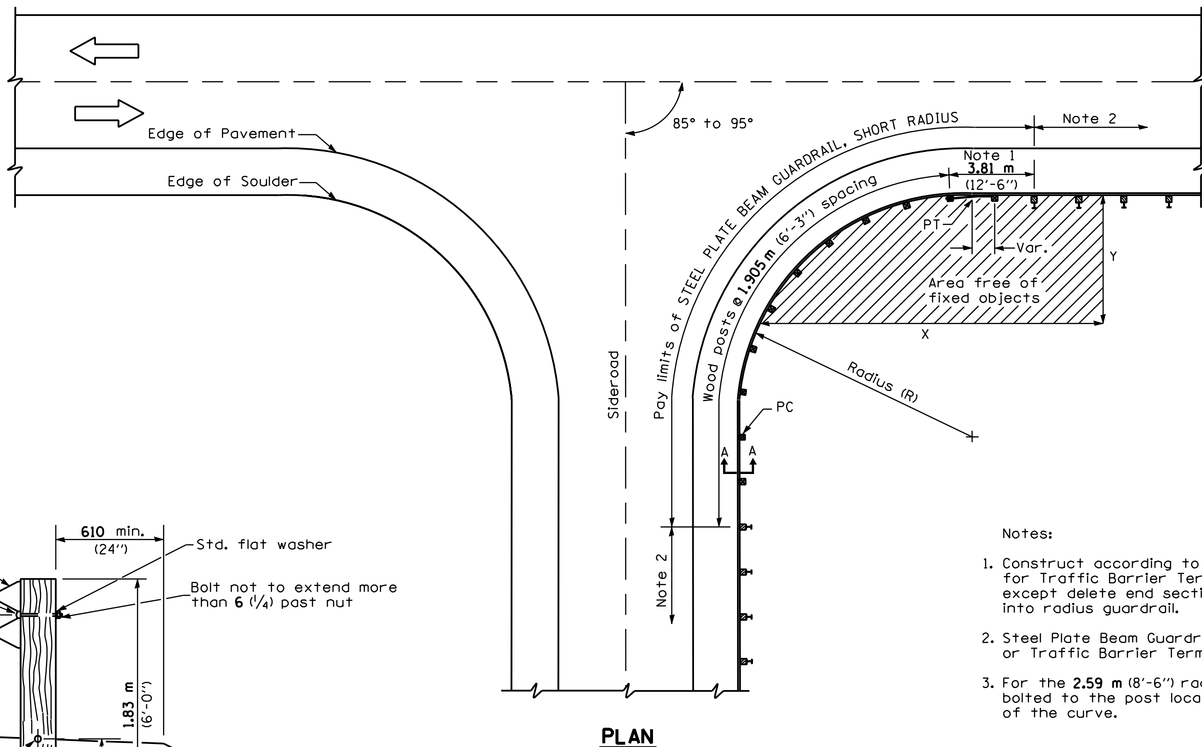
35-4.09(b) Terminate the Guardrail in Advance of the Intersecting Roadway/Entrance

When relocating or closing the roadway/entrance is not practical and where the nominal length of need may fall within the intersecting roadway (or just beyond), the designer may choose to truncate the standard guardrail with an approved terminal section in advance of the roadway. This will eliminate placing a short-radius guardrail in the intersection corner(s). Use this alternative where judgment or analysis indicates that this is preferable (e.g., flat slopes, minimal drop off) to the additional hazard posed by a short-radius guardrail installation.

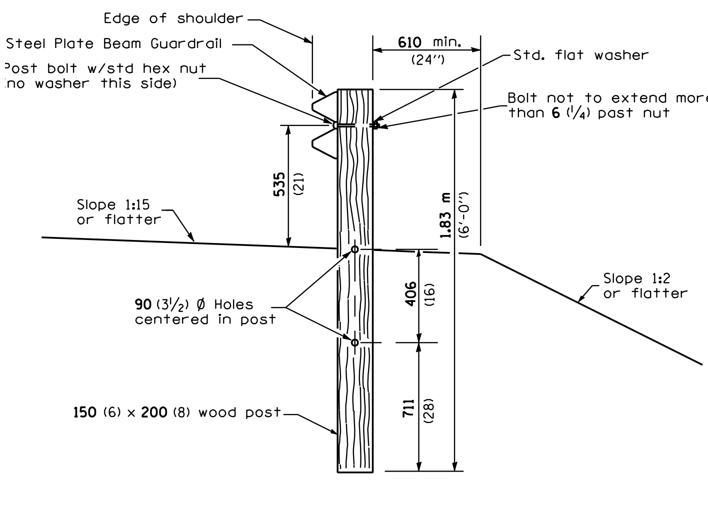
35-4.09(c) Radius Guardrail

If relocating a roadway/entrance or terminating the guardrail short of its length of need cannot be accomplished, the designer may consider radius guardrail systems. Any radius guardrail system will impose constraints on 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.

Figure 35-4L presents an acceptable short-radius guardrail design. This design employs weakened Controlled Releasing Terminal (CRT) posts in the radius area. These weakened posts break away upon impact, allowing the rail to form a deep pocket to gradually decelerate and capture the impacting vehicle.



PLAN



SECTION A-A

INSTALLATION CHARACTERISTICS PER DESIGN RADIUS (R)			
R	NO. OF WOOD POSTS	X	Y
2.59 (8'-6")	5 (Note 3)	7.6 m (25')	4.6 (15')
5.18 (17'-0")	6	9.1 m (30')	4.6 (15')
7.77 (25'-6")	8	12.2 m (40')	6.1 (20')
10.67 (35'-0")	11	15.2 m (50')	6.1 (20')

Notes:

1. Construct according to Standard 631011 for Traffic Barrier Terminal Type 2, except delete end section and splice into radius guardrail.
2. Steel Plate Beam Guardrail Type A, Type B, or Traffic Barrier Terminal as specified.
3. For the **2.59 m** (8'-6") radius, the rail is not bolted to the post located at the midpoint of the curve.

GENERAL NOTES

All slope ratios are expressed as units of vertical displacement to units of horizontal displacement (V:H).

All dimensions are in millimeters (inches) unless otherwise shown.

STEEL PLATE BEAM GUARDRAIL, SHORT RADIUS

Figure 35-4L

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, a Type 1 terminal should be used.

To allow for proper system performance, the designer should be aware of several important constraints:

1. Intersection Angle/Radii. Use of the detail in Figure 35-4L is limited to the radii shown and to intersection angles of 85° to 95°. No extrapolations to radii shorter than 8′-6″ (2.59 m) or longer than 35′-0″ (10.67 m) should be attempted. Any job-specific designs for intermediate radii and/or other intersection angles should incorporate all features of posts, attachment, etc., and should use only full length guardrail panels, shop bent to the design radius in 5 ft (1.5 m) increments.

2. Deflection Distance. Because of the required deflection distance, this design requires a considerable clear area behind the radius and adjacent guardrail. This area is detailed on Figure 35-4L with the x and y coordinates.

3. Slope. The slope in front of the installation should not be steeper than 1V:15H. Before installing this detail where there is superelevation on the main roadway, perform a special analysis to determine the potential for vaulting of a vehicle.

4. Embankment. It is important to provide the 2 ft (600 mm) earth embankment behind the CRT posts to provide adequate bearing strength if hit. It is desirable that the slopes behind the guardrail not be steeper than 1V:2H.

5. Bridges. When used in close proximity to a bridge, this design should not be used unless there is room to install an approved transition to the bridge rail.

6. Debris. In crash testing, some heavy debris was observed flying about in the area behind the impact. Judgment must be used when installing these sections where people are likely to be present in the area behind the curved section.

7. Additional Protection. Because the short-radius guardrail system still represents some compromise in roadside design, the designer should attempt to shadow it from impacts. This can be done by applying a tangent run of guardrail (the minimum is two Type 1 terminals, back-to-back) on the approach side of the intersecting roadway.

If the CRT short-radius design in Figure 35-4L cannot be used at the site, the final option is to install the Type A guardrail on the required radius. Do not use the Type B guardrail. Because the use of the Type A guardrail is a compromise in roadside safety, the designer should attempt to shadow it from impacts. This can be done by applying a tangent run of guardrail (the minimum is two Type 1 terminals, back-to-back) on the approach side of the intersecting roadway.

35-5 REFERENCES

For information on clear zones, roadside hazards, and roadside barriers review the applicable publications listed below:

1. Guidelines for Geometric Design of Very Low-Volume Roads (ADT ≤ 400), AASHTO

2. Roadside Design Guide, AASHTO