LTAP Transportation Technology Transfer Center

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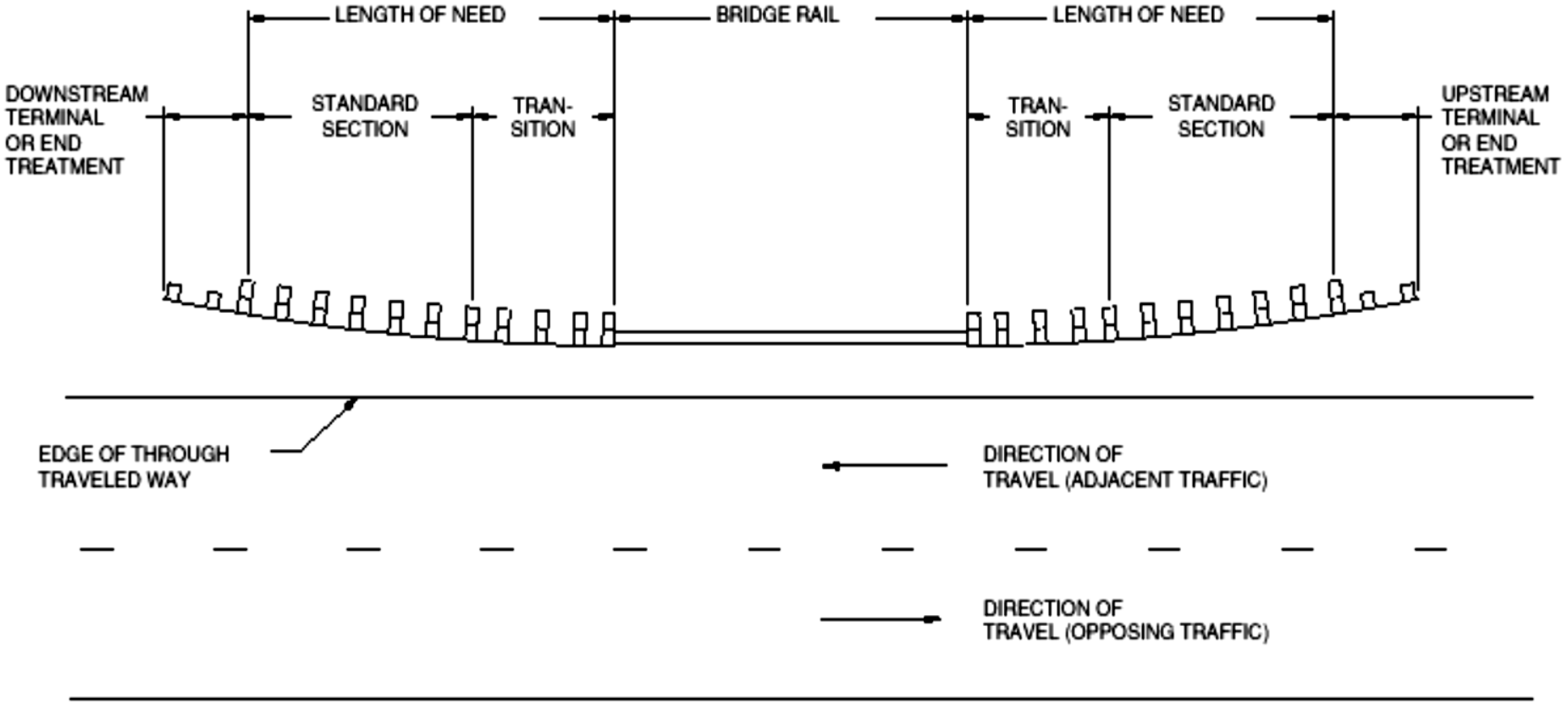
Spokesperson Decade of Action for Road Safety 2011-2020

DESIGN AND LOCATION OF ROADSIDE BARRIERS

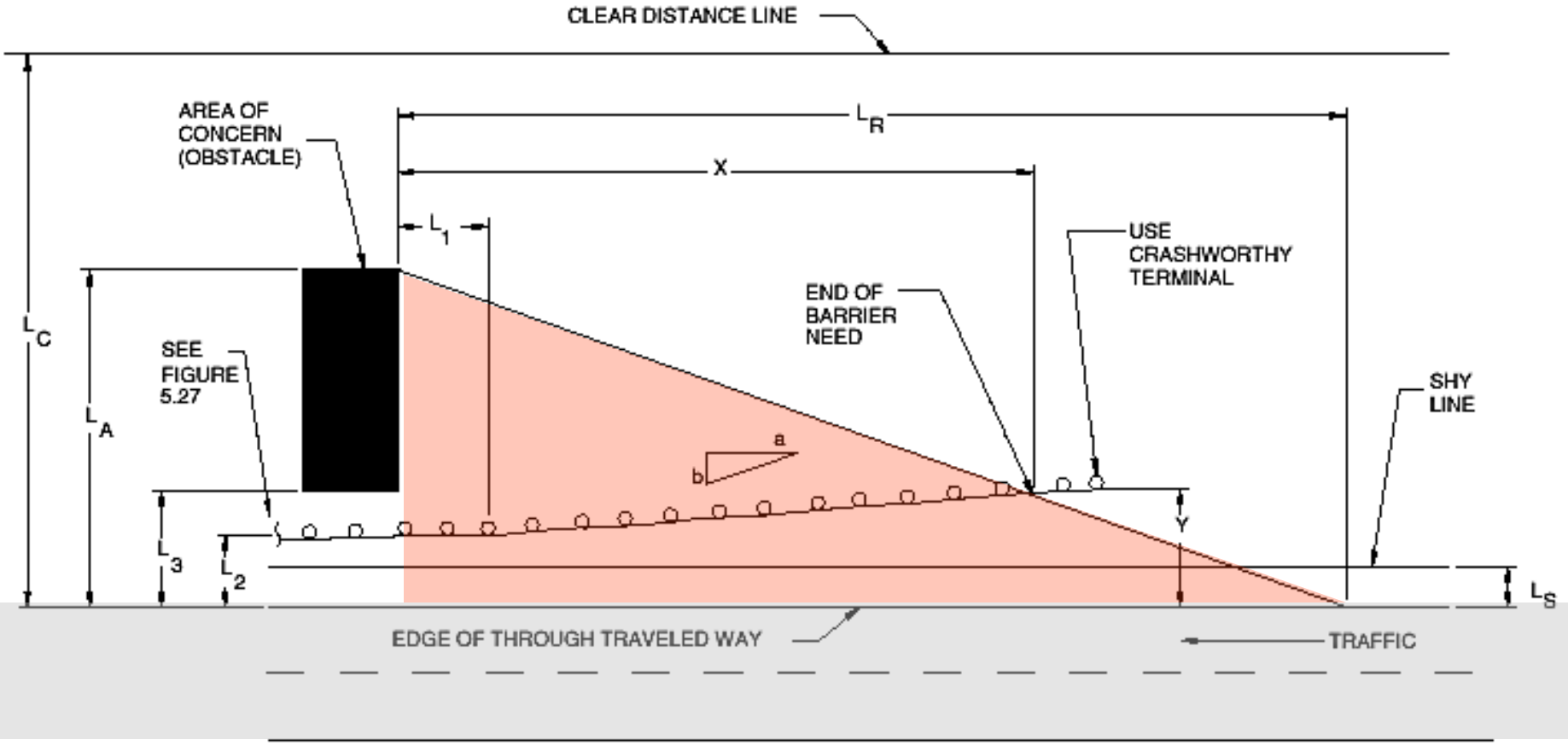
Module 5



Traffic Safety Barrier System

1. **Basic section**
2. **Terminal**
3. **Transition section**
4. **Bridge Railing**

Barrier Layout

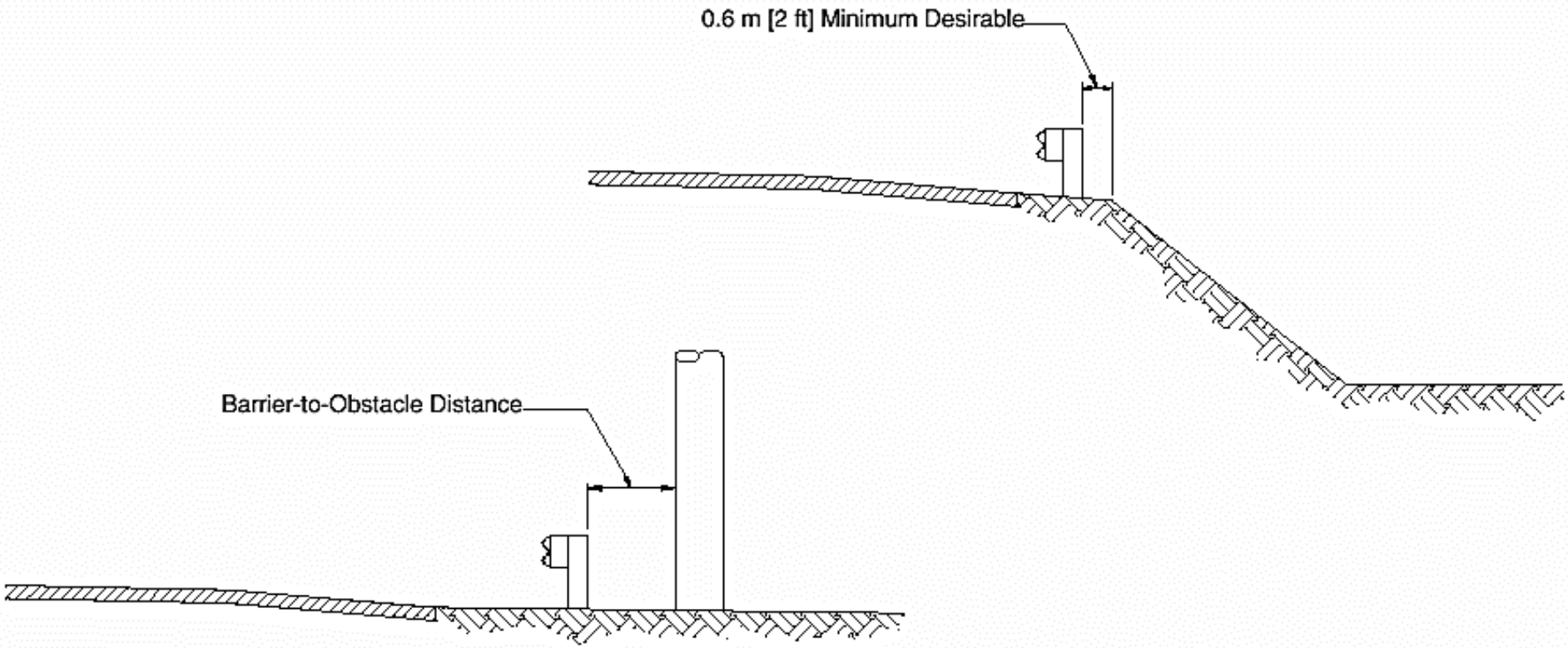


General Rules of Longitudinal Guardrail Location

- Minimum lateral distance between rail and hazard → 2 feet (0.6 m)

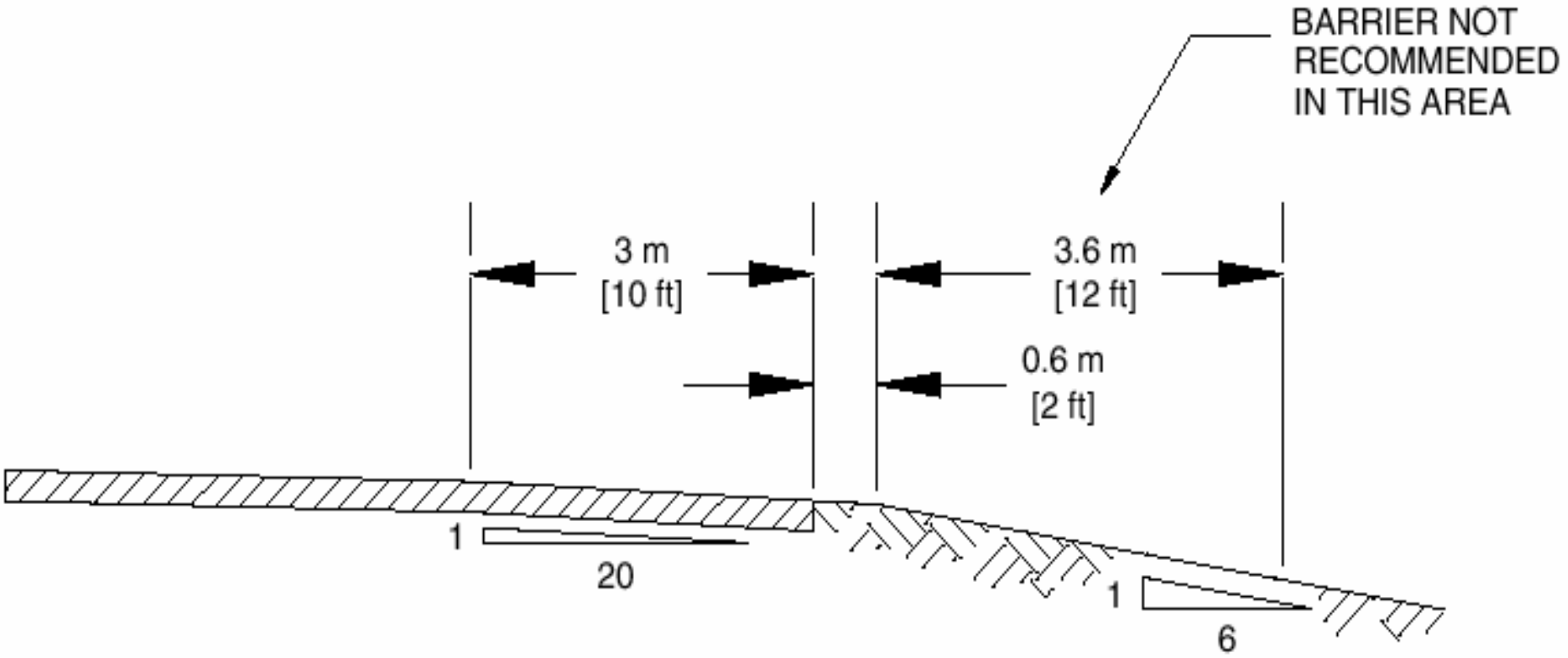
- Longitudinal distance between barriers shielding isolated hazards (utility poles each 150 feet)
  - Avoid installing individual guardrails with gaps less than 200 feet

Barrier-to-Obstacle Distance

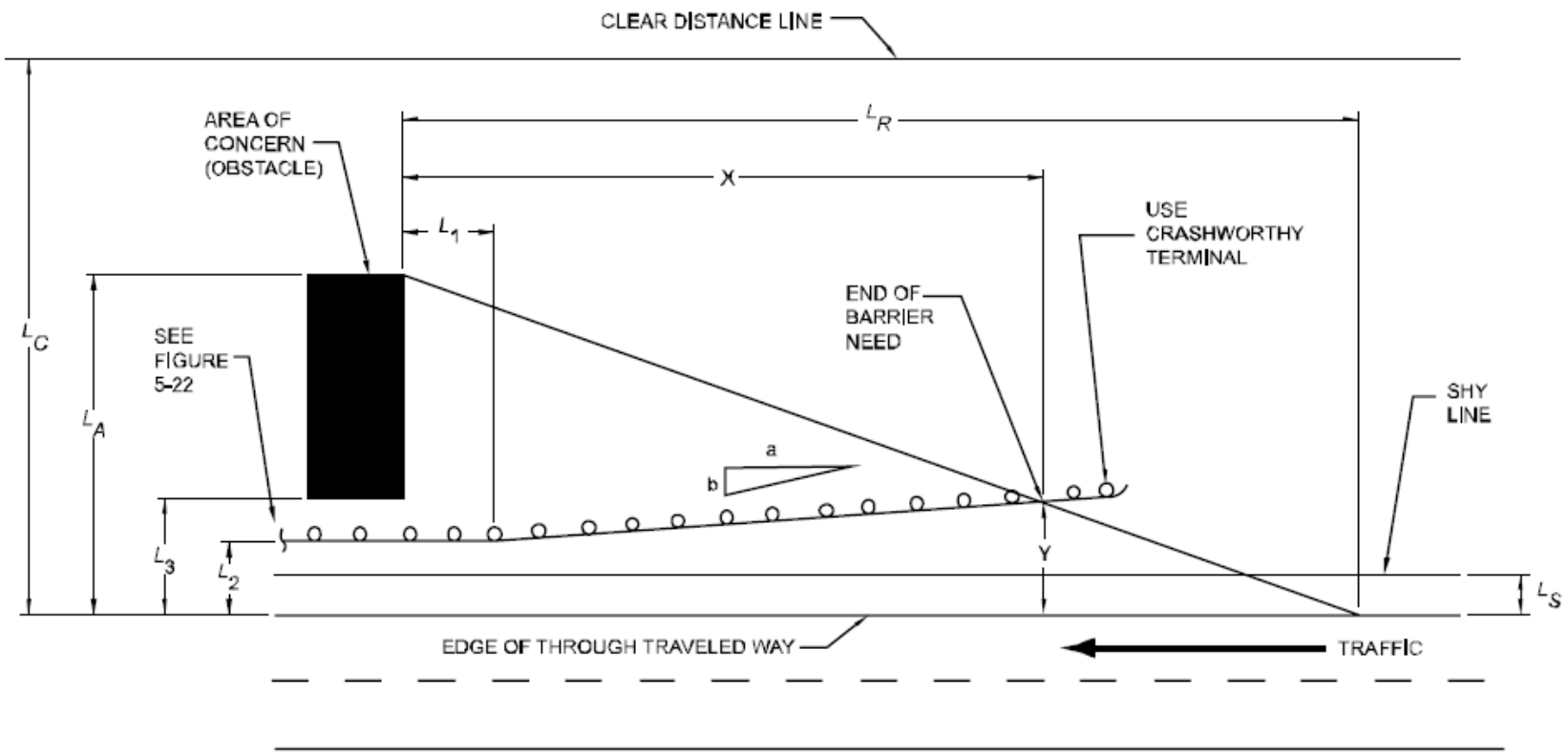


Terrain Effects

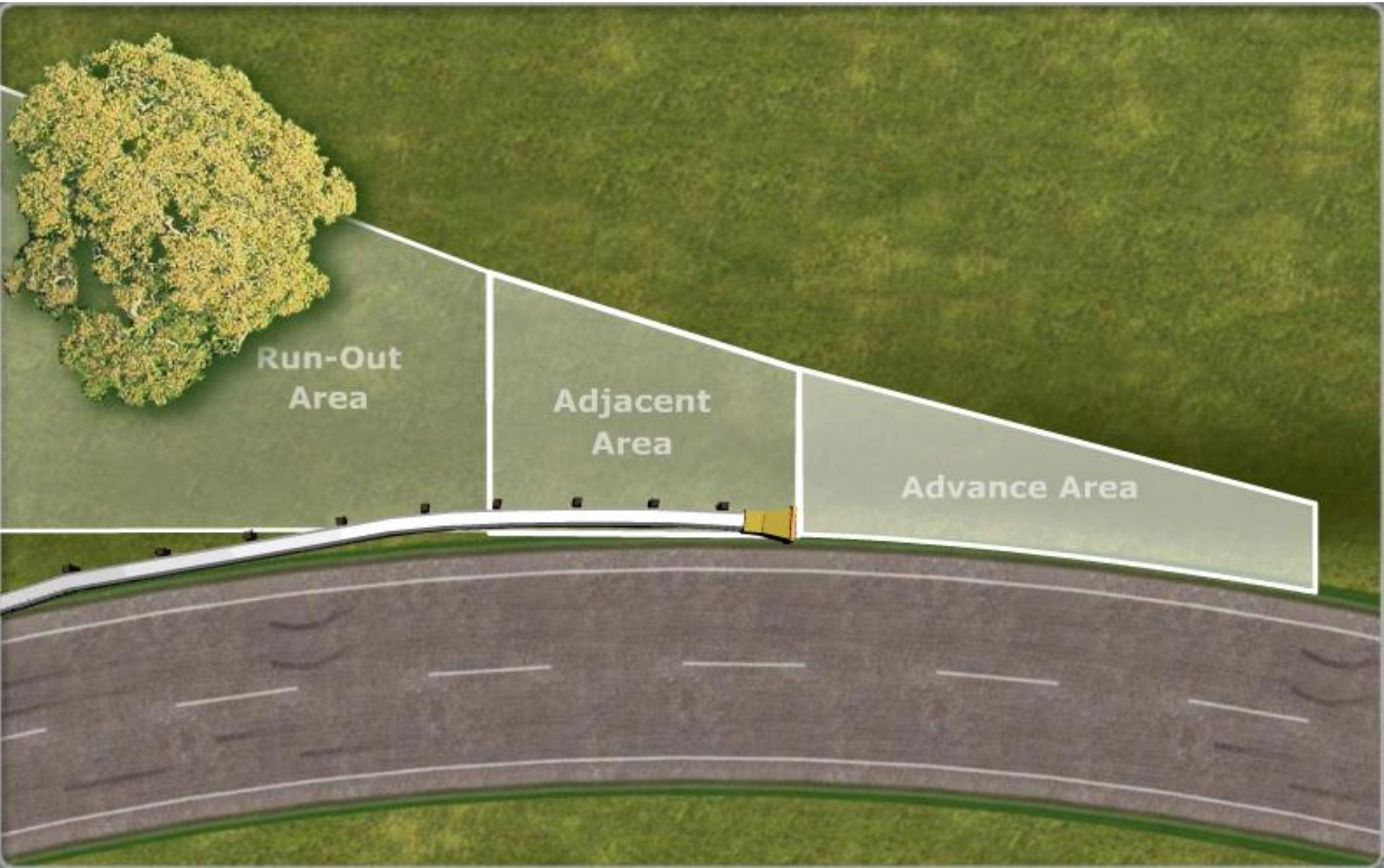
- Slopes steeper than 1V:10H may cause vehicle to go over or impact barrier too low



Roadside Slope Before Barrier



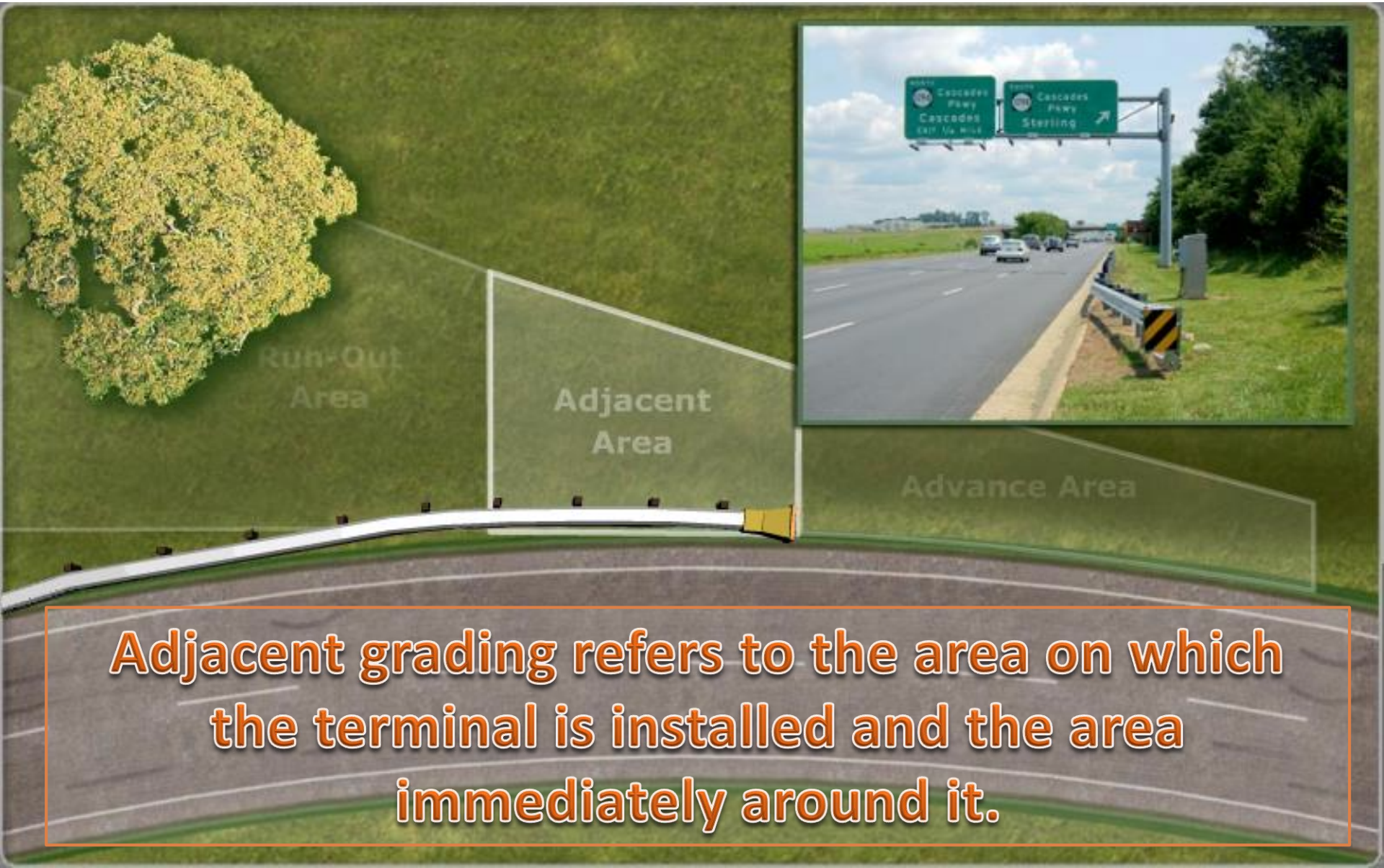
Roadside Area Side Slopes



Roadside Area Side Slopes

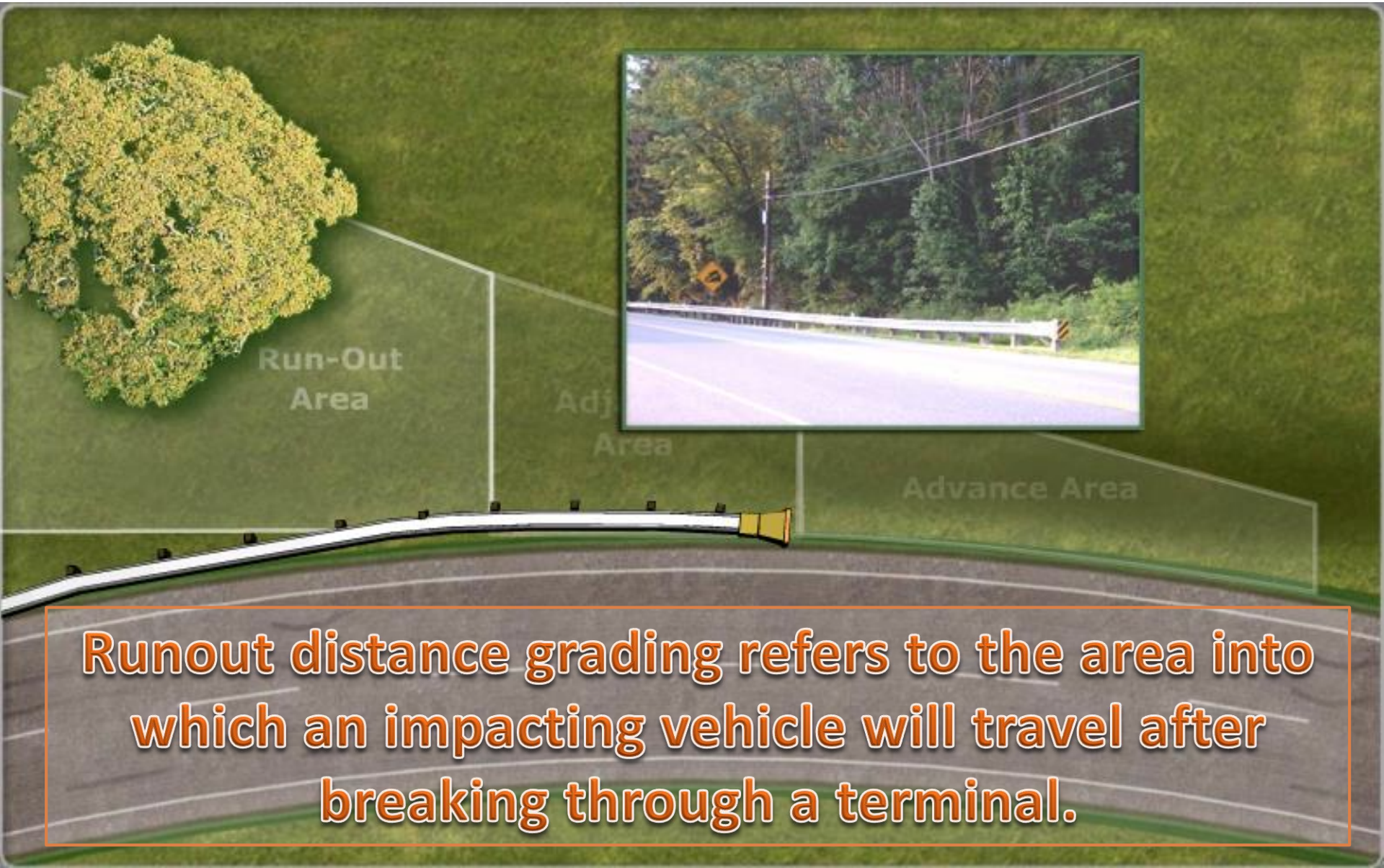
Advance grading must be applied to the terrain over which a vehicle may travel before any contact with a barrier terminal is made.

Roadside Area Side Slopes



Adjacent grading refers to the area on which the terminal is installed and the area immediately around it.

Roadside Area Side Slopes

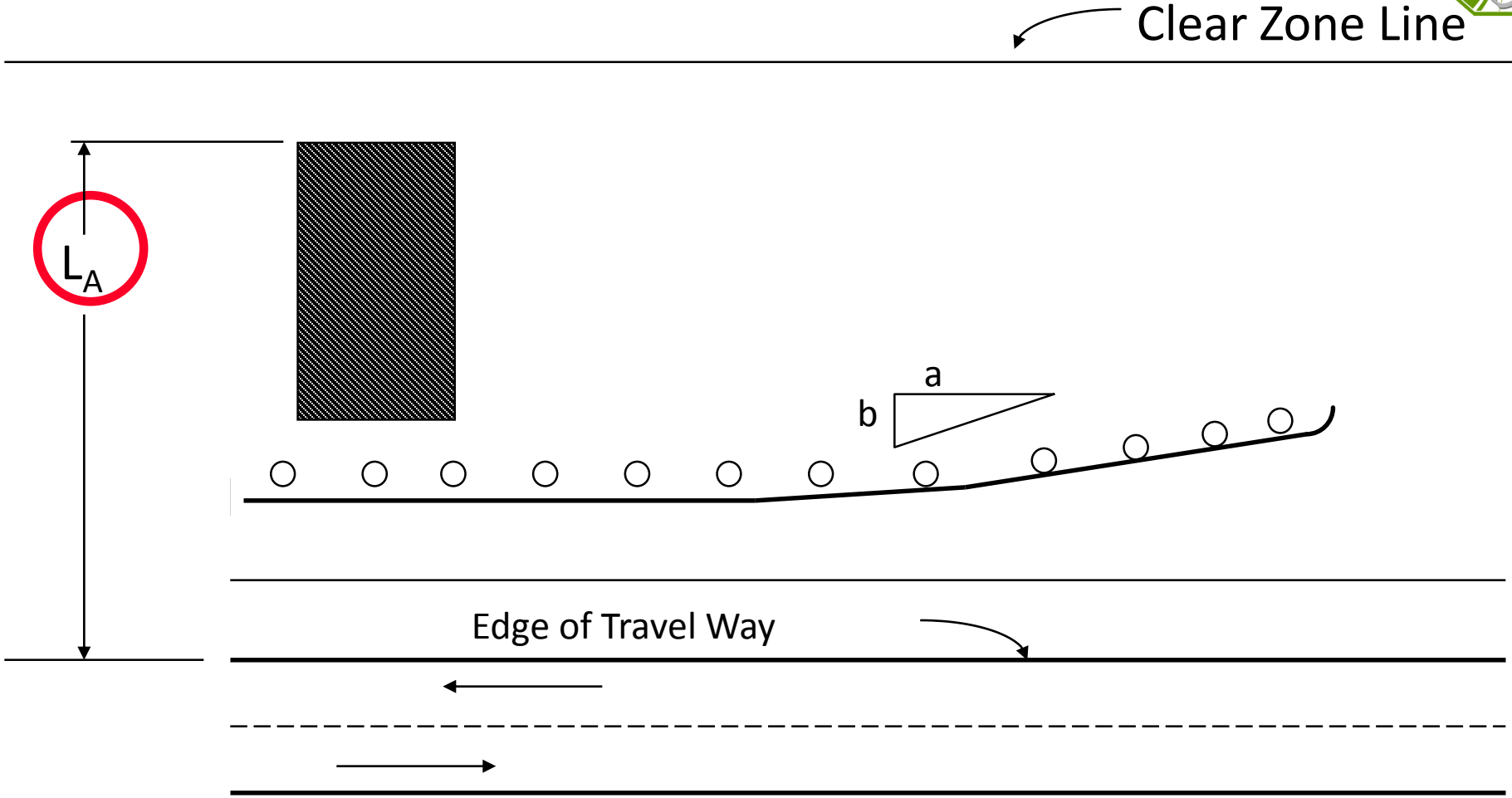


Runout distance grading refers to the area into which an impacting vehicle will travel after breaking through a terminal.

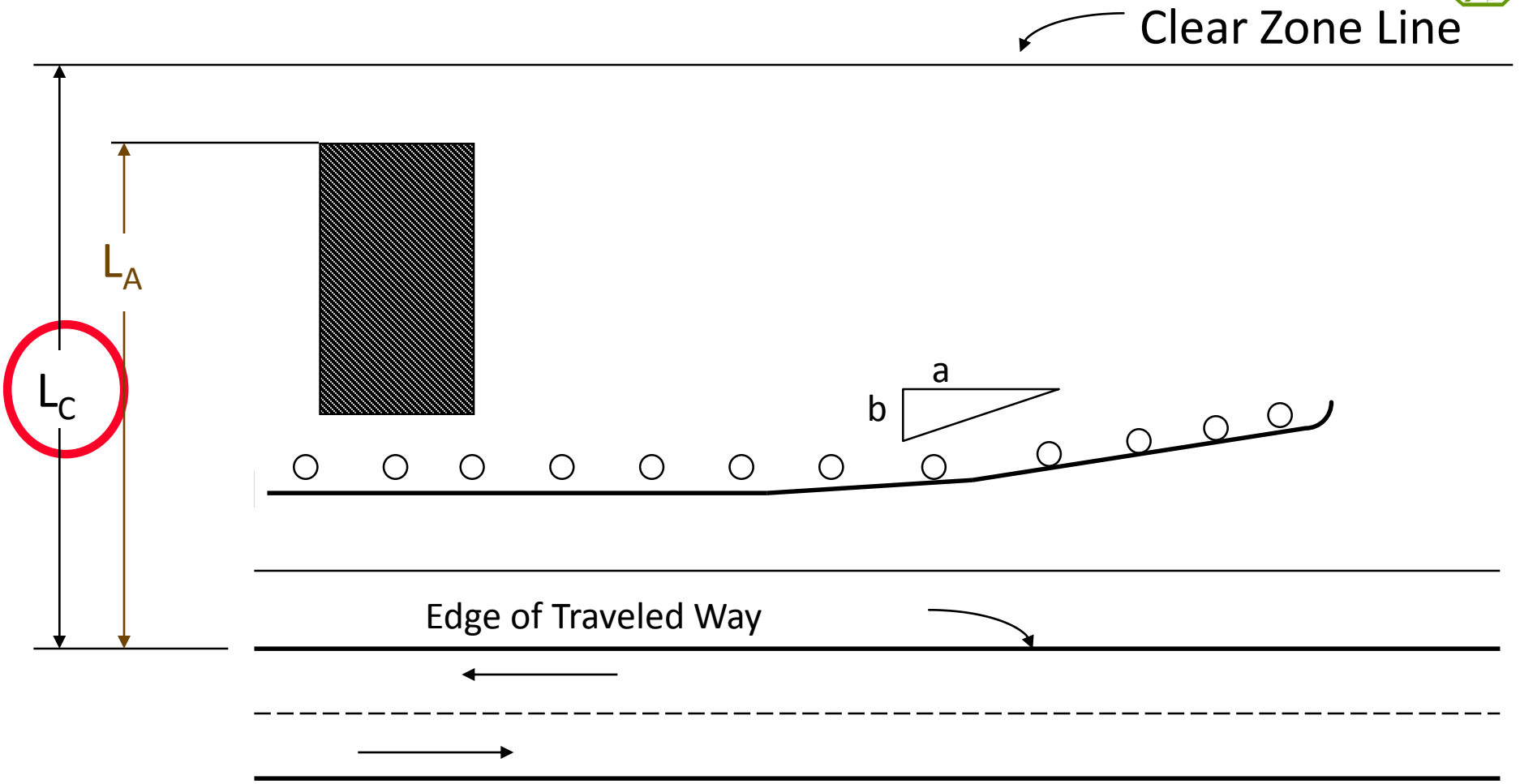
Placement Variables

- Lateral Extent of the Area of Concern L_A: distance from the edge of the traveled way to the far side of the fixed object or to the outside of the clear zone
- Lateral Extent of the Runout Length L_R: theoretical distance needed for a vehicle that has left the roadway to come to stop
- Tangent length from the Area of Concern L_1: selected by the designer (zero if no flare)

Design Factors: L_A

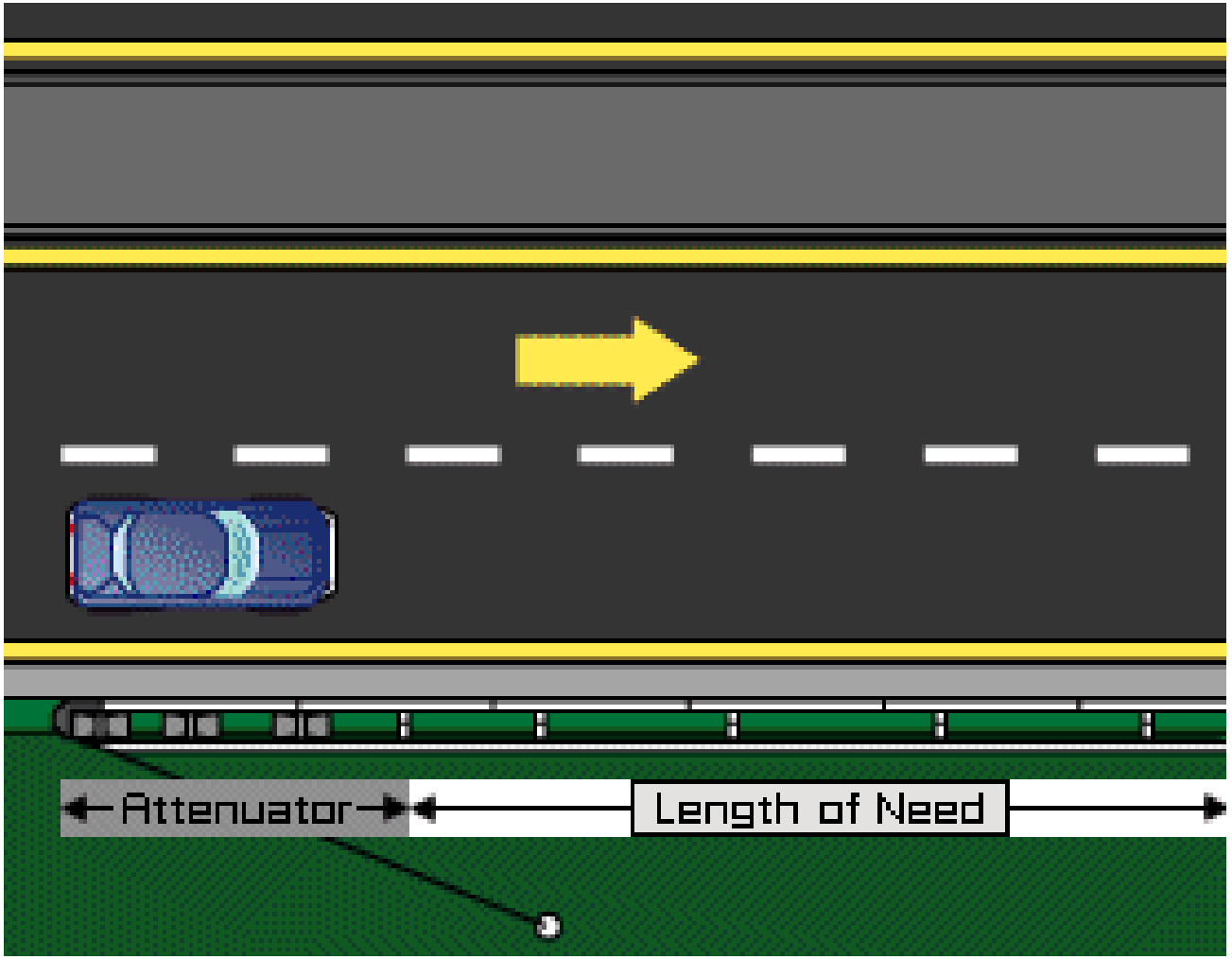


Design Factors: L_C

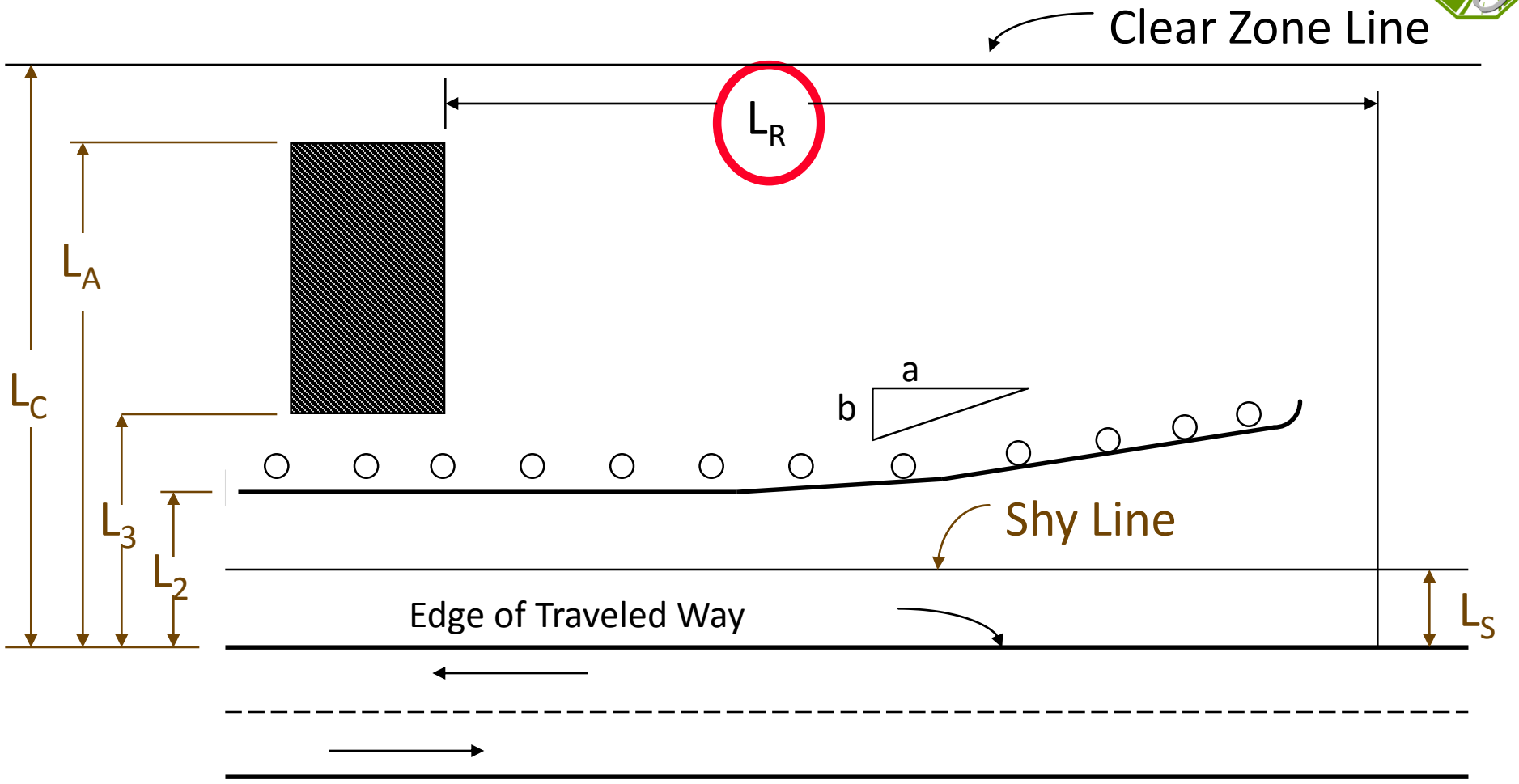


Length of Need, L_R

- Total length of a roadside barrier needed to shield a hazard



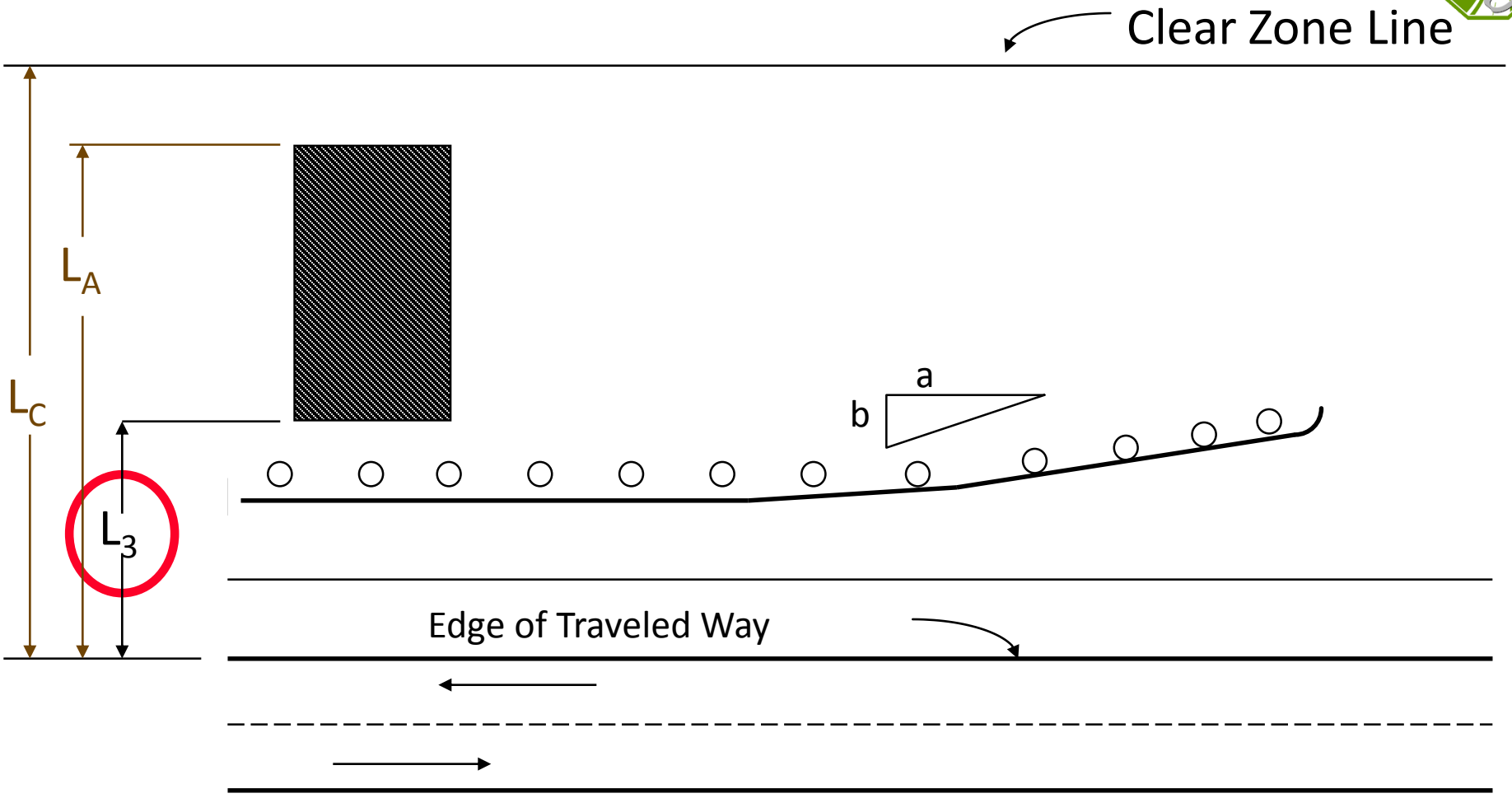
Design Factors: L_R



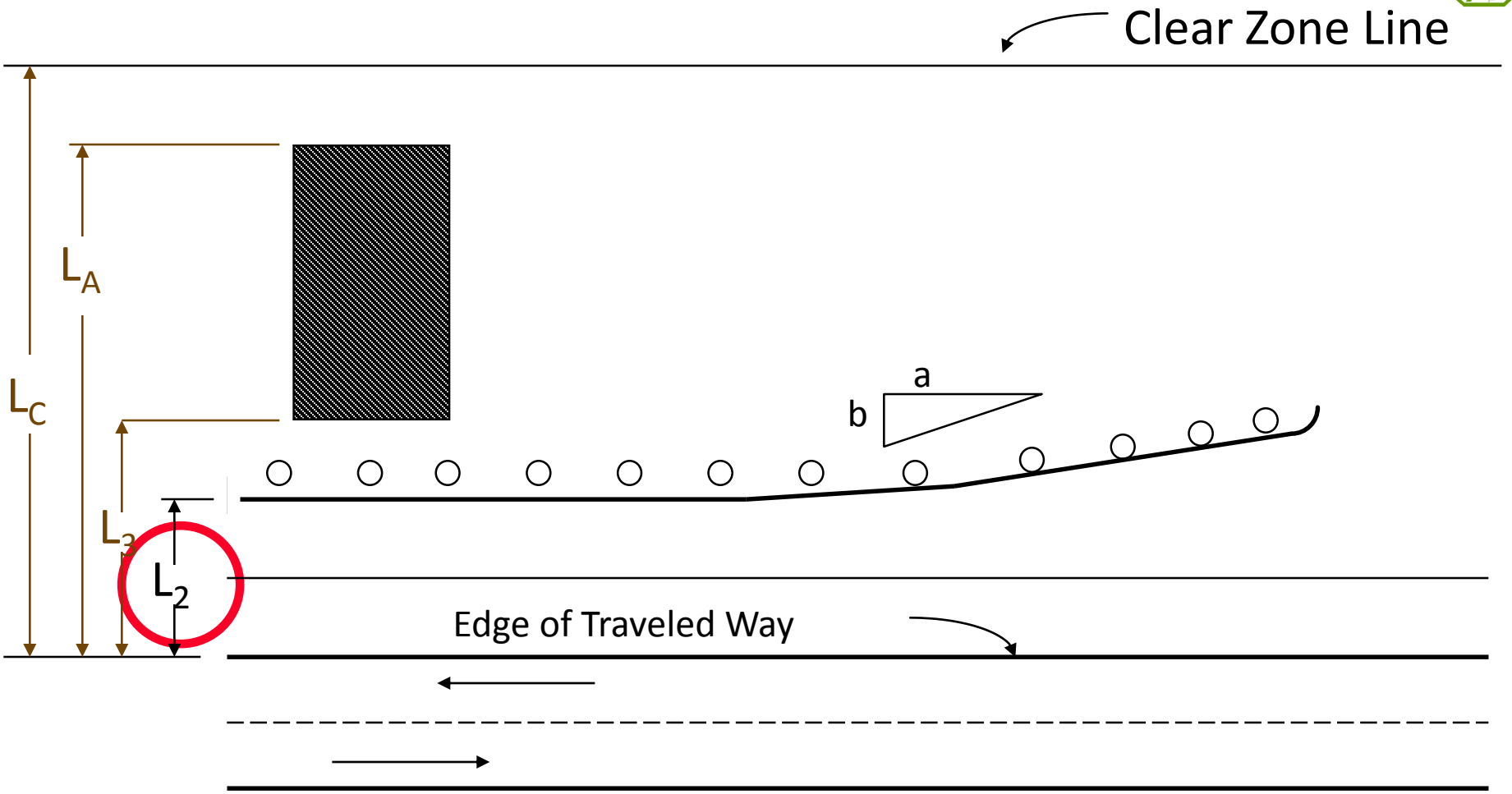
Suggested Runout Lengths

Design Speed		Traffic Volume (ADT)							
		Over 6000 vpd		2000 – 6000 vpd		800 – 2000 vpd		Under 800 vpd	
		Runout Length L_R		Runout Length L_R		Runout Length L_R		Runout Length L_R	
km/h	[mph]	m	[ft]	m	[ft]	m	[ft]	m	[ft]
110	[70]	145	[475]	135	[445]	120	[395]	110	[360]
100	[60]	130	[425]	120	[400]	105	[345]	100	[330]
90	[55]	110	[360]	105	[345]	95	[315]	85	[280]
80	[50]	100	[330]	90	[300]	80	[260]	75	[245]
70	[45]	80	[260]	75	[245]	65	[215]	60	[200]
60	[40]	70	[230]	60	[200]	55	[180]	50	[165]
50	[30]	50	[165]	50	[165]	45	[150]	40	[130]

Design Factors: L_3



Design Factors: L_2

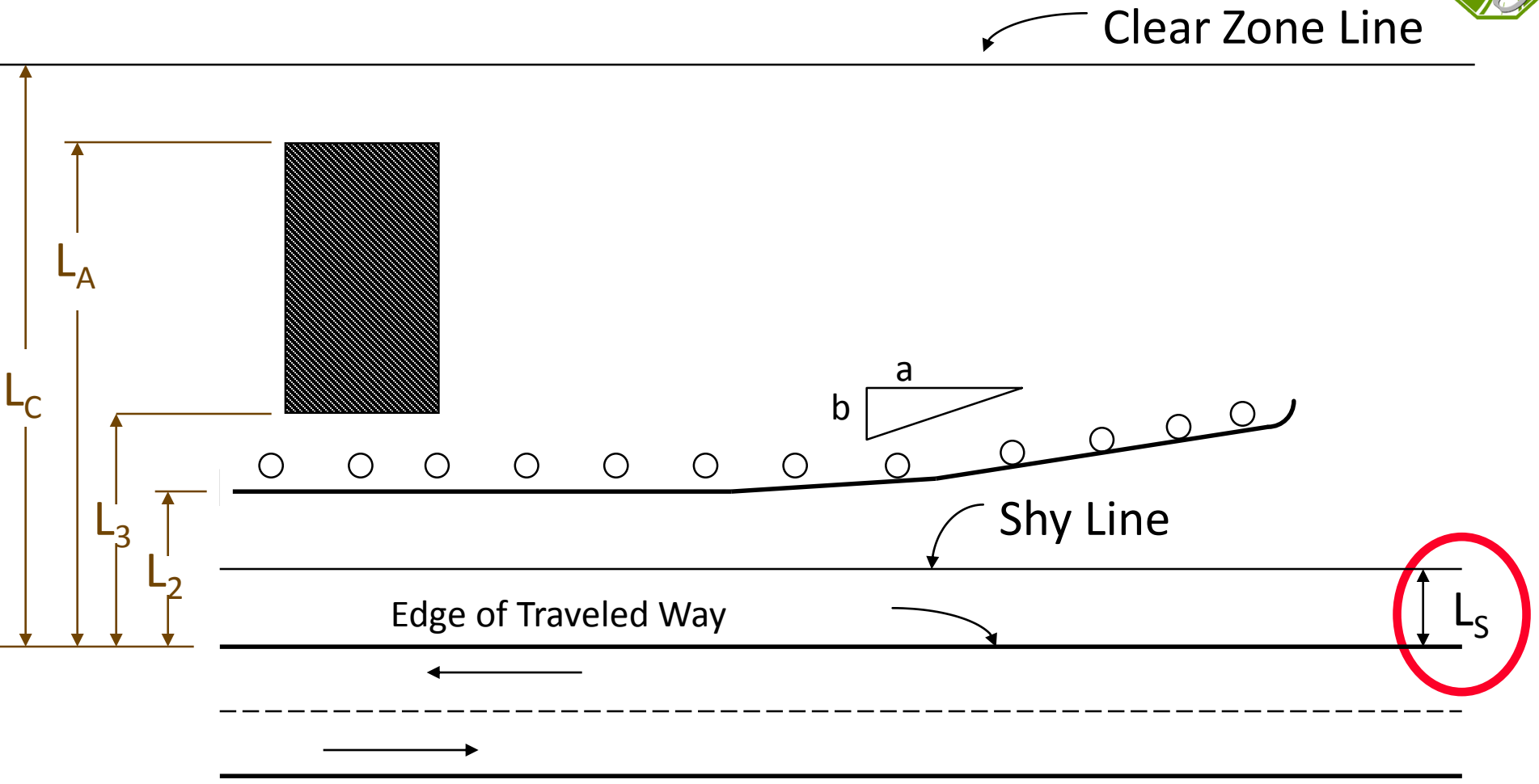


Lateral Offset L_2

- Uniform clearance
- Barrier-to-obstruction distance and barrier deflection must be considered
- Place as far from the traveled way as possible
- Shy Line Offset L_S (Table 5.5)

  Distance from the edge of the traveled way, beyond which an object will not be perceived as an obstacle and the driver will react to it

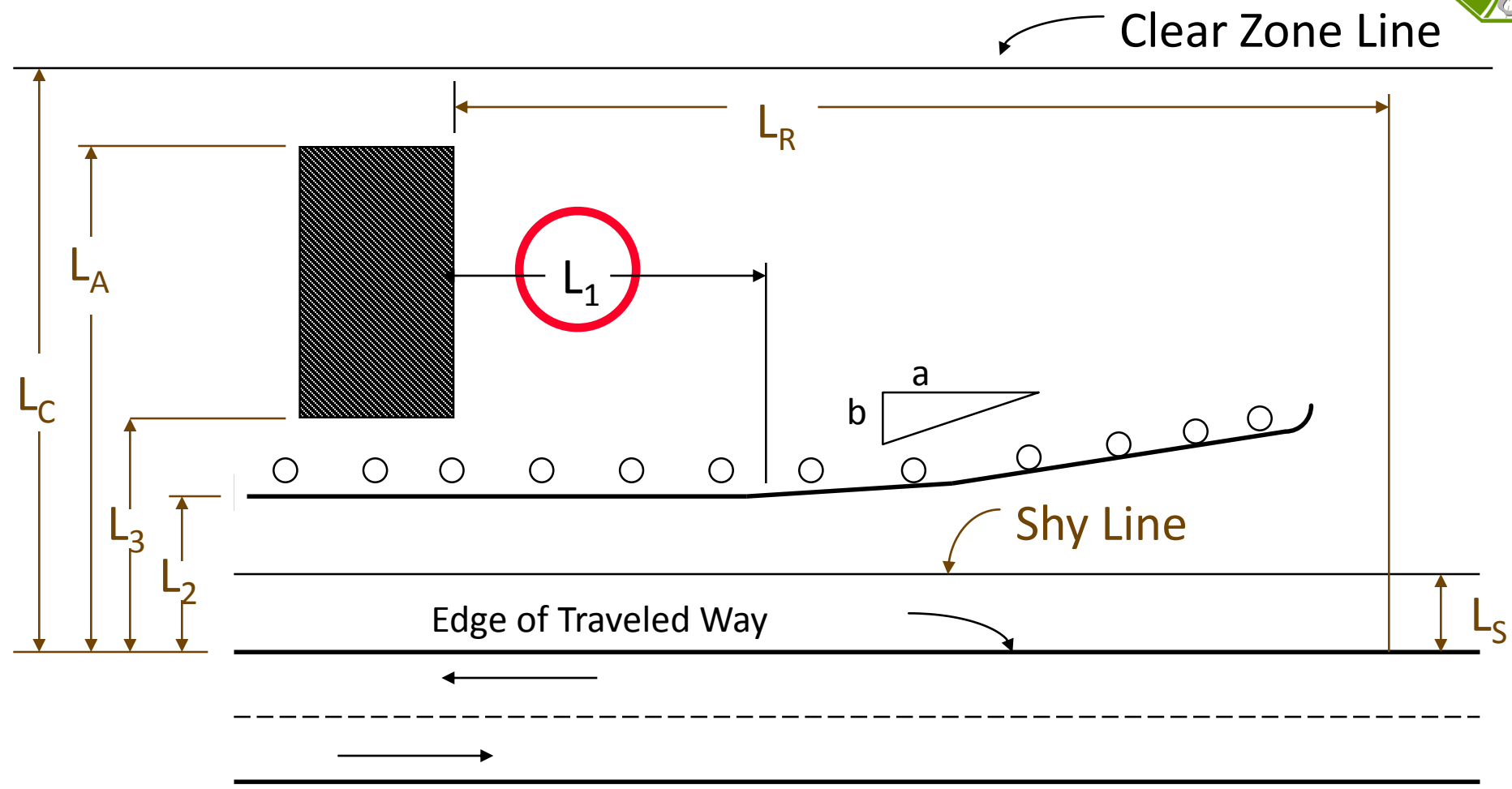
Design Factors: L_S



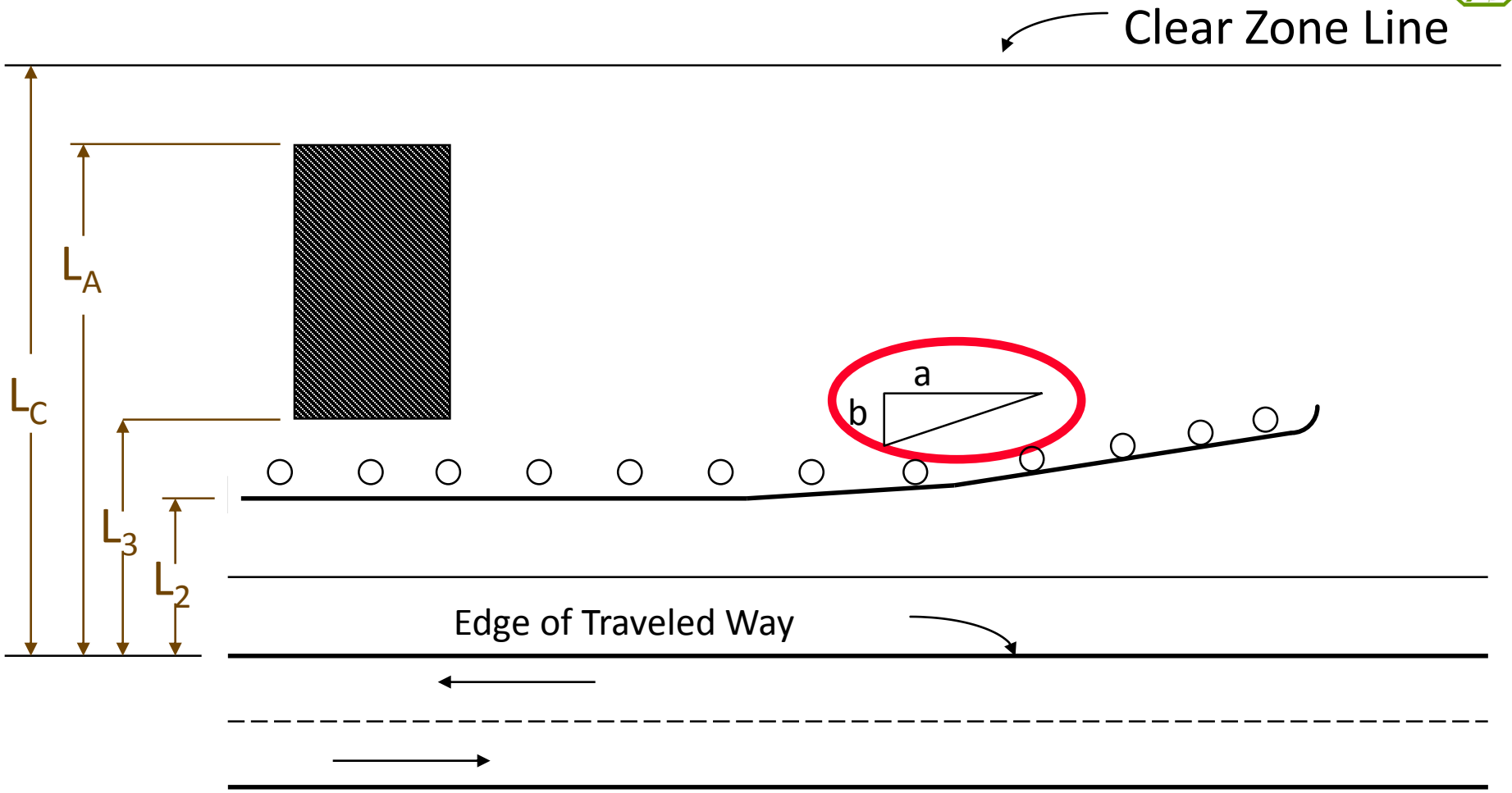
Shy Line Offset, L_s

Design Speed (mph)	Shy Line Offset, L_s (feet)
80	12.0
70	10.0
60	8.0
50	6.5
40	5.0
30	3.5

Design Factors: L_1



Design Factors: b/a



Flare Rate

- Barrier is considered flared when it is not parallel to the edge of the roadway
- Pros
  - Locate the barrier farther from the roadway
  - Minimize driver's reaction to an obstacle
  - Reduce total length of rail needed
- Cons
  - The greater the flare rate, the higher the approach angle, the higher the severity
  - Vehicle can be redirected back to roadway

Suggested Flare Rates

Design Speed		Flare Rate for Barrier Inside Shy Line	Flare Rate for Barrier at or Beyond Shy Line	
km/h	[mph]		A	B
110	[70]	30:1	20:1	15:1
100	[60]	26:1	18:1	14:1
90	[55]	24:1	16:1	12:1
80	[50]	21:1	14:1	11:1
70	[45]	18:1	12:1	10:1
60	[40]	16:1	10:1	8:1
50	[30]	13:1	8:1	7:1

Notes:

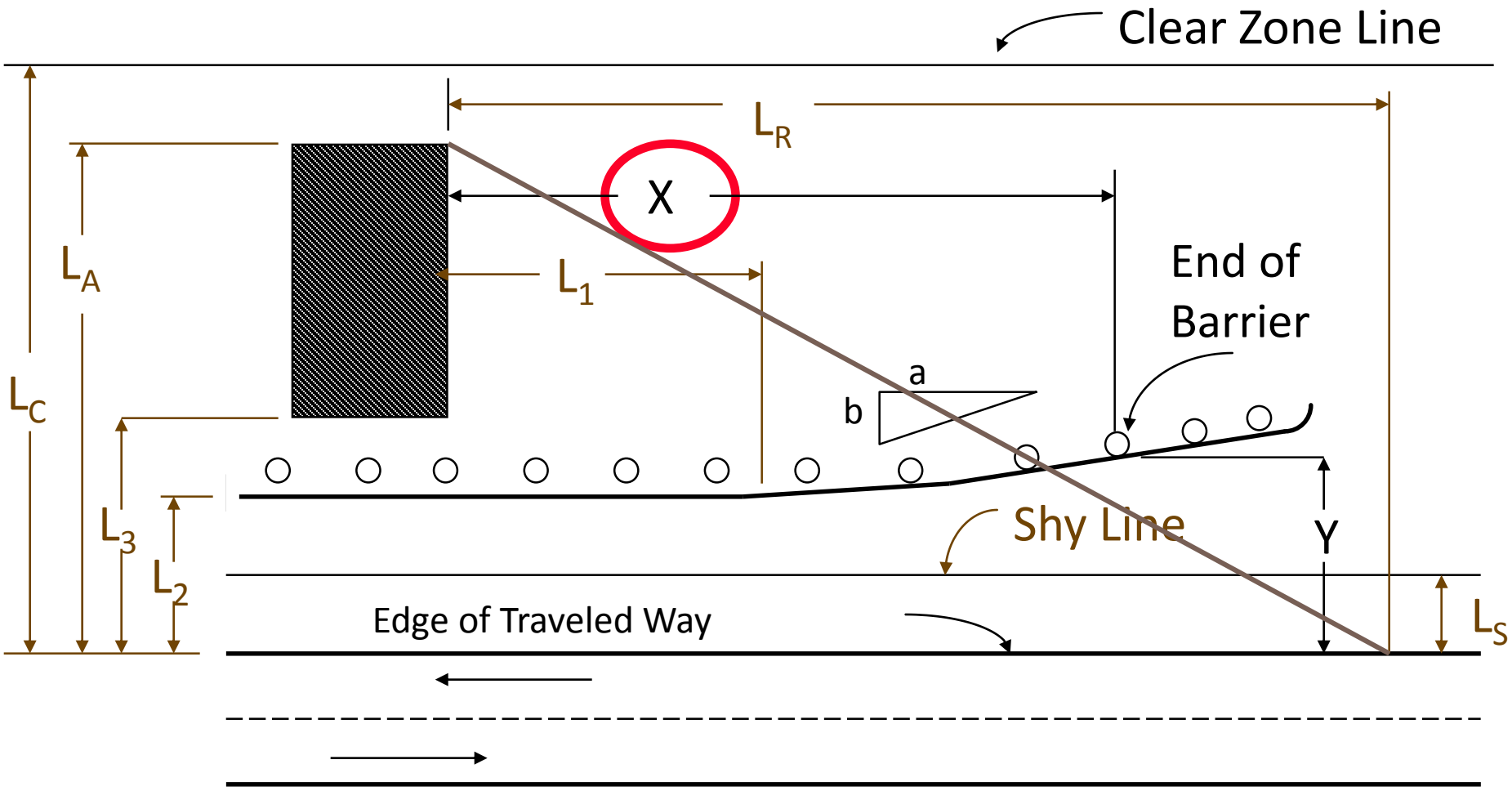
A = Suggested maximum flare rate for rigid barrier system.

B = Suggested maximum flare rate for semi-rigid barrier system.

The MGS has been tested in accordance with NCHRP Report 350 TL-3 at 5:1 flare.

Flatter flare rates for the MGS installations also are acceptable. The MGS should be installed using the flare rates shown or flatter for semi-rigid barriers beyond the shy line when installed in rock formations.

Solving for X



Required Length of Need in Advance of the Area of Concern

$$X = \frac{L_A + (b \mid a)(L_1) - L_2}{b \mid a + (L_A)/(L_R)}$$

← With Flare Rate

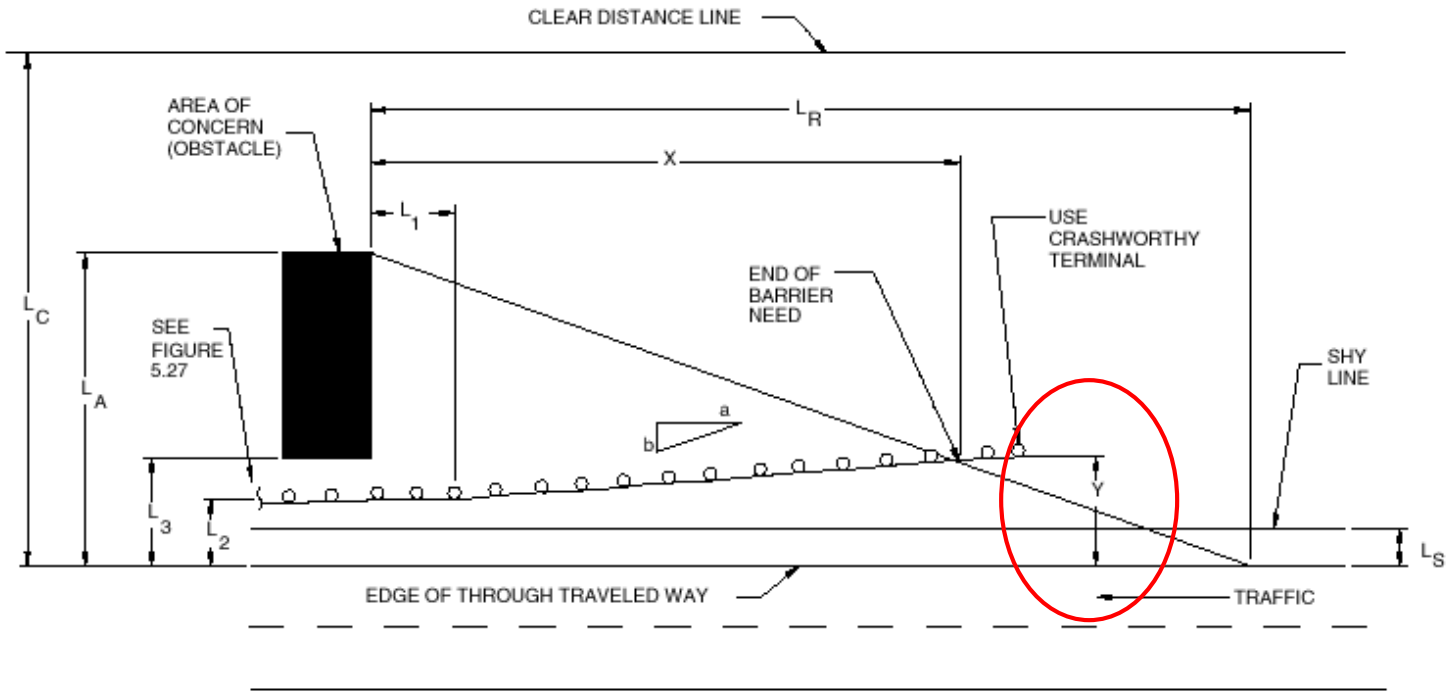
Without Flare Rate →

$$X = \frac{L_A - L_2}{(L_A)/(L_R)}$$

- End treatment length is not included in calculation
- Adjust for nominal metal beams lengths: 3.8 or 7.6 m

Lateral Offset from the Edge of the Traveled Way

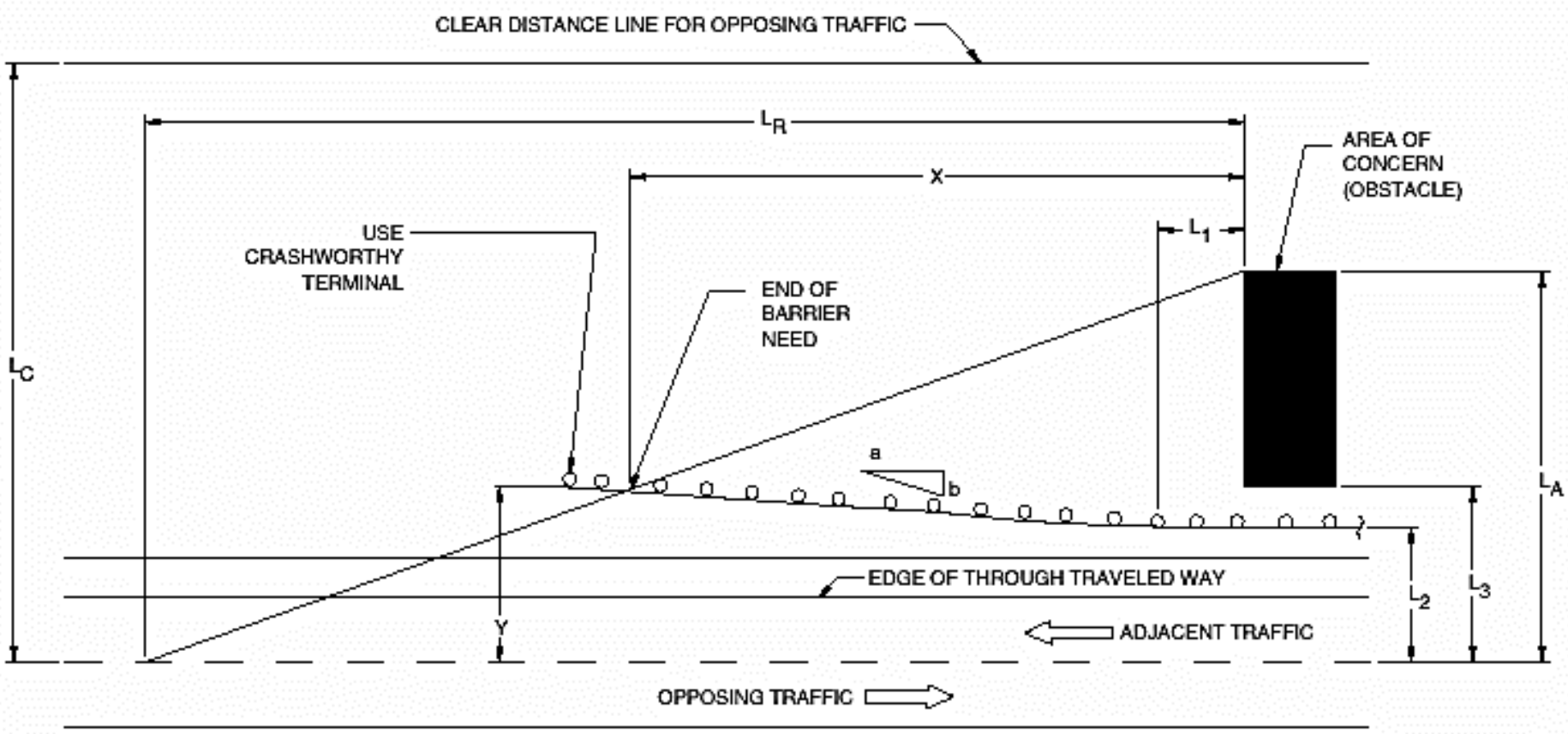
$$Y = L_A - \frac{L_A}{L_R} X$$



Barrier for Opposing Traffic

1. Barrier beyond the appropriate clear zone LC - no additional barrier or end treatment required
2. Barrier within the appropriate clear zone LC, but area of concern LA is beyond it - no additional barrier required, but end treatment should be used
3. Area of concern LA extends well beyond the clear zone LC - shield only that portion which lies within clear zone by setting LA = LC

Barrier Layout for Opposing Traffic



MEDIAN BARRIER PLACEMENT RECOMMENDATIONS

Terrain Effects & Flare Rate

Terrain Effects: Curbs

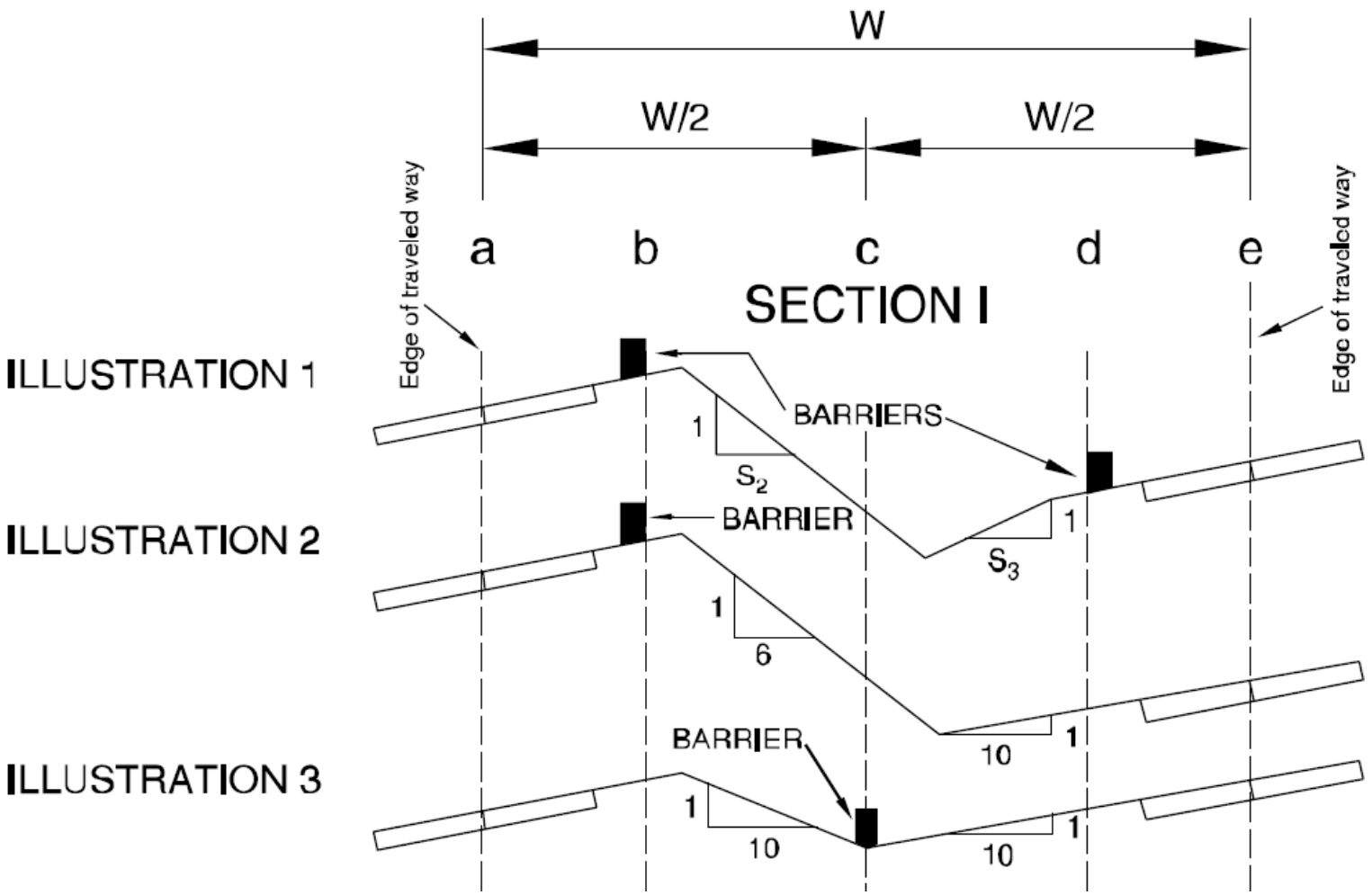
- Barrier face located within 9 in of curb's face prevents vehicle vaulting at 60 mph
- Top of rail at 27 in above the curb will make impacts at lower elevations than normal
- Add rubrail to minimize snagging
- Align faces of barrier and curb and use normal mounting height from curb bottom

Barriers on Sloped Medians

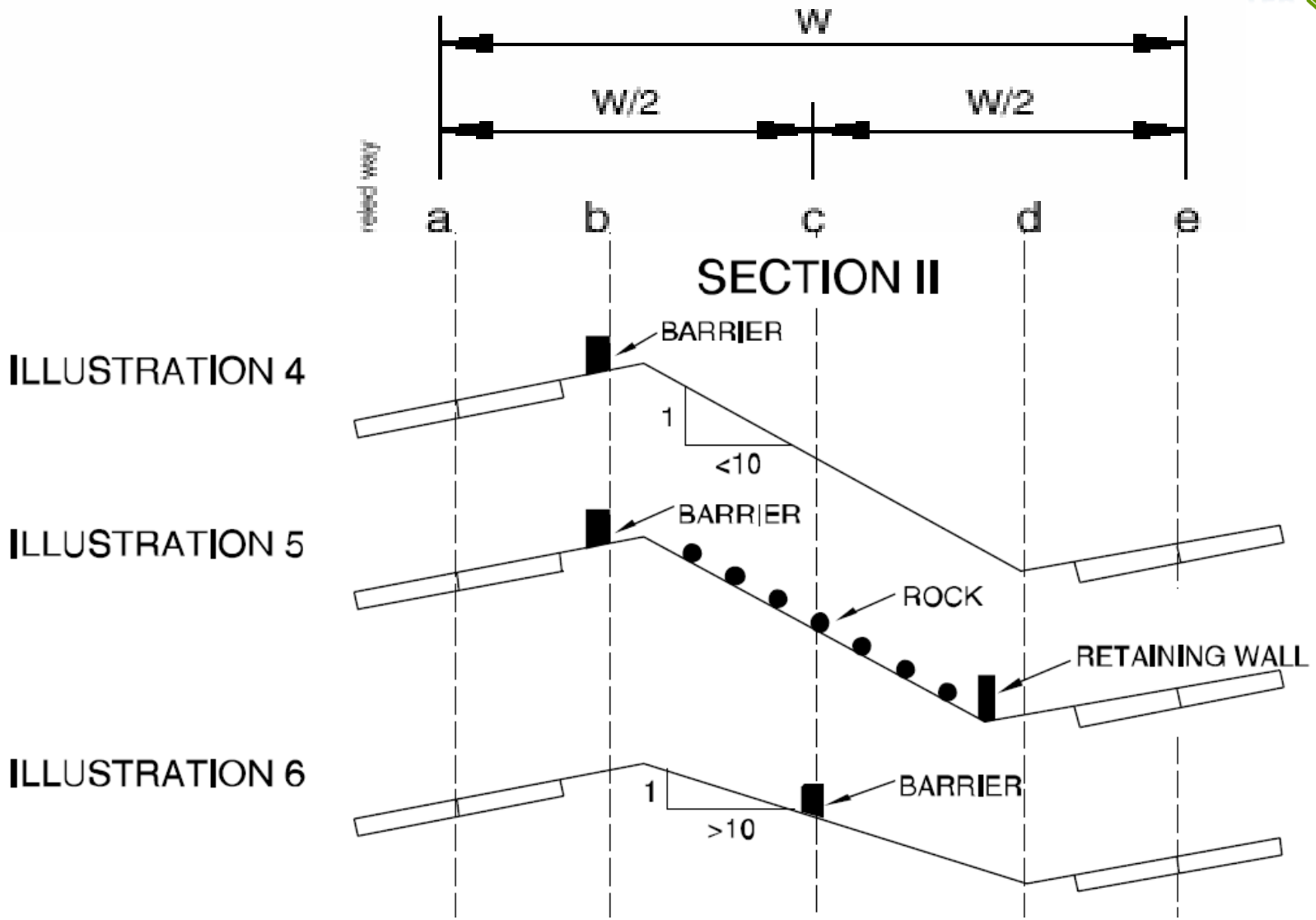
- **Most desirable median: 1H:10V slope**

- Section I – depressed median or with a ditch
- Section II – stepped median or with separated traveled ways with significant differences in elevations
- Section III – raised median or berms

Barrier Placement Section I

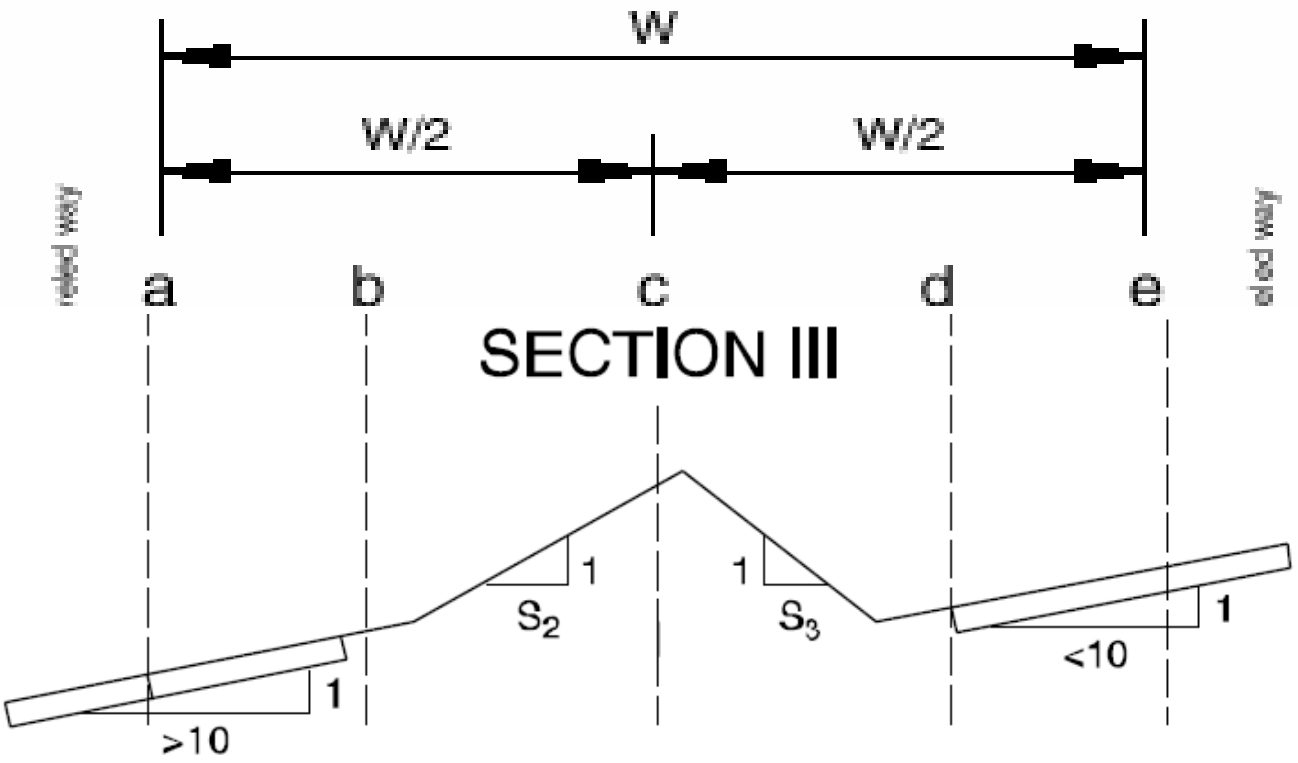


Barrier Placement Section II

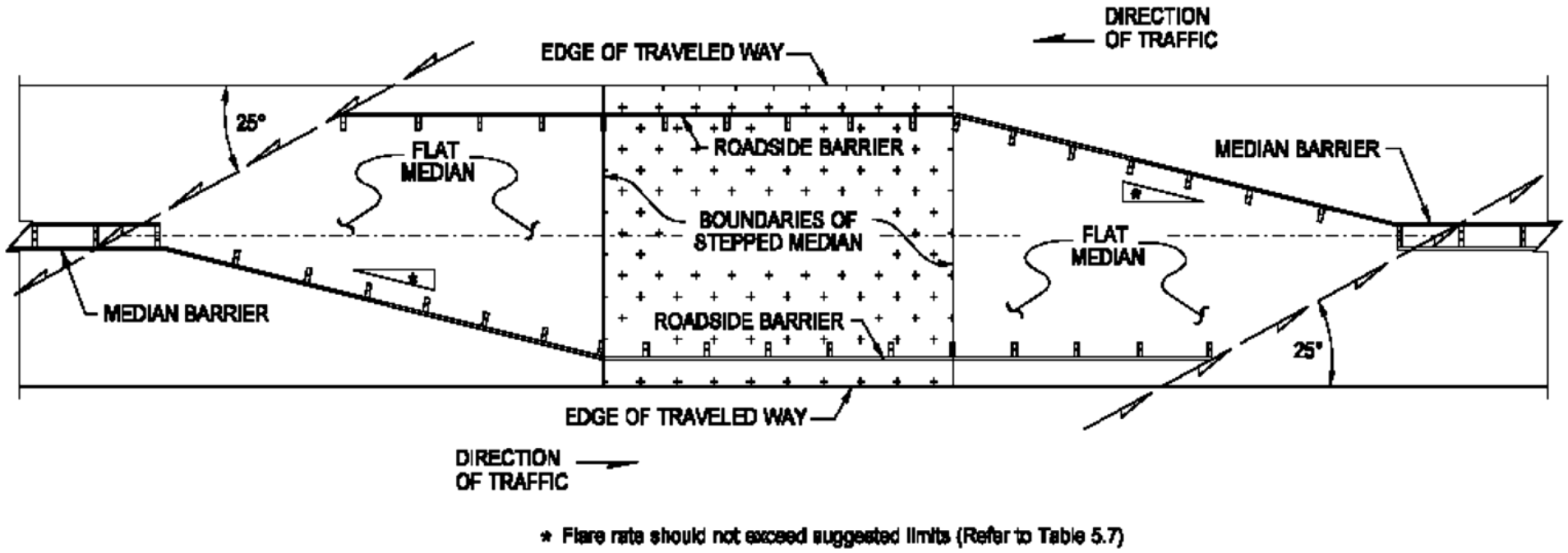


Barrier Placement Section III

ILLUSTRATION 7



Split Median Layout



Suggested Flare Rates

Design Speed		Flare Rate for Barrier Inside Shy Line	Flare Rate for Barrier at or Beyond Shy Line	
km/h	[mph]		A	B
110	[70]	30:1	20:1	15:1
100	[60]	26:1	18:1	14:1
90	[55]	24:1	16:1	12:1
80	[50]	21:1	14:1	11:1
70	[45]	18:1	12:1	10:1
60	[40]	16:1	10:1	8:1
50	[30]	13:1	8:1	7:1

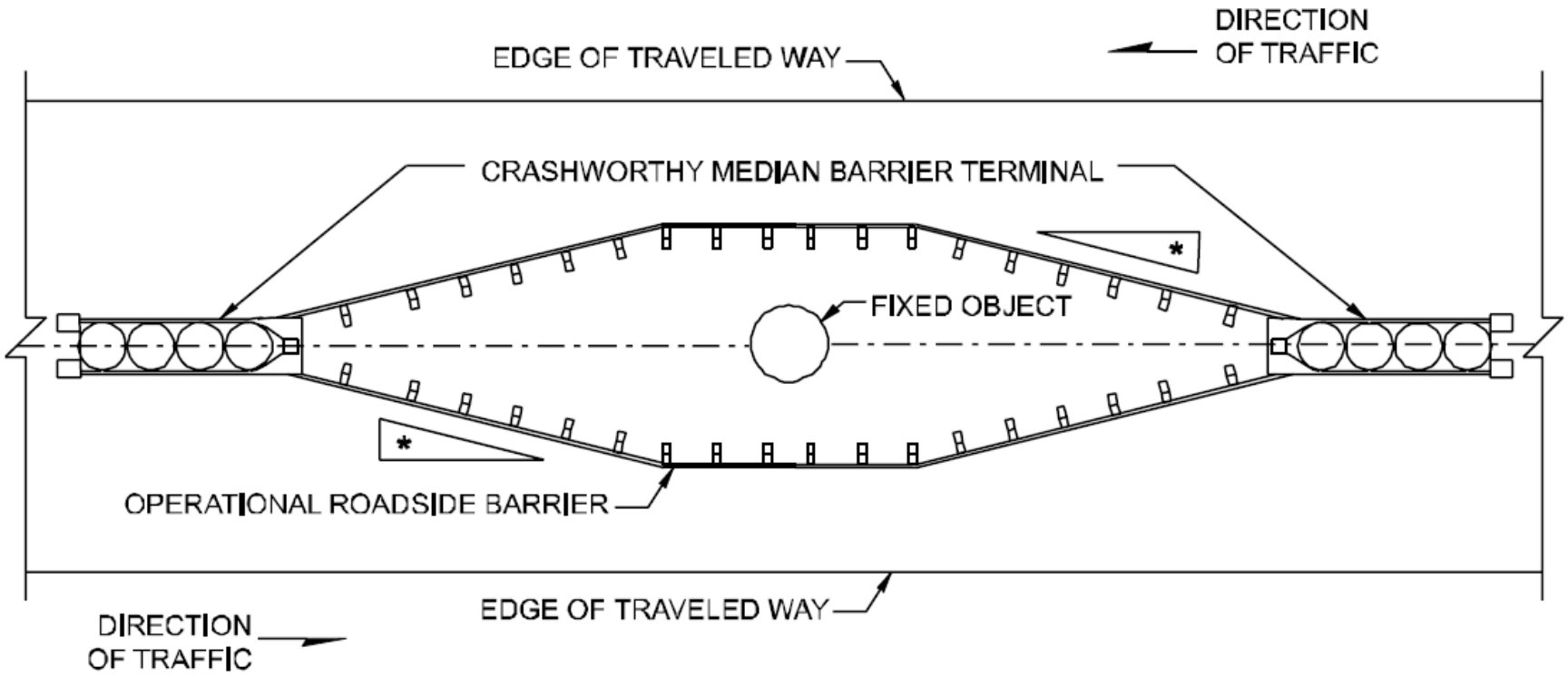
Notes:

A = Suggested maximum flare rate for rigid barrier system.

B = Suggested maximum flare rate for semi-rigid barrier system.

Same as longitudinal barriers

Shielding of Fixed Object on Median



* Flare rate should not exceed suggested limits (Refer to Table 5-9)

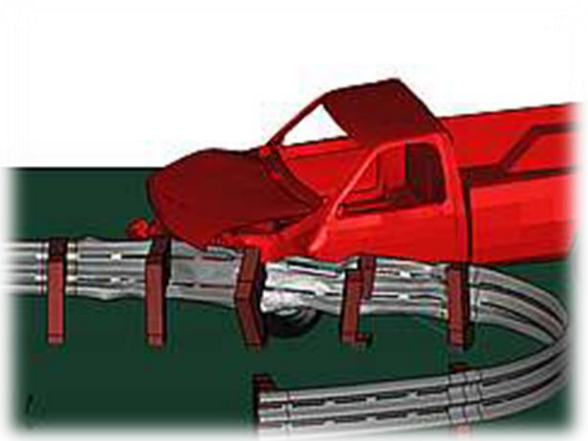
Terminals for Median Barriers

- Open guardrail systems are less expensive, but require more length, increasing the potential for vehicles to hit it
- Crash cushions involves rigid barriers with cushions on each end, are effective but expensive
- Bullnose systems (closed guardrail envelopes) wrap the guardrail completely around the hazard, are the least expensive, but more dangerous of the three designs

Inadequate Median End Treatment

Bullnose Guardrail System

- Captures vehicle like a safety net
- Protect opening between side-by-side bridges
- Deflects vehicles parallel to the roadway
- Full-scale tests showed the system successfully captured the automobile, but the light truck plunged through the guardrail








Bullnose Guardrail System

QUESTIONS, REVIEW AND EXAMPLE


Is this a
good installation?

Is this a good installation?


Is this a good installation?


Is this a good installation?

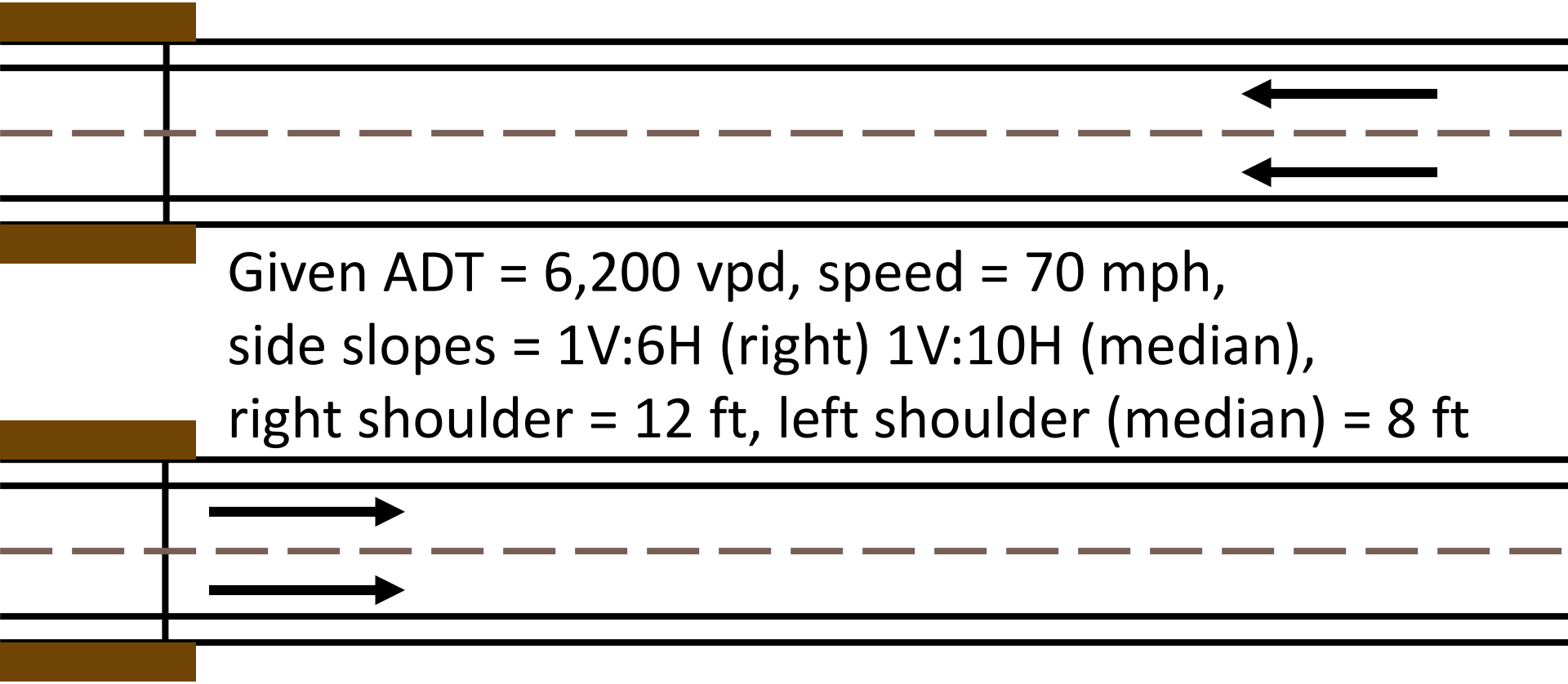
Is this a good installation?


Is this a good
installation?


Is this a good
installation?


Is this a good
installation?

Example Barrier Design for Bridge Approach



Given ADT = 6,200 vpd, speed = 70 mph,
side slopes = 1V:6H (right) 1V:10H (median),
right shoulder = 12 ft, left shoulder (median) = 8 ft

Design the barrier installation for the bridge approach

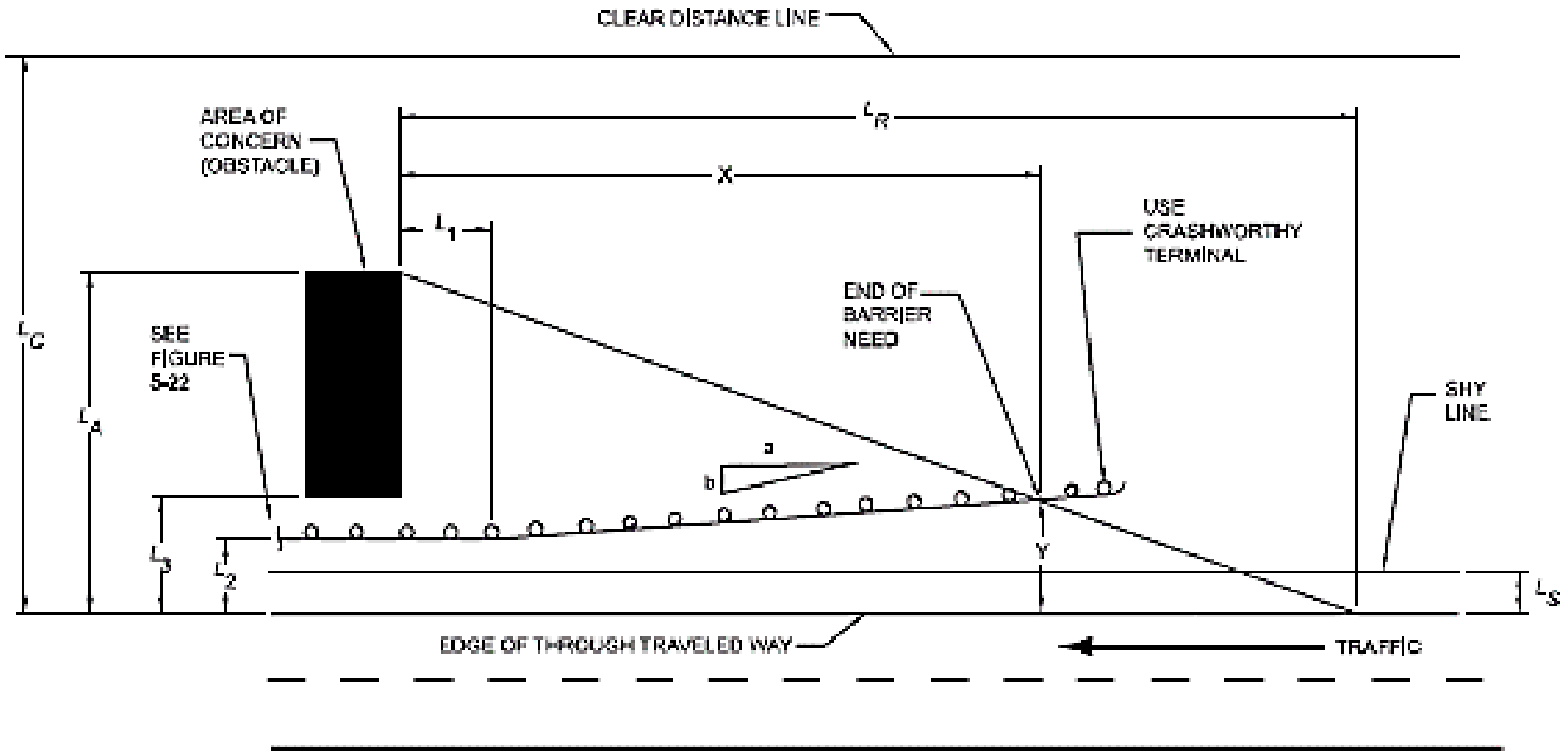
Example Barrier Design for Bridge Approach

1. Clear Zone Distance L_C (2011 RDG Table 3.1)
2. Lateral Area of Concern L_A
3. Suggested Runout Length L_R (2011 RDG Table 5.10)
4. Tangent Length from the Area of Concern L_1
5. Shy Line (2011 RDG Table 5.7)
6. Lateral Offset L_2
7. Flare rate (RDG Table 5.9)
8. Length of need X
9. Lateral Offset Y

Note: bridge transition segment length → 10-12 times the difference in lateral deflection between barriers

Approach Barrier Layout Variables

(2011 RDG Figure 5-39)



2011 RDG Table 3-1

U.S. Customary Units

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

1. Clear Zone Distance Lc = 30 ft = Lateral area of concern L_A

Suggested Runout Lengths

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

(2011 RDG Table 5-10)

Shy Line Offset L_S

Design Speed		Shy-Line Offset (L_s)	
km/h	[mph]	m	[ft]
130	[80]	3.7	[12]
120	[75]	3.2	[10]
110	[70]	2.8	[9]
100	[60]	2.4	[8]
90	[55]	2.2	[7]
80	[50]	2.0	[6.5]
70	[45]	1.7	[6]
60	[40]	1.4	[5]
50	[30]	1.1	[4]

(2011 RDG Table 5-7)

Suggested Flare Rates

(2011 RDG Table 5-9)

Design Speed		Flare Rate for Barrier Inside Shy Line	Flare Rate for Barrier at or Beyond Shy Line	
km/h	[mph]		A	B
110	[70]	30:1	20:1	15:1
100	[60]	26:1	18:1	14:1
90	[55]	24:1	16:1	12:1
80	[50]	21:1	14:1	11:1
70	[45]	18:1	12:1	10:1
60	[40]	16:1	10:1	8:1
50	[30]	13:1	8:1	7:1

Notes:

A = Suggested maximum flare rate for rigid barrier system.

B = Suggested maximum flare rate for semi-rigid barrier system.

The MGS has been tested in accordance with NCHRP Report 350 TL-3 at 5:1 flare.

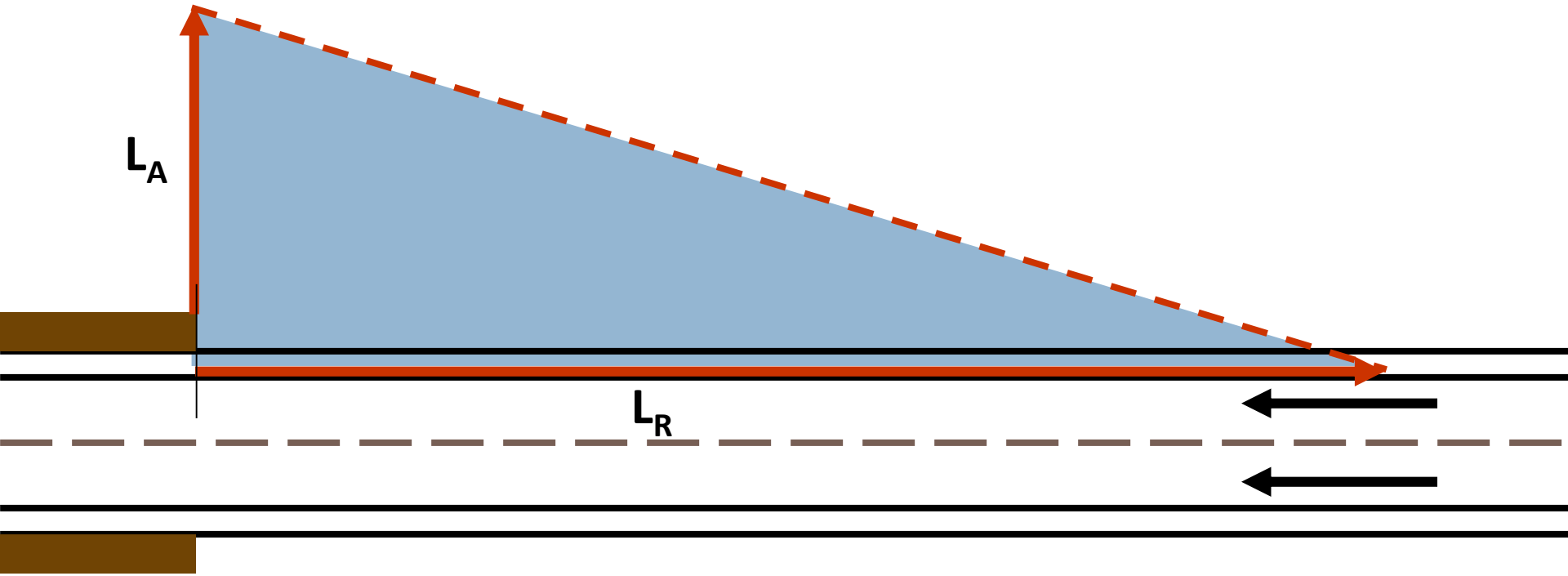
Flatter flare rates for the MGS installations also are acceptable. The MGS should be installed using the flare rates shown or flatter for semi-rigid barriers beyond the shy line when installed in rock formations.

Example Barrier Design for Bridge Approach

1. Clear Zone Distance L_C = 30-34 ft (2011 RDG Table 3-1)
2. Lateral Area of Concern $L_A = L_C$ = 30 ft (selected)
3. Suggested Runout Length L_R = 475 ft (2011 RDG Table 5-10)
4. Tangent Length from the Area of Concern L_1 = 25 ft (selected as 7.2 m → 2 guardrail elements)
5. Shy Line (2011 RDG Table 5-7) = 9.2 ft (shoulder)
6. Lateral Offset $L_{2\ right}$ = 12 ft, Lateral Offset $L_{2\ median}$ = 8 ft
7. Flare rate (2011 RDG Table 5-9) = 15:1 (external), = 30:1 (median)

Note: bridge transition segment length → 10-12 times the difference in lateral deflection between barriers

Example Barrier Design for Bridge Approach



Required Length of Need in Advance of the Area of Concern

$$X = \frac{L_A + (b|a)(L_1) - L_2}{b|a + (L_A)/(L_R)} = \frac{30 + (1/15)(25) - 12}{(1/15) + (30/475)} = 151.3\,ft$$

$$X = \frac{L_A - L_2}{(L_A)/(L_R)} = \frac{30 - 12}{30/475} = 285\,ft$$

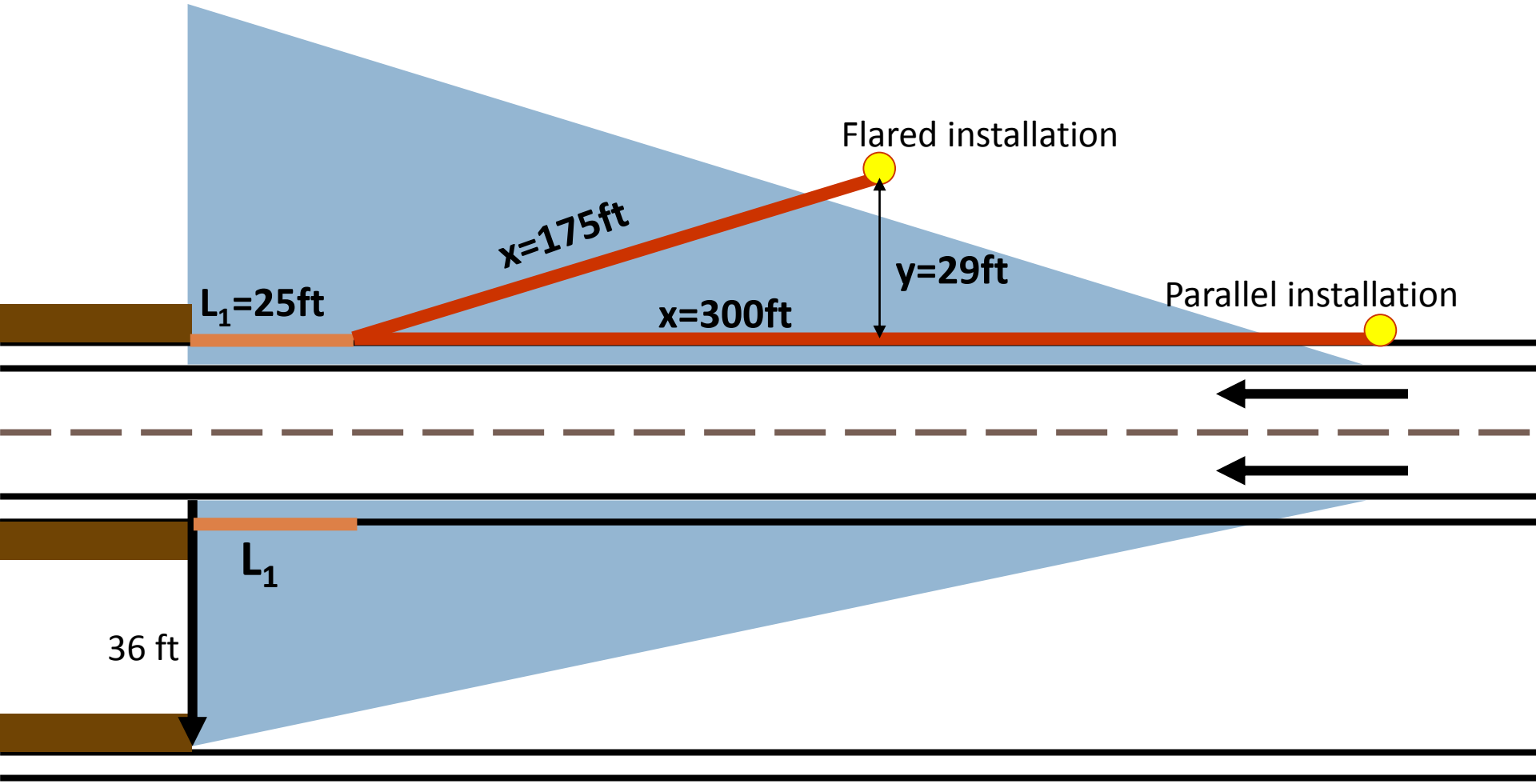
- End treatment length is not included in calculation
- Adjust for nominal metal beams lengths: 3.8 or 7.6 m (12.5 or 25 ft)

Lateral Offset
From the Edge of the Traveled Way

$$Y = L_A - \frac{L_A}{L_R} X\,(\,flared\,)$$

$$= 30 - \frac{30}{475} 175 = 29\ ft$$

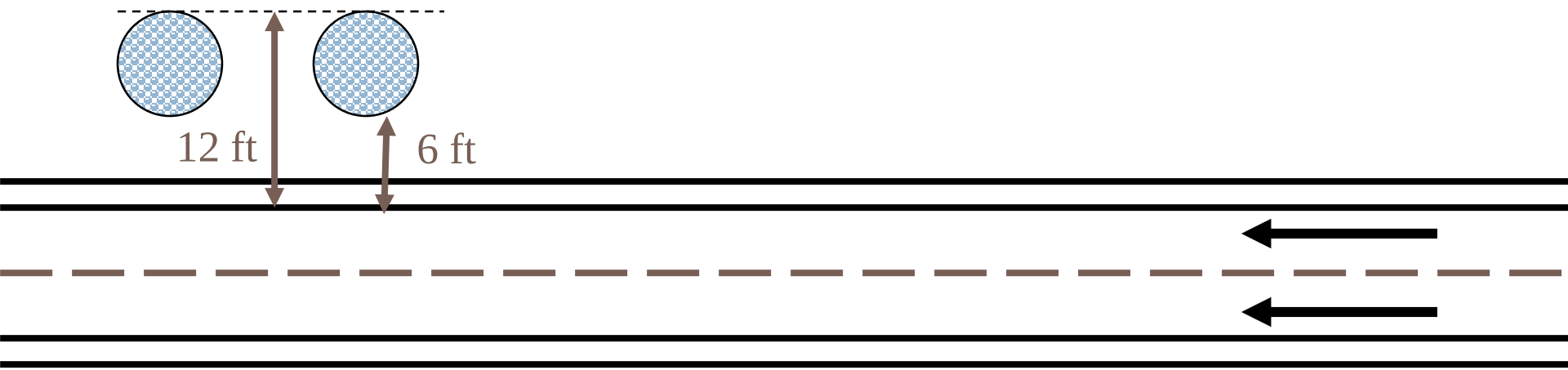
Example Barrier Design for Bridge Approach



Problem 1. Barrier Design for Bridge Piers

Given

ADT = 850 vpd, speed = 50 mph, right side slope = 1V:10H



Design the barrier installation for the bridge piers

2011 RDG Table 3-1

U.S. Customary Units

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

1. Clear Zone Distance Lc = 14-16 ft = Lateral area of concern L_A

Suggested Runout Lengths, L_R
(2011 RDG Table 5-10)

Table 5-10(b). Suggested Runout Lengths for Barrier Design (U.S. Customary Units)

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

Shy Line Offset L_s
(2011 RDG Table 5-7)

Design Speed		Shy-Line Offset L_s	
km/h	mph	m	ft
130	80	3.7	12
120	75	3.2	10
110	70	2.8	9
100	60	2.4	8
90	55	2.2	7
80	50	2	6.5
70	45	1.7	6
60	40	1.4	5
50	30	1.1	4

Suggested Flare Rates
(2011 RDG Table 5-9)

Design Speed		Flare Rate for Barrier inside Shy Line	Flare Rate for Barrier beyond Shy Line	
km/h	[mph]		*	**
110	[70]	30:1	20:1	15:1
100	[60]	26:1	18:1	14:1
90	[55]	24:1	16:1	12:1
80	[50]	21:1	14:1	11:1
70	[45]	18:1	12:1	10:1
60	[40]	16:1	10:1	8:1
50	[30]	13:1	8:1	7:1

*Suggested maximum flare rate for rigid barrier system

** Suggested maximum flare rate for semi-rigid barrier system

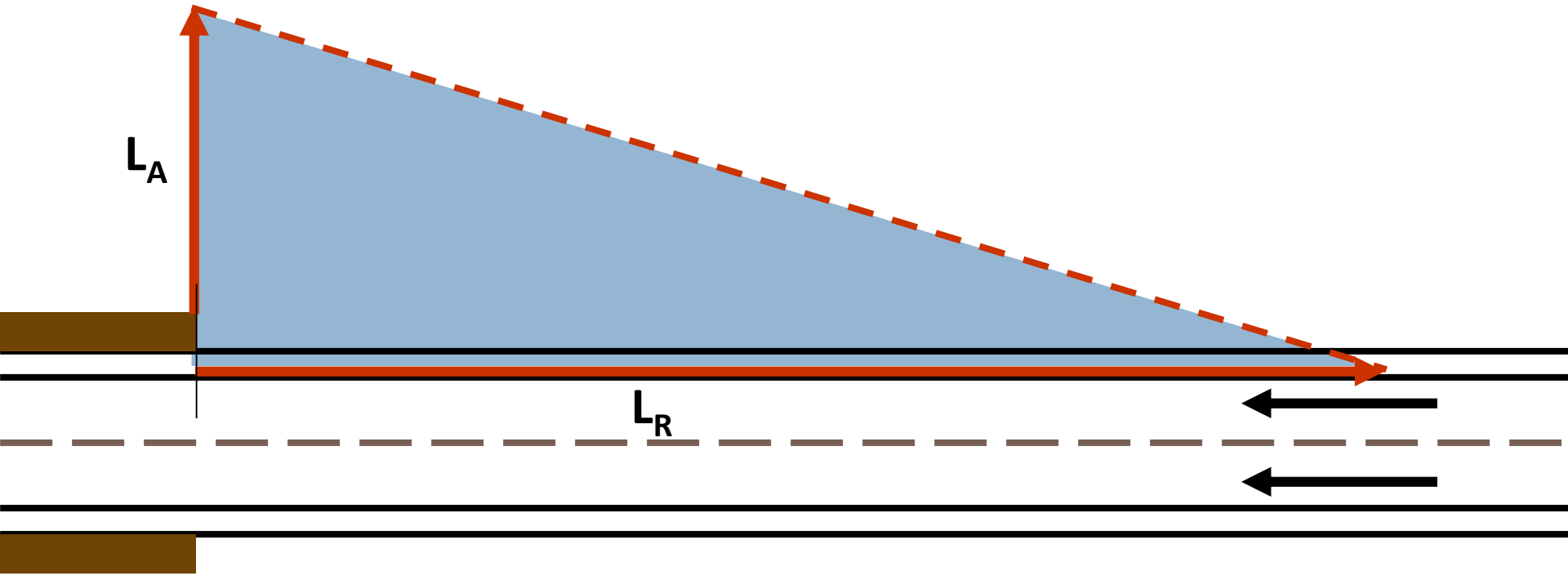
The MGS has been tested in accordance with NCHRP Report 35 TL-3 at 5:1 flare.
Flatter flare rates for the MGS installations are also acceptable. The MGS should be installed using the flare rates shown or flatter for semi-rigid barriers beyond the shy line when installed in rock formations.

Example Barrier Design for Bridge Approach

1. Clear Zone Distance L_C = 14 ft – 16 ft(2011 RDG Table 3.1)
2. Lateral Area of Concern L_A =16 ft (chosen)
3. Suggested Runout Length L_R = 150 ft (2011 RDG Table 5.10)
4. Tangent Length from the Area of Concern L_1
5. Shy Line L_S = 6.5 ft (2011 RDG Table 5.7)
6. Lateral Offset L_2
7. Flare rate (RDG Table 5.9)
8. Length of need X
9. Lateral Offset Y

Note: bridge transition segment length → 10-12 times the difference in lateral deflection between barriers

Example Barrier Design for Bridge Approach



Required Length of Need in Advance of the Area of Concern

$$X = \frac{L_A + (b \mid a)(L_1) - L_2}{b \mid a + (L_A)/(L_R)} = \frac{16 + (1/11)(25) - 6}{(1/11) + (12/150)} = 71.8\,ft \Rightarrow 75\,ft$$

$$X = \frac{L_A - L_2}{(L_A)/(L_R)} = \frac{12 - 6}{16/150} = 56.25\,ft \Rightarrow 75\,ft$$

- End treatment length is not included in calculation
- Adjust for nominal metal beams lengths: 3.8 or 7.6 m (12.5 or 25 ft)

Lateral Offset
From the Edge of the Traveled Way

$$Y = L_A - \frac{L_A}{L_R} X(\,flared\,)$$

$$= 12 - \frac{12}{150} 75 = 6\ ft$$

Example Barrier Design for Bridge Approach