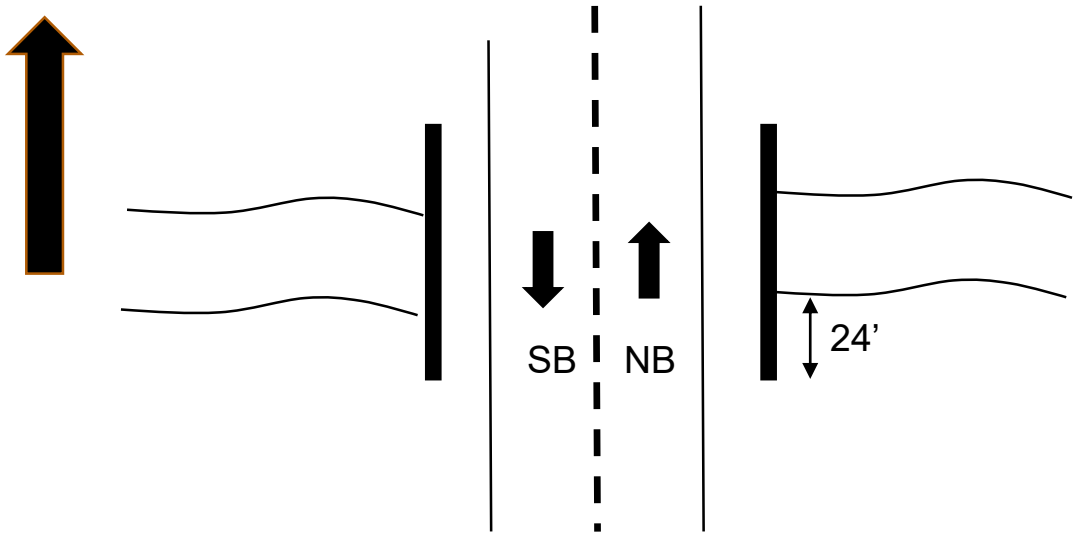
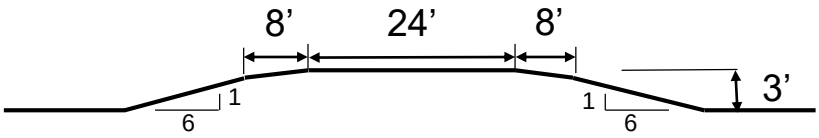
Highway Barrier Design Workshop Solutions

WORKSHOP PROBLEM 1 – BRIDGE ON RURAL ROAD WITH TWO-WAY TRAFFIC

Design speed – 60 mph
AADT – 2,250 vpd





Roadway Section

Lane width: 12 ft.

Shoulder width: 8 ft.

Side slope: 6:1 (wrapped around under bridge)

Design for both sides of road, NB

Determine Design Clear Zone (L_C) – MDT Design Manual page 9-5

Design speed – 60 mph
AADT – 2,250 vpd
Slope – 6:1

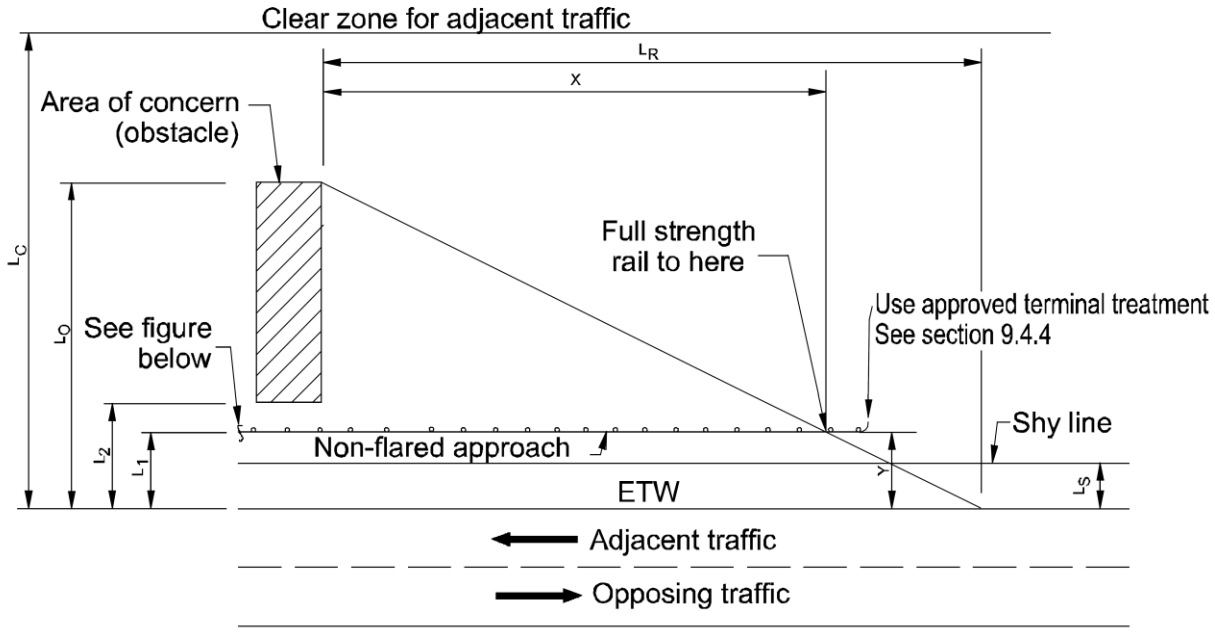
Design Speed	Design AADT	Fill Slopes/Foreslopes		
		6:1 or Flatter	5:1	4:1
40 mph or less	< 750	8	8	10
	750-1499	10	12	14
	1500-6000	12	14	16
	> 6000	14	16	18
45 mph	< 750	10	12	14
	750-1499	14	16	18
	1500-6000	16	20	24
	> 6000	20	24	26
50 mph	< 750	12	12	14
	750-1499	16	18	20
	1500-6000	18	22	26
	> 6000	22	26	28
55 mph	< 750	12	14	18
	750-1499	16	20	24
	1500-6000	20	24	30
	> 6000	22	26	32
60 mph	< 750	16	20	24
	750-1499	20	26	32
	1500-6000	26	32	40
	> 6000	30	36	44
70 mph	< 750	20	22	26
	750-1499	24	30	36
	1500-6000	30	36	42
	> 6000	32	38	46
80 mph	< 750	24	26	30
	750-1499	28	32	38
	1500-6000	34	40	46
	> 6000	38	44	50

Design Clear Zone = 26’

Identify all hazards

a. Bridge rail ends
b. River

Determine the Adjacent Length of Need (X)



Determine the Lateral distance to the backside edge of the hazard(s) - L_0.

For the bridge end:

For a right side departure it is 9’ (shoulder width plus 1’ wall thickness)

For a left side departure it is 21’ (measured from the centerline)

For the river:

Since the river is continuous, the outside edge of the hazard extends beyond the design clear zone. Normally, the back edge of hazard (L_0) is limited to the design clear zone (L_C). Therefore, L_0 will equal L_C = 26’ – for both sides.

Find L_R – The theoretical Runout Length needed for a vehicle leaving the roadway to stop.

This is a look up value from the MDT Design Manual

Design speed – 60 mph; AADT – 2,250 vpd

Design Speed (mph)	Runout Length (L_R) (ft) Design Year Traffic Volume (AADT)				Shy Line Offset L_s (ft)
	>10,000	>5,000 ≤10,000	>1,000 ≤5,000	≤1,000	
80	470	430	380	330	12
70	360	330	290	250	9
60	300	250	210	200	8
50	230	190	160	150	6.5
40	160	130	110	100	5
30	110	90	80	70	4

Therefore, L_R = 210’ – for both sides.

First, for right side departure

Determine L_1 – Guardrail offset from edge of travel lane.

The roadway has an 8’ ft. shoulder. Guardrail should be placed as far from the travelled lane as practical – without affecting its function. The 6:1 slope is not acceptable for guardrail placement (**Principle** – slope in front of barrier); regrading would be necessary. Assume too costly, so place face of rail at edge of shoulder.

Guardrail posts should have a minimum of 2 ft. of 2% sloped ground behind them for soil backing (**Principle** – soil backing and DD 606-05); placement of standard 6’ posts on the 6:1 slope needs to be justified or shoulder grading provided.

Therefore L_1 = 8 ft. (Shoulder width)

Calculating the Adjacent Length of Need

We'll only calculate the adjacent LON of the hazard of the river; when shielding the river, that barrier will also shield the end of the bridge rail

Since the back of hazard extends (well) beyond the Design Clear Zone (DCZ), use L_R formula:

$$X = \frac{L_R(L_O - L_1)}{L_O}$$

$$= \frac{210(26 - 8)}{26}$$

$$= 145.4 \text{ ft.}$$

Adjacent LON is defined as the length of effective barrier upstream from the beginning of the hazard – the stream bank. This will include:

- 24' of the bridge railing,
- 37.5' provided by the bridge approach, paid as Each
- 34.4' provided by the tangent terminal

Therefore, the amount of line guardrail needed = 145.4-24-37.5-34.4 = 49.5'; converting to full 12.5' panels is 4 panels or 50 LF of standard guardrail. Grading will also need to be provided for the terminal.

IMPLEMENTING DESIGN:

24' is paid for by the bridge rail
From the bridge rail:
37.5' is paid for as bridge approach
34.4' is paid for in the terminal bid item
50 LF is paid for as standard guardrail
Terminal – grading needed

For the left side departure

L_0 and L_R stay the same (26’ and 210’)
HOWEVER, L_1 – the guardrail offset (as well as L_0) is now measured from the **centerline**
L_1= 12+8 = 20 ft.

Since the back of hazard extends (well) beyond the Design Clear Zone (DCZ), use L_R formula:

$$X = \frac{L_R(L_0 - L_1)}{L_0}$$

$$= \frac{210(26-20)}{26}$$

= 48.5 ft.

24’ is provided by the bridge rail

37.5’ is provided by the Bridge Approach

34.4’ is provided by the tangent terminal

48.5 – 24– 37.5 – 34.4 < 0’; therefore, no LF of MGS barrier is needed*

(* If the MSKT terminal is selected by the contractor, an additional 12.5’ rail must be provided – at no cost; the tested length of the MSKT is 50’ and the pay item is only 47’, and the bridge approach has nested rail which cannot be tied directly into)

Therefore the installation will include:

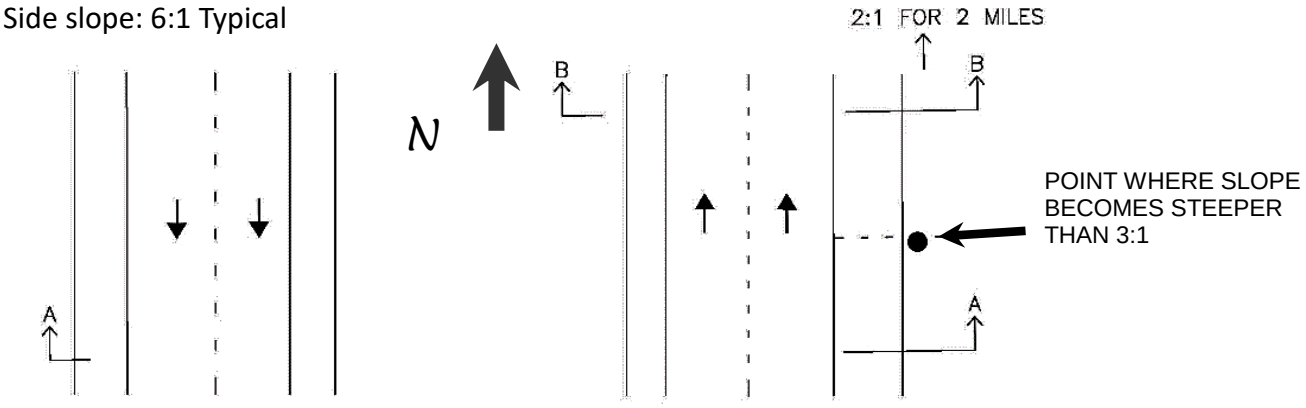
- 24’ of the bridge railing,
- 37.5’ of the bridge approach
- 34.4’ of the tangent terminal - with grading

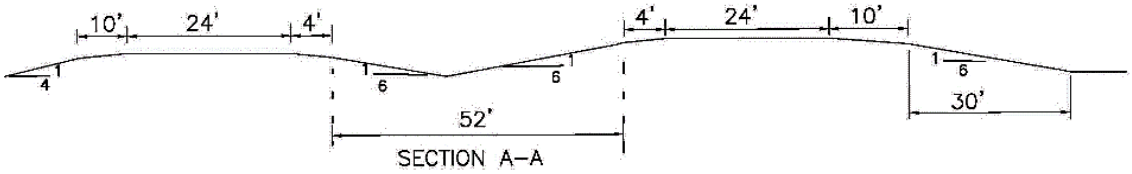
Workshop Problem 2 – 2:1 EMBANKMENT

Design speed: 70 mph

ADT: 38,000

Side slope: 6:1 Typical





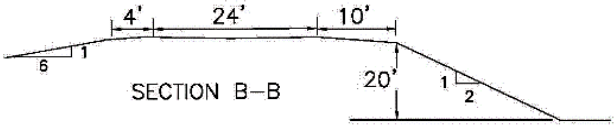
Roadway Section

Lane width: 12 ft.

Shoulder width (right): 10 ft.

Shoulder width (left): 4 ft.

Side slope (typical): 6:1



Calculate the Adjacent Length of Need (LON) for the NB outside embankment

Determine Design Clear Zone (L_C) – MDT Design Manual page 9-5

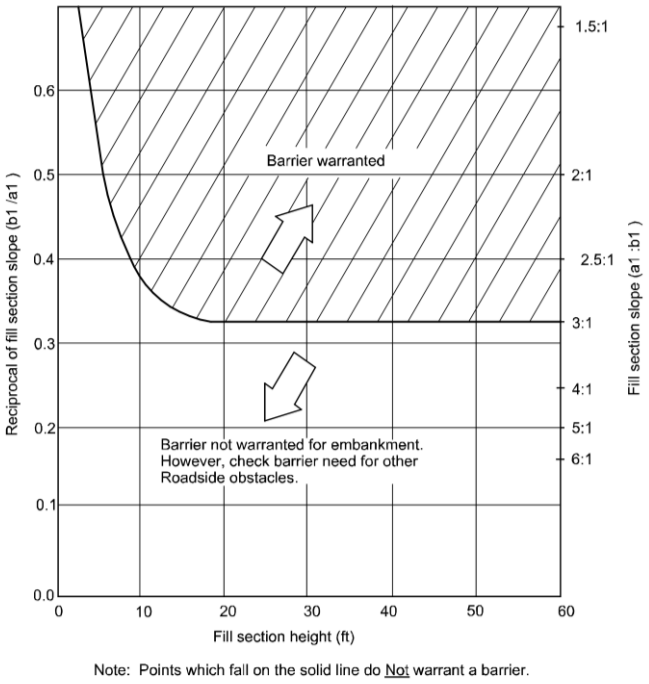
Design speed – 70 mph
AADT – 38,000 vpd
Slope – 6:1

Design Speed	Design AADT	Fill Slopes/Foreslopes		
		6:1 or Flatter	5:1	4:1
40 mph or less	< 750	8	8	10
	750-1499	10	12	14
	1500-6000	12	14	16
	> 6000	14	16	18
45 mph	< 750	10	12	14
	750-1499	14	16	18
	1500-6000	16	20	24
	> 6000	20	24	26
50 mph	< 750	12	12	14
	750-1499	16	18	20
	1500-6000	18	22	26
	> 6000	22	26	28
55 mph	< 750	12	14	18
	750-1499	16	20	24
	1500-6000	20	24	30
	> 6000	22	26	32
60 mph	< 750	16	20	24
	750-1499	20	26	32
	1500-6000	26	32	40
	> 6000	30	36	44
70 mph	< 750	20	22	26
	750-1499	24	30	36
	1500-6000	[illegible]	36	42
	> 6000	32	38	46
80 mph	< 750	[illegible]	26	30
	750-1499	28	32	38
	1500-6000	34	40	46
	> 6000	38	44	50

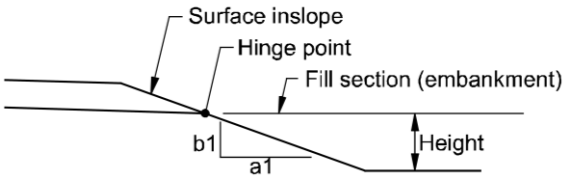
Design Clear Zone = 32’

Identify all hazards

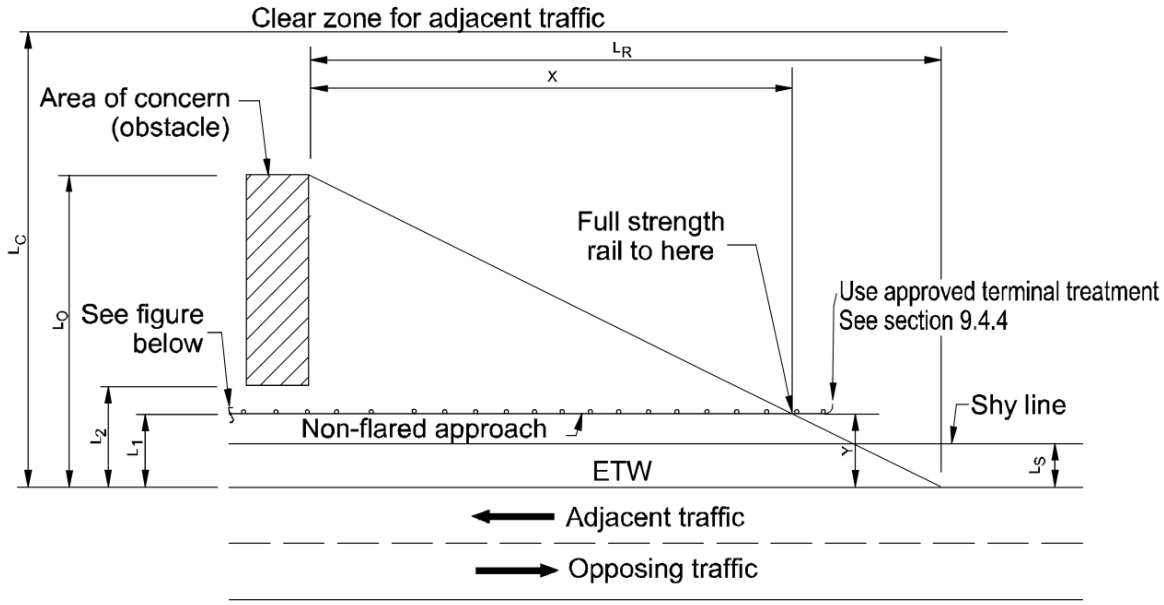
Embankment steeper than 3:1 (and over 20’ high) is critical: the vehicle will likely roll over going down the slope



Note: Points which fall on the solid line do Not warrant a barrier.



Determine the Adjacent Length of Need (L)



Determine the Lateral distance to the backside edge of the hazard(s) - L_0.

The backside edge of the hazard for a steep embankment is generally taken as the value of the L_C for the typical section in advance of the steep embankment. Therefore:

$$L_o = L_c = 32'$$

Find L_R – The theoretical Runout Length needed for a vehicle leaving the roadway to stop.

This is a look up value from the MDT Design Manual

Design speed – 70 mph; AADT – 38000 vpd

Design Speed (mph)	Runout Length (L_R) (ft)				Shy Line Offset L_s (ft)
	Design Year Traffic Volume (AADT)				
	>10,000	>5,000 ≤10,000	>1,000 ≤5,000	≤1,000	
80	470	430	380	330	12
70	360	330	290	250	9
60	300	250	210	200	8
50	230	190	160	150	6.5
40	160	130	110	100	5
30	110	90	80	70	4

Therefore, L_R = 360' – for both sides.

First, for right side departure

Determine L_1 – Guardrail offset from edge of travel lane.

The roadway has a 10' ft. shoulder. Guardrail should be placed as far from the travelled lane as practical – without affecting its function. The 6:1 slope is not acceptable for guardrail

placement (**Principle** – slope in front of barrier); regrading would be necessary. Assume too costly, so place face of rail at edge of shoulder.

Guardrail posts should have a minimum of 2 ft. of 2% sloped ground behind them for soil backing (**Principle** – soil backing and DD 606-05); placement of standard 6' posts on the 6:1 slope needs to be justified or shoulder grading provided.

Therefore L_1 = 10 ft. (Shoulder width)

. Calculating the Length of Need

Using formula:

$$X = \frac{L_R(L_O - L_1)}{L_O}$$

$$= \frac{360(32 - 10)}{32}$$

= 247.5 ft.

The barrier will extend the length of the steep embankment; this is the adjacent LON, the length IN ADVANCE OF the 3:1 steepness

34.4' provided by the terminal will be subtracted from the total LON. Convert remainder LON to panels, then to LF.
Need a One Way Departure Terminal at downstream end
Need grading for approach terminal

Pre-installation Review Guidelines
EXAMPLE

PennDOT currently requires a pre-installation review to ensure an optimal installation.

These reviews are conducted on all Interstate, expressway and/or other projects where Federal oversight is being done. The review team would consist of the PennDOT Inspector-in-Charge, District Guardrail Mentor, FHWA Representative and Contractor's Representative.

Prior to the review the contractor should place temporary markers to indicate the locations of all permanent traffic barrier and end treatments.

The following items will be reviewed:

- Barrier Length of need.
- End terminal/crash cushion selection.
- Slopes and grading.
- Miscellaneous – existing barriers to be removed, other locations within the project limits that need to be addressed, areas where barriers can be reduced or eliminated.
- Minor Revisions made immediately.
- Major changes, if any, made through existing procedures.
- Information transmitted to design as lessons learned.
- District summaries prepared annually for statewide review and corrective action.