

SECTION B

Design Considerations

The decision to use a particular road design element at a particular location should be made on the basis of an engineering analysis of the location. Thus, while this document provides design standards, it is not a substitute for engineering judgment. The American Association of State Highway Officials *Volume One (1) National Standards* shall be used for any design standards not addressed in this guide.

I. Project Scoping

The factors should be evaluated in the design.

1. System or Functional Classification. The Department has adopted separate tables of geometric design criteria for all projects based on functional classification.
2. Traffic Volumes. The designer should examine the current and projected traffic volumes within the limits of a project on an existing highway. This may influence the decisions on the extent of geometric improvements.
3. Pavement Condition. Projects are often programmed because of a significant deterioration of the existing pavement structure (including sub base, base and surface course). The extent of deterioration will determine the necessary level of pavement improvements. This decision will also influence the extent of practical geometric improvements.
 - a. For pavement overlay projects an evaluation of the roadway should include, at a minimum, field inspection to review existing pavement condition, required upgrades to guardrail, and needed replacement of drainage pipes. Maintenance personnel familiar with the project location should be consulted to determine location of problem areas such as frost heaves and poor drainage.
 - b. For pavement overlay projects, an evaluation of the rutting present in the surface needs to be evaluated as well. If there is significant rutting present (greater than $\frac{3}{4}$ "), a determination should be made whether the rutting is a surface condition, or if there is evidence of base failure. The recommended treatment should be appropriate to address the conditions.
 - c. For highway improvement projects an evaluation as derived above should be completed. In addition the use of the Falling Weight Deflectometer and soils borings are encouraged.
4. Physical Characteristics. The physical constraints within the limits of a project on an existing highway will often determine what geometric improvements are practical and

cost-effective. These include topography, adjacent development, available right-of-way , utilities, and environmental constraints. The designer also should examine the geometric features and design speeds of highway sections adjacent to the proposed project to provide design continuity with the adjacent sections. This involves a consideration of factors such as driver expectations, geometric design consistency and proper transitions between sections of different geometric designs. Other considerations should be the aesthetic, scenic, historic and cultural characteristics.

5. Traffic Controls and Regulations. All signing and pavement markings on all projects must meet the criteria of the Manual on Uniform Traffic Control Devices (MUTCD).
6. Safety Enhancement. All projects on existing highways must be designed to consider and incorporate appropriate, practical safety improvements.
7. Crash Records. The historical crash data within the limits of a proposed project on an existing highway should be evaluated as part of the project development.
8. Potential Impacts of Various Types of Improvements. Projects on existing highways may impact the aesthetic, social, environmental, operational and economic characteristics of the surrounding land and development.
9. Future Development. Project considerations should include future development and access management. (Ref: Access Management Section G).

II. Traffic Volume Controls

1. Design Year Traffic Volumes. The following table has design years beyond the construction completion date for traffic analyses (AADT, design hourly volume, etc.).

Scope of Work	Design Years
New Construction Arterials	20 years
Collector Highway Improvement Program	12 years
PPM Level 2 Rehab	6 - 8 years 10 Years 12 Years

Table 1 - Design Year

2. Traffic Data. The designer should obtain from the Bureau of Planning, Research and Community Services the traffic data necessary to determine the scope of improvement.

III. Design Speed

The geometric design features should be consistent with the design speed appropriate for the facility. This may vary from a low of 25 mph in mountainous terrain to a high of 65 mph in flat terrain. It should be noted, however, that the design speed does not necessarily represent the anticipated operating or posted speed.

IV. Vertical Alignment

1. Crest Vertical Curves

The Department's criteria for crest vertical curves is based on providing stopping sight distance (SSD).

If the existing SSD does not meet these criteria, the design should evaluate the practicality of flattening the crest vertical curve. This will be based on the crash history, traffic volumes, construction costs, community concerns, right-of-way, environmental considerations, etc.

For Resurfacing, Rehabilitation, and Restoration (3R) treatment of Arterials and all Collectors the following table shall be used:

Design Speed (mph)	Minimum Stopping Sight Distance (feet)
20	115
25	155
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645

Table 2 - Minimum SSD

For reconstruction on Arterials see *Volume One National Standards*.

2. Sag Vertical Curves

The Department has adopted the comfort criteria to evaluate the adequacy of existing sag vertical curves. To determine the adequacy of existing sag vertical curves, follow this procedure:

Calculate the design speed of the existing sag from:

$$L = \frac{AV^2}{46.5}$$

Where: V = design speed, mph

L = existing length of sag vertical curve, meters

A = existing algebraic difference in grades, percent

If an existing sag does not meet the comfort criteria, the designer should evaluate the practicality of flattening the curve. This will be based on accident history, traffic volumes, construction costs, etc.

V. Horizontal Alignment

1. Super elevation Rate/Degree of Curve

If an existing curve in a rural area has a super elevation rate steeper than 6 percent, an $E_{max}=0.08$ may be used. The designer should reference the *Volume One National Standards* for combinations of super elevation rate and degree of curve. For additional information see Typical Sections, figures (1-6), and to determine the proper combination of super elevation rate and degree of curve based on project design speed Table 5-6 will be used.

2. Reverse Curves

For reverse curves it will be acceptable to provide no tangent section between the curves unless there is significant crash history. On minor arterials, the use of reverse curves is not preferred.

3. Off Tracking

Designer should take into consideration off tracking when using tighter radius and narrow roadway widths.

When the Degree of Curve = 3° or greater pave shoulder full depth, also consideration should be given to widening pavement in this area.

In the design of Arterials see *Volume One National Standards*.

VI. Cross Section Elements

1. Right-of-Way

Right-of-way acquisition on collectors typically will involve small fee, temporary and permanent easements and grading rights. Occasionally, more extensive right of way involvement may be appropriate if, for example, a horizontal curve is flattened. See section on Right-of-Way.

2. Curbs

The following will apply to the installation or retention of curbs:

A. Location. Where curb does not exist, the need for curb will be determined on a case-by-case basis.

B. Type. Where a project will disturb existing curbs, the curb will be replaced in-kind. On new location a case-by-case basis.

C. Type 3 (bituminous curb) is used for box sections built in rural areas with low to moderate traffic volumes; on the low side of a banked curve in guardrail sections; and to delineate islands, sidewalks and parking areas where the usage is expected to be light duty. In general, mold 1 is used adjacent to sidewalks and mold 2 elsewhere. The minimum radius for Type 3 curb is 5 feet. Cape Cod mold to be considered when maintenance issues such as plowing and driving over the curb is an issue.

1) Maintenance Considerations

a) Cape Cod Curb

b) Design considerations should be given when curb is called for in rural situations, to alternate methods such as add underdrain for subgrade drainage and/or combined with shallow ditch for surface drainage.

2) An analysis of the storm water flow in the gutter indicates overtopping the curb for the design parameters (e.g., design-year frequency, ponding on roadway); and/or

3) The curb reveal after construction will be less than 3 inches.

D. Barrier curb shall not be used for design speeds greater than 45 mph.

3. Sidewalks

Where a project will disturb existing sidewalks, the sidewalk will be replaced in-kind.

Where sidewalks do not currently exist, the need for sidewalks will be determined on a case-by-case basis. Sidewalks must meet ADA regulations. See sidewalk policy.

4. Turning Radii Design

The turning radii design will be determined by the turning characteristics of a WB-67 design vehicle. The criteria for inside clearance are modified as follows. It is desirable that the WB-67 may be allowed to make the right turn such that its wheels will almost touch the pavement edge or curb line. This means that the vehicle will overhang beyond the edge. Therefore, the designer must ensure that the turning vehicle will not impact any obstructions (signal poles, mailboxes, etc.). (Ref: Exhibit 1)

5. Roadside Safety

General Application

The Department should take the opportunity to implement practical roadside safety improvements. The designer should review the roadside crash history to assist in the decision-making. See section on safety.

The design should take into consideration the use of wider shoulders for emergency parking when shoulders of 14 feet or less are used.

Consideration should be given for adding shoulder width at mailbox locations (See Figure B-1).

6. Roadside Clear Zone

Table 3 presents the clear zone distances.

Once a hazard has been identified within the clear zone, the designer should consider the following:

- A. **Crash Records.** The designer should review the crash data to estimate the extent of the roadside safety problem.
- B. **Location Relative to Clear Zone Distance.** The closer an obstacle is to the traveled way, the greater the potential benefits of treatment. It is less likely to be cost effective to treat a hazard near the outer edge of the clear zone boundary.
- C. **Location Relative to Other Hazards.** If a hazard is one of many at about the same distance from the traveled way, this decreases the benefits of treatment. As an example, it may have little benefit to remove an obstacle 12 feet from the travel lane if a line of other obstacles (e.g. trees) are located at 15 feet from the travel lane. However, it may be highly desirable to treat an isolated hazard along the roadside, which is within the clear zone distance.

D. Treatment Costs. A hazard may be removed, relocated or made breakaway. The costs of these treatments will be a factor in the decision-making process.

E. Nature of Hazard. The type of hazard and the available treatments will be a significant factor in the decision-making process. For example, a non-breakaway signpost, which is owned and maintained by the Department, can be made breakaway without any impact on the surrounding environment. However, removing natural features (e.g. trees) may impact the environment and may meet with strong public opposition.

F. Utilities. See section on utilities

G. Safety Appurtenances

All existing safety appurtenances should be examined to determine if they meet the latest safety performance and design criteria. This includes guardrail, impact attenuators, median barriers, sign supports, luminaire supports and bridge rail transitions. All safety appurtenances should be upgraded to meet the most recent design criteria.

The designer should evaluate the roadside environment. The process will be:

- 1) Determine if a barrier is warranted.
- 2) If an existing run of barrier is located where no barrier is warranted, remove the barrier.
- 3) If a barrier is warranted, consider removing or relocating the hazard; reducing its severity (e.g., flattening a slope); or making it breakaway.
- 4) If a hazard cannot be eliminated and a barrier is judged to be cost effective, then install a barrier. The designer should recognize that, depending on the specific site conditions, it may be acceptable to identify a hazard within the applicable clear zone and leave the hazard unshielded. A decision on the cost-effectiveness of barrier installation will be based on construction costs, traffic volumes, crash history, barrier adaptability to the site, etc. versus the hazard created by installing the barrier.
- 5) For any existing runs of guardrail which will remain, ensure that they meet, as practical, the applicable performance and design criteria, including:
 - i) Operational acceptability;
 - ii) Dynamic deflection criteria;
 - iii) Length of need;
 - iv) Lateral placement;
 - v) Placement on slopes and behind curbs; and
 - vi) End treatments.
 - a) Length of Need

Determine Length of Need (L). Use the following equation:

$$L = \frac{LH - LB}{\tan 10^\circ} \qquad L = \frac{LH - LB}{\tan 15^\circ} \qquad \tan 10^\circ = 0.176327 \qquad \tan 15^\circ = .267807$$

End Treatment. A crashworthy terminal should be used beyond this point. Reference should be made to the new Guardrail and Guardrail Terminal Policy located in Section G Policies. If other approved terminal ends are used, the distance beyond L may need to be adjusted to satisfy the barrier needs of the selected system. For a one-way roadway, an unanchored end is acceptable at the trailing end. The end will be located a minimum of 50' beyond an obstacle and 66' beyond a steep embankment.

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

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

Table 3 - Geometric Design Criteria

Minor Collectors

Design Year AADT	Roadway Width	Roadway (ft) Configuration	Side Slope	Design Speed	Clear Zone	Safety Considerations
Under 1000	24 ft.	12 ft. - 12 ft.	3:1	40 mph	8 ft.	Where practical increase road width to 26 ft. with stripe at 10 ft. and clear Zone to 10 ft.
1000 - 4000	28 ft.	14 ft. - 14 ft. Stripe at: 11 ft.	3:1	40 mph	9 ft.	Travel lane width of 20 ft. may be acceptable up to 3000 AADT. Where practical increase clear zone to 10 ft.
Over 4000	See	Major Collector	3:1	45 mph	10 ft.	No Safety Comments

Major Collectors

Under 1000	24 ft.	12 ft. - 12 ft.	3:1	45 mph	10 ft.	Where practical increase roadway width to 26 ft. with strip at 10 ft.
1000 - 4000	28 ft.	14 ft. - 14 ft. Stripe at: 11 ft.	3:1	45 mph	10 ft.	Travel lane width of 20 ft. May be acceptable up to 3000 AADT
4000 - 6000	30 ft.	15 ft. - 15 ft. Stripe at: 11 ft.	3:1	45 mph	10 ft.	No Safety Comments
Over 6000	36 ft.	6-24-6 ft.	3:1	45 mph	15 ft.	No Safety Comments

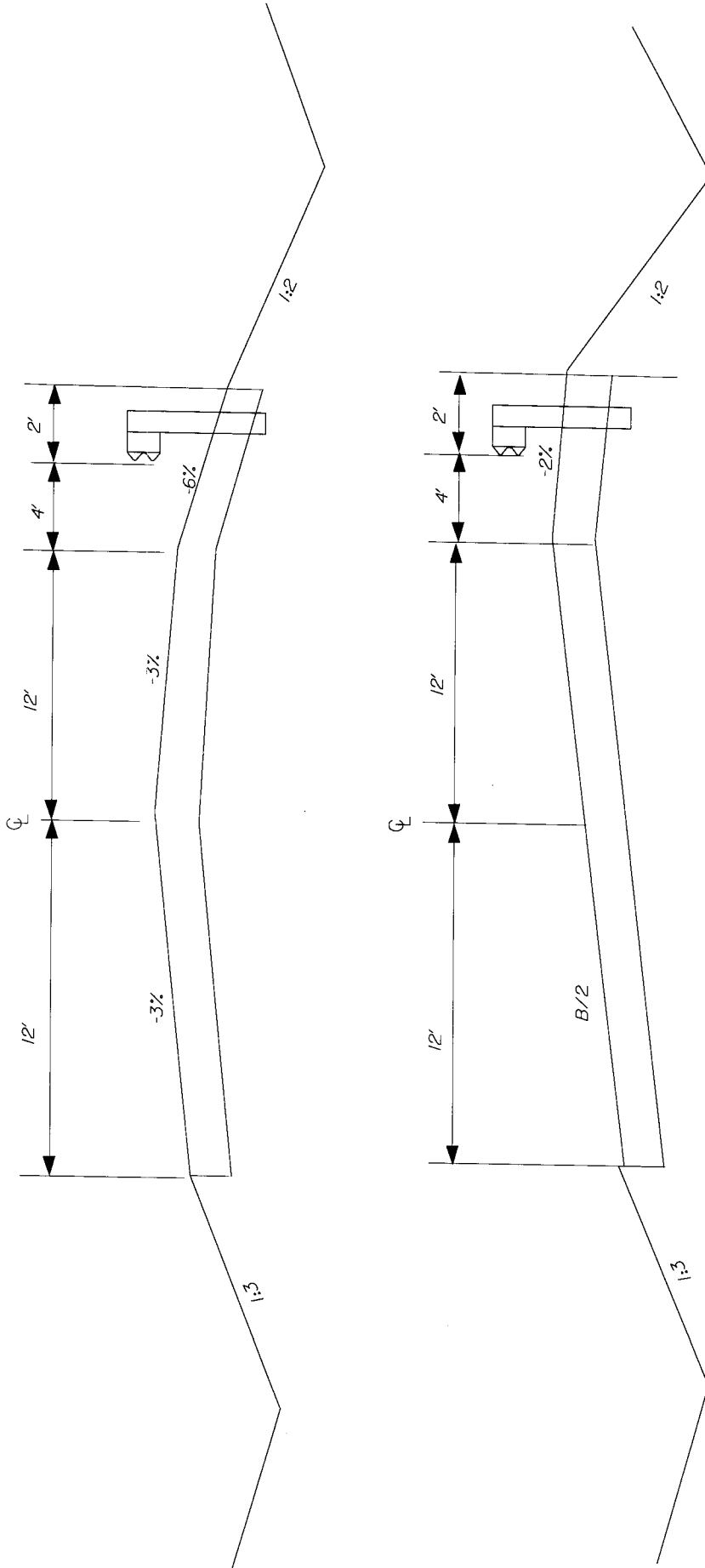
Table 3 - Geometric Design Criteria (continued)

Minor Arterials

Design Year AADT	Roadway Width	Roadway (ft.) Configuration	Side Slope	Design Speed	Clear Zone	Safety Considerations
Under 1000	28 ft.	14 - 14	3:1	45 mph	10 ft.	Travel lane width of 20 ft. May be acceptable
1000 - 6000	See	Major	Collector			Travel lane width of 20 ft.=May be acceptable up to 3000 AADT
6000 - 8000	36 ft.	(6 - 24 - 6)	1:4	55 mph	20 ft.	Travel lane width of 22 ft. May be acceptable
Over 8000	40 ft.	(8 - 24 - 8)	1:4	55 mph	20 ft.	No Safety Comments

TYPICAL ROAD WIDTHS

MINOR COLLECTOR (AADT LESS THAN 1000)



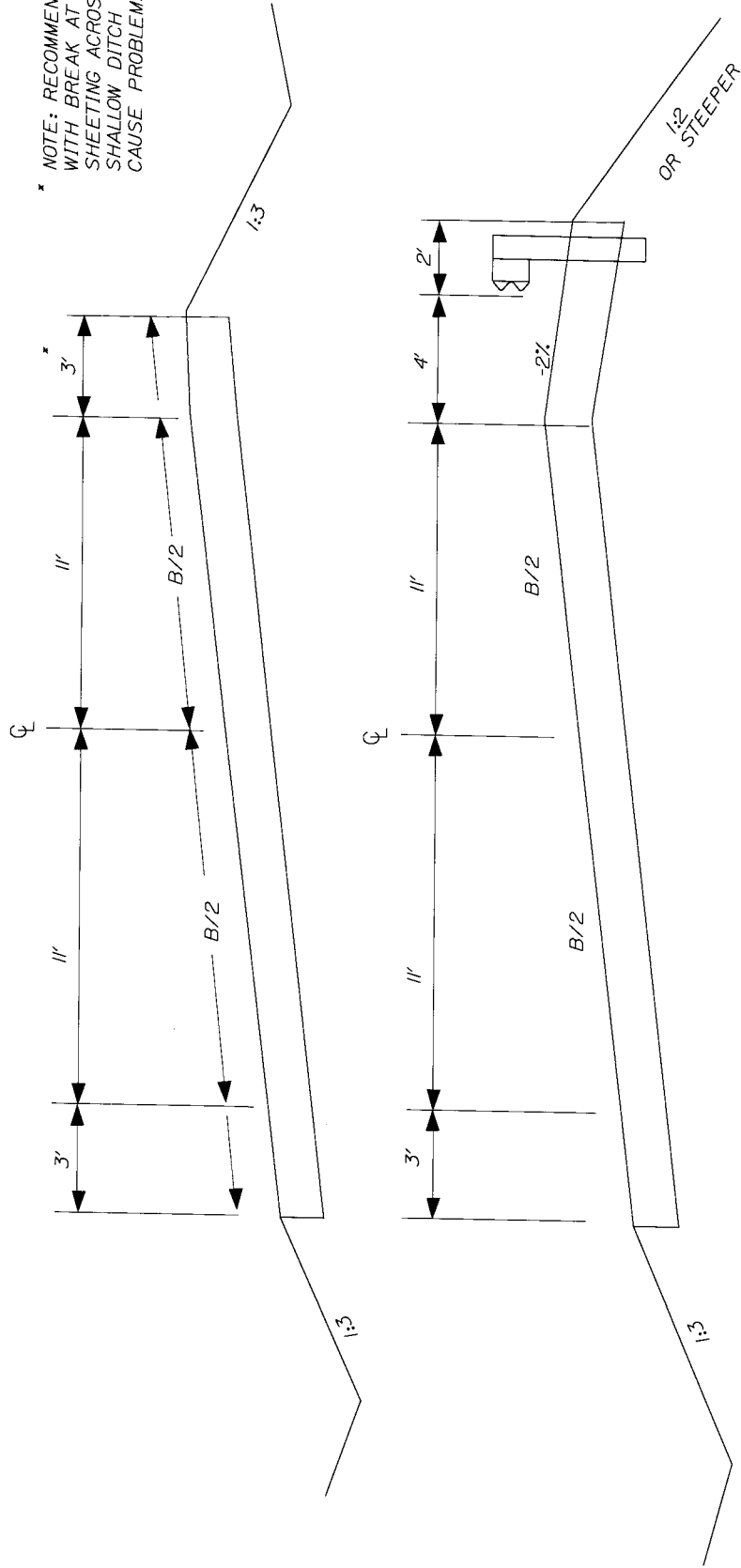
NOT TO SCALE

NOTE: WHEN GUARDRAIL IS PRESENT ON BOTH SIDES OF THE ROAD, THE RECOMMENDED OFFSET TO FACE OF RAIL IS 16 FEET.

FIGURE 1

TYPICAL ROAD WIDTHS

MINOR COLLECTOR (AADT 1000 - 4000)



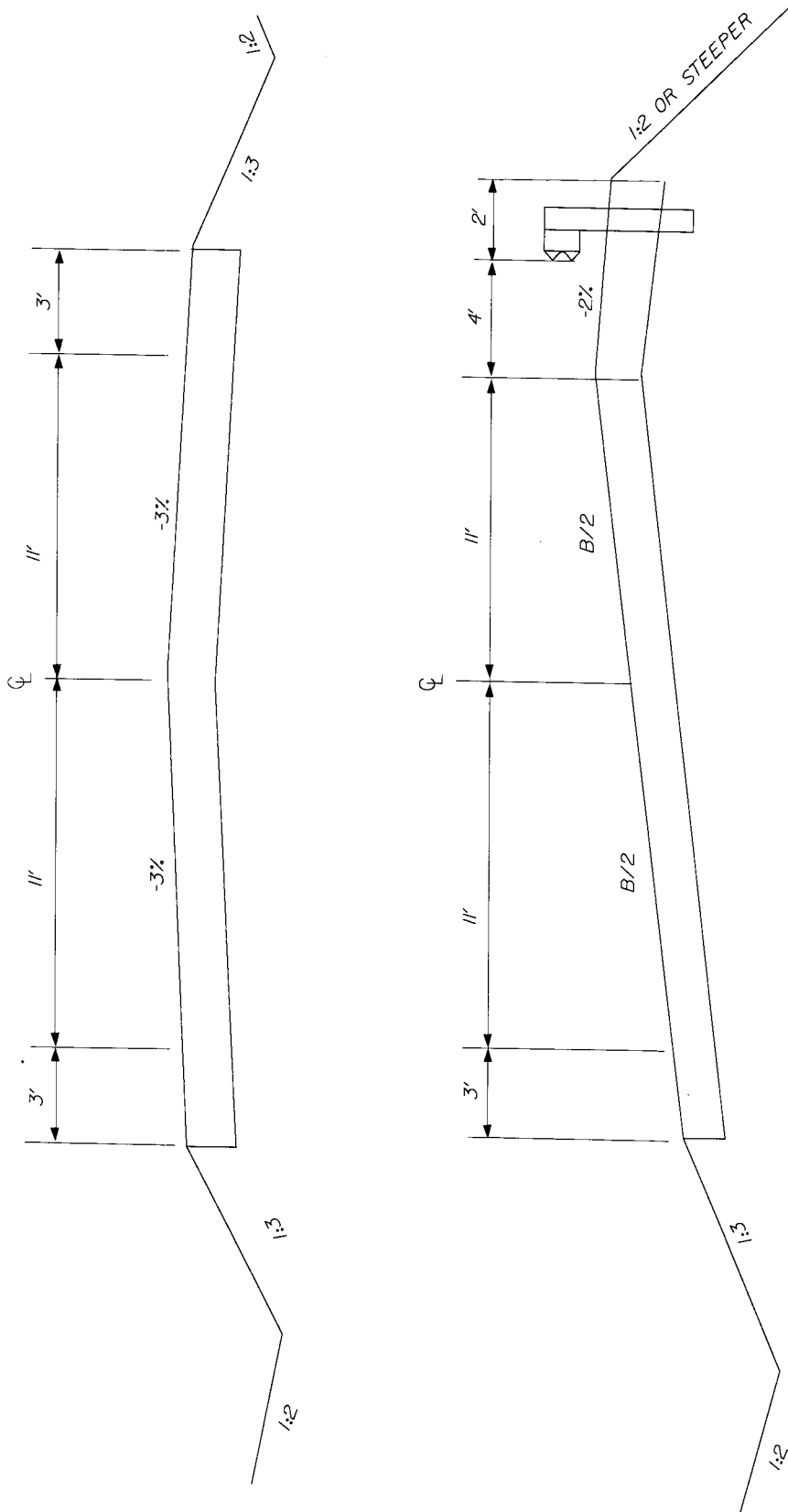
NOT TO SCALE

NOTE: WHEN GUARDRAIL IS PRESENT ON BOTH SIDES OF THE ROAD, THE RECOMMENDED OFFSET TO FACE OF RAIL IS 16 FEET.

FIGURE 2

TYPICAL ROAD WIDTHS

MAJOR COLLECTOR (AADT 1000-4000)



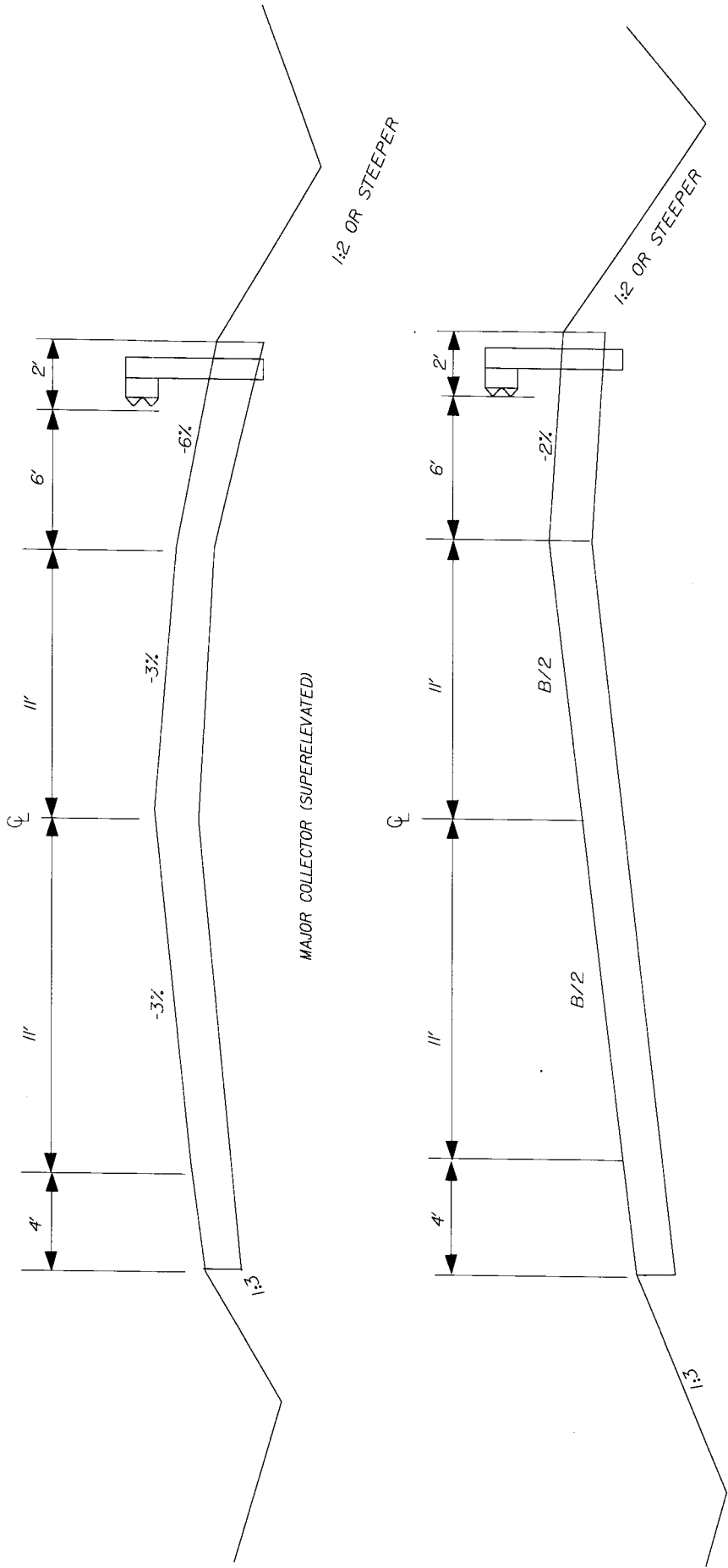
NOT TO SCALE

NOTE: WHEN GUARDRAIL IS PRESENT ON BOTH SIDES OF THE ROAD, THE RECOMMENDED OFFSET TO FACE OF RAIL IS 16 FEET.

FIGURE 3

TYPICAL ROAD WIDTHS

MAJOR COLLECTOR (AADT 4000 - 6000)

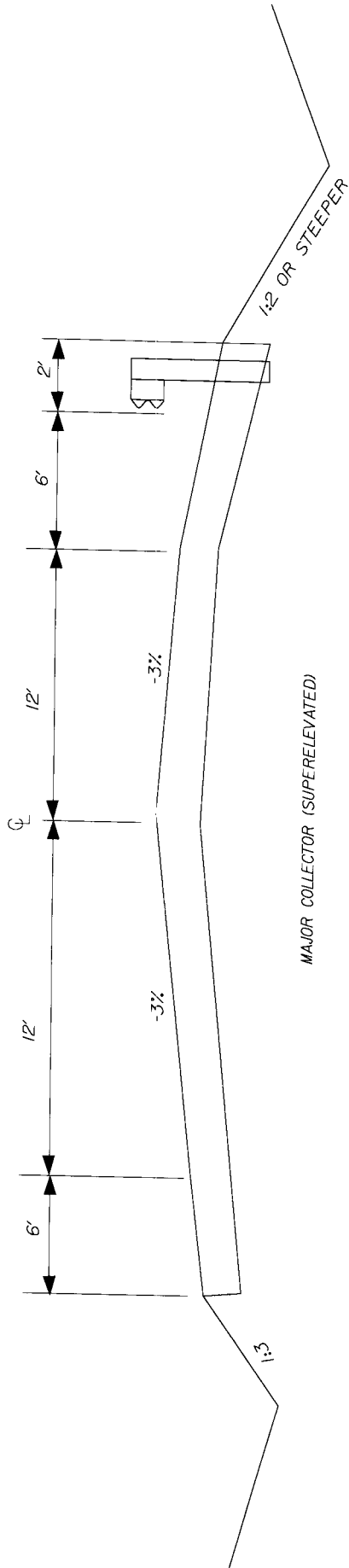


NOT TO SCALE

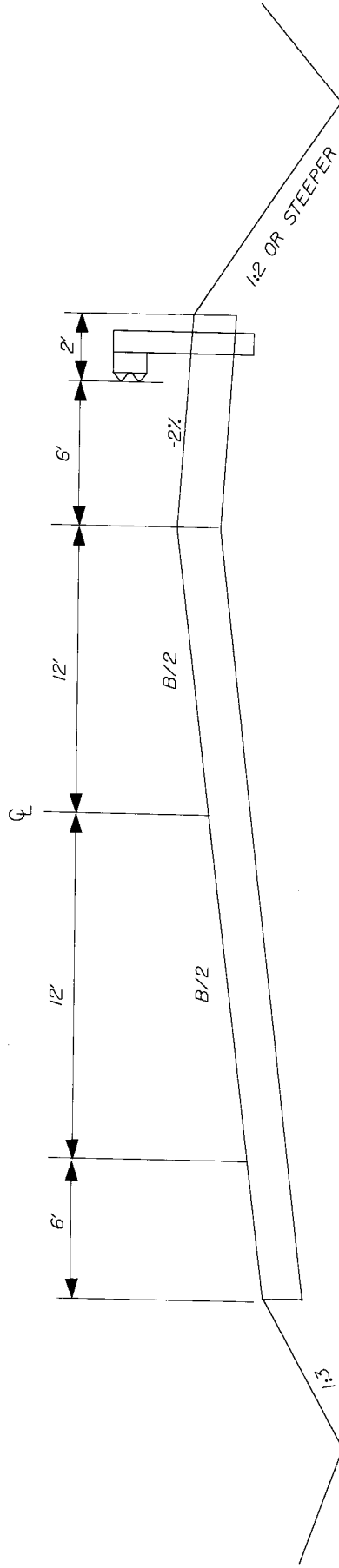
FIGURE 40

TYPICAL ROAD WIDTHS

MAJOR COLLECTOR (AADT OVER 6000)



MAJOR COLLECTOR (SUPERELEVATED)

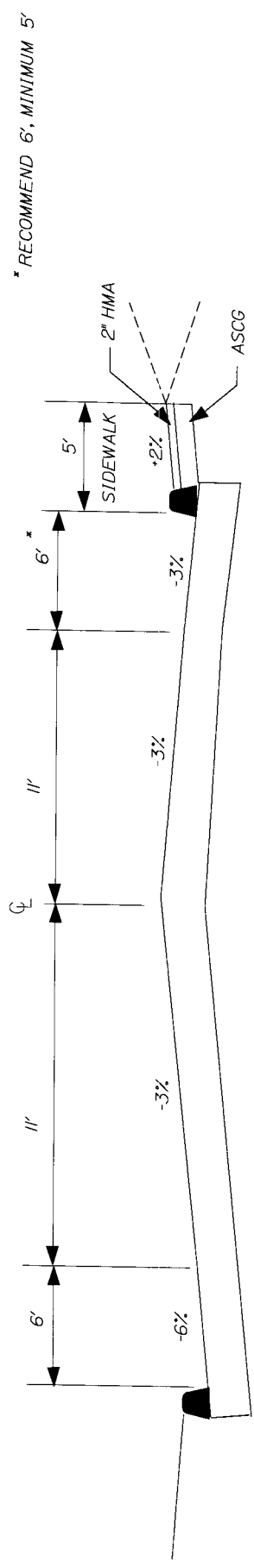


NOT TO SCALE

FIGURE 4b

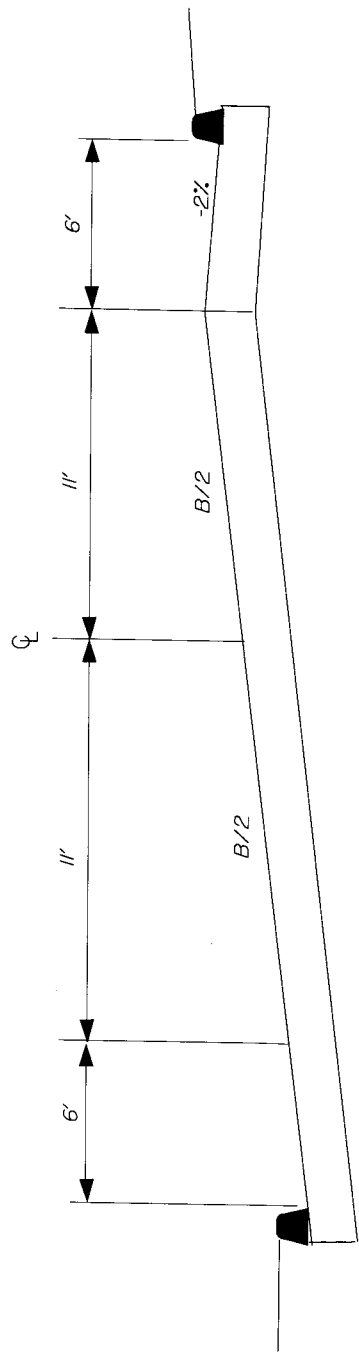
TYPICAL ROAD WIDTHS

COLLECTOR CURBED SECTIONS BOTH URBAN AND RURAL



* RECOMMEND 6', MINIMUM 5'

COLLECTOR SUPERELEVATION

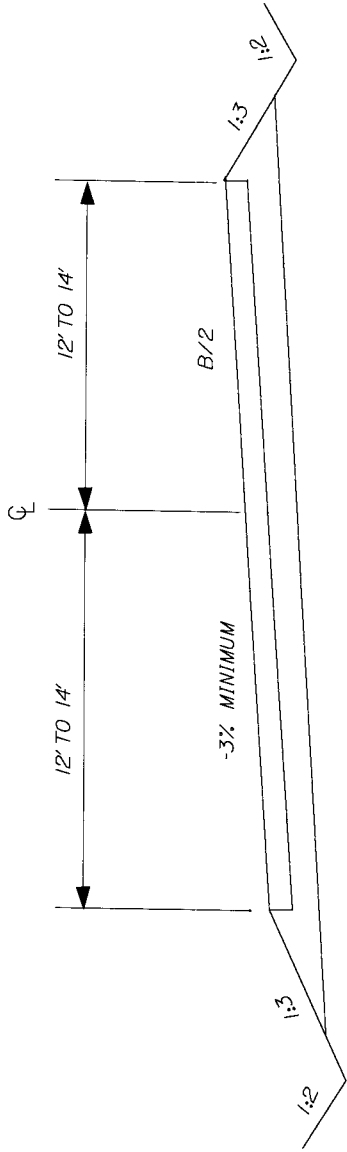


NOT TO SCALE

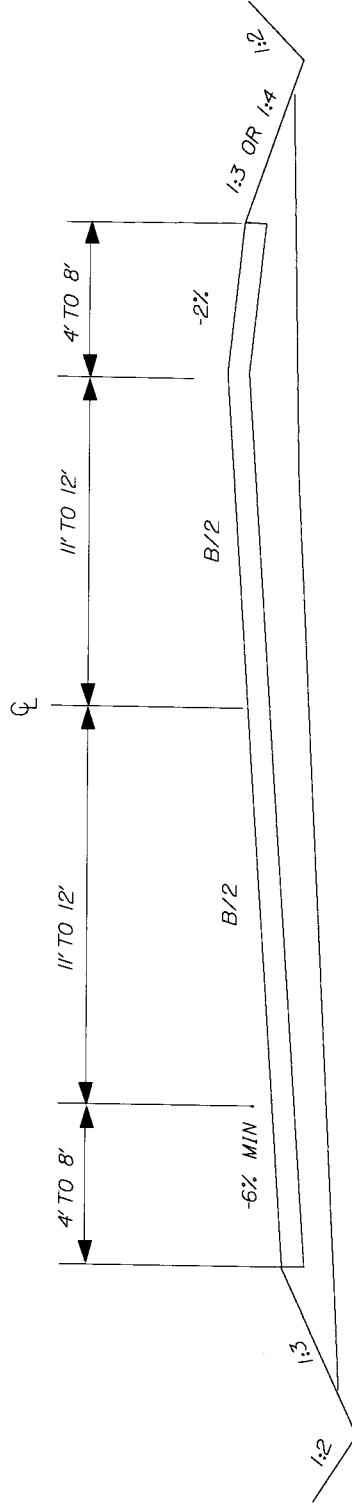
FIGURE 5

SUPERELEVATIONS

MINOR / MAJOR COLLECTORS



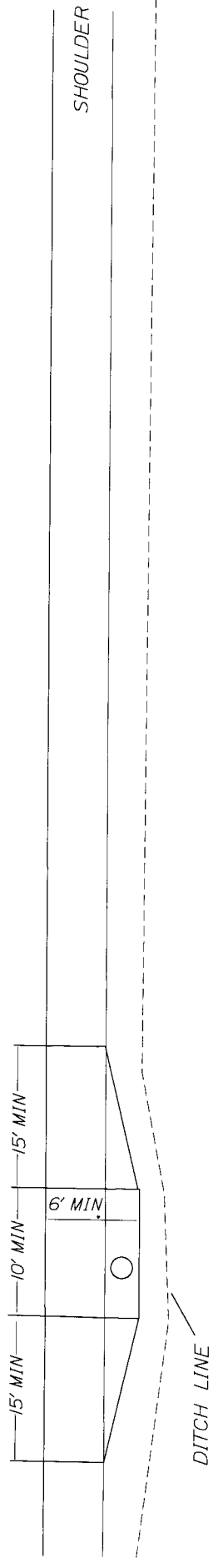
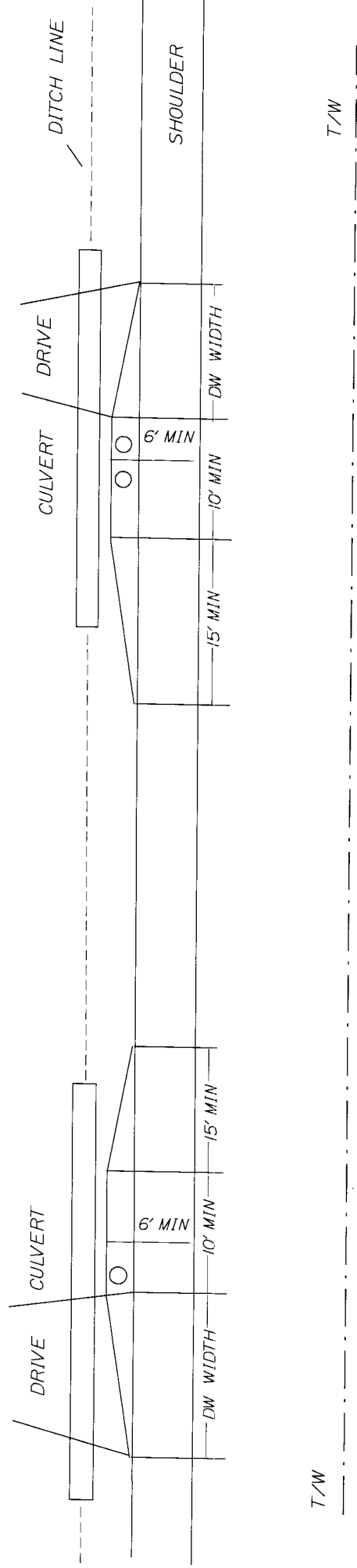
MINOR ARTERIAL



NOT TO SCALE

NOTE: 1:4 IF AADT IS OVER 6000

FIGURE 6

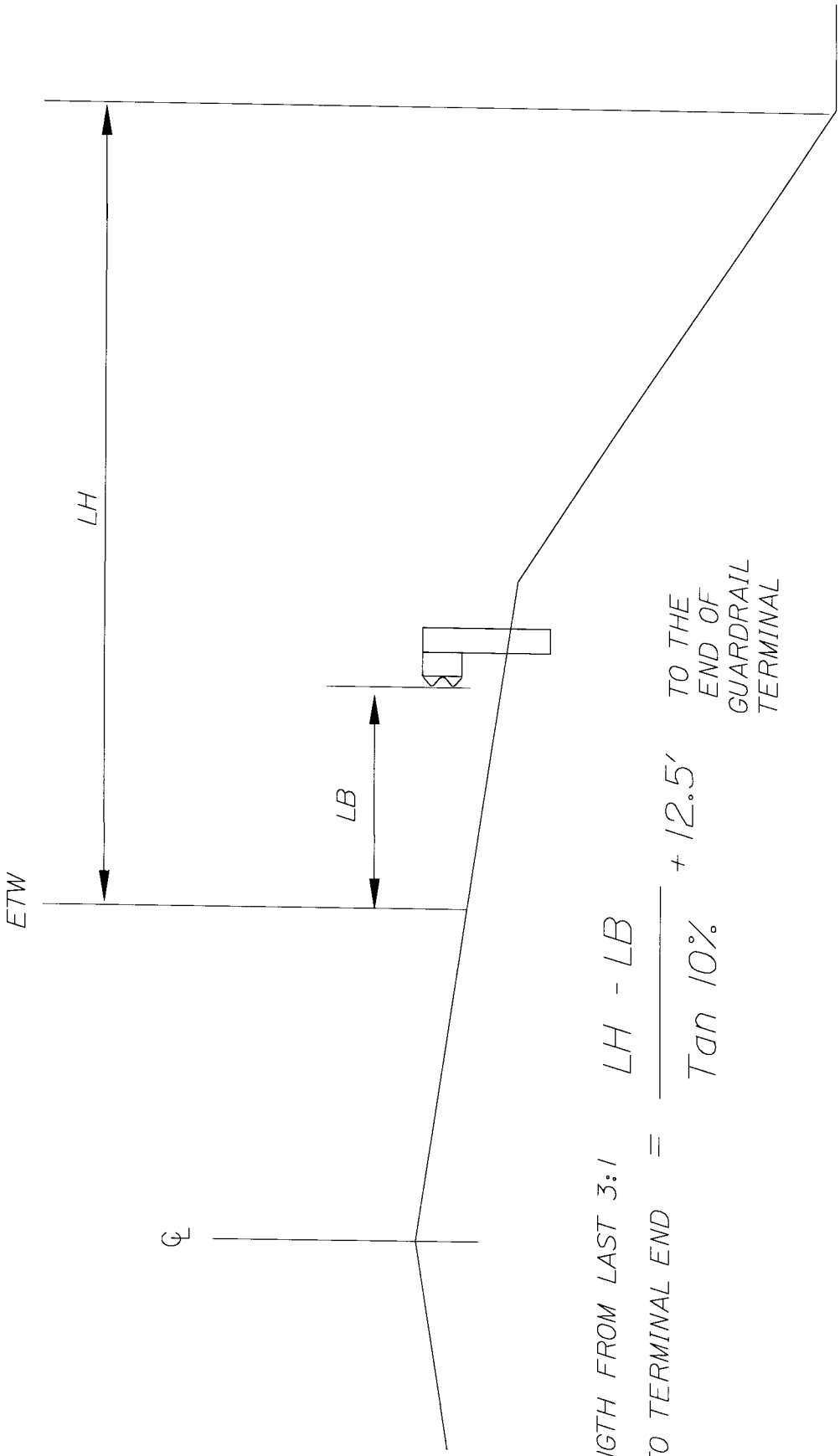


MAILBOX WIDENING AREAS
 (For Shoulders Less Than 6' Wide)

NOT TO SCALE

FIGURE B-7

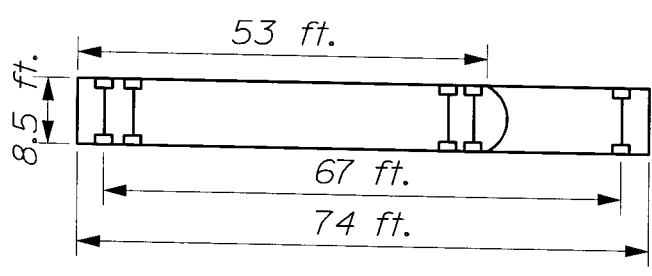
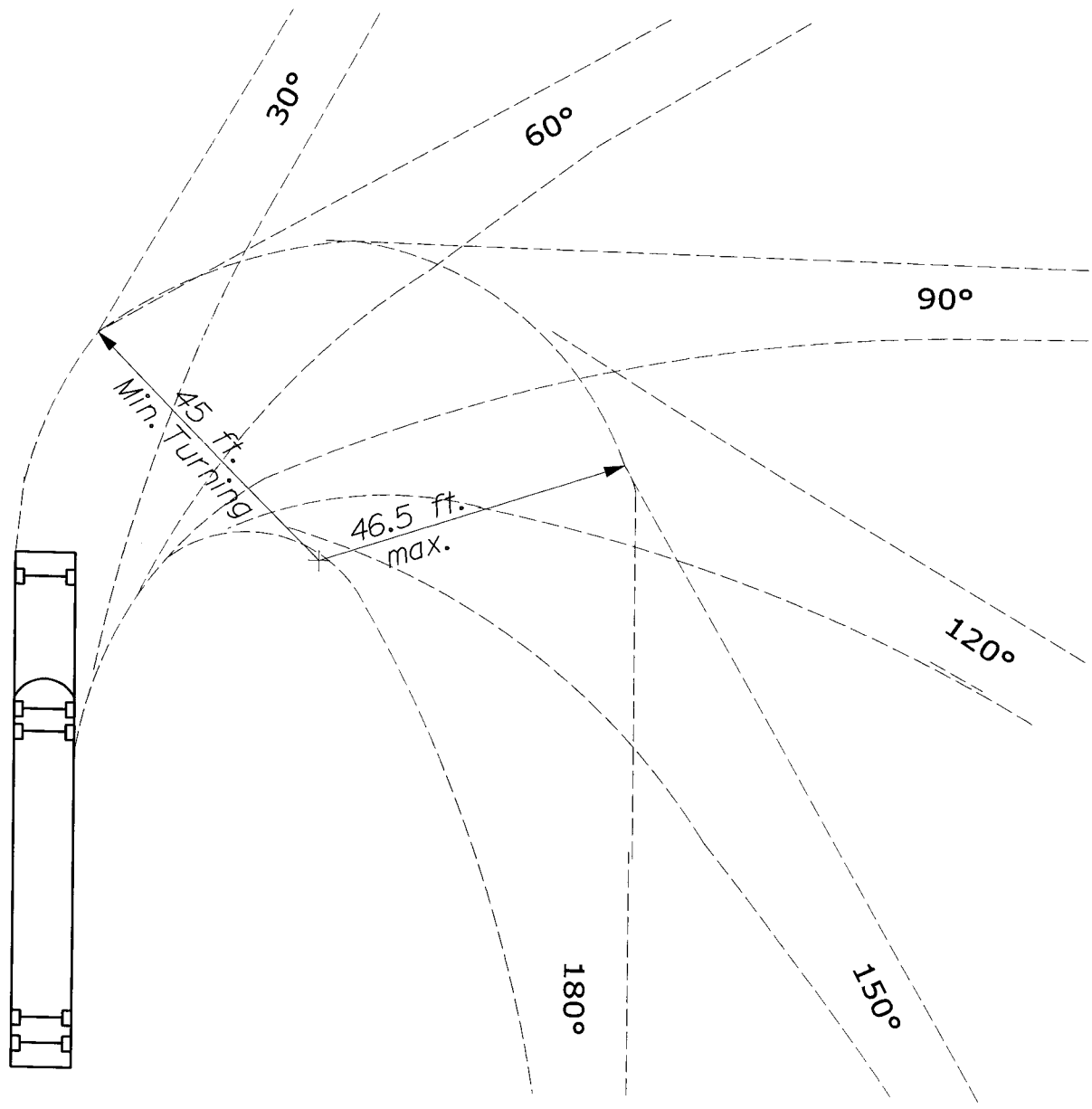
FOR OPPOSITE SIDE OF ROAD LH IS FROM ϕ



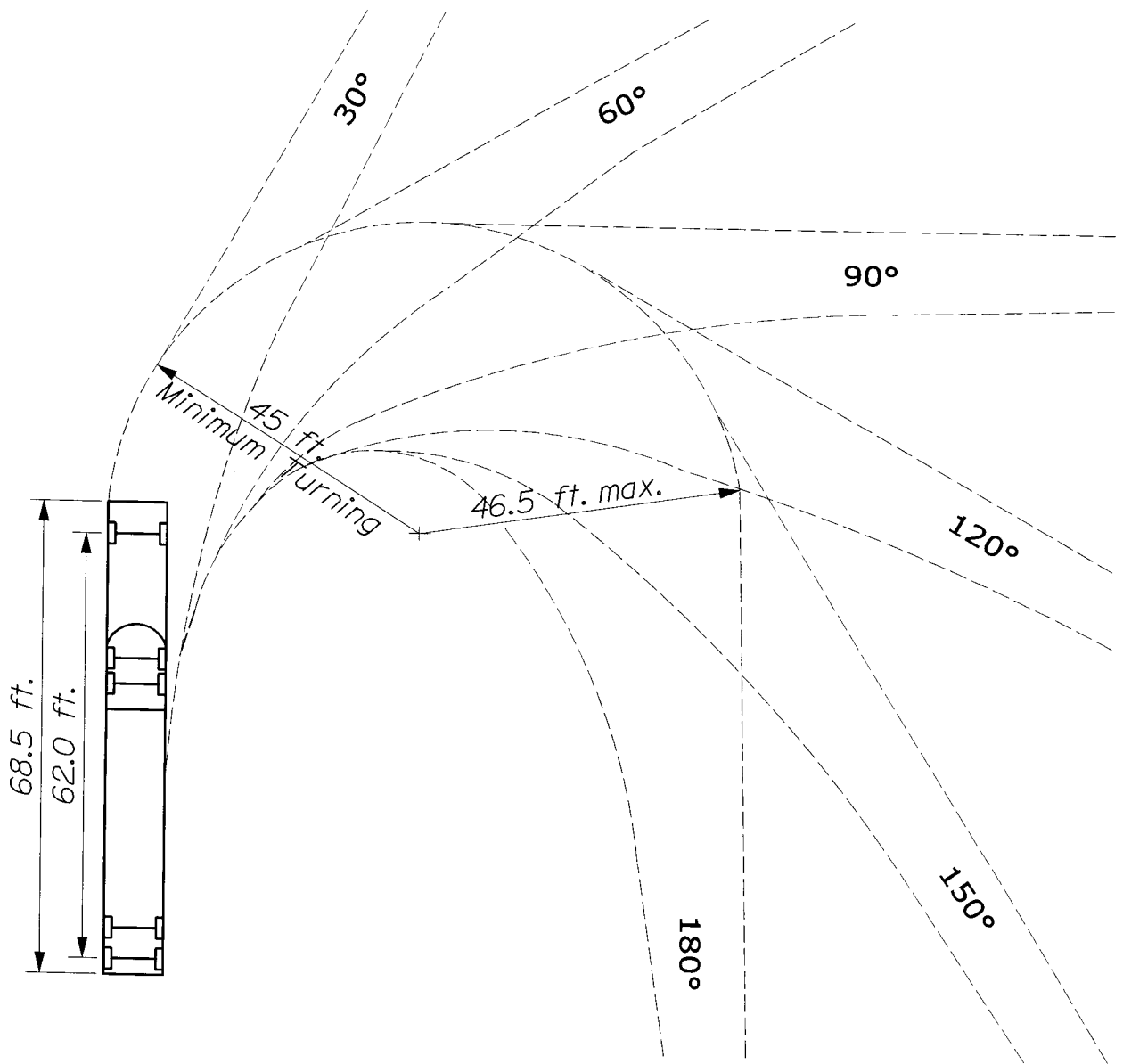
LENGTH FROM LAST 3:1 TO TERMINAL END = $\frac{LH - LB}{\tan 10\%} + 12.5'$ TO THE END OF GUARDRAIL TERMINAL

TOE AT LEAST 3:1 IF OUTSIDE CLEAR ZONE

FIGURE - 8

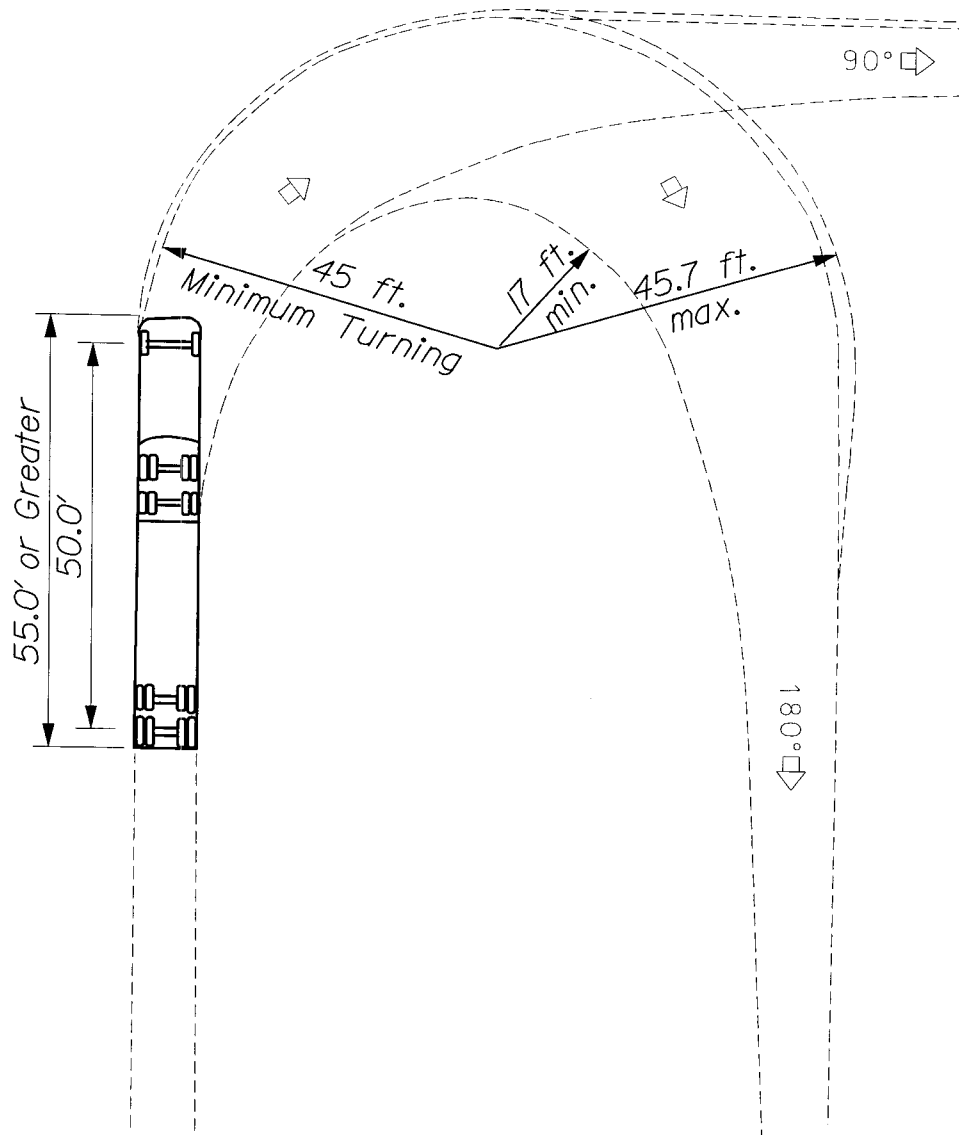


MINIMUM TURNING PATH FOR INTERSTATE SEMITRAILER (WB-65 & WB-67)



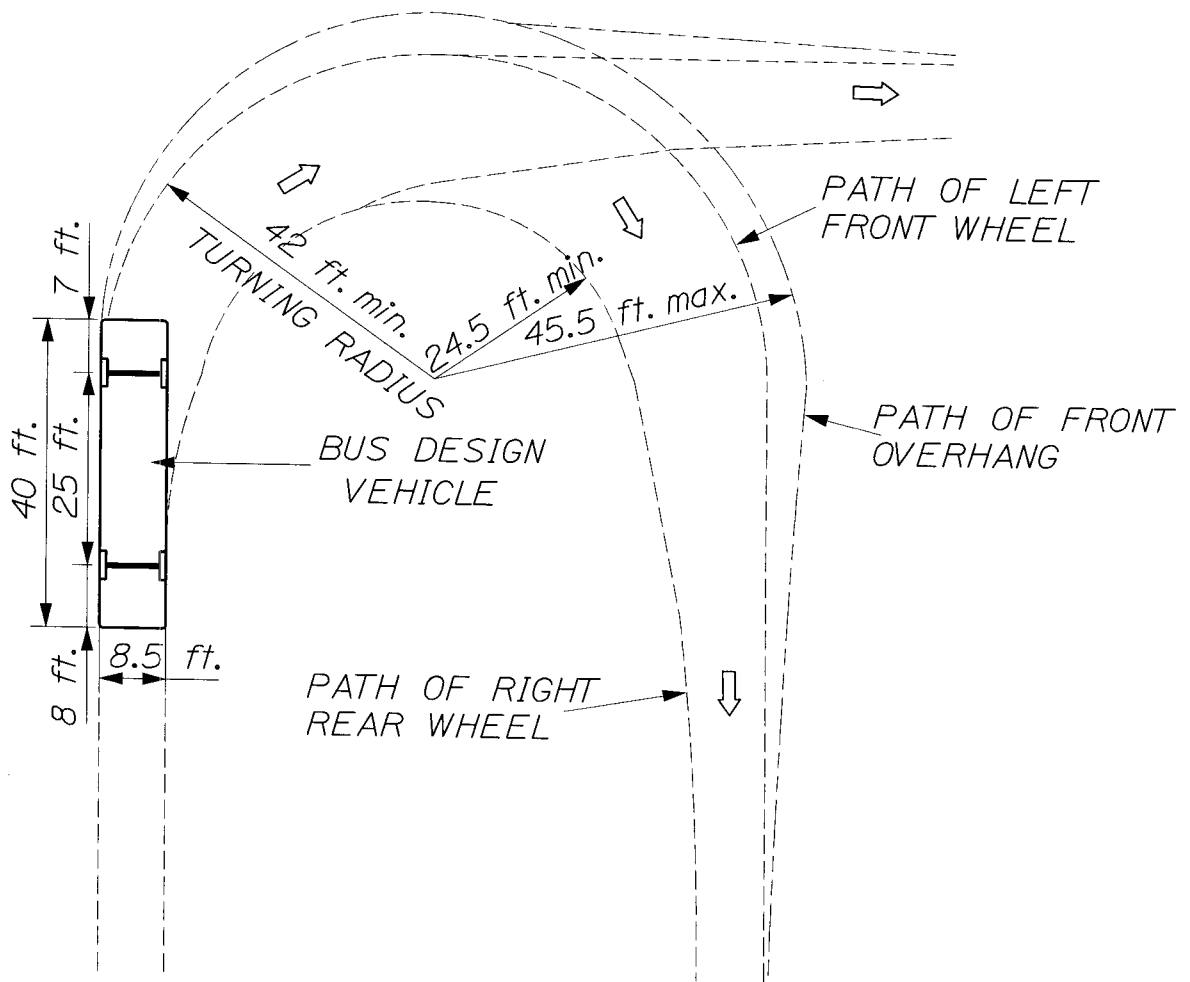
MINIMUM TURNING PATH FOR
INTERSTATE SEMITRAILER (WB-62)

Exhibit 2

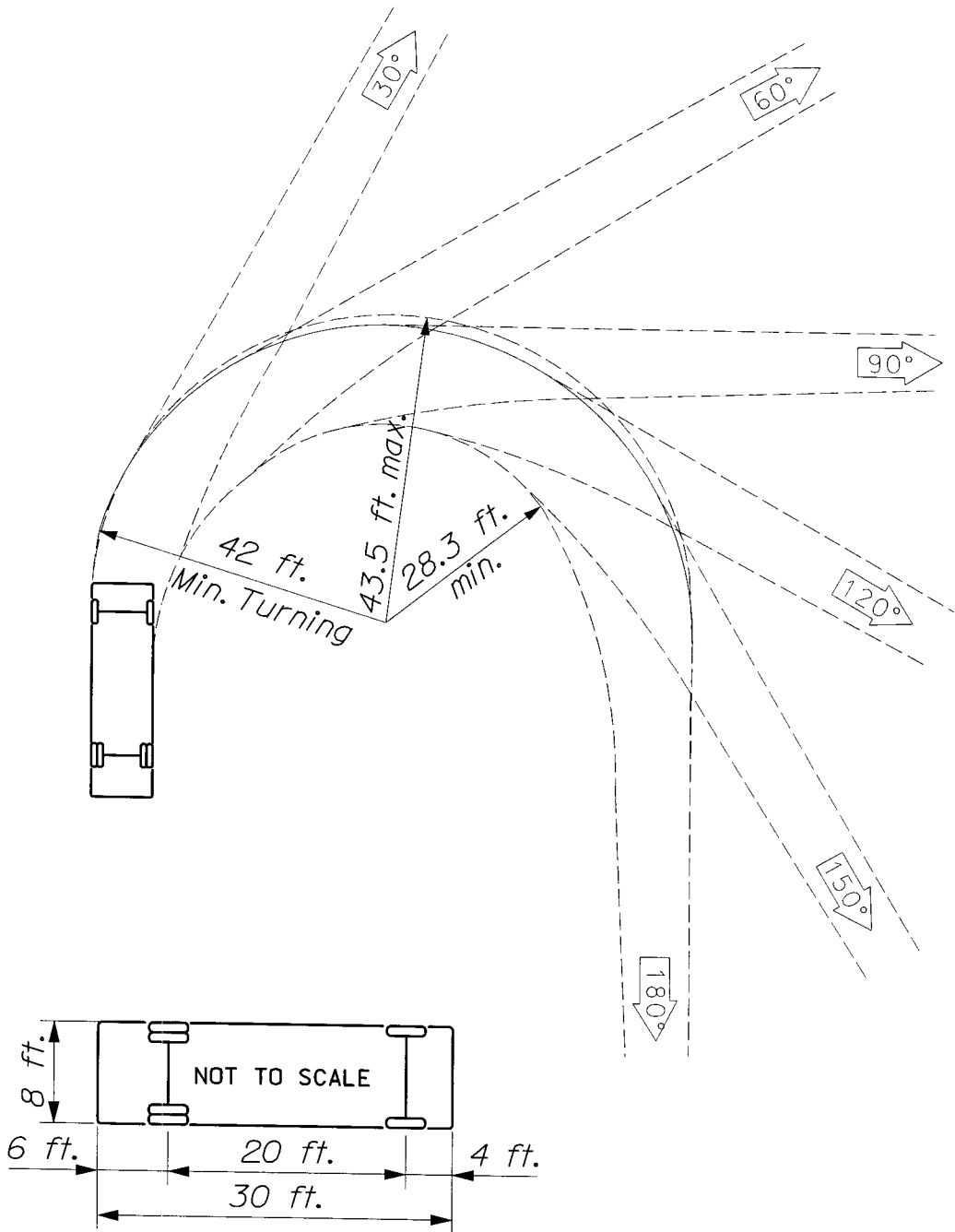


MINIMUM TURNING PATH FOR INTERMEDIATE SEMITRAILER (WB-50)

Exhibit 3



MINIMUM TURNING PATH FOR
CITY TRANSIT BUS DESIGN VEHICLE



MINIMUM TURNING PATH FOR
 SU (SINGLE UNIT) TRUCK DESIGN VEHICLE

Exhibit 5