CHAPTER ELEVEN

GEOMETRIC DESIGN OF EXISTING HIGHWAYS

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Chapter Eleven

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Chapter Eleven

GEOMETRIC DESIGN OF EXISTING HIGHWAYS

11-1 GENERAL

11-1.01 Introduction

The overall objective of the Department's program is to improve the greatest number of existing highway miles within the available funds for highway projects. "Improve" is meant to apply to all aspects which determine a facility's serviceability, including:

1. the structural integrity of the pavement, bridges and culverts;

2. the drainage design of the facility to, among other objectives, minimize ponding on the highway, to protect the pavement structure from failure, and to prevent roadway flooding during the design-year storm;

3. from a highway capacity perspective, the level of service provided for the traffic flow;

4. the adequacy of access to abutting properties;

5. the geometric design of the highway to safely accommodate expected vehicular speeds and traffic volumes;

6. the roadside safety design to reduce, within some reasonable boundary, the adverse impacts of run-off-the-road vehicles; and

7. the traffic control devices to provide the driver with critical information and to meet driver expectancies.

The Department's responsibility is to realize the greatest overall benefit from the available funds. Therefore, on individual projects, some compromises may be necessary to achieve the goals of the overall highway program. Specifically for geometric design and roadside safety, the compromise is between what is desirable (new construction criteria for the National Highway System (NHS)) and what is practical for the specific conditions of each highway project.

The desirable criteria for highway design have been discussed in detail in Chapters Three through Ten. These criteria will apply to new construction and reconstruction on all NHS and major arterial projects. In response to the National Highway System Designation Act of 1995, the Department has adopted geometric design criteria for projects on all other highways projects that are, in many cases, lower than the criteria for NHS projects. These revised criteria are based on an assessment of the underlying principles behind geometric design and on how the criteria can be modified while still enhancing highway safety.

11-1.02 Background

On June 10, 1982, the FHWA issued its Final Rule entitled "Design Standards for Highways: Resurfacing, Restoration and Rehabilitation of Streets and Highways Other Than Freeways." This rule modified 23CFR Part 625 to adopt a flexible approach to the geometric design of 3R projects. Part 625 was modified again on March 31, 1983, to explicitly state that one objective of 3R projects is to enhance highway safety. In the rule FHWA determined that it is not practical to adopt 3R design criteria for nationwide application. Instead, each State can develop its own criteria and/or procedures for the design of 3R projects, subject to FHWA approval. This approach is in contrast to the application of criteria for new construction and major reconstruction, for which the AASHTO *A Policy on Geometric Design of Highways and Streets* provides national criteria for application.

In 1987, the Transportation Research Board published Special Report 214 *Designing Safer Roads; Practices for Resurfacing, Restoration and Rehabilitation*. The objective of the TRB study was to examine the safety cost-effectiveness of highway geometric design criteria and to recommend minimum design criteria for 3R projects on non-freeways. The final TRB report (SR214) presented specific numerical criteria for the geometric design of 3R projects.

On October 17, 1988, FHWA issued the, Technical Advisory T5040.28 "Developing Geometric Design Criteria and Processes for Non-Freeway RRR Projects." The purpose of the Advisory was to provide guidance on developing or modifying criteria for the design of Federal-aid, non-freeway 3R projects. The Advisory stated that each State may choose to develop and adopt geometric design criteria specifically for non-freeway 3R projects and that SR214 may be used as the basis for developing 3R criteria. The Department then developed its own criteria for the geometric design of 3R projects. The overall objective of the Department's criteria are summarized as follows:

1. 3R projects are intended to extend the service life of the existing facility and to return its features to a condition of structural or functional adequacy.

2. 3R projects are intended to enhance highway safety.

3. 3R projects are intended to incorporate cost-effective, practical improvements to the geometric design of the existing facility.

In 1995, the National Highway System Designation Act of 1995 was passed, allowing States to establish standards for all highway construction not on the NHS. The Department developed a set of standards for highway design in response to this Act. In 2000, a Task Force appointed by the Chief Engineer revisited these standards and developed new standards for Minor Collector highways. In July 2000, the State Standards Highway Design Guide was published. Currently, all Non-NHS highway projects of Minor Arterial classification or less are designed to these State Standards.

11-1.03 Application of Chapter Eleven

***NHS and Major Arterials*:** Chapter Eleven criteria should be used on Rehabilitation and Resurfacing projects. *If the scope of work includes more than 3000 feet of continuous full reconstruction, as allowed on rehabilitation projects, the criteria from Chapters Three through Ten should be used.* When a particular criterion is not addressed in Chapter Eleven, Chapters Three through Ten will apply.

***Other Non-NHS*:** The State Standards Highway Design Guide should be used on all projects. Chapter Eleven provides additional discussion that should compliment the State Standards. When a particular criterion is not addressed in the State Standards or Chapter Eleven, Chapters Three through Ten will apply.

11-1.04 Project Evaluation

These factors should be evaluated in the design of all projects on existing highways:

1. System or Functional Classification. The Department has adopted separate tables of geometric design criteria for all projects based on functional classification and urban/rural location.

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 subbase, 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.

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 should also 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 expectancy, geometric design consistency and proper transitions between sections of different geometric designs.

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). The Traffic Engineering Division is responsible for selecting and locating the traffic control devices on the project. The designer should work with Traffic to identify possible geometric and safety problems that will not be improved by the project and, therefore, may warrant traffic control devices.

6. Safety Enhancement. All projects on existing highways must be designed to consider and incorporate appropriate, practical safety improvements.

7. Crash Records. The historical accident data within the limits of a proposed project on an existing highway should be evaluated as part of the project development. Accident data is available from the Bureau of Planning, Research, and Community Services. The following accident data analyses may be appropriate:

   a. Accident Rate versus Statewide Average (for that type facility). This will provide an overall indication of safety problems within the project limits.

   b. Accident Analysis by Type. This will indicate if certain types of accidents are a particular problem; they may occur in disproportionate numbers. For example, a large number of head-on and/or sideswipe accidents on a two-lane facility may indicate inadequate roadway width. A large number of fixed object accidents may indicate an inadequate roadside clear zone.

   c. Treatment of High Hazard Locations and Features. Accidents may cluster about certain locations, such as a horizontal curve or intersection. In particular, the designer should check to see if any locations on the Department's list of High Accident Locations, as identified by the Department's accident data system, fall within the proposed project limits.

   If an accident problem is identified, the designer should evaluate the nature of the problem and identify candidate actions to reduce the accident problem. The designer may need to discuss the accident analysis with the Traffic Engineering Division, the Bureau of Planning, Research, and Community Services and/or the Maintenance

Division. Any selected accident countermeasures should be consistent with the overall scope of project.

8. Potential Impacts of Various Types of Improvements. Projects on existing highways may impact the social, environmental and economic nature of the surrounding land and development. In particular, the existing right-of-way may severely restrict the practical extent of geometric improvements.

9. Economics. Projects on existing highways are intended to preserve the service life of the existing highway system and to enhance highway safety. This will protect the economic investment and derive the maximum economic benefit from the Department's existing highway system. Therefore, economic factors (i.e., the cost of improvement versus the anticipated benefit) are a major consideration in determining which geometric design improvements are practical and reasonable.

11-2 RECONSTRUCTION PROJECTS (Non-Freeways)

11-2.01 Definition

Section 3-6 defines reconstruction projects on non-freeways as follows:

> *If a new pavement structure (from the subgrade on up) will be constructed for more than half of the project length, this will typically be considered a reconstruction project. Reconstruction of an existing non-freeway may also include significant drainage improvements, the addition of travel lanes and/or significant changes to the existing horizontal and vertical alignment, but essentially within the existing highway corridor. These projects will often require right-of-way acquisitions.*

Because of the extent of improvement, the design of a reconstruction project will be determined by the criteria for new construction. Therefore, on NHS and Major Arterials, the criteria in Chapters Three through Ten will apply to reconstruction projects. On all other projects, the State Standards Highway Design Guide will apply. See the Discussion in Section 11-1.03.

11-3 REHABILITATION PROJECTS (Non-Freeways)

11-3.01 Definition

Section 3-6 defines 3R projects (in general) and rehabilitation projects (specifically) on non-freeways as follows:

> *Rehabilitation projects may involve significant improvements to the pavement structure, including a new pavement structure (from the subgrade on up) for up to half of the project length. In general, rehabilitation projects warrant the consideration of more significant improvements to the geometric design than restoration/resurfacing projects. Right-of-way acquisition will usually be limited takings, easements and grading rights.*

For NHS and Major Arterial projects, the geometric design criteria for rehabilitation projects on non-freeways are presented in the following sections. On all other projects, the State Standards Highway Design Guide will apply. See the Discussion in Section 11-1.03.

11-3.02 Traffic Volume Controls

The following will apply to rehabilitation projects:

1. Design Year Traffic Volumes. The design year will be 20 years beyond the construction completion date for traffic analyses (AADT, design hourly volume, etc.) for NHS and Major Arterials but may be 12 years for all other highways.

2. Level of Service. Tables 11-3 to 11-6 provide the level-of-service criteria for rehabilitation projects.

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

4. Capacity Analysis. The analytical techniques in the *Highway Capacity Manual* will be used to conduct the capacity analysis.

11-3.03 Design Speed

In most cases, the existing posted speed limit, as measured over a significant length of highway, will be acceptable as the minimum design speed on rehabilitation projects. However, the designer should check with Traffic Engineering to determine if the existing posted speed limit is likely to change after project completion.

11-3.04 Grades

1. Maximum. Tables 11-3 to 11-6 present the Department's criteria for maximum grades on rehabilitation projects.

2. Minimum. On curbed streets, the minimum grade is 0.25 percent. On uncurbed facilities, there is no minimum grade.

11-3.05 Crest Vertical Curves

The Department's criteria for crest vertical curves on rehabilitation projects are based on providing stopping sight distance (SSD) to a 2-foot height of object. This is the AASHTO recommended height of object.

To determine the adequacy of SSD on existing crest vertical curves on rehabilitation projects, follow this procedure:

1. Calculate the available SSD from:

$$S = \sqrt{\frac{2158L}{A}} \qquad (S < L)$$

OR

$$S = \frac{L}{2} + \frac{1079}{A} \qquad (S > L)$$

where: S = available stopping sight distance, feet
L = existing length of crest vertical curve, feet
A = existing algebraic difference in grades, percent

2. Compare the available SSD to the criteria in Table 11-1. If the existing SSD does not meet these criteria, the designer should evaluate the practicality of flattening the crest vertical curve. This will be based on the accident history, traffic volumes, construction costs, etc.

Design Speed (mph)	Minimum Stopping Sight Distance (ft)
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645
70	730

STOPPING SIGHT DISTANCE

Table 11-1

3. If the decision is made to flatten the crest vertical curve, the following equations (based on a 2-foot height of object) can be used to calculate the length of the curve:

$$L = \frac{AS^2}{2158} \qquad (S < L)$$

$$L = 2S - \frac{2158}{A} \qquad (S > L)$$

Desirably, the crest vertical curve will be designed to meet the criteria for a 2-foot height of object (See Section 4-2.03).

11-3.06 Sag Vertical Curves

For rehabilitation projects, 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 on rehabilitation projects, follow this procedure:

1. Calculate the design speed of the existing sag from:

$$V = \sqrt{\frac{46.5L}{A}}$$

where: V = design speed, mph
L = existing length of sag vertical curve, feet
A = existing algebraic difference in grades, percent

2. Compare the available design speed at the sag to the overall design speed for the project (see Section 11-3.03). If 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.

3. If the decision is made to flatten the sag vertical curve, the following equation (based on the comfort criteria) can be used to calculate the length of the curve:

$$L = \frac{A V^2}{46.5}$$

Desirably, the sag vertical curve will be designed to meet the headlight sight distance criteria (see Section 4-2.03).

11-3.07 Horizontal Alignment

The horizontal alignment criteria in Chapter Five will apply to rehabilitation projects, except as discussed in the following.

Superelevation Rate/Degree of Curve

Table 5-6 will be used to determine the proper combination of superelevation rate and degree of curve based on the project design speed. The table is based on an e_{max} = 6.0%. If an existing curve has a superelevation rate steeper than 6 percent, an e_{max} = 8.0% will apply. The designer should reference the AASHTO *A Policy on Geometric Design of Highways and Streets* for combinations of superelevation rate and degree of curve where an e_{max} = 8.0% applies.

Reverse Curves

For reverse curves on rehabilitation projects, it will be acceptable to provide no tangent section between the curves (i.e., the PT & PC may be coincident). On Minor Arterials, the use of reverse curves is not preferred.

11-3.08 Cross Section Elements

Tables 11-3 to 11-6 present the Department's rehabilitation criteria for the width and steepness of cross section elements. The cross section width and/or steepness of the existing highway elements should be evaluated against the criteria in the rehabilitation tables. If the existing width or steepness does not meet the rehabilitation criteria, the designer should consider widening or flattening the element. If the decision is made to improve the cross section element, the designer should provide a value that at least meets the rehabilitation criteria. However, it may be appropriate to improve the cross section element(s) beyond the rehabilitation criteria.

Right-of-Way

As indicated in the basic definition of a "Rehabilitation Project," right-of-way acquisition will usually be limited takings, easements and grading rights. Occasionally, more extensive right-of-way involvement may be appropriate if, for example, a horizontal curve is flattened.

Curbs

On rehabilitation projects, the following will apply to the installation or retention of curbs:

1. Type. Where a project will disturb existing curbs, the curb will be replaced in-kind.

2. Height. Rehabilitation projects may include pavement work that will not affect the lateral location of existing curbs, but will affect their reveal. The designer will consider adjusting the curb reveal (or the pavement design) if:

    a. 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

    b. the curb reveal after construction will be less than 3 inches.

Sidewalks

Where a rehabilitation 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 Americans with Disabilities Act (ADA) regulations - see sidewalk policy.

Fill/Cut Slopes

Rehabilitation projects may include roadway widening. Tables 11-3 to 11-6 present the Department's criteria for fill and cut slopes on rehabilitation projects. If the slopes will be steeper than those in the tables, the designer should evaluate the practicality of flattening the fill/cut slopes considering the costs and impacts of corrective actions.

Bridges

The Urban and Federal Bridge Program will determine the acceptable roadway width for bridges to remain in place and for new and rehabilitated bridges within the limits of a rehabilitation project. The Urban and Federal Bridge Program will also evaluate the adequacy of existing bridge rails. The designer will be responsible for evaluating the adequacy of the existing guardrail transition approaching the bridge rail.

Transitions

When roadway transitions are required at bridge or underpass sections or at project termini, the length of transition (L) should be computed by the formula $L = WS$ for highways with a design speed greater than 45 mph. The formula $L = WS^2/60$ should be used to compute transitions on highways with a design speed of 45 mph and below. For both formulas, L equals the taper length in meters, W the offset distance in meters, and S the design speed in mph.

11-3.09 Intersections At-Grade

The criteria in Chapter Eight on the design of intersections at-grade will apply to any intersections within the limits of a rehabilitation project as modified by the following discussion.

Intersection Sight Distance (ISD)

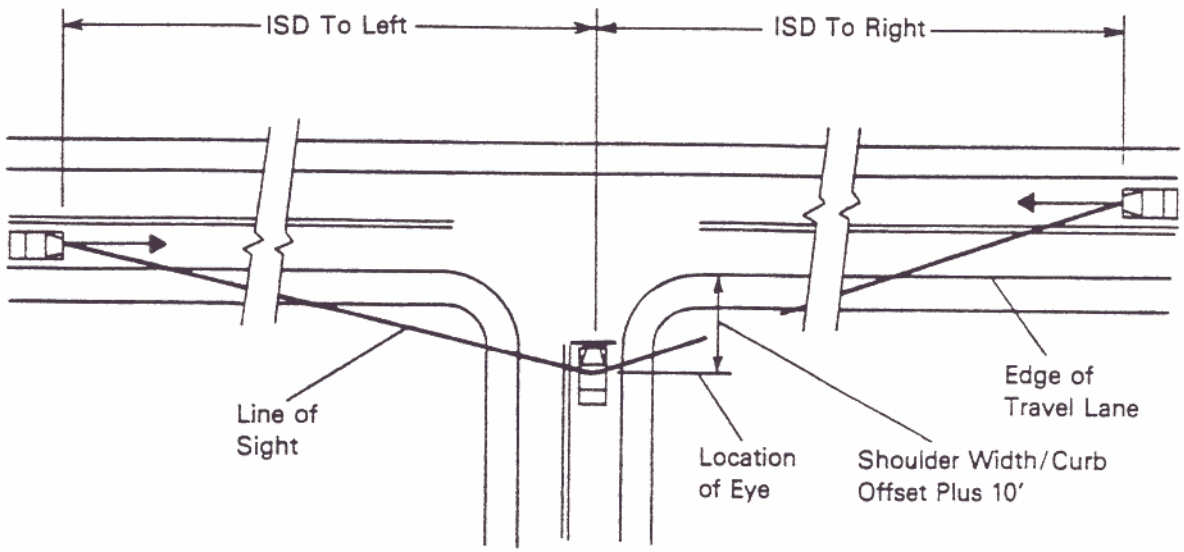
Section 8-1 presents ISD criteria based on the type of traffic control (no control, yield control, stop control or signal control). These criteria will apply to rehabilitation projects except for the ISD criteria at stop-controlled intersections. In this case, Figure 11-1 will apply. The desirable criteria are identical to the ISD criteria for new construction/reconstruction projects at stop-controlled intersections as presented in Section 8-1. The minimum criteria are based on ensuring that the driver on the mainline has (level) stopping sight distance available to the intersection assuming a 2-foot height of object.

Turning Radii Design

As described in Section 8-2, the turning radii design will be determined by the turning characteristics of a WB-62 design vehicle. For rehabilitation projects, the criteria for inside clearance are modified as follows. It is desirable that the WB-62 maintains approximately a 2-foot clearance from the pavement edge or curb line. At a minimum, the WB-62 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.).

Median Openings

As described in Section 8-6, the length of median opening will be determined by a WB-62 design vehicle making a left turn from the side road onto the divided facility. This will also apply to rehabilitation projects except for the criteria for inside clearance. It is desirable that the WB-62 maintains approximately a 2-foot clearance from the median nose. It is acceptable for the wheels of the vehicle to almost touch the edge of the median nose, assuming that the vehicular overhang will not impact any obstructions.



Design Speed (mph)		25	30	35	45	50	55	60	65
Sight Distance (ft)	***Desired***	280	335	390	500	555	610	665	720
	Minimum	155	200	250	360	425	495	570	645

Notes:

1. See Section 8-1 for more information

2. These are based on ensuring that the driver on the mainline (level) has adequate stopping sight distance available in advance of the intersection. To check for this distance, use an eye height of 3.5 ft and an object height of 2 ft for the vehicle on the mainline.

INTERSECTION SIGHT DISTANCE
(Stop Control for Rehabilitation Projects)

Figure 11-1

11-3.10 Roadside Safety

General Application

The Department should take the opportunity when designing the rehabilitation project to implement practical roadside safety improvements. The designer should review the roadside accident history to assist in the decision-making. The following discussion offers roadside safety criteria that apply specifically to rehabilitation projects.

Roadside Clear Zones

For rehabilitation projects on the NHS and Major Arterials, Table 11-2 presents the recommended clear zone distances. The procedures in Section 10-1 (e.g., clear zones across ditch sections) will apply, except that Table 11-2 will be the basis for the analysis. Tables in the State Standards Highway Design Guide will determine clear zones for all other rehabilitation projects. *The distances given there will be measured from edge of travelway and will include the slope.*

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

1. Crash Records. The designer should review the accident data to estimate the extent of the roadside safety problem. In particular, there may be sites where clusters of run-off-the-road accidents have occurred (e.g., on the outside of horizontal curves).

2. 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.

3. 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 beneficial to treat an isolated hazard along the roadside that is within the clear zone distance.

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

5. 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.

REHABILITATION PROJECTS

Design Speed (mph)	Design AADT **	Fill Slopes			Cut Section With Ditch Figure10-1(E) ***
		Recoverable (Figure 10-1(A))		Recoverable (Figure 10-1(A)) ***	
		1:6 or Flatter	1:5 to 1:4		
40 or Less	Under 750 750 - 1500 1500 - 6000 Over 6000	5 - 7 7 - 8 8 - 9 9 - 11	5 - 7 8 - 9 9 - 11 11 - 12	SEE PROCEDURE IN SECTION 10-1.03	SEE PROCEDURE IN SECTION 10-1.04
45 - 50	Under 750 750 - 1500 1500 - 6000 Over 6000	7 - 8 9 - 11 11 - 12 13 - 15	8 - 9 11 - 13 13 - 18 16 - 19		
55	Under 750 750 - 1500 1500 - 6000 Over 6000	8 - 9 11 - 12 13 - 15 15 - 16	9 - 12 13 - 16 16 - 20 17 - 21*		
60	Under 750 750 - 1500 1500 - 6000 Over 6000	11 - 12 13 - 16 17 - 20 20 - 22*	14 - 16 17 - 21* 21 - 27* 24 - 30*		
65 - 70	Under 750 750 - 1500 1500 - 6000 Over 6000	12 - 13 16 - 17 19 - 21* 20 - 23*	13 - 17 19 - 24* 23 - 28* 26 - 31*		

* *On non-freeways, the clear zone distance may be limited to 20 feet for practicality and to provide a consistent roadway template.*

** *Use the AADT projected for the design year for the overall project.*

*** *See the discussion in Section 11-3.10 and Chapter Ten.*

RECOMMENDED CLEAR ZONE DISTANCES
(In Feet Measured from Edge of Travel Lane)

Table 11-2

6. Utilities. Utility poles are a common roadside obstacle on rehabilitation projects. Relocation is mandatory when the utility poles physically interfere with construction or when their placement is inconsistent with the Department's "Policy on Above Ground Utility Locations." Relocation for safety benefits must be evaluated on a case-by-case basis.

7. Barrier Protection. The designer should realize that the barrier warrants presented in Section 10-2 are based on the relative severity between hazard and guardrail; they do not address the question of whether or not a barrier installation is cost-effective. On rehabilitation projects, the designer must judge whether or not a barrier should be installed when a hazard is within the clear zone and will be left in place.

Roadside clear zones are a controlling design element. For the purpose of determining when a design exception is necessary on a rehabilitation project, the following will apply:

1. Parallel Fill Slopes. The criteria in Table 11-2 or the State Standards Highway Design Guide will determine the applicable clear zone distance. However, where fill slopes are 1:4 or flatter, a maximum distance of 20 feet from the edge of travel lane will apply for design exceptions on rehabilitation projects. On fill slopes steeper than1:4 and where the applicable clear zone extends beyond the toe of the slope, the clear zone distance will be to the toe of the slope for design exceptions. It is desirable to provide a 10 feet clear zone beyond the toe.

2. Horizontal curves. The horizontal curvature correction in Section 10-1.05 will not apply for the purpose of determining when a design exception is necessary.

Safety Appurtenances

During the design of a rehabilitation project, 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. Chapter Ten presents the Department's criteria for the layout and design of safety appurtenances.

Roadside barrier warrants on rehabilitation projects can be especially difficult to resolve. The designer should evaluate the roadside environment against the criteria in Chapter Ten. Basically, the process will be:

1. Determine if barrier is warranted based on Chapter 10 criteria.

2. If an existing run of barrier is located where no barrier is warranted, remove the guardrail.

3. If barrier is warranted, consider removing or relocating the hazard; reducing its severity (e.g., flattening a slope); or making it breakaway.

4. If the hazard cannot be eliminated and a barrier is judged to be cost effective, then install guardrail. 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, accident history, barrier adaptability to the site, etc.

5. For existing runs of guardrail which will remain, ensure that they meet, as practical, the applicable performance and design criteria, including:
   a. operational acceptability (hardware, height, etc.);
   b. dynamic deflection criteria;
   c. length of need;
   d. lateral placement;
   e. placement on slopes and behind curbs; and
   f. end treatments.

Existing and proposed guardrail installations on rehabilitation projects will, in some cases, cause special problems. These include:

1. Guardrail Height. A common problem on rehabilitation projects will be the guardrail height of existing installations because of pavement overlay or pavement rehabilitation. Each existing run that will remain must be considered individually. As a general rule, the designer should seriously consider raising the guardrail when its height, after construction, will be more than 3 inches below the recommended height.

2. Slopes in Front of Barrier. It will be acceptable to retain existing installations on 1:6 or flatter slopes where the installation is otherwise acceptable. Existing barrier installations may have terminal sections that flare away and terminate on a slope steeper than 1:10, but flatter than or equal to 1:6. If no other barrier deficiencies exist, it will be acceptable to leave the existing installation in place. Where a flared section crosses a ditch section, it may be necessary to place a small pipe and regrade through the ditch to meet this criteria.

11-3.11 Tables of Geometric Design Criteria

Tables 11-3 to 11-6 present the criteria for the geometric design of rehabilitation projects on non-freeways. A separate table is presented for the arterial and collector functional classes in urban and rural locations.

11-3.12 Design Exception Process

The discussion in Section 3-7 on exceptions applies equally to the geometric design of rehabilitation projects. The only difference, obviously, is that the designer will be evaluating the proposed design against the criteria presented in Section 11-3 or the State Standards Highway Design Guide.

GEOMETRIC DESIGN CRITERIA FOR NHS AND MAJOR RURAL ARTERIALS
(Rehabilitation Projects)

Table 11-3

Design Element			Design Year AADT (1)	Manual Section **	2 - Lane: Under 750	2 - Lane: 750 - 2000	2 - Lane: Over 2000	Multilane: Divided	Multilane: Undivided
DESIGN CONTROLS	*Design Speed (3)			3-4	Posted Speed Limit			Posted Speed Limit	
	Access Control			3-5	Entrance Control			Entrance Control	
	Level of Service			3-3	Desirable:C Minimum: D			Desirable:C Minimum: D	
CROSS SECTION ELEMENTS	*Lane Width			6-1	11'	Des:12' Min: 11'		Desirable:12' Minimum: 11'	
	*Shoulder Width (4)		Right	6-1	4'		6'	8'	
			Left	6-1	N/A			4'	N/A
	Cross Slope		*Travel Lane	6-1	2.0%			2.0%	
			Shoulder (5)	6-1	4.0%			4.0%	
	Auxiliary Lane Width (6)			6-1	Desirable:12' Minimum: 10'			Desirable:12' Minimum: 10'	
	Median Width			6-2	N/A			Existing	N/A
	*New and Rehabilitated Bridges		Structural Capacity	~	SEE BRIDGE PROGRAM			SEE BRIDGE PROGRAM	
			Minimum Width	~					
	*Existing Bridges to Remain in Place		Structural Capacity	~					
			Minimum Width	~					
	Clear Zone			10-1	(7)			(7)	
	Side Slopes	Cut	Front Slope	6-3	1:3 or Flatter (10)		1:4	1:4	
			Depth of Ditch	6-3	(8)			(8)	
			Back Slope	6-3	1:2 (9)			1:2 (9)	
		Fill	0 - 15' Height	6-3	1:3 or Flatter (10)		1:4 (10)	1:4 (10)	
			> 15' Height	6-3	1:2 (11)			1:2 (11)	
ALIGNMENT ELEMENTS	*Minimum Stopping Sight Distance (12)			4-1	50 mph		55 mph	60 mph	
					425'		495'	570'	
	Passing Sight Distance			4-1	1835'		1985'	2135'	
	Decision Sight Distance (13)			4-1	750'		865'	990'	
	*Maximum Degree of Curve (e = 6.0%)			5-2	6° 45'		5° 15'	4° 15'	
	*Superelevation Rate			5-2	e_{max} = 6.0%/8% (14)				
	*Horizontal Sight Distance			5-2	(15)				
	*Maximum Profile Grades (16)		Level	4-2	6%		6%	5%	
			Rolling	4-2	7%		7%	6%	
			Mountainous	4-2	9%		8%	8%	
	Minimum Profile Grades			4-2	Desirable: 0.25%			Minimum: 0%	
	*Minimum Vertical Clearance (17)		New and Replaced Overpassing Bridges	4-3	Desirable: 16'-6"			Minimum: 16'-0"	
			Existing Overpassing Bridges	4-3	14'-0"				

* Controlling design criteria (See Section 3-7)

**See Section 11-3 for specific discussion on rehabilitation projects

GEOMETRIC DESIGN CRITERIA FOR NHS AND MAJOR RURAL ARTERIALS
(Rehabilitation Projects)

Footnotes to Table 11-3

1. Design Year AADT. Desirably, the design year AADT will be 20 years beyond the construction completion date.

2. Multilane Facilities. The criteria in the table for the rehabilitation of multilane facilities will apply:

   a. to an existing multilane facility, or
   b. to an existing 2-lane facility which will become one half of a divided highway.

   In the case of "b", the new half of the divided facility will be designed according to the Department's new construction criteria. See Table 7-2.

3. Design Speed. In most cases, the existing posted speed limit will be acceptable as the minimum design speed. However, the designer should check with Traffic Engineering to determine if the existing posted speed limit is likely to change after project completion.

4. Shoulder Width (Curbed Facilities). On rural arterials where curbs are provided, it is desirable to increase a proposed 4' or 6' shoulder by an additional 2'. Proposed 8' or 10' shoulders do not need to be adjusted when curbs are introduced.

5. Shoulder Cross Slope. In most cases, the shoulder will be paved. In certain situations, 2.0 % cross slopes are permitted. If an existing unpaved shoulder will remain, the shoulder cross slope will be 6.0%.

6. Auxiliary Lane Shoulders. Shoulder widths adjacent to auxiliary lanes should be 2'.

7. Clear Zone. Clear zones will vary according to design speed, traffic volumes and side slope. See Section 11-3 for clear zones on rehabilitation projects.

8. Depth of Ditch. A "V" ditch section should be used unless hydraulic capacity warrants the use of a trapezoidal ditch. It is desirable to maintain the depth of ditch 1' below the subgrade.

9. Back Slope. For 1:4 front slopes, the typical practice is to place the toe of the back slope beyond the clear zone. In rock cuts, the back slope may be as steep as 4:1. See rock cut detail in Figure 6-12. In most cases, however, an existing rock cut will not be altered as part of a rehabilitation project.

10. Fill Slopes (0 – 15' Height). If guardrail is warranted for reasons other than the fill slope, use a 1:2 slope in combination with the guardrail rather than a 1:3 or 1:4 slope.

11. Fill Slopes (Height > 15'). A 1:1 slope is acceptable to avoid significant right-of-way and/or environmental concerns, however this will require geotechnical consideration.

12. Minimum Stopping Sight Distance. See Section 11-3 for a discussion on the application of the stopping sight distance to crest and sag vertical curves on rehabilitation projects.

13. Decision Sight Distance. The values provided are for a directional change (e.g., lane change) at the design speed. See Section 4-1 for decision sight distance values for other conditions.

14. Superelevation Rate. Where an $e_{max} = 6.0\%$ applies, use Table 5-6 to determine the superelevation rate. Where an $e_{max} = 8.0\%$ applies, see the AASHTO *A Policy on Geometric Design of Highways and Streets* to determine the superelevation rate.

15. Horizontal Sight Distance. For a given design speed, the necessary middle ordinate should be determined by the degree of curve and required sight distance (see Section 5-2).

16. Maximum Grades. Grades 1 percent steeper may be used on one-way downgrades on divided facilities.

17. Minimum Vertical Clearance. The vertical clearances apply to the arterial passing under. For the 16'-6" clearance, 6" is provided for future resurfacing. The minimum vertical clearance is 17'-6" for the arterial passing under a new sign truss, and 17'-0" for the arterial passing under an existing sign truss. A 22'-6" (±6") clearance, depending on site conditions, is required at railroad underpasses beneath the arterial.

    Note that "existing overpassing bridges" refers to any bridge work, which does not require the total replacement of both the substructure and superstructure. For example, a bridge deck rehabilitation would be considered an existing overpassing bridge for the purpose of determining the minimum vertical clearance.

    The Urban and Federal Bridge Program will make the final determination on the adequacy of existing or proposed vertical clearances.

GEOMETRIC DESIGN CRITERIA FOR NON-NHS MINOR ARTERIAL AND COLLECTOR ROADS (Rehabilitation Projects)

Table 11-4

Design Element			Design Year AADT (1)	Manual Section **	All Traffic Volumes					
DESIGN CONTROLS	*Design Speed (3)			3-4	Posted Speed Limit					
	Access Control			3-5	Entrance Control					
	Level of Service			3-3	Desirable: C				Minimum: D	
CROSS SECTION ELEMENTS	*Lane Width			6-1	11'					
	*Shoulder Width (3)			6-1	4'					
	Cross Slope		*Travel Lane	6-1	2.0%					
			Shoulder (5)	6-1	Paved: 4.0%, 2.0% allowable				Unpaved: 6.0%	
	Auxiliary Lane Width (4)			6-1	Desirable: 11'				Minimum: 10'	
	*New and Rehabilitated Bridges		Structural Capacity	~	SEE BRIDGE PROGRAM				SEE BRIDGE PROGRAM	
			Minimum Width	~						
	*Existing Bridges to Remain in Place		Structural Capacity	~						
			Minimum Width	~						
	Clear Zone			10-1	(5)					
	Side Slopes	Cut	Front Slope	6-3	1:3					
			Depth of Ditch	6-3	(6)					
			Back Slope	6-3	1:2 (7)					
		Fill	0 - 15' Height	6-3	1:3 (110					
			> 15' Height	6-3	1:2 (9)					
ALIGNMENT ELEMENTS	*Minimum Stopping Sight Distance (10)			4-1	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
					200'	250'	305'	360'	425'	495'
	Passing Sight Distance			4-1	1090'	1280'	1470'	1625'	1835'	1985'
	Decision Sight Distance (13)			4-1	450'	525'	600'	675'	750'	865'
	*Maximum Degree of Curve (e = 6.0%)			5-2	21° 00'	15° 00'	11° 15'	8° 45'	6° 45'	5° 15'
	*Superelevation Rate			5-2	e_{max} = 6.0%/8.0% (12)					
	*Horizontal Sight Distance			5-2	(13)					
	*Maximum Profile Grades		Level	4-2	9%	9%	9%	9%	8%	8%
			Rolling	4-2	11%	10%	10%	10%	9%	9%
			Mountainous	4-2	12%	12%	12%	12%	11%	11%
	Minimum Profile Grades			4-2	Desirable: 0.25%				Minimum: 0%	
	*Minimum Vertical Clearance (14)		New and Replaced Overpassing Bridges	4-3	Desirable: 15'-6"				Minimum: 15'-0"	
			Existing Overpassing Bridges	4-3	14'-0"					

* Controlling design criteria (See Section 3-7)

**See Section 11-3 for specific discussion on rehabilitation projects

GEOMETRIC DESIGN CRITERIA FOR NON-NHS MINOR ARTERIAL AND COLLECTOR ROADS (Rehabilitation Projects)

Footnotes to Table 11-4

1. Design Year AADT. Desirably, the design year AADT will be 20 years beyond the construction completion date. On rehabilitation, the design year may be 12 years beyond the construction completion date.

2. Design Speed. In most cases, the existing posted speed limit will be acceptable as the minimum design speed. However, the designer should check with Traffic Engineering to determine if the existing posted speed limit is likely to change after project completion.

3. Shoulder Width (Curbed Facilities). On rural collectors where curbs are provided, it is desirable to increase a proposed 4' or 6' shoulder by an additional 2'.

4. Auxiliary Lane Shoulders. Shoulder widths adjacent to auxiliary lanes should be 2'.

5. Clear Zone. Clear zones will vary according to design speed, traffic volumes and side slope. See the State Standards Highway Design Guide for clear zone requirements.

6. Depth of Ditch. A "V" ditch section should be used unless hydraulic capacity warrants the use of a trapezoidal ditch. It is desirable to maintain the depth of ditch 0.3 m below the subgrade.

7. Back Slope. In rock cuts, the back slope may be as steep as 4:1. See rock cut detail in Figure 6-12. In most cases, however, an existing rock cut will not be altered as part of a rehabilitation project.

8. Fill Slopes (0-15'Height). If guardrail is warranted for reasons other than the fill slope, use a 1:2 slope in combination with the guardrail rather than a 1:3 or flatter slope.

9. Fill Slope (Height > 15'). A 1:1 slope is acceptable to avoid significant right-of-way and/or environmental concerns, however this will require geotechnical consideration.

10. Minimum Stopping Sight Distance. See the State Standards Highway Design Guide and Section 11-3 for a discussion on the application of the stopping sight distance to crest and sag vertical curves on rehabilitation projects.

11. Decision Sight Distance. The values provided are for a directional change (e.g., lane change) at the design speed. See Section 4-1 for decision sight distance values for other conditions.

12. Superelevation Rate. Where an e_{max} = 6.0% applies, use Table 5-6 to determine the superelevation rate. Where an e_{max} = 8.0% applies, see the AASHTO *A Policy on Geometric Design of Highways and Streets* to determine the superelevation rate.

13. Horizontal Sight Distance. For a given design speed, the necessary middle ordinate should be determined by the degree of curve and required sight distance (see Section 5-2).

14. Minimum Vertical Clearance. The vertical clearances apply to the collector passing under. For the 15'-6" clearance, 6" is provided for future resurfacing. A 22'-6" (±6") clearance, depending on actual site conditions, is required at railroad underpasses beneath the collector.

    Note that "existing overpassing bridges" refers to any bridge work which does not require the total replacement of both the substructure and superstructure. For example, a bridge deck rehabilitation would be considered an existing overpassing bridge for the purpose of determining the minimum vertical clearance.

    The Urban and Federal Bridge Program will make the final determination on the adequacy of existing or proposed vertical clearances.

GEOMETRIC DESIGN CRITERIA FOR URBAN NHS AND MAJOR ARTERIALS (Rehabilitation Projects)

Table 11-5

Design Element			Manual Section **	2-Lane		Multi-lane (Divided/Undivided) (1)	
				With Curb	Without Curb	With Curb	Without Curb
DESIGN CONTROLS	* Design Speed (3)		3-4	Posted Speed Limit		Posted Speed Limit	
	Access Control		3-5	Entrance Control		Entrance Control	
	Level of Service		3-3	Desirable:C Minimum: D		Desirable:C Minimum: D	
	On-Street Parking		6-1	(3)		(3)	
CROSS SECTION ELEMENTS	*Lane Width		6-1	Desirable: 12' Minimum: 11'		Desirable: 12' Minimum: 11'	
	*Shoulder Width/Curb Offset	Right	6-1	6'	4'	Des: 2' Min: 1'	Des: 6' Min: 4'
		Left	6-1	N/A		1'	Des: 6' Min: 4'
	Cross Slope	*Travel Lane	6-1	2.0%		2.0%	
		Shoulder/Curb Offset (4)	6-1	4.0%, 2.0% allowable		4.0%, 2.0% allowable	
	Auxiliary Lane Width (5)		6-1	Desirable: 12'	Minimum: 10'	Desirable: 12'	Minimum: 10'
	CTWLT Lane Width (6)		8-5	Desirable: 12'	Minimum: 11'	Desirable: 12'	Minimum: 11'
	Parking Lane Width (7)		6-1	Desirable: 10'	Minimum: 7'	Desirable: 10'	Minimum: 7'
	Sidewalk Width (8)		6-1	5' Minimum		5' Minimum	
	Median Width		6-2	N/A		Existing	
	*New and Rehabilitated Bridges	Structural Capacity	~	SEE BRIDGE PROGRAM		SEE BRIDGE PROGRAM	
		Minimum Width	~				
	*Existing Bridges to Remain in Place	Structural Capacity	~				
		Minimum Width	~				
	Clear Zone		10-1	1' Min.	(9)	1' Min.	(9)
	Side Slopes		6-3	See Figure 6-11	See Table 11-4	See Figure 6-10	See Table 11-4
ALIGNMENT ELEMENTS	*Minimum Stopping Sight Distance (10)		4-1	35 mph	40 mph	45 mph	50 mph
				250'	305'	360'	425'
	Passing Sight Distance		4-1	1280'	1470'	1625'	1835'
	Decision Sight Distance (11)		4-1	720'	825'	930'	1030'
	*Maximum Degree of Curve		5-2	16° 30' (e_{max} = 4.0%)	11° 30' (e_{max} = 4.0%)	8° 45' (e_{max} = 6.0%)	6° 45' (e_{max} = 6.0%)
	*Superelevation Rate		5-2	Fig. 5-11 (e_{max} = 4.0%)		e_{max} = 6.0%/8.0% (12)	
	*Horizontal Sight Distance		5-2	(13)			
	*Maximum Profile Grades	Level	4-2	10%	9%	8%	8%
		Rolling	4-2	11%	10%	9%	9%
		Mountainous	4-2	13%	12%	11%	11%
	Minimum Profile Grades		4-2	Curbed: Desirable~0.5%; Min.~0.25%		Uncurbed: Desirable~0.25%; Min.~0%	
	*Minimum Vertical Clearance (14)	New and Replaced Overpassing Bridges	4-3	Desirable: 16'-6"		Minimum: 16'-0"	
		Existing Overpassing Bridges	4-3	14'-0"			

* Controlling design criteria (See Section 3-7)

**See Section 11-3 for specific discussion on rehabilitation projects

GEOMETRIC DESIGN CRITERIA FOR URBAN NHS AND MAJOR ARTERIALS
(Rehabilitation Projects)

Footnotes to Table 11-5

1. Multilane Facilities. The criteria in the table for the rehabilitation of multilane facilities will apply to:

   a. an existing multilane facility, or
   b. an existing 2-lane facility which will become one half of a divided highway.

   In the case of "b", the new half of the divided facility will be designed according to the Department's new construction criteria. See Table 7-5.

2. Design Speed. In most cases, the existing posted speed limit will be acceptable as the minimum design speed. However, the designer should check with Traffic Engineering to determine if the existing posted speed limit is likely to change after project completion.

3. On-Street Parking. The decision to provide on-street parking will be made on a case-by-case basis. See Section 6-1 for more information.

4. Cross Slope (Curb Offset). For curb offsets (shoulder width less than 4'), the cross slope will be the same as the cross slope of the adjacent travel lane.

5. Auxiliary Lane Shoulders. Shoulder widths adjacent to auxiliary lanes should be 2'.

6. CTWLT Lane Width. In industrial areas with large truck traffic turning frequently, the desirable CTWLT lane width is 14'.

7. Parking Lanes. Where the parking lane will be used as a travel lane during peak hours or may be converted to a travel lane in the future, the width should be 11'. Cross slope for parking lanes should be 4.0%.

8. Sidewalk Width. Where roadside appurtenances are located within the sidewalk, the minimum width should be 7'. In built-up areas, the sidewalk is often paved between the curb and building line.

9. Clear Zone. Clear zones will vary according to design speed, traffic volumes and side slope. See the State Standards Highway Design Guide for clear zone requirements.

10. Minimum Stopping Sight Distance. See Section 11-3 for a discussion on the application of the stopping sight distance to crest and sag vertical curves on rehabilitation projects.

11. Decision Sight Distance. The values provided are for a directional change (e.g., lane change) at the design speed. See Section 4-1 for decision sight distance values for other conditions.

12. Superelevation Rate. Where an e_{max} = 6.0% applies, use Table 5-6 to determine the superelevation rate. Where an e_{max} = 8.0% applies, see the AASHTO *A Policy on Geometric Design of Highways and Streets* to determine the superelevation rate.

13. Horizontal Sight Distance. For a given design speed, the necessary middle ordinate should be determined by the radius of curve and required sight distance (see Section 5-2).

14. Minimum Vertical Clearance. The vertical clearances apply to the arterial passing under. For the 16'-6" clearance, 6" is provided for future resurfacing. The minimum vertical clearance is 17'-6" for the arterial passing under a new sign truss, and 17-0" for the arterial passing under an existing sign truss. A 22'-6" ($\pm$6") clearance, depending on actual site conditions, is required at railroad underpasses beneath the arterial.

    Note that "existing overpassing bridges" refers to any bridge work which does not require the total replacement of both the substructure and superstructure. For example, a bridge deck rehabilitation would be considered an existing overpassing bridge for the purpose of determining the minimum vertical clearance.

    The Urban and Federal Bridge Program will make the final determination on the adequacy of existing or proposed vertical clearances.

GEOMETRIC DESIGN CRITERIA FOR URBAN NON-NHS MINOR ARTERIAL AND COLLECTOR ROADS/STREETS (Rehabilitation Projects)

Table 11-6

Design Element			Manual Section **	With Curb		Without Curb	
DESIGN CONTROLS	* Design Speed (3)		3-4	Posted Speed Limit			
	Access Control		3-5	Entrance Control			
	Level of Service		3-3	Desirable: C		Minimum: D	
	On-Street Parking		6-1	(2)			
CROSS SECTION ELEMENTS	*Lane Width (3)		6-1	Minimum: 11'			
	*Shoulder Width/Curb Offset (4)		6-1	6'		4'	
	Cross Slope	*Travel Lane	6-1	2.0%			
		Shoulder/Curb Offset (5)	6-1	4.0%, 2.0% allowable			
	Auxiliary Lane Width (6)		6-1	Desirable: 11'		Minimum: 10'	
	Parking Lane Width (7)		6-1	Desirable: 10'		Minimum: 7'	
	Sidewalk Width (8)		6-1	5' Minimum			
	*New and Rehabilitated Bridges	Structural Capacity	~	SEE BRIDGE PROGRAM		SEE BRIDGE PROGRAM	
		Minimum Width	~				
	*Existing Bridges to Remain in Place	Structural Capacity	~				
		Minimum Width	~				
	Clear Zone		10-1	Minimum: 1'		See Table 11-5	
	Side Slopes		6-3	See Figure 6-11		See Table 11-5	
ALIGNMENT ELEMENTS	*Minimum Stopping Sight Distance (10)		4-1	25 mph	30 mph	35 mph	40 mph
				155'	200'	250'	305'
	Passing Sight Distance		4-1	900'	1090'	1280'	1470'
	Decision Sight Distance (11)		4-1	540'	620'	720'	825'
	*Maximum Degree of Curve (e = 4.0%)		5-2	40° 00'	24° 45'	16° 30'	11° 30'
	*Superelevation Rate		5-2	Figure 5-11 (e_{max} = 4.0%)			
	*Horizontal Sight Distance		5-2	(12)			
	*Maximum Profile Grades	Level	4-2	11%	11%	11%	10%
		Rolling	4-2	14%	13%	12%	11%
		Mountainous	4-2	15%	14%	14%	13%
	Minimum Profile Grades		4-2	Desirable~0.25%; Min.~0%			
	*Minimum Vertical Clearance (13)	New and Replaced Overpassing Bridges	4-3	Desirable: 15'-6"		Minimum: 15'-0"	
		Existing Overpassing Bridges	4-3	14'-0"			

* Controlling design criteria (See Section 3-7)

**See Section 11-3 for specific discussion on rehabilitation projects

GEOMETRIC DESIGN CRITERIA FOR URBAN NON-NHS MINOR ARTERIAL AND COLLECTOR ROADS/STREETS (Rehabilitation Projects)

Footnotes to Table 11-6

1. Design Speed. In most cases, the existing posted speed limit will be acceptable as the minimum design speed. However, the designer should check with Traffic Engineering to determine if the existing posted speed limit is likely to change after project completion.

2. On-Street Parking. The decision to provide on-street parking will be made on a case-by-case basis. See Section 6-1 for more information.

3. Lane Widths. In industrial areas, lanes should be 11' wide.

4. Shoulder Width. On facilities with curbs, a minimum offset of 2' between the edge of travel lane and curb may be used in restricted locations. However, the minimum curb-to-curb width is 26'.

5. Cross Slope (Curb Offset). For curb offsets (shoulder width less than 4'), the cross slope will be the same as the cross slope of the adjacent travel lane.

6. Auxiliary Lane Shoulders. Shoulder widths adjacent to auxiliary lanes should be 2'desirable and 1' minimum.

7. Parking Lanes. Where the parking lane will be used as a travel lane during peak hours or may be converted to a travel lane in the future, the width should be 11'. Cross slopes for parking lanes should be 4.0%.

8. Sidewalk Width. Where roadside appurtenances are located within the sidewalk, the minimum width should be 7'. In built-up areas, the sidewalk is often paved between the curb and building line.

9. Clear Zone. Clear zones will vary according to design speed, traffic volumes and side slope. See the State Standards Highway Design Guide for clear zone requirements.

10. Minimum Stopping Sight Distance. See the State Standards Highway Design Guide and Section 11-3 for a discussion on the application of the stopping sight distance to crest and sag vertical curves on rehabilitation projects.

11. Decision Sight Distance. The values provided are for a directional change (e.g., lane change) at the design speed. See Section 4-1 for decision sight distance values for other conditions.

12. Horizontal Sight Distance. For a given design speed, the necessary middle ordinate should be determined by the degree of curve and required sight distance (see Section 5-2).

13. Minimum Vertical Clearance. The vertical clearances apply to the collector passing under. For the 15'-6" clearance, 6" is provided for future resurfacing. A 22'-6" (±6") clearance, depending on actual site conditions, is required at railroad underpasses beneath the collector.

    Note that "existing overpassing bridges" refers to any bridge work which does not require the total replacement of both the substructure and superstructure. For example, a bridge deck rehabilitation would be considered an existing overpassing bridge for the purpose of determining the minimum vertical clearance.

    The Urban and Federal Bridge Program will make the final determination on the adequacy of existing or proposed vertical clearances.

11-4 RESTORATION/RESURFACING PROJECTS (Non-Freeways)

11-4.01 Definition

Section 3-6 defines 3R projects (in general) and restoration/resurfacing projects (specifically) on non-freeways as follows:

> *Restoration/resurfacing projects are usually intended to resurface the existing pavement. Geometric design improvements are usually only included to correct obvious deficiencies on the existing highway. Right-of-way acquisition will usually be limited takings, easements and grading rights.*

For NHS and Major Arterial projects, the geometric design criteria for restoration/resurfacing projects on non-freeways are presented in the following sections. On all other projects, the State Standards Highway Design Guide will apply. See the Discussion in Section 11-1.03.

11-4.02 Traffic Volume Controls

The following will apply to restoration/resurfacing projects:

1. Design Year Traffic Volumes. The design year will be 10 years beyond the construction completion date for traffic analyses (AADT, design hourly volume, etc.).

2. Level of Service. Tables 11-8 to 11-11 provide the level-of-service criteria for restoration/ resurfacing projects.

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

4. Capacity Analysis. The analytical techniques in the *Highway Capacity Manual* will be used to conduct the capacity analysis.

11-4.03 Design Speed

In most cases, the existing posted speed limit will be acceptable as the minimum design speed on restoration/resurfacing projects. However, the designer should check with Traffic Engineering to determine if the existing posted speed limit is likely to change after project completion.

11-4.04 Grades

The existing grades will typically be incorporated into restoration/resurfacing projects.

11-4.05 Crest Vertical Curves

In most cases, existing crest vertical curves will be incorporated into the restoration/resurfacing project. However, the designer should consider reconstruction of a crest vertical curve if:

a. the crest hides from view major hazards such as intersections, sharp horizontal curves or narrow bridges; and

b. the design speed of the existing crest (based on minimum stopping sight distance to an 2' height of object) is more than 20 mph below the project design speed; and

c. the design year AADT is greater than 1500.

11-4.06 Sag Vertical Curves

The existing sag vertical curves will typically be incorporated into restoration/resurfacing projects.

11-4.07 Horizontal Alignment

The existing horizontal alignment will typically be incorporated into restoration/resurfacing projects.

Superelevation Rate/Degree of Curve

To determine the adequacy of the existing curvature and superelevation on a horizontal curve, follow this procedure:

1. Determine the design speed of the existing curve from Figure 11-2.

2. Compare the design speed of the existing curve to the overall design speed for the project (See Section 11-4.03). If the design speed at the curve is less than the project design speed, the designer should evaluate the practicality of increasing the superelevation rate and/or flattening the curve.

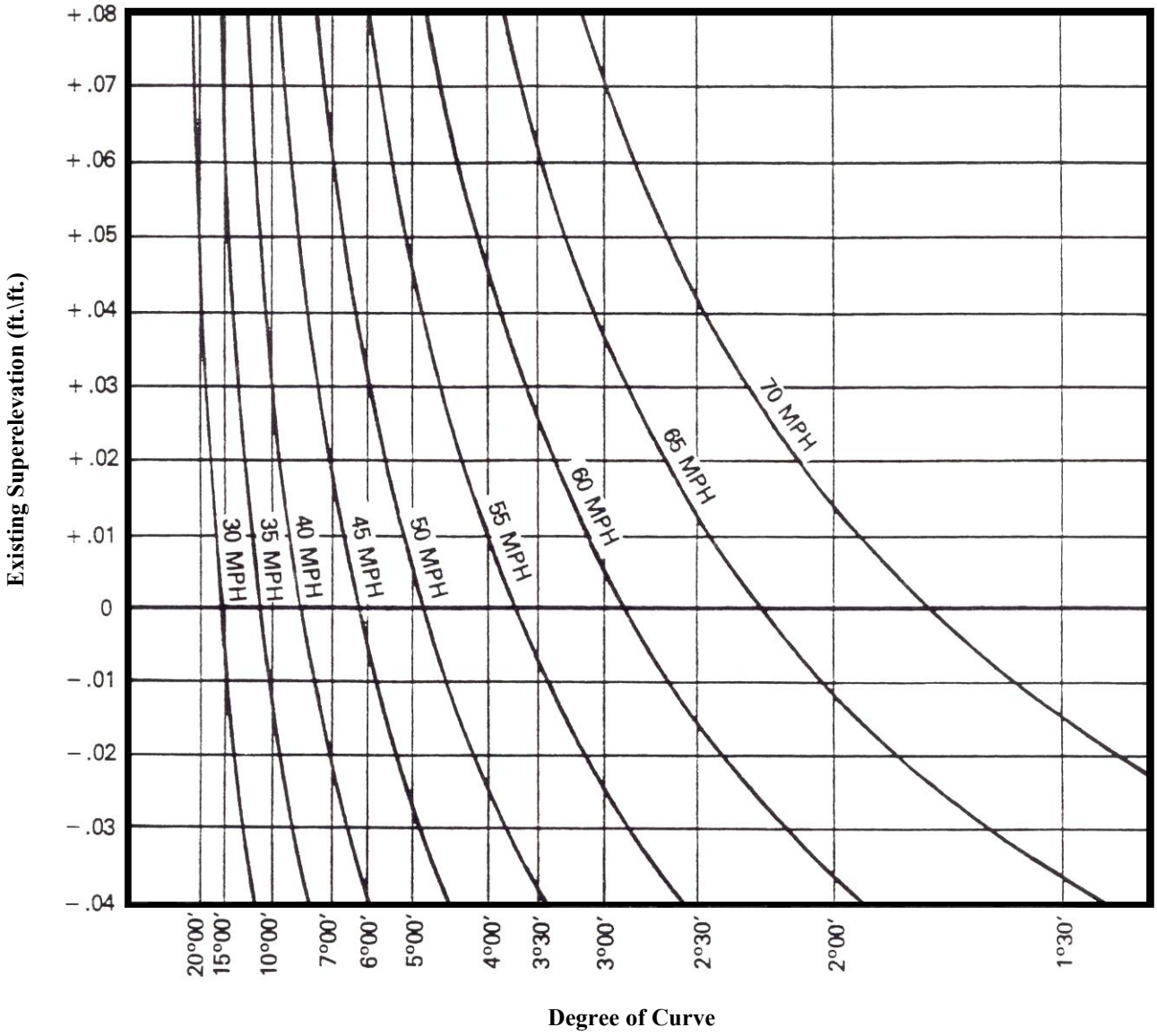
3. If the decision is made to take corrective action, the combination of superelevation and degree of curve will (at a minimum) be based on Figure 11-2.

4. If an existing slope around a curve is less than +1.0%, the designer should consider superelevating the curve at the typical cross slope.

5. Figure 11-2 can also be used to determine the appropriate advisory speed for signing curves that are below the project design speed but will remain in place.

Reverse Curves

For reverse curves on restoration/resurfacing projects, it will be acceptable to provide no tangent section between the curves (i.e., the PT & PC may be coincident).



Note: Figure applies to all rural highways and urban facilities where the design speed is greater than 45 mph

HORIZONTAL CURVATURE FOR RESTORATION/RESURFACING PROJECTS

Figure 11-2

Travelway Widening

The need for widening the travelway on a horizontal curve may be justified even where no changes will be made in the superelevation rate. Section 5-2 presents the applicable criteria.

11-4.08 Cross Section Elements

Tables 11-8 to 11-11 present the Department's restoration/resurfacing criteria for the width of cross section elements. The cross section width and/or steepness of the existing highway should be evaluated against the criteria in the restoration/resurfacing tables. If the existing width or steepness does not meet these criteria, the designer should consider widening the element. If the decision is made to improve the cross section element, the designer should provide a value that at least meets the restoration/resurfacing criteria. However, it may be appropriate to improve the cross section element(s) beyond the restoration/resurfacing criteria.

Right-of-Way

As indicated in the basic definition of a "Restoration/Resurfacing Project," right-of-way acquisition will usually be limited takings, easements and grading rights. Occasionally, more extensive right-of-way involvement may be appropriate if, for example, a horizontal curve is flattened.

Curbs

On restoration/resurfacing projects, the following will apply to the installation or retention of curbs:

1. Type. Where a project will disturb existing curbs, the curb will be replaced in-kind.

2. Height. Restoration/resurfacing projects may include pavement work that will not affect the lateral location of existing curbs, but will affect their reveal. The designer will consider adjusting the reveal of curb (or the pavement design) if:

    a. 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

    b. the curb reveal after construction will be less than 3 inches.

Sidewalks

Where a restoration/resurfacing project will disturb existing sidewalks, the sidewalk will be replaced in-kind. Existing sidewalks may also be resurfaced when necessary. Where sidewalks do not currently exist, the need for sidewalks will be determined on a case-by-case basis.

Fill/Cut Slopes

The existing fill and cut slopes will typically be incorporated into the restoration/resurfacing project according to the original design.

Bridges

The Urban and Federal Bridge Program will determine the acceptable roadway width for bridges to remain in place and for new and rehabilitated bridges within the limits of a restoration/resurfacing project. The Urban and Federal Bridge Program will also evaluate the adequacy of existing bridge rails. The designer will be responsible for evaluating the adequacy of the existing guardrail transition approaching the bridge rail.

Transitions

When roadway transitions are required at bridge or underpass sections or at project termini, the length of transition (L) should be computed by the formula $L = WS$ for highways with a design speed greater than 45 mph. The formula $L = WS^2/60$ should be used to compute transitions on highways with a design speed of 45 mph and below. For both formulas, L equals the taper length in feet, W the offset distance in feet, and S the design speed in mph.

11-4.09 Intersections At-Grade

The following summarizes the design of intersections at-grade within the limits of a restoration/resurfacing project.

Intersection Sight Distance (ISD)

The existing ISD will be acceptable.

Turning Radii Design

Normally, the existing radii at an intersection will be acceptable, unless a specific safety or operational problem is identified.

Entrance Design

Section 8-8 and the *MDOT Standard Details* present detailed criteria for entrance design. On restoration/resurfacing projects, the designer should attempt to meet the following objectives:

1. The entrance design should match the roadway work where the existing entrance design is impacted.

2. Where the mainline shoulders are paved and the entrance is gravel, the designer should provide the 3-foot paved apron if not already present. See the entrance figures in Section 8-8 and in the *MDOT Standard Details*.

3. The criteria for handicapped accessibility should be met at entrances.

4. The designer should evaluate safety considerations at driveways (e.g., proximity to intersections) and make any practical improvements.

11-4.10 Roadside Safety

General Application

The Department should take the opportunity of the restoration/resurfacing project to implement practical roadside safety improvements. The designer should review the roadside accident history to assist in the decision-making. The following discussion offers roadside safety criteria that apply specifically to restoration/resurfacing projects.

Roadside Clear Zones

For restoration/resurfacing projects on the NHS and Major Arterials, Table 11-7 presents the recommended clear zone distances. The procedures in Section 10-1 (e.g., clear zones across ditch sections) will apply, except that Table 11-7 will be the basis for the analysis. Tables in the State Standards Highway Design Guide will determine clear zones for all other restoration/resurfacing projects. *The distances given there will be measured from edge of travelway and will include the slope.*

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

1. Accident Records. The designer should review the accident data to estimate the extent of the roadside safety problem. In particular, there may be sites where clusters of run-off-the-road accidents have occurred (e.g., on the outside of horizontal curves).

2. 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.

3. 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 beneficial to treat an isolated hazard along the roadside that is within the clear zone distance.

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

5. 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.

6. Utilities. Utility poles are a common roadside obstacle on restoration/resurfacing projects. Relocation is mandatory when the utility poles physically interfere with construction or when their placement is inconsistent with the Department's "Policy on Above Ground Utility Locations." Relocation for safety benefits must be evaluated on a case-by-case basis.

RESTORATION/RESURFACING PROJECTS

Design Speed (mph)	Design AADT **	Fill Slopes			Cut Section With Ditch Figure 10-1(E) ***
		Recoverable (Figure 10-1(A))		Non-recoverable Figure 10-1(B) ***	
		1:6 or Flatter	1:5 to 1:4		
40 or Less	Under 750 750 - 1500 1500 - 6000 Over 6000	4 5 - 6 6 - 7 7 - 8	4 - 5 6 - 7 7 - 8 8 - 9	SEE PROCEDURE IN SECTION 10-1.03	SEE PROCEDURE IN SECTION 10-1.04
45-50	Under 750 750 - 1500 1500 - 6000 Over 6000	5 - 6 7 - 8 8 - 9 10 - 11	6 - 7 8 - 10 10 - 13 12 - 14*		
55	Under 750 750 - 1500 1500 - 6000 Over 6000	6 - 7 8 - 9 10 - 12 11 - 12	7 - 9 10 - 12 12 - 15* 13 - 16*		
60	Under 750 750 - 1500 1500 - 6000 Over 6000	8 - 9 10 - 12 13 - 15* 15 - 16*	10 - 12 13 - 16* 16 - 20* 18 - 22*		
65-70	Under 750 750 - 1500 1500 - 6000 Over 6000	9 - 10 12 - 13 14 - 16* 15 - 17*	10 - 13* 14 - 18* 17 - 21* 19 - 23*		

* *On non-freeways, the clear zone distance may be limited to 12' for practicality and to provide a consistent roadway template.*

** *Use the AADT projected for the design year for the overall project.*

*** *See the discussion in Section 11-3.10 and Chapter Ten.*

RECOMMENDED CLEAR ZONE DISTANCES
(In Meters Measured From Edge of Travel Lane)

Table 11-7

7. Barrier Protection. The designer should realize that the barrier warrants are based on the relative severity between hazard and guardrail; they do not address the question of whether or not a barrier installation is cost-effective. On restoration/resurfacing projects, the designer must judge whether or not a barrier should be installed when a hazard is within the clear zone and will be left in place.

Roadside clear zones are a controlling design element. For the purpose of determining when a design exception is necessary on a restoration/resurfacing project, the following will apply:

1. Parallel Fill Slopes. The criteria in Table 11-7 or the State Standards Highway Design Guide will determine the applicable clear zone distance. However, where fill slopes are 1:4 or flatter, a maximum distance of 20 feet from the edge of travel lane will apply for design exceptions on rehabilitation projects. On fill slopes steeper than1:4 and where the applicable clear zone extends beyond the toe of the slope, the clear zone distance will be to the toe of the slope for design exceptions. It is desirable to provide a 10 feet clear zone beyond the toe.

2. Horizontal Curves. The horizontal curvature correction in Section 10-1.05 will not apply for the purpose of determining when a design exception is necessary.

Safety Appurtenances

During the design of a restoration/resurfacing project, 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. Chapter Ten presents the Department's criteria for the layout and design of safety appurtenances.

Roadside barrier warrants on restoration/resurfacing projects can be especially difficult to resolve. The designer should evaluate the roadside environment against the criteria in Chapter Ten. Basically, the process will be:

1. Determine if barrier is warranted.

2. If an existing run of barrier is located where no barrier is warranted, remove the guardrail.

3. If barrier is warranted, consider removing or relocating the hazard; reducing its severity (e.g., flattening a slope); or making it breakaway.

4. If the hazard cannot be eliminated and a barrier is judged to be cost effective, then install guardrail. 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, accident history, barrier adaptability to the site, etc.

5. For existing runs of guardrail which will remain, ensure that they meet, as practical, the applicable performance and design criteria, including:

   a. operational acceptability (hardware, height, etc.);
   b. dynamic deflection criteria;
   c. length of need;
   d. lateral placement;
   e. placement on slopes and behind curbs; and
   f. end treatments.

Existing and proposed guardrail installations on restoration/resurfacing projects will, in some cases, cause special problems. These include:

1. Guardrail Height. A common problem on restoration/resurfacing projects will be the guardrail height of existing installations because of a pavement overlay. Each existing run that will remain must be considered individually. As a general rule, the designer should seriously consider raising the guardrail when its height, after construction, will be more than 3 inches below the recommended height.

2. Slopes in Front of Barrier. . It will be acceptable to retain existing installations on 1:6 or flatter slopes where the installation is otherwise acceptable. Existing barrier installations may have terminal sections that flare away and terminate on a slope steeper than 1:10, but flatter than or equal to 1:6. If no other barrier deficiencies exist, it will be acceptable to leave the existing installation in place. Where a flared section crosses a ditch section, it may be necessary to place a small pipe and regrade through the ditch to meet this criteria.

3. Length of Need. All existing barrier installations will be evaluated to determine if the existing length of barrier meets the Department's length-of-need criteria in Section 10-4. If the existing length is within 25 feet of the calculated value from Section 10-4, it is not necessary to extend the guardrail.

4. Placement Relative to Shoulder. It is acceptable to place the barrier at the edge of the normal shoulder width where the full 5-foot offset is not attainable. Three feet is the minimum acceptable distance from the face of rail to the shoulder berm.

11-4.11 Tables of Geometric Design Criteria

Tables 11-8 to 11-11 present the criteria for the geometric design of restoration/resurfacing projects on non-freeways. A separate table is presented for the arterial and collector functional classes in urban and rural locations.

11-4.12 Design Exception Process

The discussion in Section 3-7 on exceptions applies equally to the geometric design of restoration/resurfacing projects. The only difference, obviously, is that the designer will be evaluating the proposed design against the criteria presented in Section 11-4.

GEOMETRIC DESIGN CRITERIA FOR RURAL NHS AND MAJOR ARTERIALS
(Restoration/Resurfacing Projects)

Table 11-8

Design Element				Manual Section **	2 - Lane	Multilane Divided	Multilane Undivided
DESIGN CONTROLS	*Design Speed (2)			3-4	Posted Speed Limit	Posted Speed Limit	
	Access Control			3-5	Entrance Control	Entrance Control	
	Level of Service			3-3	Minimum: D	Minimum: D	
CROSS SECTION ELEMENTS	*Lane Width			6-1	11'	11'	
	*Shoulder Width		Right	6-1	4'	4'	
			Left	6-1	N/A	3'	N/A
	Cross Slope		*Travel Lane	6-1	1.0% to 4.0%	1.0% to 4.0%	
			Shoulder (3)	6-1	4.0%, 2.0% allowable	4.0%, 2.0% allowable	
	Auxiliary Lane Width (4)			6-1	Desirable:11' Minimum: 10'	Desirable:11'	
	Median Width			6-2	N/A	Existing	N/A
	*New and Rehabilitated Bridges		Structural Capacity	~	**SEE BRIDGE PROGRAM**	**SEE BRIDGE PROGRAM**	
			Minimum Width	~			
	*Existing Bridges to Remain in Place		Structural Capacity	~			
			Minimum Width	~			
	Clear Zone			10-1	(5)	(5)	
	Side Slopes (6)	Cut	Front Slope	6-3	Existing	Existing	
			Depth of Ditch	6-3	Existing	Existing	
			Back Slope	6-3	Existing	Existing	
		Fill		6-3	Existing	Existing	
				6-3	Existing	Existing	
ALIGNMENT ELEMENTS	*Minimum Stopping Sight Distance			4-1	50 mph / 55 mph / 60 mph		
					Existing (7)		
	Passing Sight Distance			4-1	Existing		
	Decision Sight Distance			4-1	N/A		
	*Maximum Degree of Curve			5-2	(8)		
	*Superelevation Rate			5-2	(8)		
	*Horizontal Sight Distance			5-2	Existing		
	*Maximum Profile Grades		Level	4-2	Existing		
			Rolling	4-2	Existing		
			Mountainous	4-2	Existing		
	Minimum Profile Grades			4-2	Desirable: 0.25%	Minimum: 0%	
	*Minimum Vertical Clearance (9)		New and Replaced Overpassing Bridges	4-3	Desirable: 16'-6"	Minimum: 16'-0"	
			Existing Overpassing Bridges	4-3	14'-0"		

* Controlling design criteria (See Section 3-7)

**See Section 11-4 for specific discussion on restoration/resurfacing projects

GEOMETRIC DESIGN CRITERIA FOR RURAL NHS AND MAJOR ARTERIALS
(Restoration/Resurfacing Projects)

Footnotes to Table 11-8

1. Multilane Facilities. The criteria in the table for the restoration/resurfacing of multilane facilities will apply to:

   a. an existing multilane facility, or
   b. an existing 2-lane facility which will become one half of a divided highway.

   In the case of "b", the new half of the divided facility will be designed according to the Department's new construction criteria. See Table 7-2.

2. Design Speed. In most cases, the existing posted speed limit will be acceptable as the minimum design speed. However, the designer should check with Traffic Engineering to determine if the existing posted speed limit is likely to change after project completion.

3. Shoulder Cross Slope. In most cases, the shoulder will be paved. If an existing unpaved shoulder will remain, the shoulder cross slope will be 6.0%. If an existing paved shoulder has a cross slope of 6.0%, it may remain at this rate as part of the restoration/resurfacing project.

4. Auxiliary Lane Shoulders. Shoulder widths adjacent to auxiliary lanes should be 2'.

5. Clear Zone. Clear zones will vary according to design speed, traffic volumes and side slope. See Section 11-4 for clear zones on restoration/resurfacing projects.

6. Side Slopes. In most cases, retention of the existing side slope shape according to the original design will be acceptable.

7. Stopping Sight Distance. The designer should consider reconstruction of a crest vertical curve if:

   a. the crest hides from view major hazards such as intersections, sharp horizontal curves or narrow bridges; and

   b. the design speed of the existing crest (based on minimum SSD to a 2' height of object) is more than 20 mph below the selected design speed for the project; and

   c. the design year AADT is greater than 1500.

8. Maximum Degree of Curve/Superelevation Rate. The combination of degree of curve and superelevation rate will yield a design speed of the existing horizontal curve. See Figure 11-2.

9. Minimum Vertical Clearance. The vertical clearances apply to the arterial passing under. For the 16'-6" clearance, 6" is provided for future resurfacing. The minimum vertical clearance is 17'-6" for the arterial passing under a new sign truss, and 17'-0" for the arterial passing under an existing sign truss. A 22'-6" ($\pm$6") clearance, depending on actual site conditions, is required at railroad underpasses beneath the arterial.

   Note that "existing overpassing bridges" refers to any bridge work which does not require the total replacement of both the substructure and superstructure. For example, a bridge deck rehabilitation would be considered an existing overpassing bridge for the purpose of determining the minimum vertical clearance.

   The Urban and Federal Bridge Program will make the final determination on the adequacy of existing or proposed vertical clearances.

GEOMETRIC DESIGN CRITERIA FOR RURAL NON-NHS MINOR ARTERIAL AND COLLECTOR ROADS (Restoration/Resurfacing Projects)

Table 11-9

Design Element				Manual Section **	All Traffic Volumes					
DESIGN CONTROLS	*Design Speed (3)			3-4	Posted Speed Limit					
	Access Control			3-5	Entrance Control					
	Level of Service			3-3	Minimum: D					
CROSS SECTION ELEMENTS	*Lane Width			6-1	11'					
	*Shoulder Width/Curb Offset (4)			6-1	4'					
	Cross Slope		*Travel Lane	6-1	1.0% to 4.0%					
			Shoulder	6-1	Paved: 4.0%, 2.0% allowable				Unpaved: 6.0%	
	Auxiliary Lane Width (2)			6-1	Desirable: 11'				Minimum: 10'	
	*New and Rehabilitated Bridges		Structural Capacity	~	SEE BRIDGE PROGRAM				SEE BRIDGE PROGRAM	
			Minimum Width	~						
	*Existing Bridges to Remain in Place		Structural Capacity	~						
			Minimum Width	~						
	Clear Zone			10-1	(3)					
	Side Slopes (4)	Cut	Front Slope	6-3	Existing					
			Depth of Ditch	6-3	Existing					
			Back Slope	6-3	Existing					
		Fill		6-3	Existing					
ALIGNMENT ELEMENTS	*Minimum Stopping Sight Distance (10)			4-1	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
					Existing (5)					
	Passing Sight Distance			4-1	Existing					
	Decision Sight Distance (11)			4-1	N/A					
	*Maximum Degree of Curve (e = 4.0%)			5-2	(6)					
	*Superelevation Rate			5-2	(6)					
	*Horizontal Sight Distance			5-2	Existing					
	*Maximum Profile Grades		Level	4-2	Existing					
			Rolling	4-2	Existing					
			Mountainous	4-2	Existing					
	Minimum Profile Grades			4-2	Desirable: 0.25%				Minimum: 0%	
	*Minimum Vertical Clearance (7)		New and Replaced Overpassing Bridges	4-3	Desirable: 15'-6"				Minimum: 15'-0"	
			Existing Overpassing Bridges	4-3	14'-0"					

* Controlling design criteria (See Section 3-7)

**See Section 11-4 for specific discussion on restoration/resurfacing projects

GEOMETRIC DESIGN CRITERIA FOR RURAL NON-NHS MINOR ARTERIAL AND COLLECTOR ROADS (Restoration/Resurfacing Projects)

Footnotes to Table 11-9

1. Design Speed. In most cases, the existing posted speed limit will be acceptable as the minimum design speed. However, the designer should check with Traffic Engineering to determine if the existing posted speed limit is likely to change after project completion.

2. Auxiliary Lane Shoulders. Shoulder widths adjacent to auxiliary lanes should be 2'.

3. Clear Zone. Clear zones will vary according to design speed, traffic volumes and side slope. See the State Standards Highway Design Guide for clear zone requirements.

4. Side Slopes. In most cases, retention of the existing side slope shape according to the original design will be acceptable.

5. Stopping Sight Distance. The designer should consider reconstruction of a crest vertical curve if:

   a. the crest hides from view major hazards such as intersections, sharp horizontal curves or narrow bridges; and

   b. the design speed of the existing crest (based on minimum SSD to a 2' height of object) is more than 20 mph below the selected design speed for the project; and

   c. the design year AADT is greater than 1500.

6. Maximum Degree of Curve/Superelevation Rate. The combination of degree of curve and superelevation rate will yield a design speed of the existing horizontal curve. See Figure 11-2.

7. Minimum Vertical Clearance. The vertical clearances apply to the collector passing under. For the 15'-6" clearance, 6" is provided for future resurfacing. A 22'-6" (±6") clearance, depending on actual site conditions, is required at railroad underpasses beneath the collector.

   Note that "existing overpassing bridges" refers to any bridge work which does not require the total replacement of both the substructure and superstructure. For example, a bridge deck rehabilitation would be considered an existing overpassing bridge for the purpose of determining the minimum vertical clearance.

   The Urban and Federal Bridge Program will make the final determination on the adequacy of existing or proposed vertical clearances.

GEOMETRIC DESIGN CRITERIA FOR URBAN NHS AND MAJOR ARTERIAL ROADS/STREETS (Restoration/Resurfacing Projects)

Table 11-10

Design Element			Manual Section **	2-Lane		Multi-lane (Divided/Undivided) (1)	
				With Curb	Without Curb	With Curb	Without Curb
DESIGN CONTROLS	* Design Speed (2)		3-4	Posted Speed Limit		Posted Speed Limit	
	Access Control		3-5	Entrance Control		Entrance Control	
	Level of Service		3-3	Minimum: D		Minimum: D	
	On-Street Parking		6-1	(3)		(3)	
CROSS SECTION ELEMENTS	*Lane Width		6-1	11'		11'	
	*Shoulder Width/Curb Offset	Right	6-1	Existing	4'	Existing	4'
		Left	6-1	N/A		Existing	
	Cross Slope	*Travel Lane	6-1	1.0% to 4.0%		1.0% to 4.0%	
		Shoulder/Curb Offset (6)	6-1	4.0%, 2.0% allowable		4.0%, 2.0% allowable	
	Auxiliary Lane Width		6-1	Existing		Existing	
	CTWLT Lane Width		8-5	Existing		Existing	
	Parking Lane Width		6-1	Existing		Existing	
	Sidewalk Width		6-1	Existing		Existing	
	Median Width		6-2	N/A		Existing	
	*New and Rehabilitated Bridges	Structural Capacity	~	SEE BRIDGE PROGRAM		SEE BRIDGE PROGRAM	
		Minimum Width	~				
	*Existing Bridges to Remain in Place	Structural Capacity	~				
		Minimum Width	~				
	Clear Zone		10-1	1'	(7)	1'	(7)
	Side Slopes (8)		6-3	Existing		Existing	
ALIGNMENT ELEMENTS	*Minimum Stopping Sight Distance		4-1	35 mph	40 mph	45 mph	50 mph
				Existing (9)			
	Passing Sight Distance		4-1	Existing			
	Decision Sight Distance		4-1	N/A			
	*Maximum Degree of Curve		5-2	16° 30' (e_{max} = 4.0%)	11° 30' (e_{max} = 4.0%)	See Figure 11-2	
	*Superelevation Rate		5-2	Fig. 5-11 (emax = 4.0%)		See Figure 11-2	
	*Horizontal Sight Distance		5-2	Existing			
	*Maximum Profile Grades	Level	4-2	Existing			
		Rolling	4-2	Existing			
		Mountainous	4-2	Existing			
	Minimum Profile Grades		4-2	Curbed: 0.25% Uncurbed: 0%			
	*Minimum Vertical Clearance (10)	New and Replaced Overpassing Bridges	4-3	Desirable: 16'-6"		Minimum: 16'-0"	
		Existing Overpassing Bridges	4-3	14'-0"			

* Controlling design criteria (See Section 3-7)

**See Section 11-3 for specific discussion on restoration/resurfacing projects

GEOMETRIC DESIGN CRITERIA FOR URBAN NHS AND MAJOR ARTERIAL ROADS/STREETS (Restoration/Resurfacing Projects)

Footnotes to Table 11-10

1. Multilane Facilities. The criteria in the table for the restoration/resurfacing of multilane facilities will apply to:

   a. an existing multilane facility, or
   b. an existing 2-lane facility which will become one half of a divided highway.

   In the case of "b", the new half of the divided facility will be designed according to the Department's new construction criteria. See Table 7-5.

2. Design Speed. In most cases, the existing posted speed limit will be acceptable as the minimum design speed. However, the designer should check with Traffic Engineering to determine if the existing posted speed limit is likely to change after project completion.

3. On-Street Parking. Typically, a restoration/resurfacing project will neither introduce nor remove on-street parking.

4. Lane Width. In restricted built-up areas (e.g., CBD), a 10' lane width is acceptable.

5. Shoulder Width. On non Federal-aid projects, the existing shoulder width may be retained.

6. Cross Slope (Curb Offset). For curb offsets (shoulder width less than 4'), the cross slope will be the same as the cross slope of the adjacent travel lane.

7. Clear Zone. Clear zones will vary according to design speed, traffic volumes and side slope. See Section 11-4 for clear zones on restoration/resurfacing projects.

8. Side Slopes. In most cases, retention of the existing side slope shape according to the original design will be acceptable.

9. Stopping Sight Distance. The designer should consider reconstruction of a crest vertical curve if:

   a. the crest hides from view major hazards such as intersections, sharp horizontal curves or narrow bridges; and

   b. the design speed of the existing crest (based on minimum SSD to a 2' height of object) is more than 20 mph below the selected design speed for the project; and

   c. the design year AADT is greater than 1500.

10. Minimum Vertical Clearance. The vertical clearances apply to the arterial passing under. For the 16'-6" clearance, 6" is provided for future resurfacing. The minimum vertical clearance is 17'-6"for the arterial passing under a new sign truss, and 17'-0" for the arterial passing under an existing sign truss. A 22'-6" (±6") clearance, depending on actual site conditions, is required at railroad underpasses beneath the arterial.

    Note that "existing overpassing bridges" refers to any bridge work which does not require the total replacement of both the substructure and superstructure. For example, a bridge deck rehabilitation would be considered an existing overpassing bridge for the purpose of determining the minimum vertical clearance.

    The Urban and Federal Bridge Program will make the final determination on the adequacy of existing or proposed vertical clearances.

GEOMETRIC DESIGN CRITERIA FOR
URBAN NON-NHS MINOR ARTERIAL AND COLLECTOR ROADS/STREETS
(Restoration/Resurfacing Projects)

Table 11-11

Design Element			Manual Section **	With Curb		Without Curb	
DESIGN CONTROLS	* Design Speed (1)		3-4	Posted Speed Limit			
	Access Control		3-5	Entrance Control			
	Level of Service		3-3	Minimum: D			
	On-Street Parking		6-1	(2)			
CROSS SECTION ELEMENTS	*Lane Width		6-1	Minimum: 11'			
	*Shoulder Width		6-1	Existing		Minimum: 4' (3)	
	Cross Slope	*Travel Lane	6-1	1.0% to 4.0%		1.0% to 4.0%	
		Shoulder (4)	6-1	4.0%, 2.0% allowable			
	Auxiliary Lane Width		6-1	Existing			
	Parking Lane Width		6-1	Existing			
	Sidewalk Width		6-1	Existing			
	*New and Rehabilitated Bridges	Structural Capacity	~	**SEE BRIDGE PROGRAM**		**SEE BRIDGE PROGRAM**	
		Minimum Width	~				
	*Existing Bridges to Remain in Place	Structural Capacity	~				
		Minimum Width	~				
	Clear Zone		10-1	Minimum: 1'		(5)	
	Side Slopes (6)		6-3	Existing			
ALIGNMENT ELEMENTS	*Minimum Stopping Sight Distance		4-1	25 mph	30 mph	35 mph	40 mph
				Existing (7)			
	Passing Sight Distance		4-1	Existing			
	Decision Sight Distance		4-1	N/A			
	*Maximum Degree of Curve (e = 4.0%)		5-2	Figure 5-12		Existing	
	*Superelevation Rate		5-2	Figure 5-12		Existing	
	*Horizontal Sight Distance		5-2	Existing			
	*Maximum Profile Grades	Level	4-2	Existing			
		Rolling	4-2	Existing			
		Mountainous	4-2	Existing			
	Minimum Profile Grades		4-2	0.25%		0%	
	*Minimum Vertical Clearance (8)	New and Replaced Overpassing Bridges	4-3	Desirable: 15'-6"		Minimum: 15'-0"	
		Existing Overpassing Bridges	4-3	14'-0"			

* Controlling design criteria (See Section 3-7)

**See Section 11-4 for specific discussion on restoration/rehabilitation projects

GEOMETRIC DESIGN CRITERIA FOR URBAN NON-NHS MINOR ARTERIAL AND COLLECTOR ROADS/STREETS (Restoration/Resurfacing Projects)

Footnotes to Table 11-11

1. Design Speed. In most cases, the existing posted speed limit will be acceptable as the minimum design speed. However, the designer should check with Traffic Engineering to determine if the existing posted speed limit is likely to change after project completion.

2. On-Street Parking. Typically, a restoration/resurfacing project will neither introduce nor remove on-street parking.

3. Shoulder Width. On non Federal-aid projects, the existing shoulder width may be retained.

4. Cross Slope (Curb Offset). For curb offsets (shoulder width less than 4'), the cross slope will be the same as the cross slope of the adjacent travel lane.

5. Clear Zone. Clear zones will vary according to design speed, traffic volumes and side slope. See the State Standards Highway Design Guide for clear zone requirements.

6. Side Slopes. In most cases, retention of the existing side slope shape according to the original design will be acceptable.

7. Stopping Sight Distance. The designer should consider reconstruction of a crest vertical curve if:

   a. the crest hides from view major hazards such as intersections, sharp horizontal curves or narrow bridges; and

   b. the design speed of the existing crest (based on minimum SSD to a 2' height of object) is more than 20 mph below the selected design speed for the project; and

   c. the design year AADT is greater than 1500.

8. Minimum Vertical Clearance. The vertical clearances apply to the collector passing under. For the 15'-6" clearance, 6" is provided for future resurfacing. A 22'-6" (±6") clearance, depending on actual site conditions, is required at railroad underpasses beneath the collector.

   Note that "existing overpassing bridges" refers to any bridge work which does not require the total replacement of both the substructure and superstructure. For example, a bridge deck rehabilitation would be considered an existing overpassing bridge for the purpose of determining the minimum vertical clearance.

   The Urban and Federal Bridge Program will make the final determination on the adequacy of existing or proposed vertical clearances.

11-5 4R FREEWAY PROJECTS

11-5.01 Definition

Section 3-6 defines 4R freeway projects as follows:

> *4R projects (resurfacing, restoration, rehabilitation and/or reconstruction) on existing freeways are primarily intended to extend the service life of the existing facility, to enhance highway safety and to make improvements to the existing geometrics, where practical.*

If the nature of the work on an existing freeway is considered reconstruction, the criteria in Table 7-1 for new construction/reconstruction projects will apply, and the criteria in Chapters Three to Ten will apply. If the nature of the work is considered rehabilitation, restoration or resurfacing, the criteria in Section 11-5 will apply.

11-5.02 4R Project Objectives

As with non-freeway 3R projects, it is often impractical to fully apply new construction criteria to 4R freeway projects without some qualifications. Therefore, the objective of a 4R project is, within practical limits, to return the freeway to its original level of serviceability or to improve its serviceability to meet current and future demands. This objective applies to all aspects of the freeway's serviceability, including:

1. structural adequacy,
2. drainage,
3. level of service for the traffic flow,
4. geometric design,
5. roadside safety, and
6. traffic control.

11-5.03 Application

4R freeway projects are most often initiated to make a specific improvement to the freeway. Therefore, the Department’s approach to the geometric design of 4R freeway projects is to selectively evaluate and improve the existing geometrics. Table 11-12 presents the Department's geometric design criteria for 4R projects. The 4R approach is summarized as follows:

1. Nature of Improvement. This may include:

   a. pavement resurfacing, restoration, rehabilitation or reconstruction, including shoulders;

   b. adding through travel lanes to improve the level of service;

   c. improving roadway delineation;

   d. upgrading roadside safety (always required);

   e. increasing the length of acceleration or deceleration lanes at an interchange;

   f. widening an existing bridge as part of a bridge rehabilitation project; and/or

   g. improving the roadside drainage.

   The designer will exercise judgment when determining any other improvements that may be practical.

2. Exceptions. The discussion in Section 3-7 on design exceptions will only apply to the geometric design of the specific freeway improvement(s).

11-5.04 Traffic Volume Controls

The following will apply to 4R freeway projects:

1. Design Year Traffic Volumes. The design year will be 20 years beyond the construction completion date for traffic analyses (AADT, design hourly volume, etc.).

2. Level of Service. The desirable level of service is B; the minimum level of service in rural areas is C and in urban areas is D.

3. Traffic Data. The designer should obtain from the Bureau of Planning the traffic data necessary to determine the level of improvement.

4. Capacity Analysis. The analytical techniques in the *Highway Capacity Manual* will be used to conduct the capacity analysis.

11-5.05 Design Speed

In most cases, the existing posted speed limit will be acceptable as the minimum design speed for the 4R freeway project. However, the designer should check with the Traffic Engineering Division to determine if the existing posted speed limit is likely to change after project completion.

11-5.06 Horizontal/Vertical Alignment

Unless the specific objective of the 4R freeway project is to improve one or more horizontal/vertical features, the existing alignment will be acceptable. The Urban and Federal Bridge Program is responsible for determining the adequacy of existing or proposed vertical clearances.

11-5.07 Bridges

The Urban and Federal Bridge Program will determine the acceptable width for bridges to remain in place and for new and rehabilitated bridges within the limits of a 4R project. The Urban and Federal Bridge Program will also evaluate the adequacy of existing bridge rails. The designer will be responsible for evaluating the adequacy of the existing guardrail transition at the bridge rail.

11-5.08 Interchanges

A 4R freeway project may include proposed work on a freeway interchange. The work may be to rehabilitate the entire interchange or to make only selective improvements to the interchange geometrics. The designer will apply Chapter Nine to the design of the interchange elements.

11.5.09 Roadside Safety

All 4R freeway projects will be evaluated for potential roadside safety improvements within the project limits. The criteria in Chapter Ten will fully apply to the evaluation. This includes roadside clear zones, barrier warrants, barrier design and drainage features.

Existing intersecting slopes in the median will be evaluated for potential improvements. In general, existing median slopes may be retained in the absence of an adverse accident history. If the existing median slope is flattened, it should be reconstructed to a 1:10 (desirable) or a 1:6 slope (acceptable).

11-5.10 Table of Geometric Design Criteria

Table 11-12 presents the Department's criteria for the geometric design of 4R freeway projects.

GEOMETRIC DESIGN CRITERIA FOR FREEWAYS***
(4R Projects)

Table 11-12

Design Element				Manual Section **	Rural		Urban	
DESIGN CONTROLS		* Design Speed (1)		3-4	Posted Speed Limit		Posted Speed Limit	
		Access Control		3-5	Controlled Access		Controlled Access	
		Level of Service		3-3	Desirable: B Minimum: D		Desirable: B Minimum: D	
CROSS SECTION ELEMENTS	*Lane Width			6-1	12'		12'	
	*Shoulder Width	Right		6-1	10'		10'	
		Left		6-1	4'		4'	
	Cross Slope	*Travel Lane		6-1	1.5% to 2.0%		1.5% to 2.0%	
		Shoulder (4)		6-1	4.0% to 6.0%		4.0% to 6.0%	
	Auxiliary Lane Width (3)			6-1	12'		12'	
	Median Width (4)			6-21	Existing		Existing	
	*New and Rehabilitated Bridges	Structural Capacity		~	SEE BRIDGE PROGRAM		SEE BRIDGE PROGRAM	
		Minimum Width		~				
	*Existing Bridges to Remain in Place	Structural Capacity		~				
		Minimum Width		~				
	Clear Zone			10-1	(5)		(5)	
	Side Slopes (6)	Cut	Front Slope	6-3	Existing		Existing	
			Depth of Ditch	6-3	Existing		Existing	
			Back Slope	6-3	Existing		Existing	
		Fill		6-3	Existing		Existing	
ALIGNMENT ELEMENTS	*Minimum Stopping Sight Distance			4-1	55 mph	60 mph	65 mph	70 mph
					Existing			
	Decision Sight Distance			4-1	Existing			
	*Maximum Degree of Curve			5-2	Existing			
	*Superelevation Rate			5-2	Existing (7)			
	*Horizontal Sight Distance			5-2	Existing			
	*Maximum Profile Grades		Level	4-2	Existing			
			Rolling	4-2	Existing			
			Mountainous	4-2	Existing			
	Minimum Profile Grades			4-2	Desirable: 0.25% Minimum: 0%			
	*Minimum Vertical Clearance (8)		New and Replaced Overpassing	4-3	16'-6"			
			Existing Overpassing	4-3	16'-0"			

* Controlling design criteria (See Section 3-7)

**See Section 11-5 for specific discussion on 4R projects

***Table 11-15 applies to freeway projects considered rehabilitation, restoration or resurfacing. For freeway reconstruction projects, see Table 7-1.

GEOMETRIC DESIGN CRITERIA FOR FREEWAYS
(4R Projects)

Footnotes to Table 11-12

1. Design Speed. In most cases, the existing posted speed limit will be acceptable as the minimum design speed. However, the designer should check with the Traffic Engineering Division to determine if the existing posted speed limit is likely to change after project completion.

2. Shoulder Width. Where a concrete median barrier is used, the desirable left shoulder is 6' for freeways with two lanes in one direction. For all freeways with three or more lanes in one direction, the desirable left shoulder is 10'.

3. Auxiliary Lane Shoulders. Shoulder widths adjacent to auxiliary lanes should be 8'.

4. Median Width. It is acceptable to reduce the existing median width where travel lanes are added in the median.

5. Clear Zone. Clear zones will vary according to design speed, traffic volume and side slope. See Section 10-1.

6. Side Slopes. In most cases, retention of the existing side slope shape according to the original design will be acceptable.

7. Superelevation Rate. Normally, the existing superelevation rate will be adequate. However, the designer should refer to Table 5-6 to determine if any improvements should be considered.

8. Minimum Vertical Clearance. The vertical clearances apply to the freeway passing under. For the 16'-6" sign truss clearance, 6" is provided for future resurfacing. The minimum vertical clearance is 17'-6" for the freeway passing under a new pedestrian bridge or new. The clearance is 17'-0" for the freeway passing under an existing pedestrian bridge or existing sign truss. A 22'-6" (±6") clearance, depending on actual site conditions, is required at railroad underpasses beneath the freeway.

   Note that "existing overpassing bridges" refers to any bridge work which does not require the total replacement of both the substructure and superstructure. For example, a bridge deck rehabilitation would be considered an existing overpassing bridge for the purpose of determining the minimum vertical clearance.

   The Urban and Federal Bridge Program will make the final determination on the adequacy of existing or proposed vertical clearances.

11-6 SPOT IMPROVEMENT PROJECTS (Non-Freeways)

11-6.01 Definition

Section 3-6 defines spot improvements as follows:

> *Spot improvements are intended to correct an identified deficiency at an isolated location. The deficiency may be related to structural, geometric, safety, and drainage or traffic control problems. These projects are not intended to provide a general upgrading of the highway, as are projects categorized as new construction, reconstruction, 3R or 4R.*

One example of a spot improvement is a safety project at a site with a disproportionate number of accidents. These projects are intended to provide cost-effective countermeasures to reduce the accident potential. Typical projects are intersection improvements, flattening a horizontal curve, installing guardrail or installing traffic control devices. The Traffic Engineering Division is responsible for conducting a preliminary evaluation of the site and recommending improvements. When roadway work is involved, the Urban and Arterial Highway Program is responsible for preparing the detailed project design.

11-6.02 Application

The Department has adopted a flexible approach to the geometric design of spot improvement projects. The following summarizes the approach:

1. Numerical Criteria. The designer should consider the level of improvement that will most likely be used to upgrade the highway section in the future as well as the roadway classification. Refer to the discussion in Section 11-1.03. Spot improvements should be made with the applicable criteria in mind.

2. Design Speed. The existing posted speed limit will usually be acceptable as the minimum design speed. However, the designer should check with Traffic Engineering to determine if the existing posted speed limit is likely to change after project completion.

3. Application. The designer should apply the selected criteria specifically to the geometric improvement related to the objective of the spot improvement project (e.g., install guardrail, flatten a curve, add a left-turn lane). In addition, the designer should evaluate other geometric design deficiencies within the project limits. The designer should consider improving any severe deficiencies, even if not related to the specific objective of the spot

improvement. The designer will exercise his/her judgment when determining any other improvements that may be justified.

4. Exceptions. For spot improvements, the exception process will apply to those specific elements that are improved by the project. See Section 3-7 for a discussion on the design exception process.