Washington State Department of Transportation

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Remarks and Instructions

What's changed in the Design Manual for July 2017?

See the summary of revisions beginning on Page 3.

How do you stay connected to current design policy?

It's the designer's responsibility to apply current design policy when developing transportation projects at WSDOT. The best way to know what's current is to reference the manual online.

Access the current electronic WSDOT *Design Manual,* the latest revision package, and individual chapters at: www.wsdot.wa.gov/publications/manuals/m22-01.htm

We're ready to help. If you have comments or questions about the Design Manual, please don't hesitate to contact us.

Area of Practice	Your Contacts		
Geometric Design, Roadside Safety and Traffic Barriers	Jeff Petterson	360-705-7246	PETTERJ@wsdot.wa.gov
	Kurt Sielbach	360/705-7937	SIELBAK@wsdot.wa.gov
General Guidance and Support	Chris Schroedel	360-705-7299	SCHROEC@wsdot.wa.gov
	John Donahue	360-705-7952	DONAHJO@wsdot.wa.gov

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HQ Design Office Signature **/s/ Jeff Carpenter**	Phone Number 360-705-7821

Remove/Insert instructions for those who maintain a printed manual

NOTE: Also replace the Title Page

CHAPTER/SECTION	REMOVE PAGES	INSERT PAGES
Contents/Exhibits	Entire Contents	Entire Contents
Technical Errata July 2016	TE-1&2	N/A Errata retired
100 Manual Description	Entire chapter	Entire chapter
210 Public Involvement and Hearings	Pages 210-1 – 6	Pages 210-1 – 6
300 Design Documentation, Approval, and Process Review	Entire chapter	Entire chapter
301 Design and Maintenance Coordination	301-19&20	301-19&20
305 Managing Projects	Entire chapter	Entire chapter
310 Value Engineering	Entire chapter	Entire chapter
321 Sustainable Safety Analysis	Entire chapter	Entire chapter
560 Fencing	Entire chapter	Entire chapter
610 Investigation of Soils, Rock, and Surfacing Materials	610-11&12	610-11&12
710 Site Data for Structures	Entire chapter	Entire chapter
720 Bridges	Entire chapter	Entire chapter
1010 Work Zone Safety and Mobility	Entire chapter	Entire chapter
1030 Delineation	Entire chapter	Entire chapter
1040 Illumination	Entire chapter	Entire chapter
1100 Practical Design	Entire chapter	Entire chapter
1101 Need Identification	Entire chapter	Entire chapter
1102 Context Identification	Entire chapter	Entire chapter
1103 Design Control Selection	Entire chapter	Entire chapter
1104 Alternatives Analysis	Entire chapter	Entire chapter
1105 Design Element Selection	Entire chapter	Entire chapter
1106 Design Element Dimensions	Entire chapter	Entire chapter
1120 Preservation Projects	Entire chapter	Entire chapter
1230 Geometric Cross Section	Entire chapter	N/A
1230 Geometric Cross Section Basics	N/A	Entire chapter
1231 Geometric Cross Section – Highways	N/A	Entire chapter
1232 Geometric Cross Section – Freeways	N/A	Entire chapter
1238 Geometric Cross Section – Streetside and Parking	N/A	Entire chapter
1239 Geometric Cross Section – Shoulders, Side Slopes, Curb, and Medians	N/A	Entire chapter
1250 Superelevation	Entire chapter	N/A
1250 Cross slope and Superelevation	N/A	Entire chapter
1270 Auxiliary Lanes	Entire chapter	Entire chapter
1300 Intersection Control Type	Entire chapter	Entire chapter
1310 Intersections	1310-1 – 4, 37&38, 41&42	1310-1 – 4, 37&38, 41&42
1320 Roundabouts	Entire chapter	Entire chapter
1330 Traffic Control Signals	Entire chapter	Entire chapter
1360 Interchanges	Entire chapter	Entire chapter
1410 High-Occupancy Vehicle Facilities	1410-5&6	1410-5&6
1420 HOV Direct Access	1420-11–16	1420-11–16
1430 Transit Facilities	1430-17&18	1430-17&18
1510 Pedestrian Facilities	1510-1 – 6 & 31 – 34	1510-1 – 6 & 31 – 34
1600 Roadside Safety	Entire chapter	Entire chapter
1610 Traffic Barriers	Entire chapter	Entire chapter
Glossary	Entire Glossary	Entire Glossary

About revision marks and footer dates:

- A new date appears in the footer of each page that has changes.
- Changes include inserted or deleted content and existing content that shifts to a new page.
- New or substantially rewritten chapters will have no revision marks. This is the case with many chapters this publication.
- In some cases, just a page of a chapter changed with a spot revision, such as a correction or new chapter reference.

Summary of *Design Manual* Changes – July 2017

(Revisions merit careful study beyond this summary)

Highlights of the More Substantial Revisions

Chapter 300 Design Documentation, Approval, and Process Review

- Document operational changes included in a project
- Early real estate acquisition
- Design Approval requirements
- Projects of Division Interest (PoDI) added to Exhibit 300-1; revised some notes
- Crash Analysis Report added to Exhibit 300-2.

Chapter 321 Sustainable Safety Analysis

- Rewritten Chapter provides safety analysis policy and links to new *Safety Analysis Guide*.

Chapter 1010 Work Zone Safety and Mobility

- Coordinate with WSDOT Freight and Public Transportation Divisions for work zone needs.
- Added text regarding project complexity and scale of TMP.
- Replaced *shy distance* with *minimum lateral buffer*.
- Revised 1010.07(4) Abrupt Lane Edges because it duplicated content in the *Standard Specifications*.

Chapter 1030 Delineation

- Revised reflectors used on guide posts used at intersections. Changed from using green reflectors to using white-silver. Type name changed from G1 and G2 to IC1 and IC2. *Standard Plans* revised for same.
- Other updates includes text on composite beads, terms updated, simplified notes on exhibit tables.

Chapter 1040 Illumination

- Areas with required illumination: HOT lanes (added access weave lane); chain up/off parking areas (clarifies when luminaries are energized); work zones and detours section shortened (refers to 1010).
- Minor changes to design area requirements.
- Light Standards: removed standard pole height of 50 foot, standards over 40 foot are called out only for certain conditions specified; removed angular Type 2 mast arms; Signal Maintenance approval required for all median mounted luminaires except chain on/off areas.
- The standard luminaire in use for roadway lighting is cobra head style type III LED fixture.

Chapter 1100 Practical Design

- Practical Design overview chapter. Several revisions based on changes to the other 1100 chapters.
- Removed term *MAISA*; using *project advisory team* instead.
- Removed phrase *changed or employed* related to design elements. Just using term *changed.*

- Replaced term *Least cost planning* with *Practical Solutions Planning.*
- Simplified Exhibit 1100-1 Basis of Design Flowchart.

Chapter 1101 Need Identification

- Removed reference to Chapter 1106 about performance target refinement procedures, because 1106 no longer says to use a performance target refinement form. Use the BOD to show refined targets.
- New text inserted in 1101.02 to consider and coordinate needs statements with other processes such as VE, IJR, NEPA/SEPA.

Chapter 1102 Context Identification

- Rewritten to provide guidance and structure for determining land use and transportation contexts.
- Chapter based on emerging best practices for context identification as established in NCHRP Project 15-52 Developing a Context-Sensitive Functional Classification System for More Flexibility in Geometric Design.

Chapter 1103 Design Control Selection

- Clarified and reduced content on Design Year.
- Structured guidance to help choose which modes to prioritize.
- Tied design speed to the roadway types and land use contexts found in revised 1102.

Chapter 1104 Alternatives Analysis

- Deleted text referring to Ch 1106 for target refinement instructions.
- Policy now is to use the BOD to document refined performance targets (see revised 1106.)

Chapter 1105 Design Element Selection

- Removed *employed* from the chapter as related to design elements. Using *changed*.
- Other minor changes.

Chapter 1106 Design Element Dimensions

- Performance Target Refinement Form discontinued; instruction provided to enter refined performance targets on the Basis of Design form.

Chapter 1120 Preservation Projects

- Added content to 1120.01 to allow project engineer option to include other elements in a preservation project
- Added content in 1102.03(1) to reinstall rumble strips.
- 1120.03(2) ADA – added content about project delivery or design memorandums.
- Added DDP to vertical clearance section.
- 1120.03(7) – added conditional bullets for adjusting height of Type 1 and Type 31 guardrail. Revised Breakaway Cable Terminal instruction to include more routes on which to replace BCTs.
- Removed term *employs* related to design elements. This coincides with other policy revisions in the 1100 and 1200 series.
- Updated references to chapters in the 1200 series to coincide with new chapter organization.

Chapter 1230 Geometric Cross Section Basics

- Presents cross section basics and guides use of other new 1230 cross section chapters.

Chapter 1231 Geometric Cross Section – Highways

- Most content moved from previous Chapter 1230.
- Covers all highway types except freeways, which has its own chapter now (1232).
- Exhibits are oriented to modes as previous content did; added notes to exhibits about speed.

Chapter 1232 Geometric Cross Section – Freeways

- Cross section criteria for freeways including interstates.
- Much of the content shifted from the previous version of 1230, with additional edits.

Chapter 1238 Geometric Cross Section – Streetside and Parking

- Streetside zones and parking content from previous 1230 moved here to its own chapter.

Chapter 1239 Geometric Cross Section – Shoulders, Side Slopes, Curb, and Medians

- Content moved from previous 1230 pertaining to shoulders, medians, side slopes, and curbs; with minor edits.

Chapter 1250 Cross slope and Superelevation

- Moved cross slope content to this chapter from previous version of 1230.

Chapter 1270 Auxiliary Lanes

- Minor changes to coincide with new chapters in 1200 series.
- Revised to reflect updated policy regarding choice of shoulder width and associated documentation requirements.

Chapter 1300 Intersection Control Type

- Simplified ICA section with step-by-step process.
- Emphasized "roundabout-first" guidance.
- Specific performance measures related to off-peak hours.
- Content for Median U-turn, Restricted Crossing U-turn, and Displaced Left Turn intersections.
- Guidance on Pedestrian Considerations.
- Relocated and simplified Operational Considerations; moved some under procedures.

Chapter 1320 Roundabouts

- Added Compact Roundabout
- Return of "R" Values
- Text changes to coincide with *Standard Plan* updates (text updates for SP or Plan Sheet Library plans – signing, pavement marking)
- Cross slope percent changed to range, with 2% preferred.
- Inscribed circle diameter revised to a range for multilane roundabouts (See Table – Exhibit 1320-1).
- Various text changes throughout; new photos and illustrations.

Chapter 1330 Traffic Control Signals

- Rewritten and reorganized to reflect current requirements, standards, policies, and practices, as well as address current technology and provide frequently requested clarifications.
- Removed "Vacant" exhibits and out of date information.

Chapter 1600 Roadside Safety

- Mitigative measures list in 1600.01 aligns with AASHTO *Roadside Design Guide*.
- Revised clear zone section and documentation instruction.
- Removed reference to *shy distance*. Doing this across the manual.
- Content on how to address wider medians.
- Updated content on roadway, shoulder, and centerline rumble strips.
- Headlight Glare section reorganized and reduced.

Chapter 1610 Traffic Barriers

- Significant reorganization, sections moved, retitled, rewritten to eliminate redundancies and better group information on topics.
- Exhibits moved to the appropriate sections.
- Added text about MASH implementation.
- Moved some content to roadside safety website
    - Type 1 guardrail placement cases and terminals.
    - Specifics regarding acceptable Type 31 terminals (list can be updated more often)
- Removed from chapter
    - Transition section Type 20. (No plans to go to a MASH compliant version, and the Type 21 transition is interchangeable and it is intended to get to MASH compliancy.)
    - Type 20 and Type 21 (weak post guardrail) as it is little-used, and there are no plans to go to MASH compliant versions.
- Modified some exhibits. For example, reworked the figures showing placement of barrier on slopes and in the median to make the guidance clearer
- Deleted *shy distance* from this chapter.
- Revised cable barrier deflection guidance to use a conservative value of 12 ft.

Highlights of Other Chapter Revisions

Chapter 100 Manual Description

- Updated to reflect new and revised chapters in this revision package.

Chapter 301 Design and Maintenance Coordination

- Chapter reference changed from 1600 to 1230.

Chapter 305 Managing Projects

- Rewritten on WSDOT project management tools and processes.
- Changes coincide with updated Project Management Guide.

Chapter 310 Value Engineering

- Improved language and clarification, primarily around the subject of timing the VE.
- Reduced or eliminated references to risk.

Chapter 560 Fencing

- Updated reference from 1230 to 1239 for rock cuts.
- Updated reference to Access and Hearings Manager.

Chapter 610 Investigation of Soils, Rock, and Surfacing Materials

- Updated reference from 1230 to 1239 for rock cuts.

Chapter 710 Site Data for Structures

- Clarified the term *bridge* in this chapter and in Chapter 720.
- Revised instruction on CAD and plan sheet scales; removed Exhibit 710-1.
- Clarified instruction about Coast Guard involvement.
- Removed term *shy distance*; replaced with *lateral clearances* in 710.04(2)(c).
- Added *EEDS Manual* and *Hydraulics Manual* references.
- Exhibit 710-2 renumbered 710-1.

Chapter 720 Bridges

- Clarified Region and Bridge office roles.
- Instruction for structures involving railroads.

- Instruction for evaluating median gaps between parallel bridges.
- Seismic retrofit content in 720.03(5)(c)(1) and vertical clearance table.
- Reduced liquefaction considerations in 720.03(6); refers to updated *Bridge Design Manual*.

Chapter 1310 Intersections

- Removed text about design element dimensioning; updated chapter references.
- Replaced terms *design deviation* and *evaluate upgrade* with *Design Analysis*.
- (Retires the Technical Errata that instructed to replace *deviation* with *Design Analysis*.)

Chapter 1360 Interchanges

- Updated chapter references

Chapter 1410 High-Occupancy Vehicle Facilities

- Replaced term *deviation* with *Design Analysis*.
- (Retires the Technical Errata that instructed to replace *deviation* with *Design Analysis*.)

Chapter 1420 HOV Direct Access

- Updated chapter and section references; replaced *shy distance* at barrier with *lateral clearance* to curb and barrier

Chapter 1510 Pedestrian Facilities

- Updated ADA references
- Added notes within clear space and reach range sections to refer to Chapter 1330.

Washington State Department of Transportation

Design Manual

M 22-01.14

July 2017

Division 1 – General Information
Division 2 – Hearings, Environmental, and Permits
Division 3 – Project Documentation
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Division 6 – Soils and Paving
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Division 8 – Hydraulics
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Division 16 – Roadside Safety Elements
Division 17 – Roadside Facilities

Engineering and Regional Operations

Development Division, Design Office

Americans with Disabilities Act (ADA) Information

Materials can be made available in an alternative format by emailing the WSDOT Diversity/ADA Affairs Team at wsdotada@wsdot.wa.gov or by calling toll free: 855-362-4ADA (4232). Persons who are deaf or hard of hearing may contact that number via the Washington Relay Service at 7-1-1.

Title VI Notice to Public

It is Washington State Department of Transportation (WSDOT) policy to ensure no person shall, on the grounds of race, color, national origin, or sex, as provided by Title VI of the Civil Rights Act of 1964, be excluded from participation in, be denied the benefits of, or be otherwise discriminated against under any of its federally funded programs and activities. Any person who believes his/her Title VI protection has been violated may file a complaint with WSDOT's Office of Equal Opportunity (OEO). For Title VI complaint forms and advice, please contact OEO's Title VI Coordinator at 360-705-7082 or 509-324-6018.

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Division 10 – Traffic Safety Elements

Division 11 – Practical Design

Division 13 – Intersections and Interchanges

Division 15 – Pedestrian and Bicycle Facilities

Chapter 100 Manual Description

100.01 Purpose

The Washington State Department of Transportation (WSDOT) has developed the *Design Manual* to reflect policy, outline a uniformity of methods and procedures, and communicate vital information to its employees and others who develop projects on state highways. When properly used, the manual will facilitate the development of a highway system consistent with the needs of the multimodal traveling public.

WSDOT designers are required to comply with the *Design Manual*. The Federal Highway Administration (FHWA) has agreed to approve designs that follow guidance in the *Design Manual*; therefore, adherence to the guidance presented is not optional for state highway projects.

The information, guidance, and references contained herein are not intended as a substitute for sound engineering judgment. The *Design Manual* is not a comprehensive textbook on highway engineering, nor does it attempt to cover all the possible scenarios Washington's highways present. It is recognized that some situations encountered are beyond the scope of this presentation.

If you have design questions not answered by the *Design Manual*, contact the Headquarters (HQ) Design Office.

100.02 Presentation and Revisions

The *Design Manual* is available on the Internet. It can be accessed through the:

- WSDOT Home Page:
  www.wsdot.wa.gov/
- Design Policy Web Page:
  www.wsdot.wa.gov/design/policy/
- Active *Design Manual* Revisions Web Page:
  www.wsdot.wa.gov/design/manual/activerevisions.htm
- Publications Services Web Page:
  www.wsdot.wa.gov/publications/manuals/index.htm

The online version of the manual enables you to conduct a word search of the entire manual. Opening an individual chapter is faster, but a word search is limited to that chapter.

The *Design Manual* is continually revised to reflect changing processes, procedures, regulations, policies, and organizations. Feedback from users is encouraged to improve the manual for everyone. Comments may be submitted by any method that is convenient for you. There is a comment form in the front of the manual, or comments may be made via the contact names on the Design Policy Internet page (see link above). Note that the Design Policy Internet page includes a link to an errata page, which provides a list of known technical errors in the manual. Manual users are encouraged to view this page on a regular basis.

A contents section lists all chapters and the major headings of the sections/pages. The exhibits section lists all the exhibits in the manual.

Most chapters include a list of references, including laws, administrative codes, manuals, and other publications, which are the basis for the information in the chapter. The definitions for terms used in the *Design Manual* are found in the Glossary.

100.03 Practical Solutions

WSDOT deploys Practical Solutions to enable more flexible and sustainable transportation investment decisions. It encourages this by: (1) increasing the focus on addressing identified performance gaps (needs) throughout all phases of development, and (2) engaging local stakeholders at the earliest stages of scope definition to ensure their input is included at the right stage of the solution development process. Practical Solutions includes one or a combination of strategies, including, but not limited to, operational improvements, off-system solutions, transportation demand management, and incremental strategic capital solutions. (See Chapter 1100 for more information.)

100.04 Manual Applications

Design Manual guidance is provided to encourage the statewide uniform application of design details under normal conditions. It also guides designers through the project development process used by WSDOT. The *Design Manual* is used by the department to:

- Interpret current design principles, including American Association of State Highway and Transportation Officials (AASHTO) and other appropriate policy sources, findings, and federal and state laws.
- Develop projects that address modal and community performance needs.
- Balance the competing performance needs of highway construction projects.
- Design for low-cost solutions.

The *Design Manual* is designed to allow for flexibility in design for specific and unusual situations. For unusual circumstances, the manual provides mechanisms for documenting the reasons for the choices made.

The *Design Manual* is developed for use on Interstate and state highways and may not be suitable for projects on county roads or city streets.

100.05 Manual Use

The WSDOT *Design Manual* is intended to be used for design of department-owned facilities, especially the transportation facilities associated with state highways as designated by RCW 47.17.

For state highway routes, projects are designed using the *Design Manual* practical design approach (see Chapter 1100 and Division 11). If WSDOT guidance is not used on a project, appropriate documentation and approvals are required (see Chapters 300 and 1100).

When WSDOT designs facilities that will be turned over to local jurisdictions, those facilities are to be designed using appropriate local geometric design criteria.

When local jurisdictions design any element of state highway facilities, the *Design Manual* must be used. Local jurisdictions are free to adopt this manual for their local criteria or to develop their own specialized guidance for facilities not on state highway routes.

100.06 Manual Organization

The *Design Manual* is divided into a series of divisions that address a portion of the project development and design processes. The divisions are composed of chapters that address the general topic in detail and are, in some cases, specific to a particular discipline.

Division 1 – General Information: Presents general background on planning, managing project delivery, project development, and programming.

- **Chapter 100 – Manual Description:** Chapter content/resources within the *Design Manual*.
- **Chapter 110 – Design-Build Projects:** How the *Design Manual* applies to design-build projects: includes terminology and reference to design-build contract documents.

Division 2 – Hearings, Environmental, and Permits: Provides the designer with information about the public involvement and hearings process, the environmental documentation process, and the permit process.

- **Chapter 210 – Public Involvement and Hearings:** Developing a project-specific public involvement plan; the ingredients of an effective public involvement plan; and methods for public involvement.
- **Chapter 225 – Environmental Coordination:** Provides a summary of the relevant provisions in the *Environmental Manual*. Gives designers a brief overview and direction to environmental resources.

Division 3 – Project Documentation: Provides designers with information on value engineering, traffic analysis, design documentation, and approvals.

- **Chapter 300 – Design Documentation, Approval, and Process Review:** Building the Project File (PF) and the Design Documentation Package (DDP) and recording the recommendations and decisions that lead to a project by preserving the documents from the planning, scoping, programming, and design phases (includes permits, approvals, contracts, utility relocation, right of way, advertisement and award, and construction). Links to websites to download documentation templates.

- **Chapter 301 – Design and Maintenance Coordination – Best Practices:** Means and methods for coordinating design with maintenance concerns and needs.
- **Chapter 305 – Project Management:** Brief description and links to WSDOT project management resources.
- **Chapter 310 – Value Engineering:** A systematic, multidisciplinary process study early in the project design stage to provide recommendations to improve scope, functional design, constructability, environmental impacts, or project cost—required by federal law for high-cost, complex projects.
- **Chapter 320 – Traffic Analysis:** Procedural guidance and general requirements for conducting traffic analyses.
- **Chapter 321 – Sustainable Safety Analysis:** Informational and procedural guidance for conducting safety analyses, within the current extent of the applications.

Division 4 – Surveying: Includes criteria for surveying, mapping, and monumentation requirements.

- **Chapter 400 – Surveying and Mapping:** The procedures within WSDOT for project surveying.
- **Chapter 410 – Monumentation:** The requirements and procedures for Monumentation.

Division 5 – Right of Way and Access Control: Provides guidance on right of way considerations; interchange justification reports; limited/managed access; and fencing.

- **Chapter 510 – Right of Way Considerations:** The right of way and easement acquisition process.
- **Chapter 520 – Access Control:** WSDOT Access Control program information.
- **Chapter 530 – Limited Access Control:** Clarification on full, partial, and modified limited access control.
- **Chapter 540 – Managed Access Control:** The classes of managed access highways and the access connection permitting process.
- **Chapter 550 – Interchange Justification Report:** The process for access point revisions on limited access controlled highways and the steps for producing an interchange justification report.
- **Chapter 560 – Fencing:** The purpose of fencing, types of fencing, and fencing design criteria.

Division 6 – Soils and Paving: Presents guidance for investigating soils, rock, and surfacing materials; estimating tables; and guidance and criteria for the use of geosynthetics.

- **Chapter 610 – Investigation of Soils, Rock, and Surfacing Materials:** The requirements for qualifying a materials source, geotechnical investigations, and the documentation to be included in the Project File.
- **Chapter 620 – Design of Pavement Structures:** Estimating tables for the design of pavement structures.
- **Chapter 630 – Geosynthetics:** The types/applications of geosynthetic drainage, earthwork, erosion control, and soil reinforcement materials.

Division 7 – Structures: Provides guidance for the design of structures for highway projects, including site data for structures, bridges, retaining walls, and noise walls.

- **Chapter 700 – Project Development Roles and Responsibilities for Projects With Structures:** WSDOT's project development process: roles and responsibilities for projects with structures during the project development phase of a project.
- **Chapter 710 – Site Data for Structures:** Information required by the HQ Bridge and Structures Office to provide structural design services.
- **Chapter 720 – Bridges:** Basic design considerations for developing preliminary bridge plans and guidelines on basic bridge geometric features.
- **Chapter 730 – Retaining Walls and Steep Reinforced Slopes:** Design principles, requirements, and guidelines for retaining walls and steep reinforced slopes.
- **Chapter 740 – Noise Barriers:** Factors considered when designing a noise barrier.

Division 8 – Hydraulics: Addresses the issue of hydraulics and serves as a guide to highway designers to identify and consider hydraulic-related factors that may impact the design.

- **Chapter 800 – Hydraulic Design:** Hydraulic considerations for highway projects involving flood plains, stream crossings, channel changes, and groundwater.

Division 9 – Roadside Development: Provides guidance on the portion of state highways between the traveled way and the right of way boundary.

- **Chapter 900 – Roadside Development:** Managing the roadside environment, including the area between the traveled way and the right of way boundary, unpaved median strips, and auxiliary facilities such as rest areas, wetlands, and stormwater treatment facilities.
- **Chapter 950 – Public Art:** Policies and procedures for including public art in state transportation corridors.

Division 10 – Traffic Safety Elements: Introduces the designer to traffic safety elements such as work zone traffic control, signing, delineation, illumination, traffic control signals, and Intelligent Transportation Systems (ITS).

- **Chapter 1010 – Work Zone Safety and Mobility:** Planning, design, and preparation of highway project plans that address work zone safety and mobility requirements.
- **Chapter 1020 – Signing:** The use of signing to regulate, warn, and guide motorists.
- **Chapter 1030 – Delineation:** The use of pavement markings to designate safe traffic movement.
- **Chapter 1040 – Illumination:** Illumination design on state highway construction projects.
- **Chapter 1050 – Intelligent Transportation Systems (ITS):** Applying computer and communication technology to optimize the safety and efficiency of the highway system.

Division 11 – Practical Design: Provides practical design guidance for WSDOT projects.

- **Chapter 1100 – Practical Design:** Includes an overview and description of the WSDOT Practical Solutions initiative, the practical design process, and the relevant chapter information necessary to complete each process step.

- **Chapter 1101 – Need Identification:** Includes guidance on accurate and concise identification of project needs for practical design.
- **Chapter 1102 – Context Identification:** Guidance provided to help determine the highway's land use context and transportation context.
- **Chapter 1103 – Design Control Selection:** Provides guidance on design controls used in WSDOT projects.
- **Chapter 1104 – Alternatives Analysis:** Discusses how information determined from planning phases and *Design Manual* chapters is utilized in alternative solution formation, and how to evaluate the alternative solutions developed.
- **Chapter 1105 – Design Element Selection:** Provides guidance on selecting design elements for projects.
- **Chapter 1106 – Design Element Dimensions:** Discusses the practical design approach to selecting design element dimensions.
- **Chapter 1120 – Preservation Projects:** Provides scoping links and elements and features to be evaluated in preservation projects.

Division 12 – Geometrics: Covers geometric plan elements; horizontal alignment; lane configurations and pavement transitions; geometric profile elements; vertical alignment; geometric cross sections; and sight distance.

- **Chapter 1210 – Geometric Plan Elements:** The design of horizontal alignment, lane configuration, and pavement transitions.
- **Chapter 1220 – Geometric Profile Elements:** The design of vertical alignment.
- **Chapter 1230 – Geometric Cross Section – Basics:** Roadway cross section introductory chapter; guide to other cross section chapters; provides jurisdictional guidance.
- **Chapter 1231 – Geometric Cross Section – Highways:** Geometric cross section guidance for all highways except freeways.
- **Chapter 1232 – Geometric Cross Section – Freeways:** cross section guidance for freeways and Interstates.
- **Chapter 1238 – Geometric Cross Section – Streetside and Parking**: provides information on parking and streetside elements.
- **Chapter 1239 – Geometric Cross Section – Shoulders, Side Slopes, Curbs, and Medians:** Provides information on geometric cross section components common to many facility types. Cross section elements include: shoulders, medians and outer separations, side slopes, and curbing
- **Chapter 1240 – Turning Roadways:** Widening curves to make the operating conditions comparable to those on tangent sections.
- **Chapter 1250 – Cross Slope and Superelevation:** Cross slope design information is provided as well as superelevating curves and ramps so design speeds can be maintained.
- **Chapter 1260 – Sight Distance:** Stopping, passing, and decision sight distance design elements.

- **Chapter 1270 – Auxiliary Lanes:** Auxiliary facilities such as climbing lanes, passing lanes, slow-vehicle turnouts, shoulder driving for slow vehicles, emergency escape ramps, and chain-up areas.

Division 13 – Intersections and Interchanges: Addresses the design considerations of at-grade intersections, roundabouts, road approaches, railroad grade crossings, and traffic interchanges.

- **Chapter 1300 – Intersection Control Type:** Guidance on preliminary intersection analysis and selection of control type.
- **Chapter 1310 – Intersections:** Designing intersections at grade, including at-grade ramp terminals.
- **Chapter 1320 – Roundabouts:** Guidance on the design of roundabouts.
- **Chapter 1330 – Traffic Control Signals:** The use of power-operated traffic control devices that warn or direct traffic.
- **Chapter 1340 – Driveways:** The application and design of road approaches on state highways.
- **Chapter 1350 – Railroad Grade Crossings:** The requirements for highways that cross railroads.
- **Chapter 1360 – Traffic Interchanges:** The design of interchanges on interstate highways, freeways, and other multilane divided routes.
- **Chapter 1370 – Median Crossovers:** Guidance on locating and designing median crossovers for use by maintenance, traffic service, emergency, and law enforcement vehicles.

Division 14 – HOV and Transit: Provides design guidance on HOV lanes and transit facilities.

- **Chapter 1410 – High-Occupancy Vehicle Facilities:** Evaluating and designing high-occupancy vehicle (HOV) facilities.
- **Chapter 1420 – HOV Direct Access:** Design guidance on left-side direct access to HOV lanes and transit facilities.
- **Chapter 1430 – Transit Facilities:** Operational guidance and information for designing transit facilities such as park & ride lots, transfer/ transit centers, and bus stops and pullouts.

Division 15 – Pedestrian and Bicycle Facilities: Provides guidance on pedestrian and bicycle facility design.

- **Chapter 1510 – Pedestrian Facilities:** Designing facilities that encourage efficient pedestrian access that meets ADA.
- **Chapter 1515 – Shared-Use Paths:** Guidance that emphasizes pedestrians are users of shared-use paths and accessibility requirements apply in their design.
- **Chapter 1520 – Roadway Bicycle Facilities:** Selecting and designing useful and cost-effective bicycle facilities.

Division 16 – Roadside Safety Elements: Addresses design considerations for the area outside the roadway, and includes clear zone, roadside hazards, safety mitigation, traffic barriers, and impact attenuator systems.

- **Chapter 1600 – Roadside Safety:** Clear zone design, roadside hazards to consider for mitigation, and some roadside safety features.
- **Chapter 1610 – Traffic Barriers:** Design of traffic barriers based on the design levels identified in the design matrices.
- **Chapter 1620 – Impact Attenuator Systems:** Permanent and work zone impact attenuator systems.

Division 17 – Roadside Facilities: Provides design guidance for the area outside the roadway, including rest areas and truck weigh sites.

- **Chapter 1710** – **Safety Rest Areas and Traveler Services**: Typical layouts for safety rest areas.
- **Chapter 1720 – Weigh Sites:** Guidance on designing permanent, portable, and shoulder-sited weigh sites.

Chapter 210 Public Involvement and Hearings

210.01 General

The Washington State Department of Transportation (WSDOT) strives to keep the public informed about transportation issues, involve the public in transportation decision making, and make transportation decisions based on the public's best interests.

One of the best ways to achieve WSDOT's goals is to collaborate with the public, community groups, and various agencies. These participants often have differing, and sometimes conflicting, perspectives and interests. In addition, many participants and organizations are not able to spend the time and effort required to fully engage in transportation decision making. Despite these challenges, active collaboration:

- Gives WSDOT access to important information and new ideas.
- Puts us in a position to help solve problems and resolve conflicts.
- Creates a sense of community.
- Fosters greater acceptance of projects.
- Helps us build and sustain a credible and trusting relationship with the public.
- Ultimately leads to transportation improvements that better meet the public's needs and desires.

When collaborating with the public about transportation projects or issues, WSDOT uses more formal techniques like public hearings, direct mail, and presentations to city councils and legislators; as well as less formal but equally important techniques, like telephone and e-mail discussions, meetings with community groups, media relations, and project Internet pages.

Law requires that many types of capital transportation projects go through a formal public hearing process; thus, the legal procedures necessary for public hearings is the primary focus of this chapter. Public involvement plans are briefly discussed, and referrals to WSDOT's communications resources are included to further guide their development and implementation.

210.02 References

(1) Federal/State Laws and Codes

United States Code (USC) Title 23, Highways, Sec. 128, Public hearings

USC Title 23, Highways, Sec. 771.111, Early coordination, public involvement, and project development

23 Code of Federal Regulations (CFR) 200.7, FHWA Title VI Policy

23 CFR 200.9(b)(4), Develop procedures for the collection of statistical data of participants and beneficiaries of state highway programs

23 CFR 200.9(b)(12), Develop Title VI information for dissemination to the general public

23 CFR 450.212, Public involvement

28 CFR Part 35, Nondiscrimination on the basis of disability in state and local government services

49 CFR Part 27, Nondiscrimination on the basis of disability in programs or activities receiving federal financial assistance

Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 36, Appendix A)

Civil Rights Restoration Act of 1987

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations

Executive Order 13166, Improving Access to Services for Persons with Limited English Proficiency

Revised Code of Washington (RCW) 47.50, Highway Access Management

RCW 47.52, Limited Access Facilities

Section 504 of the Rehabilitation Act of 1973, as amended

Title VI of the Civil Rights Act of 1964

(2) Design Guidance

Design Manual, Chapter 225, for environmental references, and Division 5 chapters for access control and right of way references

Environmental Manual, M 31-11
www.wsdot.wa.gov/publications/manuals/m31-11.htm

WSDOT Headquarters (HQ) Access and Hearings Section Manager, (360) 705-7266 home page:
www.wsdot.wa.gov/design/accessandhearings

(3) Supporting Information

Improving the Effectiveness of Public Meetings and Hearings, Federal Highway Administration (FHWA) Guidebook

Public Involvement Techniques for Transportation Decision-Making, FHWA September 1996; provides tools and techniques for effective public involvement:
www.fhwa.dot.gov/reports/pittd/cover.htm

Relocation brochures: www.wsdot.wa.gov/realestate

WSDOT *Communications Manual* for public involvement:
www.wsdot.wa.gov/communications/

WSDOT Context Sensitive Solutions Internet site and national context sensitive site:
http://www.wsdot.wa.gov/design/policy/csdesign
www.contextsensitivesolutions.org/

210.03 Definitions

affidavit of publication A notarized written declaration stating that a ***notice of hearing*** (or ***notice of opportunity for a hearing***) was published in the legally prescribed manner.

affidavit of service by mailing A notarized written declaration stating that the limited access hearing packet was mailed at least 15 days prior to the hearing and entered into the record at the hearing.

auxiliary aids and services (1) Qualified interpreters, notetakers, transcription services, written materials, telephone handset amplifiers, assistive listening devices, assistive listening systems, telephones compatible with hearing aids, open and closed captioning, telecommunications devices for deaf persons (TDDs), videotext displays, or other effective methods for making aurally delivered materials available to individuals with hearing limitations; (2) Qualified readers, taped texts, audio recordings, Brailled materials, large print materials, or other effective methods for making visually delivered materials available to individuals with visual impairments; (3) Acquisition or modification of equipment or devices; (4) Other similar services and actions; and (5) Providing and disseminating information, written materials, and notices in languages other than English, where appropriate.

context sensitive solutions (CSS) *A collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic, and environmental resources while maintaining safety and mobility. CSS is an approach that considers the total context within which a transportation improvement project will exist*.* (See 210.02 and 210.04(2) for more information.)

*From *"Understanding Flexibility in Transportation Design – Washington,"* WSDOT, April 2005

court reporter A person with a license to write and issue official accounts of judicial or legislative proceedings.

findings and order A document containing the findings and conclusions of a limited access hearing approved by the Assistant Secretary, Engineering & Regional Operations (see 210.09(12) and (13)).

hearing An assembly to which the public is invited and at which participation is encouraged. Types of hearings include:

- ***administrative appeal hearing*** A formal process whereby a property owner may appeal WSDOT's implementation of access management legislation. The appeal is heard by an administrative law judge (ALJ), who renders a decision. (See Chapter 540 for administrative appeal hearing procedures.)

- ***combined hearing*** A hearing held when there are public benefits to be gained by combining environmental, corridor, design, and/or limited access subjects.
- ***corridor hearing*** A formal or informal hearing that presents the corridor alternatives to the public for review and comment before a commitment is made to any one route or location. This type of hearing is beneficial for existing corridors with multiple Improvement projects programmed over a long duration.
- ***design hearing*** A formal or informal hearing that presents the design alternatives to the public for review and comment before the selection of a preferred alternative.
- ***environmental hearing*** A formal or informal hearing documenting that social, economic, and environmental impacts have been considered and that public opinion has been solicited.
- ***limited access hearing*** A formal hearing that gives local public officials, owners of abutting properties, and other interested persons an opportunity to be heard about the limitation of access to the highway system.
- ***formal hearing format*** A hearing conducted by a moderator using a formal agenda, overseen by a hearing examiner, and recorded by a court reporter, as required by law. Limited access hearings require the use of the formal hearing format (see 210.05(3)).
- ***informal hearing format*** A hearing where oral comments are recorded by a court reporter, as required by law. An informal hearing often uses the "open house" format (see 210.04(1)(a)). A formal agenda and participation by a hearing examiner are optional.

hearing agenda An outline of the actual public hearing elements, used with formal hearings. (See 210.05(9)(a) for contents.)

Hearing Coordinator The HQ Access and Hearings Section Manager, (360) 705-7266.

hearing examiner An administrative law judge from the Office of Administrative Hearings, or a WSDOT designee, appointed to moderate a hearing.

hearing script A written document of text to be presented orally by department representatives at a hearing.

hearing summary Documentation prepared by the region and approved by Headquarters that summarizes environmental, corridor, and design hearings. (See 210.05(10) for content requirements.)

hearing transcript A document prepared by the court reporter that transcribes verbatim all oral statements made during the hearing, including public comments. This document becomes part of the official hearing record.

NEPA National Environmental Policy Act.

notice of appearance A form provided by WSDOT for anyone wanting to receive a copy of the findings and order and the adopted limited access plan (see 210.09(3) and (8)).

notice of hearing (or ***hearing notice***) A published advertisement that a public hearing will be held.

notice of opportunity for a hearing An advertised offer to hold a public hearing.

order of hearing The official establishment of a hearing date by the Director & State Design Engineer, Development Division.

prehearing packet A concise, organized collection of all necessary prehearing data, prepared by the region and approved by the HQ Access and Hearings Section Manager prior to the hearing (see 210.05(4) and Exhibit 210-3).

project management plan A formal, approved document that defines how the project is executed, monitored, and controlled. It may be in summary or detailed form and may be composed of one or more subsidiary management plans and other planning documents. For further information, see the *Project Management Online Guide*:
http://www.wsdot.wa.gov/projects/projectmgmt/pmog.htm

public involvement plan A plan to collaboratively involve the public in decision making, tailored to the specific needs and conditions of a project and the people and communities it serves. It is often part of a broader communications plan.

relocation assistance program A program that establishes uniform procedures for relocation assistance that will ensure legal entitlements and provide fair, equitable, and consistent treatment to persons displaced by WSDOT-administered projects, as defined in the *Right of Way Manual*.

résumé An official notification of action taken by WSDOT following adoption of a findings and order (see 210.09(14)).

SEPA State Environmental Policy Act.

study plan A term associated with environmental procedures, this plan proposes an outline or "road map" of the environmental process to be followed during the development of a project that requires complex NEPA documentation. (See 210.06 and the *Environmental Manual*.)

210.04 Public Involvement

Developing and implementing an effective plan for collaboration with the public:

- Is critical to the success of WSDOT's project delivery effort.
- Provides an opportunity to understand and achieve diverse community and transportation goals.

Effective public involvement must begin with clearly defined, project-related goals that focus on specific issues, specific kinds of input needed, and specific people or groups that need to be involved. The more detailed a public involvement plan, the greater its chances of obtaining information WSDOT can use in decision making.

Transportation projects with high visibility or community issues or effects often attract the attention of a broad range of interested people. These types of projects will best benefit from early public involvement, which can influence the project's success and community acceptance.

Developing a profile (through demographic analysis) of the affected community is critical to achieving successful public involvement and should be the first order of business when developing a public involvement plan. The profile will enable the department to tailor its outreach efforts toward the abilities and needs of the community.

Individuals from minority and ethnic groups and low-income households, who are traditionally underserved by transportation, often find participation difficult. While these groups form a growing portion of the population, particularly in urban areas, historically they have experienced barriers to participation in the public decision-making process and are therefore underrepresented. These barriers arise from both the historical nature of the public involvement process and from cultural, linguistic, and economic differences. For example, a community made up of largely senior citizens (with limited mobility/automobile usage) may mean:

- Meetings/open houses are planned in locations easily accessible to them, such as senior centers and neighborhood community centers.
- Meetings are scheduled in the mornings or midday to accommodate individuals who prefer not to leave home after dark.
- Meetings are scheduled in the evenings to accommodate persons who work during the day.

A project's affected area might consist of a population with limitations in speaking or understanding English. This may entail:

- Developing/disseminating materials in other languages, as appropriate.
- Having a certified translator on hand at the meetings.

Extra effort may be needed to elicit involvement from people unaccustomed to participating in the public involvement process. They often have different needs and perspectives than those who traditionally participate in transportation decision making, and they may have important, unspoken issues that should be heard. They not only may have greater difficulty getting to jobs, schools, recreation, and shopping than the population at large, but also they are often unaware of transportation proposals that could dramatically change their lives.

NEPA and SEPA environmental policies and procedures are intended to provide relevant environmental information to public officials, agencies, and citizens, and allow public input to be considered before decisions are made. There are also various other laws, regulations, and policies that emphasize public involvement, including 23 CFR, Title VI of the Civil Rights Act, the Americans with Disabilities Act, and Executive Orders 12898 and 13166.

WSDOT's collaborative process with the public should be open, honest, strategic, consistent, inclusive, and continual. Initiating a project in an atmosphere of collaboration and partnership can go a long way toward providing equal opportunities for all parties (local, state, tribal, private, nonprofit, or federal) to participate in a project vision. This collaboration requires an intensive communications effort that is initiated during project visioning and extends through construction and eventual operation of the facility.

Department specialists in public communications, environmental procedures, traffic engineering, real estate services, and limited access control are routinely involved with public outreach efforts and project hearings. Depending on the scale and complexity of a project, the region is encouraged to engage the participation of interdisciplinary experts when developing a public involvement plan and communicating project details.

Chapter 300 Design Documentation, Approval, and Process Review

300.01 General

This chapter provides the WSDOT design procedures, documentation and approvals necessary to deliver successful projects on the transportation network in Washington, including projects involving the Federal Highways Administration.

This chapter presents critical information for design teams, including:

- WSDOT's Project Development process.
- Design documentation tools, procedures, and records retention policy.
- Major Project approvals including Design Approval, Project Development Approval, Basis of Design, Design Analysis, and other specific project documents for design-bid-build and for design-build delivery methods.
- FHWA oversight and approvals on Projects of Division Interest (PoDI).
- WSDOT and FHWA approvals for non-PoDI projects including Interstate new and reconstruction and other specific documents as shown in the approvals exhibits.
- Information about conducting project process reviews.
- Additional references and resources.

For local agency and developer projects on state highways, design documentation is also needed. It is retained by the region office responsible for the project oversight, in accordance with the WSDOT records retention policy. All participants in the design process are to provide the appropriate documentation for their decisions. For more information about these types of projects, see the *Local Agency Guidelines* and *Development Services Manual* available at the Publications Services Index website:
www.wsdot.wa.gov/Publications/Manuals/index.htm

For operational changes identified by the Traffic Office Low Cost Enhancement or Field Assessment Program that are included in a project, design documentation is also needed. It is retained by the region office responsible for the project oversight, in accordance with the WSDOT records retention policy. This documentation will be developed by the region Traffic Office in accordance with HQ Traffic Office direction and included in the design documentation for the project.

For emergency projects, also refer to the *Emergency Relief Procedures Manual*. It provides the legal and procedural guidelines for WSDOT employees to prepare all necessary documentation to respond to, and recover from, emergencies and disasters that affect the operations of the department.

300.02 WSDOT Project Delivery

A project, and its delivery method, is developed in accordance with all applicable procedures, Executive Orders, Directives, Instructional Letters, Supplements, and manuals; the Washington State Highway System Plan; approved corridor sketches and planning studies; the FHWA/WSDOT Stewardship and Oversight Agreement; scoping phase documentation, and the Basis of Design.

The delivery method is determined using the WSDOT Project Delivery Method Selection Guidance Memorandum found here:
www.wsdot.wa.gov/Projects/delivery/designbuild/PDMSG.htm

See the implementation memorandum for procedural policy and guidance in the selection of probable and final project delivery method, timing for these determinations, and approval and endorsement levels.

The region develops and maintains documentation for each project using this chapter and the Project File / Design Documentation Package checklists (see 300.03(3))

Refer to the *Plans Preparation Manual* for PS&E documentation. Exhibit 300-4 is an example checklist of recommended items to be turned over to the construction office at the time of project transition. An expanded version is available here:
www.wsdot.wa.gov/design/projectdev/

300.02(1) Environmental Requirements

All projects involving a federal action require National Environmental Policy Act (NEPA) documentation. WSDOT uses the Environmental Review Summary (ERS) portion of Project Summary for FHWA concurrence on the environmental class of action (EIS/EA/CE). The environmental approval levels are shown in Exhibit 300-2.

Upon receipt of the ERS approval for projects requiring an EA or EIS under NEPA, the region proceeds with environmental documentation, including public involvement, appropriate for the magnitude and type of the project (see Chapter 210 and *WSDOT Community Engagement Plan*).

300.02(2) Real Estate Acquisition

Design Approval and approval of right of way plans are required prior to acquiring property. A temporary construction easement may be acquired prior to Design Approval for State funded projects and with completion of NEPA for Federally funded projects. For early acquisition of right of way, consult the Real Estate Services Office, the April 2, 2013 memorandum on early acquisition policy, and *Right of Way Manual* Chapter 6-3.

300.03 Design Documentation and Records Retention Policy

300.03(1) Purpose

Design documentation records the evaluations and decisions by the various disciplines that result in design recommendations. Design assumptions and decisions made prior to and during the scoping phase are included. Changes that occur throughout project development are documented. Required justifications and approvals are also included.

300.03(2) Certification of Documents by Licensed Professionals

All original technical documents must bear the certification of the responsible licensee as listed in Executive Order E 1010.

300.03(3) Project File and Design Documentation Package

The Project File and Design Documentation Package include documentation of project work, including planning; scoping; community engagement; environmental action; the Basis of Design; right of way acquisition; Plans, Specifications, and Estimates (PS&E) development; project advertisement; and construction.

The **Project File (PF)** contains the documentation for planning, scoping, programming, design, approvals, contract assembly, utility relocation, needed right of way, advertisement, award, construction, and maintenance review comments for a project. A Project File is completed for all projects and is retained by the region office responsible for the project. Responsibility for the project may pass from one office to another during the life of a project, and the Project File follows the project as it moves from office to office. With the exception of the DDP, the Project File may be purged when retention of the construction records is no longer necessary.

See the Project File checklist for documents to be preserved in the Project File:
www.wsdot.wa.gov/Design/Support.htm

The **Design Documentation Package (DDP)** is a part of the Project File and preserves the decision documents generated during the design process. In each package, a summary (list) of the documents included is recommended. The DDP documents and explains design decisions, design criteria, and the design process that was followed. The DDP is retained in a permanent retrievable file for a period of 75 years, in accordance with the Washington State Department of Transportation (WSDOT) records retention policy.

The Basis of Design, Design Parameters, Alternatives Comparison Table, and Design Analyses are tools developed to document WSDOT practical design and decisions. Retain these in the DDP.

Refer to the remainder of this chapter and DDP checklist for documents to be preserved in the DDP. See Design Documentation Package Checklist here:
www.wsdot.wa.gov/Design/Support.htm

300.04 Project Design Approvals

This section describes WSDOT's project design milestones known as Design Approval and Project Development Approval. They are required approvals regardless of delivery method chosen by WSDOT. Many of the documents listed under these milestones are described further in 300.06.

Information pertaining to FHWA approvals and oversight is provided in 300.05 which describes Projects of Division Interest (PoDI) which are governed by a separate plan that specifies FHWA and State responsibilities for the project. Documents for projects requiring FHWA review, Design Approval, and Project Development Approval are submitted through the HQ Design Office.

300.04(1) Design Approval

When the Project Summary (see 300.06) documents are approved, and the region is confident that the proposed design adequately addresses the purpose and need for the project, a Design Approval should be pursued and granted at this early stage. Early approval is beneficial at this point in the design phase and is most relevant to larger projects with longer PE phases Design Approval establishes the policy for three years. This is a benefit for longer PE phases in that it avoids design changes due to policy updates during that time and provides consistency when purchasing right of way or producing environmental documentation.

The items below are included in the combined Design Approval/Project Development Approval Package. Design Approval may occur prior to NEPA approval. Generally, Design Approval will not be provided prior to an IJR being approved on an Interstate project. Approval levels for design and PS&E documents are presented in Exhibits 300-1 through 300-3.

The following items are to be provided for Design Approval. See 300.06 for additional information.

- Stamped cover sheet (project description)
- A reader-friendly memo that describes the project
- Project Summary documents
- Basis of Design
- Alternatives Comparison Table
- Design Parameters worksheets
- Crash Analysis Report or Safety Analysis
- Design Analysis
- List of known Variances (contact your ASDE)
- Channelization plans, intersection plans, or interchange plans (if applicable)
- Alignment plans and profiles (if project significantly modifies either the existing vertical or horizontal alignment)
- Current cost estimate with a Basis of Estimate
- Completed Environmental Review Summary (see Section 300.02(1)). Required environmental documentation (Design-Build projects only) Required environmental documentation (Design-Build projects only)

Design Approval is entered into the Design Documentation Package and remains valid for three years or as approved by the HQ Design Office.

- If the project is over this three-year period and has not advanced to Project Development Approval, evaluate policy changes or revised design criteria that are adopted by the department during this time to determine whether these changes would have a significant impact on the scope or schedule of the project.
- If it is determined that these changes will not be incorporated into the project, document this decision with a memo from the region Project Development Engineer that is included in the DDP.
- For an overview of design policy changes, consult the Detailed Chronology of Design Manual revisions: www.wsdot.wa.gov/design/policy/default.htm

300.04(1)(a) Design-Build Projects

Design Approval applies to design-build projects and is required prior to issuing a design-build request for proposal (RFP).

Environmental documentation completion is recommended prior to issuing RFP, but is required prior to contract execution.

300.04(2) Project Development Approval

When all project development documents are completed and approved, Project Development Approval is granted by the approval authority designated in Exhibit 300-1. The Project Development Approval becomes part of the DDP.

Refer to this chapter and the DDP checklist for design documents that may lead to Project Development Approval. Exhibits 300-1 through 300-3 provide approval levels for project design and PS&E documents.

The following items must be approved prior to Project Development Approval:

- Required environmental documentation
- Design Approval documents (and any supplements)
- Updated Basis of Design
- Updated list of Variances (Contact your ASDE)
- Updated Cost estimate
- Stamped cover sheet (project description)

Project Development Approval remains valid for three years.

- Evaluate policy changes or revised design criteria that are adopted by the department during this time to determine whether these changes would have a significant impact on the scope or schedule of the project.
- If it is determined that these changes will not be incorporated into the project, document this decision with a memo from the region Project Development Engineer that is included in the DDP.

- For an overview of design policy changes, consult the Detailed Chronology of Design Manual revisions: www.wsdot.wa.gov/design/policy/default.htm

300.04(2)(a) Design-Build Projects

For design-build projects, the design-builder shall refer to the project Request for Proposal (RFP) for specification on final and intermediate deliverables and final records for the project. Project Development Approval is required prior to project completion.

It is a prudent practice to start the compilation of design documentation early in a project and to acquire Project Development Approval before the completion of the project. At the start of a project, it is critical that WSDOT project administration staff recognize the importance of all required documentation and how it will be used in the design-build project delivery process.

300.05 FHWA Oversight and Approvals

The March 2015 Stewardship & Oversight (S&O) Agreement between WSDOT and FHWA Washington Division created new procedures and terminology associated with FHWA oversight and approvals. One such term, and new relevant procedure, is "Projects of Division Interest" (PoDI) described below.

For all projects, on the National Highway System (NHS), the level of FHWA oversight and approvals can vary for numerous reasons such as type of project, the agency doing the work, PoDI/non-PoDI designation, and funding sources. Oversight and funding do not affect the level of design documentation required for a project.

Documents for projects requiring FHWA review, Design Approval, and Project Development Approval are submitted through the HQ Design Office.

300.05(1) FHWA Projects of Division Interest (PoDI)

Projects of Division Interest (PoDI) are a primary set of projects for which FHWA determines the need to exercise oversight and approval authority. These are projects that have an elevated risk, contain elements of higher risk, or present a meaningful opportunity for FHWA involvement to enhance meeting program or project objectives. Collaborative identification of these projects allows FHWA Washington Division to concentrate resources on project stages or areas of interest. It also allows WSDOT to identify which projects are PoDIs and plan for the expected level of engagement with FHWA.

The Stewardship & Oversight Agreement generally defines Projects of Division Interest as:

- Major Projects (A federal aid project with total cost >$500M)
- TIGER Discretionary Grant Projects
- NHS Projects that may require FHWA Project or Program Approvals
- Projects Selected by FHWA based on Risk or Opportunity

The S&O Agreement also states: Regardless of retained project approval actions, any Federal-aid Highway Project either on or off the NHS that the Division identifies as having an elevated level of risk can be selected for risk-based stewardship and oversight and would then be identified as a PoDI.

For each project designated as a PoDI, FHWA and WSDOT prepare a Project-Specific PoDI Stewardship & Oversight Agreement which identifies project approvals and related responsibilities specific to the project.

300.05(2) FHWA Approvals on Non-PoDI Projects

On projects that are not identified as PoDI, FHWA approvals are still required for various items as shown in Exhibit 300-1. For example, FHWA approval is still required for any new or revised access point (including interchanges, temporary access breaks, and locked gate access points) on the Interstate System, regardless of funding source or PoDI designation (see Chapter 550).

The Exhibit 300-1 approval table refers to New/Reconstruction projects on the Interstate. New/Reconstruction projects include the following types of work:

- Capacity changes: add a through lane, convert a general-purpose (GP) lane to a special-purpose lane (such as an HOV or HOT lane), or convert a high-occupancy vehicle (HOV) lane to GP.
- Other lane changes: add or eliminate a collector-distributor or auxiliary lane. (A rural truck climbing lane that, for its entire length, meets the warrants in Chapter 1270 is not considered new/reconstruction.)
- New interchange.
- Changes in interchange type such as diamond to directional or adding a ramp.
- New or replacement bridge (on or over, main line, or interchange ramp).
- New Safety Rest Areas Interstate.

Documents for projects requiring FHWA review, Design Approval, and Project Development Approval are submitted through the HQ Design Office.

300.06 Project Documents and Approvals

This section lists several major design documents generated for a project and they all are retained in the Design Documentation Package. The Basis of Design, Alternatives Comparison Table, Design Parameters, and Design Analyses are tools used to document practical design decisions.

See the Project File and Design Documentation Package checklists described in 300.03(3) for complete list of documents.

For approval levels see Exhibits 300-1 through 300-3 or a project-specific S&O Agreement for PoDI projects.

300.06(1) Project Summary

The Project Summary provides information on the results of the scoping phase; links the project to the Washington State Highway System Plan and the Capital Improvement and Preservation Program (CIPP); and documents the design decisions, the environmental classification, and agency coordination. The Project Summary is developed and approved before the project is funded for design and construction, and it consists of the ERS, and PD documents. The Project Summary database contains specific online instructions for completing the documents.

300.06(1)(a) Project Definition (PD)

The PD identifies the various disciplines and design elements that are anticipated to be encountered in project development. It also states the purpose and need for the project, the program categories, and the recommendations for project phasing. The PD is initiated early in the scoping phase to provide a basis for full development of the ERS, schedule, estimate, Basis of Estimate, and Basis of Design (where indicated in scoping instructions). If circumstances necessitate a change to an approved PD, process a Project Change Request Form for approval by the appropriate designee.

300.06(1)(b) Environmental Review Summary (ERS)

The ERS lists the potentially required environmental permits and approvals, environmental classifications, and environmental considerations. The ERS is prepared during the scoping phase and is approved by the region. If there is a change in the PD, the information in the ERS must be reviewed and revised to match the rest of the Project Summary. For actions classified as a CE under NEPA, the approved ERS becomes the ECS when the project is funded and moves to design. The region may revise the ECS as appropriate (usually during final design) as the project advances. The ECS serves as the NEPA environmental documentation for CE projects. The region Environmental Manager approves the ECS and may send it to FHWA for their approval. The ERS/ECS database includes fully integrated help screens that provide detailed guidance. Contact your region Environmental Office for access.

300.06(2) Basis of Design (BOD)

The BOD captures important decisions that control the outcome of a project, including identified performance needs, context, design controls and design elements necessary to design the practical alternative. When applicable attach supporting documents, such as the Alternatives Comparison Table and Design Parameters to the BOD. (See Chapter 1100 for further discussion on these documents). The Basis of Design (BOD) is part of the DDP.

300.06(3) Basis of Estimate (BOE)

The BOE contains the assumptions, risks, and information used to develop an estimate. The BOE is reviewed and updated during each phase of a project. The confidence of the estimate, either overall or for particular items, is also identified within the BOE. Generally, the BOE is started during the scoping phase because it is required for Project Summary approval; however, in more complex situations the BOE may have begun during the planning phase. For more information, see the *Cost Estimating Manual for WSDOT Projects*.

300.06(4) Design Analysis

A Design Analysis is a process and tool used to document important design decisions, summarizing information needed for an approving authority to understand and support the decision.

A Design Analysis is required where a dimension chosen for a design element that will be changed by the project is outside the range of values provided for that element in the *Design Manual*. A Design Analysis is also required where the need for one is specifically referenced in the *Design Manual*.

A region approved Design Analysis is required if a dimension or design element meets current AASHTO guidance adopted by the Federal Highway Administration (FHWA), such as A Policy on Geometric Design of Highways and Streets, but is outside the corresponding *Design Manual* criteria. See Exhibit 300-1 for Design Analysis approval authorities.

In the case of a shoulder width reduction at an existing bridge pier or abutment, sign structure or luminaire base in a run of median barrier, the Design Parameter Sheet may be used instead of a Design Analysis to document the dimensioning decision for the shoulder at that location.

A template is available to guide the development of the Design Analysis document here: www.wsdot.wa.gov/design/support.htm.

Email a PDF copy of all Region approved Design Analyses to the ASDE supporting your region.

300.07 Process Review

The Assistant State Design Engineers work with the regions on project development and conduct process reviews on projects. The process review is done to provide reasonable assurance that projects are prepared in compliance with established policies and procedures and that adequate records exist to show compliance with state and federal requirements. Process reviews are conducted by WSDOT, FHWA, or a combination of both.

The design and PS&E process review is performed at least once each year by the HQ Design Office. The documents used in the review process are the Design Documentation Package Checklist(s), Basis of Design, Basis of Estimate, the PS&E Review Checklist, and the PS&E Review Summary. These are generic forms used for all project reviews. Copies of these working documents are available for reference when assembling project documentation. The HQ Design Office maintains current copies at: www.wsdot.wa.gov/design/support.htm.

Each project selected for review is examined completely and systematically beginning with the scoping phase (including planning documents) and continuing through contract plans and, when available, construction records and change orders. Projects are normally selected after contract award. For projects having major traffic design elements, the HQ Traffic Operations Office is involved in the review. The WSDOT process reviews may be held in conjunction with FHWA process reviews.

The HQ Design Office schedules the process review and coordinates it with the region and FHWA.

300.07(1) Process Review Agenda

When conducting joint process review with FHWA, the Process Review Report will outline specific agenda items.

A WSDOT process review follows this general agenda:

1. Review team meets with region personnel to discuss the objective of the review.
2. Review team reviews the design and PS&E documents, construction documents, and change orders (if available) using the checklists.
3. Review team meets with region personnel to ask questions and clarify issues of concern.
4. Review team meets with region personnel to discuss findings.

5. Review team submits a draft report to the region for comments and input.
6. If the review of a project shows a serious discrepancy, the region design authority is asked to report the steps that will be taken to correct the deficiency.
7. Process review summary forms are completed.
8. Summary forms and checklists are evaluated by the Director & State Design Engineer, Development Division.
9. Findings and recommendations of the Director & State Design Engineer, Development Division, are forwarded to the region design authority for action and/or information within 30 days of the review.

300.08 References

300.08(1) Federal/State Laws and Codes

23 Code of Federal Regulations (CFR) 635.111, Tied bids

23 CFR 635.411, Material or product selection

Revised Code of Washington (RCW) 47.28.030, Contracts – State forces – Monetary limits – Small businesses, minority, and women contractors – Rules

RCW 47.28.035, Cost of project, defined

"Washington Federal-Aid Stewardship Agreement,"
www.wsdot.wa.gov/publications/fulltext/design/ASDE/2015_Stewardship.pdf

300.08(2) Design Guidance

WSDOT Directional Documents Index, including the one listed below:
http://wwwi.wsdot.wa.gov/publications/policies

Executive Order E 1010, "Certification of Documents by Licensed Professionals," WSDOT

WSDOT technical manuals, including those listed below:

www.wsdot.wa.gov/publications/manuals/index.htm

- *Advertisement and Award Manual*, M 27-02, WSDOT
- *Cost Estimating Manual for WSDOT Projects*, M 3034.03, WSDOT
- *Design Manual*, M 22-01, WSDOT
- *Emergency Relief Procedures Manual*, M 3014, WSDOT
- *Environmental Manual*, M 31-11, WSDOT
- *Hydraulics Manual*, M 23-03, WSDOT
- *Highway Runoff Manual*, M 31-16, WSDOT
- *Plans Preparation Manual*, M 22-31, WSDOT
- *Project Control and Reporting Manual*, M 3026, WSDOT
- *Roadside Manual*, M 25-30, WSDOT
- *Roadside Policy Manual*, M 3110, WSDOT
- *Temporary Erosion and Sediment Control Manual*, M 3109, WSDOT

Limited Access and Managed Access Master Plan, WSDOT
www.wsdot.wa.gov/design/accessandhearings/

Washington State Highway System Plan, WSDOT
www.wsdot.wa.gov/planning/

300.08(3) Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2011

Mitigation Strategies for Design Exceptions, FHWA, July 2007. This publication provides detailed information on design exceptions and mitigating the potential adverse impacts to highway safety and traffic operations.

Highway Capacity Manual (HCM), latest edition, Transportation Research Board, National Research Council

Highway Safety Manual (HSM), AASHTO

Exhibit 300-1 Approval Authorities

Project Type	Basis of Design (BOD) Approval	Design Analysis Approval [1] [2] [11]	Design Approval and Project Development Approval
Project of Division Interest (PoDI)	[10]	[10]	[10]
Interstate			
New/Reconstruction Regardless of funding source [3]	FHWA	FHWA	FHWA [4]
Intelligent Transportation Systems (ITS) Improvement Project over $1 million Preservation project	 HQ Design HQ Design	 HQ Design HQ Design	 HQ Design Region
All Other Regardless of funding source [12]	HQ Design	HQ Design	Region
National Highway System (NHS)			
Projects on all limited access highways, or on managed access highways outside of incorporated cities and towns	HQ Design	HQ Design [5]	Region
Projects on managed access highways within incorporated cities and towns Inside curb or EPS [6][7] Outside curb or EPS	 HQ Design City/Town	 HQ Design HQ LP	 Region City/Town
Non-National Highway System (Non-NHS)			
Improvement projects on all limited access highways, or on managed access highways outside of incorporated cities and towns	HQ Design	HQ Design	Region
Improvement projects on managed access highways within incorporated cities and towns [9] Inside curb or EPS [6][7] Outside curb or EPS	 HQ Design City/Town	 HQ Design HQ LP	 Region City/Town
Preservation projects on limited access highway, or on managed access highways outside of incorporated cities and towns, or within unincorporated cities and towns [8]	Region	Region	Region
Preservation projects on managed access highways within incorporated cities and towns [8] Inside curb or EPS [6][7] Outside curb or EPS	 Region City/Town	 Region HQ LP	 Region City/Town

FHWA = Federal Highway Administration
HQ = WSDOT Headquarters
HQ LP = WSDOT Headquarters Local Programs Office
EPS = Edge of paved shoulder where curbs do not exist
NHS = National Highway System
www.wsdot.wa.gov/mapsdata/travel/hpms/NHSRoutes.htm

For table notes, see the following page.

Exhibit 300-1 Approval Authorities (continued)

Notes:

[1] These approval levels also apply to Design Analysis processing for local agency and developer work on a state highway.

[2] See 300.06(4). Where still encountered in the *Design Manual* replace the term *deviation* with *Design Analysis*.

[3] For definition of New/Reconstruction, see 300.05(2).

[4] FHWA will provide Design Approval prior to NEPA Approval, but will not provide Project Development Approval until NEPA is complete.
http://www.wsdot.wa.gov/publications/fulltext/design/ASDE/2015_Stewardship.pdf

[5] For guidance on the need for Design Analyses related to access management, see Chapters 530 and 540.

[6] Includes raised medians (see Chapter 1600).

[7] Curb ramps are still included (see Chapter 1510).

[8] For Bridge Replacement projects in the Preservation program, follow the approval level specified for Improvement projects.

[9] Refer to RCW 47.24.020 for more specific information about jurisdiction and responsibilities that can affect approvals.

[10] Projects of Division Interest (PoDI) must receive FHWA approvals per the PoDI Agreement regardless of funding source or project type.

[11] A region approved Design Analysis is required if a dimension or design element meets current AASHTO guidance adopted by the Federal Highway Administration (FHWA), such as *A Policy on Geometric Design of Highways and Streets*, but is outside the range of corresponding *Design Manual* criteria. Email a PDF copy of all Region approved Design Analyses to the ASDE supporting your region.

[12] Reduction of through lane or shoulder widths (regardless of project type) requires FHWA review and approval, except shoulder reductions for existing bridge pier or abutment, sign structure or luminaire base in a run of median barrier as allowed by 300.06(4).

Exhibit 300-2 Approvals

Item	Approval Authority		
	Region	HQ	FHWA
Program Development			
Work Order Authorization		X	X [1]
Public Hearings			
Corridor Hearing Summary		X [2]	
Design Hearing Summary		X [3]	X [8]
Limited Access Hearing Plan		X [4]	
Limited Access Findings and Order		X [5]	
Environmental Document			
Class I NEPA (EIS)		[7]	X
SEPA (EIS)		X	
Class II NEPA – Categorical Exclusion (CE) Documented in ECS form	X		
SEPA – Categorical Exemption (CE)	X		
Class Ill NEPA – Environmental Assessment (EA)		[7]	X
SEPA Environmental Checklist & Determination of Non-Significance (DNS)	X		
Design			
Basis of Design (BOD)	[9]	[9]	[9]
Intersection Control Type	X [20]	X [22]	
Experimental Features		X	X
Environmental Review Summary	X		
Final Project Definition		X [10]	
Interstate Interchange Justification Report		[7]	X
Any Break in Interstate Limited Access		[7]	X
Non-Interstate Interchange Justification Report		X	
Break in Partial or Modified Limited Access		X	
Intersection or Channelization Plans	X		
Right of Way Plans	[11]	X	
Monumentation Map	X		
Materials Source Report		X [12]	
Pavement Determination Report		X [12]	
Roundabout Geometric Design (see Chapter 1320 for guidance)	X		
Resurfacing Report		X [12]	
Signal Permits	X [13]		
Geotechnical Report		X [12]	
Tied Bids	X [14]		

Table continued on the following page, which also contains the notes.

Exhibit 300-2 Approvals (continued)

Item	Approval Authority		
	Region	HQ	FHWA
Bridge Design Plans (Bridge Layout)	X	X	
Preliminary Bridge Plans for Unusual/Complex Bridges on the Interstate		[7]	X
Structures Requiring TS&Ls		X	
Hydraulic Report	X [15]	[15]	
Preliminary Signalization Plans		X [6][18]	
Signalization Plans	X [20]		
Illumination Plans	X [20]		
Intelligent Transportation System (ITS) Plans	X [20]		
ITS Systems Engineering Analysis Worksheet (Exhibit 1050-2)	X [20]		
Rest Area Plans		X	
Roadside Restoration Plans	X [16]	X [17]	
Planting Plans	X [16]	X [17]	
Grading Plans	X		
Continuous Illumination – Main Line		X [18]	
Tunnel Illumination		X [18]	
High Mast Illumination		X [18]	
Project Change Request Form	X [19]	X [19]	
Work Zone Transportation Management Plan/Traffic Control Plan	X [20]		
Public Art Plan – Interstate (see Chapter 950)	X [16]	X [17][21]	X
Public Art Plan – Non-Interstate (see Chapter 950)	X [16]	X [17][21]	
Crash Analysis Report	X [20]	X	
ADA Maximum Extent Feasible Document (see Chapter 1510)	X	X	

Notes:

[1] Federal-aid projects only.

[2] Approved by Assistant Secretary, Engineering & Regional Operations.

[3] Approved by Director & State Design Engineer, Development Division.

[4] Approved by Right of Way Plans Manager.

[5] Refer to Chapter 210 for approval requirements.

[6] Final review & concurrence required at the region level prior to submittal to approving authority.

[7] Final review & concurrence required at HQ prior to submittal to approving authority.

[8] On Interstate projects, the Director & State Design Engineer, Development Division, (or designee) submits the approved design hearing summary to the FHWA for federal approval. (See Chapter 210.)

[9] See Exhibit 300-1 for BOD Approvals.

[10] Approved by HQ Capital Program Development and Management (CPDM).

[11] Certified by the responsible professional licensee.

[12] Submit to HQ Mats Lab for review and approval.

[13] Approved by Regional Administrator or designee.

[14] Per 23 CFR 635.111.

[15] See the *Hydraulics Manual* for approvals levels.

[16] Applies to regions with a Landscape Architect.

[17] Applies to regions without a Landscape Architect.

[18] Approved by State Traffic Engineer.

[19] Consult CPDM for clarification on approval authority.

[20] Region Traffic Engineer or designee.

[21] The State Bridge and Structures Architect reviews and approves the public art plan (see Chapter 950 for further details on approvals).

[22] State Traffic Engineer or designee.

Exhibit 300-3 PS&E Process Approvals NHS (including Interstate) and Non-NHS

Item	Headquarters or Region Approval Authority
DBE/training goals * **	Office of Equal Opportunity
Right of way certification for federal-aid projects***	Region; HQ Real Estate Services Office or HQ Local Programs Right of Way Manager [7]
Right of way certification for state or local funded projects***	Region; HQ Real Estate Services Office or HQ Local Programs Right of Way Manager
Railroad agreements	HQ Design Office
Work performed for public or private entities *	Region [1][2]
State force work *	Region [3][4]
Use of state-furnished materials *	Region [3][4]
Work order authorization	Capital Program Development and Management [5]
Ultimate reclamation plan approval through DNR	Region
Proprietary item use *	[4][6] HQ Design Office
Mandatory material sources and/or waste sites *	Region [4]
Nonstandard bid item use *	Region
Incentive provisions	HQ Construction Office
Nonstandard time for completion liquidated damages *	HQ Construction Office
Interim liquidated damages *	Statewide Travel and Collision Data Office

Notes:
FHWA PS&E Approval has been delegated to WSDOT unless otherwise stated differently in a Project Specific PoDI S&O Agreement.

[1] This work requires a written agreement.
[2] Region approval subject to $250,000 limitation.
[3] Use of state forces is subject to $60,000 limitation and $100,000 in an emergency situation, as stipulated in RCWs 47.28.030 and 47.28.035. Region justifies use of state force work and state-furnished materials and determines if the work is maintenance or not. HQ CPDM reviews to ensure process has been followed.
[4] Applies only to federal-aid projects; however, document for all projects.
[5] Prior FHWA funding approval required for federal-aid projects.
[6] The HQ Design Office is required to certify that the proprietary product is either: (a) necessary for synchronization with existing facilities, or (b) a unique product for which there is no equally suitable alternative.
[7] For any federal aid project FHWA only approves Right of Way Certification 3s (All R/W Not Acquired), WSDOT approves Right of Way Certification 1s and 2s for all other federal aid projects.

References:
* *Plans Preparation Manual*
** *Advertisement and Award Manual*
*** *Right of Way Manual*

Exhibit 300-4 Design to Construction Transition Project Turnover Checklist Example

This checklist is recommended for use when coordinating project transition from design to construction.

1. **Survey**
   - ❑ End areas (cut & fill)
   - ❑ Staking data
   - ❑ Horizontal/Vertical control
   - ❑ Monumentation/Control information
2. **Design Backup**
   - ❑ Index for all backup material
   - ❑ Backup calculations for quantities
   - ❑ Geotech shrink/swell assumptions
   - ❑ Basis of Design, Design decisions and constraints
   - ❑ Approved Design Analyses
   - ❑ Hydraulics/Drainage information
   - ❑ Clarify work zone traffic control/workforce estimates
   - ❑ Geotechnical information (report)
   - ❑ Package of as-builts used (which were verified) and right of way files
   - ❑ Detailed assumptions for construction CPM schedule (working days)
   - ❑ Graphics and design visualization information (aerials)
   - ❑ Specific work item information for inspectors (details not covered in plans)
   - ❑ Traffic counts
   - ❑ Management of utility relocation
3. **Concise Electronic Information With Indices**
   - ❑ Detailed survey information (see Survey above)
   - ❑ Archived InRoads data
   - ❑ Only one set of electronic information
   - ❑ "Storybook" on electronic files (what's what)
   - ❑ CADD files
4. **Agreements, Commitments, and Issues**
   - ❑ Agreements and commitments by WSDOT
   - ❑ RES commitments
   - ❑ Summary of environmental permit conditions/commitments
   - ❑ Other permit conditions/commitments
   - ❑ Internal contact list
   - ❑ Construction permits
   - ❑ Utility status/contact
   - ❑ Identification of the work elements included in the Turnback Agreement (recommend highlighted plan sheets)
5. **Construction Support**
   - ❑ Assign a Design Technical Advisor (Design Lead) for construction support

An expanded version of this checklist is available at: www.wsdot.wa.gov/design/projectdev

The *Owner's Manual* versions will be supplied to both maintenance and the construction office, upon contract advertisement. ***Note:*** This may not be necessary if needed content is captured within the area's Integrated Vegetation Management (IVM) Plan.

If changes occur during post advertisement for a particular asset or feature listed in the *Owner's Manual*, it is the responsibility of the construction office and maintenance to coordinate an update of the *Owner's Manual*, as appropriate. As the construction phase ends, after punch list items are resolved, Maintenance staff should undergo a final review to ensure the *Owner's Manual* is complete and accurate.

301.03(2)(f) Maintenance Agreements

Some project locations may have multiple maintenance jurisdictions, at both the state and local levels. In these circumstances, involve all maintenance jurisdictions throughout the planning and design process. They can help you understand their capabilities and the reasonable accommodations necessary for frequent maintenance operations. To understand the likely split between local and state jurisdictions, refer to Chapter 1230 and the Conformed Agreement… for the Construction, Operations and Maintenance Responsibilities…
www.wsdot.wa.gov/localprograms/lag/construction.htm

Some maintenance and operations agreements between state and local agencies exist for streets that are also state highways, and are important to the success of these projects. These agreements may need to be created, updated, or replaced due to the nature of the project. The potential agreements need to identify the maintenance, operational, and jurisdictional boundaries, roles, and responsibilities of the parties entering into the agreement, including liability, indemnification, and insurance. The Conformed Agreement (above) lists the likely split of jurisdictional responsibilities. However, maintenance jurisdiction(s) may want to create an operational plan or agreement for the infrequent maintenance functions that designs may not be able to accommodate. It is also possible that one maintenance jurisdiction will be better equipped to handle certain maintenance elements than another. It will be necessary to document the split of maintenance responsibilities even if responsibilities remain the same as those listed within the Conformed Agreement.

Agreements require a level of detail that will not be known early in project development, so it is important to document trade-offs, benefits, and impacts with the affected maintenance jurisdictions while early decisions are being made.

Maintenance patching pavement at an intersection requires significant planning, night work, and traffic control

301.04 Documentation

Refer to Chapter 300 for design documentation requirements. Examples of documentation and checklists can be found at: www.wsdot.wa.gov/design/policy/default.htm

301.05 References

301.05(1) Federal/State Laws, Codes and Agreements

City Streets as Part of State Highways Guidelines Reached by the Washington State Department of Transportation and the Association of Washington Cities on Interpretation of Selected Topics of RCW 47.24 and Figures of WAC 468-18-050 for the Construction, Operations and Maintenance Responsibilities of WSDOT and Cities for such Streets, 4-30-1997, amended 4-2-2013 www.wsdot.wa.gov/localprograms/lag/construction.htm

301.05(2) Design Guidance and Supporting Information

A Policy on Geometric Design of Highways and Streets, AASHTO, current edition

Cost Estimating Manual for WSDOT Projects, M 3034, WSDOT

Electronic Engineering Data Standards, M 3028, WSDOT

Highway Runoff Manual, M 31-16, WSDOT

Maintenance Manual, M 51-01, WSDOT

Roadside Design Guide, AASHTO, current edition

Roadside Policy Manual, M 3110, WSDOT

Secretary's Executive Order 1032, Project Management

Chapter 305 Project Management

305.01 Introduction

The Washington State Department of Transportation (WSDOT) utilizes best practices to develop project management plans to successfully deliver projects on schedule and within budget. WSDOT's project management process provides an organized approach to building collaborative teams. Resources including methods, processes, tools, templates, and examples offer the opportunity to enhance project management.

This chapter serves as a reference and gives a brief overview of project management resources and links for your use. This chapter outlines the steps of project management. Project management includes strategies to manage:

- Teams – identify roles and responsibilities; align team project goal
- Collaboration – engage internal and external stakeholders and participants
- Deliverables – identify what must be produced
- Tasks – plan and organize sequence and levels of effort work to provide the deliverables
- Schedules – determine duration and task linkages
- Costs – plan and control project budget
- Risks – determine project exposure to threats and opportunities
- Integration and coordination of processes – eliminate waste
- Change – describe decision making, approving and reporting change
- Quality – assure, control and verify quality
- Communication – based on project needs, project team and external parties.

Effective project management must include a strong commitment to communication about the project within and external to the design team. Following are descriptions and links to project management resources.

Executive Orders 1032, 1038, and 1053 ensure a consistent process for practical design, project management, and risk management statewide.

305.02 Project Management

Project management processes provide the framework for project managers and team members to deliver projects on time and within scope and budget. Project management resources are consistent with a practical design approach and offer structure for organizing collaborative teams to engage stakeholders and the community.

Exhibit 305-1 shows the project management process used to deliver projects. Each of the five parts shown is briefly described in the sections that follow.

Exhibit 305-1 WSDOT Project Management Process

305.02(1) Initiate and Align

Teams deliver projects; hence one of the first orders of business in project management is to initiate and align the team. Our projects are successful based on the effectiveness of the team delivering them. To that end initiating and aligning the team is an important early accomplishment. Aligning the team establishes communications and responsibilities of the project manager and team. The Initiate and Align worksheet is a tool that can be helpful in this phase.

305.02(2) Planning the Work

Plan the Work is the portion of the project management process that produces the Project Management Plan.

The Project Management Plan defines the project performance baseline – including deliverables, schedule and budget plans – and the management methods used to deliver the project. As we plan the work for our projects we integrate and coordinate processes in a manner that optimizes resources and reduces waste. For example if your project requires an interchange justification report (IJR), national environmental policy act (NEPA) documentation, or a value engineering study (VE) coordinate and align these efforts in a manner that makes use of common information and subject matter experts and in a way that ensures the need statements and function work together for the project.

The performance baseline documents the team goals for project performance. Performance baseline includes:

- Scope – the deliverables to be produced by the project team.
- Schedule – the logical sequence of work and related milestones.
- Budget – the allocation for the project.
- Risk – uncertainty that affects project objectives.

The Project Management Plan includes management plans for Risk, Change, Communication, Quality, Transition and Closure. These plans align the team toward uniform goals. A complete project management plan considers how the project will start, how it will be executed, monitored, and controlled, and how the project will close.

305.02(3) Executing the Work

The executing process is where we actually perform the planned work. During execution, we coordinate our team, subject matter experts and others as necessary to produce the deliverables. During execution, we ensure the integration of various project development and design processes that are optimal for completing the required work and meeting the performance objectives.

305.02(4) Monitoring and Controlling

As the work is being executed we track and report progress. If changes or course corrections are required, we want to identify those and take appropriate action in a timely manner. As we monitor progress and control variance we may need to take actions that include: developing and implementing recovery strategies, updating the project management plan, implementing risk response strategies and updating the risk assessment. Obtain change request approvals as necessary and ensure the quality plan is being implemented. Report on the performance of the team and provide early and meaningful communication to management, staff and team.

305.02(5) Closing the Project

As a project comes to an end it will either close or transition to a new phase. We want to perform the closure and transition in an orderly and appropriate manner. This involves demobilizing and reassigning staff and transferring resources or facilities.

Address the closure and transition phase of the project management process during creation of the project management plan and the work plan.

At the end of the project it is helpful to review lessons learned and to reward and recognize the team for successes. Capturing lessons learned and recognize people occurs throughout the project however, the closure phase provides an opportunity to finalize this and bring it to conclusion.

Project transitions can be aided by using the Deliverable Expectation Matrix which provides a range of project development deliverables and the general order in which they will occur.

A project is complete after transition and closure is accomplished and the project manager is released from responsibility for the project.

305.03 Project Management Tools

For an overview of project management, with links to the WSDOT project management process and tools for delivering the WSDOT Capital Construction Program, see the following website: www.wsdot.wa.gov/projects/projectmgmt

The three more common tools are described below.

305.03(1) WSDOT's Master Deliverables List (MDL)

The Master Deliverables List (MDL) is a comprehensive listing of project elements. This list serves as a starting point for creating the project Work Breakdown Structure (WBS) and ensures:

- Appropriate project deliverables are included in the project management plan and schedule.
- A common vocabulary across project teams, region and Headquarters (HQ), and specialty/support groups.

For additional information, see the MDL:
www.wsdot.wa.gov/projects/projectmgmt/masterdeliverables.htm

305.03(2) Deliverables Expectation Matrix

The Deliverables Expectation Matrix (DEM) is another tool used to identify design project deliverables. The DEM is a simpler presentation than the MDL and shows recommended deliverables at project phases like 30% design. The DEM is here:
www.wsdot.wa.gov/publications/fulltext/design/demintro.pdf

305.03(3) Project Management and Reporting System (PMRS)

The PMRS is a tool for effective and efficient management of design project schedules, resources, and costs. The following website provides tools for project planning, work breakdown structure (WBS) development, scheduling, and resource and cost management:
http://wwwi.wsdot.wa.gov/planning/cpdmo/pmrs.htm

305.04 Cost and Risk Management

There are several WSDOT sources for cost estimating guidance, including:

- Strategic Analysis and Estimating:
  http://www.wsdot.wa.gov/Design/SAEO/
- Estimating Information
  http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/Information.htm
- Cost Estimating Manual
  http://www.wsdot.wa.gov/publications/manuals/m3034.htm

Risk management, as an integral part of project management, occurs regularly.
With proactive risk management, projects are monitored to assess and document risks and uncertainty. For more information on risk planning and risk management, see:
www.wsdot.wa.gov/publications/fulltext/cevp/projectriskmanagement.pdf

For more information on risk assessment, see:
www.wsdot.wa.gov/projects/projectmgmt/riskassessment/

Document each estimate review in the Project File, and clearly show any changes made to the estimate as a result of the review.

305.05 References

305.05(1) Federal/State Laws and Codes

23 United States Code (USC) 106, Project approval and oversight

305.05(2) WSDOT Policies

Directives, Executive Orders, Instructional Letters, Manuals, and Policy Statements
http://wwwi.wsdot.wa.gov/publications/policies/default.htm

Executive Order E 1032, Project Management
http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1032.pdf

Executive Order E 1038, Enterprise Risk Management
http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1038.pdf

Executive Order E 1053, Project Risk Management and Risk Based Estimating
www.wsdot.wa.gov/publications/fulltext/cevp/1053policy.pdf

Executive Order E 1090, Moving Washington Forward: Practical Solutions
http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1090.pdf

Executive Order E 1096, WSDOT 2015–17: Agency Emphasis and Expectations
http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1096.pdf

Executive Order E 1082, Business Practices for Moving Washington
http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1082.pdf

Policy Statement P 2047.00 "Estimating Project Budget and Uncertainty"
http://wwwi.wsdot.wa.gov/publications/policies/fulltext/2047.pdf

Project Delivery Memos
www.wsdot.wa.gov/design/projectdev/memos.htm

305.05(3) WSDOT Project Management References

Project Management Guide:
http://www.wsdot.wa.gov/Projects/ProjectMgmt/OnlineGuide/ProjectManagementOnlineGuide.htm

Project Management Glossary:
www.wsdot.wa.gov/publications/fulltext/projectmgmt/pmog/pm_glossary.pdf

Glossary for Cost Risk Estimating Management:
http://www.wsdot.wa.gov/publications/fulltext/CEVP/Glossary.pdf

Cost Estimating Manual for Projects:
http://www.wsdot.wa.gov/publications/manuals/fulltext/M3034/EstimatingGuidelines.pdf

Project Risk Management Guide:
www.wsdot.wa.gov/projects/projectmgmt/riskassessment/default.htm

Chapter 310 Value Engineering

310.01 General

Value engineering (VE) is a systematic review of a project by a multidisciplinary team not directly involved in the planning and development phases of the project. The VE process includes consideration of design; construction; maintenance; contractor; state, local, and federal approval agencies; other stakeholders; and the public.

Properly timing a Value analysis influences its benefits. Value analyses are typically conducted fairly early in project development to identify ideas to reduce cost and; refine scope. Section 310.02(3) VE Analysis Timing, of this chapter offers additional information about timing.

A VE analysis [1] may be applied as a quick-response study to address a problem or as an integral part of an overall organizational effort to stimulate innovation and improve performance characteristics.

Project managers are accountable for ensuring their projects meet all applicable value engineering requirements. In addition, local programs projects are accountable for ensuring they comply with Local Agency Guidelines requirements. In all cases, when a VE study is completed, the project manager is accountable for completing, signing, and submitting the VE Recommendations Approval Form.

310.02 Statewide VE Program

310.02(1) Annual VE Plan

The State VE Manager coordinates annually with the Capital Program Development and Region VE Coordinators to prepare an annual VE Plan, with specific projects scheduled quarterly. The VE Plan is the basis for determining the projected VE program needs, including team members, team leaders, consultants, and training. The Statewide VE Plan is a working document that reflects coordination between Headquarters (HQ) and the regions to keep it updated and projects on schedule.

[1] The terms "value management", "value engineering", "value study" and "value analysis" are used interchangeably.

310.02(2) Selecting Projects for VE Analysis

310.02(2)(a) Requirements

WSDOT projects for VE studies may be selected from any of the categories identified in the Highway Construction Program, including Preservation and Improvement projects, depending on the size and/or complexity of the project. In addition to cost, other issues adding to the complexity of the project design or construction are considered in the selection process. These include projects that have critical constraints, difficult technical issues, expensive solutions, external influences, and complicated functional requirements, regardless of the estimated project cost. These include projects that have critical constraints, difficult technical issues, expensive solutions, external influences, and complicated functional requirements, regardless of the estimated project cost.

WSDOT may conduct VE analyses on any projects the project manager determines will benefit from the exercise. In addition, WSDOT conducts VE analyses for all projects as required by the criteria set forth in Federal Highway Administration (FHWA) Value Engineering Policy Order.

1. WSDOT policy requires a value engineering analysis for:
   - Any project with an estimated cost (which includes project development, design, right of way, and construction costs) of $25 million or more, regardless of funding;
   - Each bridge project located on or off of the federal-aid system with an estimated total cost of $20 million or more (WSDOT policy is to conduct a VE analysis regardless of funding source); and
   - Any other projects the Secretary or FHWA determines to be appropriate.
2. In addition to the projects described above, WSDOT strongly encourages a VE analysis on other projects where there is a high potential for cost savings or improved project performance or quality. Projects involving complex technical issues, challenging project constraints, unique requirements, and competing community and stakeholder objectives offer opportunities for improved value by conducting VE analyses.
3. Any use of Federal-Aid Highway Program (FAHP) funding on a Major Project[2] requires that a VE analysis be conducted. In some cases, regardless of the amount of FAHP funding, a project team may be required to perform more than one VE analysis for a Major Project.
4. After completing the required VE analysis, if the project is subsequently split into smaller projects in final design or is programmed to be completed by the advertisement of multiple construction contracts, an additional VE analysis is not required. However, splitting a project into smaller projects or multiple construction contracts is not an accepted method to avoid the requirements to conduct a VE analysis.
5. WSDOT may require a VE analysis to be conducted if a region or public authority encounters instances when the design of a project has been completed but the project does not immediately proceed to construction.
   a. If a project meeting the above criteria encounters a three-year or longer delay prior to advertisement for construction, and a substantial change to the project's scope or

[2] Based on the *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU),* signed into law on August 10, 2005, a Major Project is defined as "a project with a total estimated cost of $500 million or more that is receiving financial assistance." FHWA also has the discretion to designate a project with a total cost of less than $500 million as a Major Project.

design is identified, WSDOT may require a new VE analysis or an update to the previous VE analysis; or

b. If a project's estimated cost was below the criteria identified above but the project advances to construction advertisement, and a substantial change occurs to the project's scope or design, causing an increase in the project cost so that it meets the criteria identified above and results in a required re-evaluation of the environmental document, WSDOT requires that a VE analysis be conducted.

6. When the design of a project has been completed but the project does not immediately proceed to construction, the requirement to conduct a VE analysis is considered to be satisfied, or not necessary, if:

   a. A project met the criteria identified above and had a VE analysis conducted, and the project advances to advertisement for construction without any substantial changes in its scope or its design; or

   b. A project's estimated cost initially fell below the criteria identified above, but when advancing to advertisement for construction, falls above the criteria due to inflation, standard escalation of costs, or minor modifications to the project's design or contract.

Other projects that should be considered for value engineering have a total estimated cost exceeding $5 million and include one or more of the following:

- Alternative solutions that vary the scope and cost
- New alignment or bypass sections
- Capacity improvements that widen the existing highway
- Major structures
- Interchanges
- Extensive or expensive environmental or geotechnical requirements
- Materials that are difficult to acquire or that require special efforts
- Inferior materials sources
- New/Reconstruction projects
- Major traffic control requirements or multiple construction stages

310.02(3) VE Analysis Timing

310.02(3)(a) When to Conduct the VE Analysis

Timing is very important to the success of the VE analysis. A VE analysis should be coordinated with other project development activities. For example, a project requiring an Interchange Justification Report (IJR), NEPA and a VE should consider how to best integrate the processes with development of project need statements.

Optimizing the timing of a VE analysis minimizes impacts of approved recommendations on previous commitments (agency, community, or environmental) and project's scope. VE analyses can also be coordinated with project risk assessments.
See www.wsdot.wa.gov/design/saeo/

Benefits can be realized by performing a VE analysis at any time during project development; however, the WSDOT VE program identifies the following three windows of opportunity for performing a VE analysis.

1. Scoping Phase

Early in preliminary engineering is a good time for value analysis consideration. This is a time to consider alternatives or design solutions with a high potential for implementing VE recommendations. At the conclusion of the VE study, the project scope, preliminary costs, and major design decisions are informed by the recommendations.

When conducting value engineering during the scoping phase of a project, the VE analysis focuses on project drivers. This stage often provides an opportunity for community engagement and building consent with stakeholders.

2. Start of Design

At the start of design, the project scope and preliminary costs have been established and major design decisions have been made. Some Plans, Specifications, and Estimates (PS&E) activities may have begun, and coordination with support groups and subject matter experts is underway. At this stage, the project scope, costs, and schedule define the limits of the VE analysis. There is opportunity to focus on the technical issues of the design elements.

3. Design Approval

After Design Approval, most of the important project decisions have been made and the opportunity to affect the design is limited. Provided there is time to incorporate VE recommendations, the VE analysis may likely focus on constructability, construction sequencing, staging, traffic control, and significant design issues.

An additional VE analysis may be beneficial late in the development stage when the estimated cost of the project exceeds the project budget. The value engineering process can be applied to the project to lower the cost while maintaining the value and quality of the design.

310.02(4) VE Program Roles and Responsibilities

310.02(4)(a) Region VE Coordinator

- Identifies region projects for VE analyses (from Project Summaries and available planning documents).
- Makes recommendations for timing of the VE analysis for each project.
- Presents a list of the identified projects to region management to prioritize into a regional annual VE Plan.
- Identifies potential team facilitators and members for participation statewide.

310.02(4)(b) State VE Manager

- Reviews regional VE Plans regarding content and schedule.

310.02(4)(c) State VE Coordinator

- Incorporates the regional annual VE Plans and the Headquarters Plan to create the Statewide VE Plan.
- Prepares annual VE Report.
- Maintains policy documents for the department.
- Coordinates studies.

- Arranges training for future VE team leaders and members.

310.02(4)(d) VE Team Leader

The quality of the VE analysis largely depends on the skills of the VE team leader. This individual guides the team's efforts and is responsible for its actions during the analysis. The VE team leader should be knowledgeable and proficient in transportation design and construction and in the VE analysis process for transportation projects.

The VE team leader's responsibilities include the following:

- Plans, leads, and facilitates the VE study.
- Ensures proper application of a value methodology.
- Follows the Job Plan.
- Guides the team through the activities needed to complete the pre-study, the VE study, and the post-study stages of a VE study.
- Schedules a pre-workshop meeting with the project team and prepares the agenda for the VE study.

Team leaders from within WSDOT are encouraged, but not required, to be certified by the Society of American Value Engineers (SAVE) as an Associate Value Specialist, Certified Value Specialist (CVS) or as a Value Methodology Practitioner (VMP). Team leadership can be supplied from within the region, from another region, or from Headquarters. A statewide pool of qualified team leaders is maintained by the State VE Coordinator, who works with the Region VE Coordinator to select the team leader.

Consultants who lead VE teams are required to be SAVE certified.

310.02(4)(e) VE Team Members

The VE teams are usually composed of six to ten people with diverse expertise relevant to the project under study. The team members may come from regions; Headquarters; other local, state, or federal agencies; or the private sector.

Team members are not directly involved in the planning and development phases of the project. They are selected based on the expertise needed to address major functional areas and critical high-cost issues of the study. All team members must be committed to the time required for the study. It is desirable for team members to have attended Value Engineering Module 1 training before participating in a VE study.

310.03 VE Procedure

The WSDOT VE analysis uses the Seven-Phase Job Plan shown in Exhibit 310-1. A detailed discussion of how each phase is supposed to be conducted can be found in the document, Value Methodology Standard and Body of Knowledge, developed by SAVE International, The Value Society. This document can be downloaded at the SAVE website: www.value-eng.org/

310.03(1) Pre-Study Preparation

To initiate a VE study, the project manager submits a Request for Value Engineering Study form to the Region VE Coordinator at least two months before the proposed study date. The form is located on the WSDOT value engineering website:
www.wsdot.wa.gov/design/valueengineering/tools/

The Region VE Coordinator then works with the State VE Coordinator to determine the team leader and team members for the VE study. Contacts are listed on the WSDOT value engineering website: www.wsdot.wa.gov/design/valueengineering

The design team prepares a study package of project information for each of the team members. (A list of potential items is shown in Exhibit 310-2). Work with the State VE Coordinator for the best/most concise list of materials to send to the team members. If the package is provided via a network drive or FTP site, make sure the materials are well titled and sorted in a well-titled file structure. The VE team members should receive this information or a link to this information at least one week prior to the study so they have time to review the material.

The region provides a facility and the equipment for the study (see Exhibit 310-2).

310.03(2) VE Analysis Requirements

The time required to conduct a VE analysis varies with the complexity and size of the project, but typically ranges from three to five days. The VE team leader working with the project manager will determine the best length of time for the study.

The VE analysis Final Report includes an executive summary; a narrative description of project information; the background, history, constraints, and controlling decisions; the VE team's focus areas; a discussion of the team's speculation and evaluation processes; and the team's final recommendations. All of the team's evaluation documentation, including sketches, calculations, analyses, and rationale for recommendations, is included in the Final Report. A copy of the Final Report is to be included in the Project File. A copy of the report is also provided to FHWA for projects on the National Highway System or federal-aid system.

Post-VE analysis activities include:

- The Project Manager and Project team are responsible for:
  - Implementation and evaluation of the approved recommendations.
  - Documentation of reasons recommendations were not implemented.

310.03(3) Implementation (Phase 7 of VE)

As soon as possible, preferably no more than two weeks following the VE analysis, the project manager reviews and evaluates the VE team's recommendation(s). The project manager completes the VE Recommendation Approval form included in the Final Report and returns it to the Statewide VE Manager.

Recommendations not approved or modified by the project manager require a brief justification in the VE Recommendation Approval form.

The project manager sends the completed VE Recommendation Approval form to the State VE Manager following receipt of the Final Report and not later than September 1 of each year, whichever comes first, so the results can be included in WSDOT's annual VE Report to FHWA.

Exhibit 310-1 Seven-Phase Job Plan for VE Studies

VE Study Phase	Job Plan
1. Information	Gather project information, including project commitments and constraints. • *Investigate technical reports and field data* • *Develop team focus and objectives*
2. Function Analysis	Analyze the project to understand the required functions. • *Define project functions using active verb/measurable noun context* • *Review and analyze these functions to determine which need improvement, elimination, or creation to meet project goals*
3. Creative	Generate ideas on ways to accomplish the required functions that improve project performance, enhance quality, and lower project costs. • *Be creative* • *Brainstorm alternative proposals and solutions to lower project costs, improve project performance, and enhance quality*
4. Evaluation	Evaluate and select feasible ideas for development. • *Analyze design alternatives, technical processes, and life cycle costs*
5. Development	Develop the selected alternatives into fully supported recommendations. • *Develop technical and economic supporting data to prove the benefits and feasibility of the desirable concepts* • *Develop team recommendations (long-term as well as interim solutions)*
6. Presentation	Present the VE recommendation to the project stakeholders. • *Present the VE recommendation to the project team and region management in an oral presentation* • *Provide a written report*
7. Implementation	The decision to implement or not implement recommendations is documented in the signed VE Recommendation Approval form. The Project Manager implements approved recommendations.
Note: Phases 1–6 are performed during the study; see *Value Standard and Body of Knowledge* for procedures during these steps.	

Exhibit 310-2 VE Analysis Team Tools

Project-Related Input* and Design Resources (Study Package)
Project Management Plan
Vicinity map
Aerial photos
Large-scale aerial photographs
Pertinent maps - Land use, contours, quadrant, etc.
Crash data with collision analysis
Existing as-built plans
Design file
Cross sections and profiles
Environmental documents Environmental constraints, and commitments
Estimates (and associated Basis Of Estimate)
Geotechnical reports
Hydraulic Report
Plan sheets
Quantities
Right of way plans
Bridge List/Bridge condition report
Design Manual
Field Formulas and *Field Tables*
Standard Plans
Standard Specifications
State Highway Log
Other manuals as needed

Study-Related Facilities and Equipment
AASHTO *Green Book*
Calculators
Computer (with network if available) / projector
Easel(s) and easel paper pads
Marking pens
Masking and clear tape
Power strip(s) and extension cords
Room with a large table and adequate space for the team
Scales, straight edges, and curves
Telephone
Vehicle or vehicles with adequate seating to transport the VE team for a site visit**

*Not all information listed may be available to the team, depending on the project stage. Work with your Region VE Coordinator or the State VE Coordinator to verify that all needed information is available.

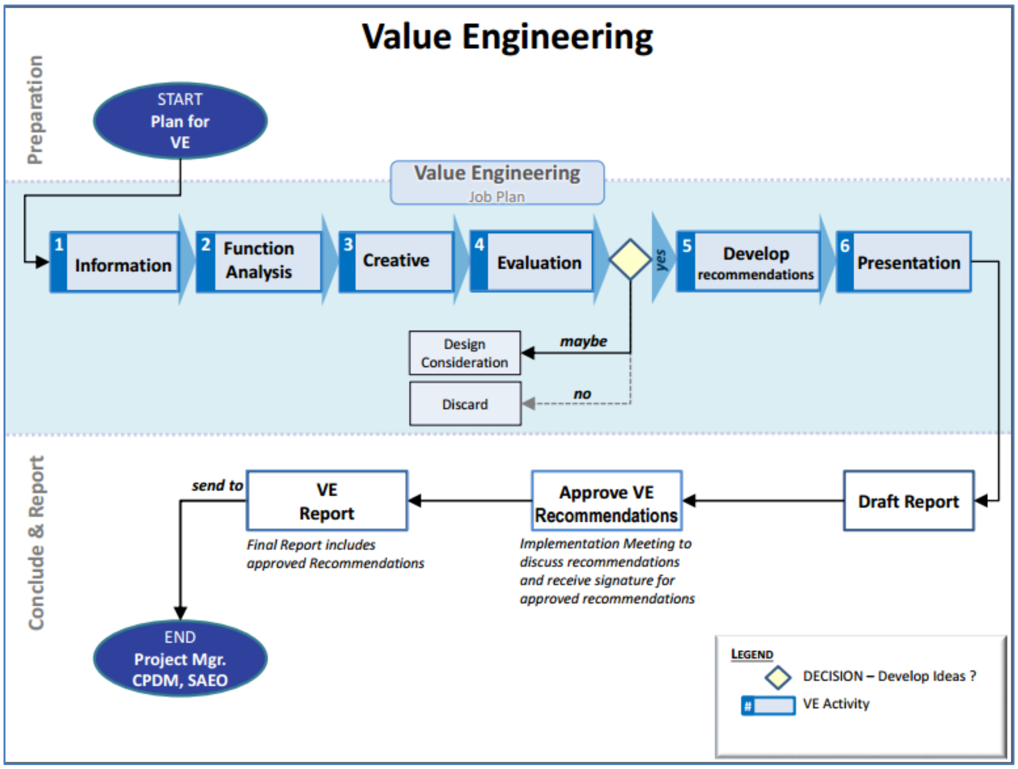
**If a site visit is not possible, perform a “virtual” tour of the project.

310.04 Value Engineering Job Plan

The VE process is comprised of a 6-step Job Plan. FHWA adds a “7th” step known as implementation. Exhibit 310-3 depicts the process for Value Engineering. An interactive version of this exhibit is available at:

http://www.wsdot.wa.gov/publications/fulltext/CEVP/VE_JobPlan.pdf

Exhibit 310-3 Value Engineering Job Plan



310.05 Project Management Accountability

Project Managers are required to make a determination for each VE recommendation. To that end, project managers, in consultation with their project teams, support staff, other management support, and subject matter experts, decide the action to be taken for each recommendation.

310.06 Documentation

Refer to Chapter 300 for design documentation requirements.

The following value engineering documentation is required:

- **Project File** – Value Engineering Final Report
- **Design Approval** – Design Documentation Package for Approval – the Value Engineering Recommendation Approval Form
- **Project File** – Value Engineering Recommendation Approval Form

310.07 References

310.07(1) Federal Laws and Codes

Title 23 U.S.C. Section 106(e) – Value Engineering Analysis

Title 23 CFR Part 627 – Value Engineering

MAP-21 (Moving Ahead for Progress in the 21st Century), Section 1503

Circular A-131, Office of Management and Budget (OMB)
http://www.whitehouse.gov/omb/circulars_a131

FHWA Value Engineering Policy
https://www.fhwa.dot.gov/legsregs/directives/orders/13111b.cfm

310.07(2) Design Guidance

Value Engineering for Highways, Study Workbook, U.S. Department of Transportation, FHWA
Value Standard and Body of Knowledge, SAVE International, The Value Society:
http://www.value-eng.org/

WSDOT Value Engineering website:
www.wsdot.wa.gov/design/valueengineering/

Chapter 321 Sustainable Safety Analysis

321.01 Sustainable Safety Related Policy

The Washington State Strategic Highway Safety Plan, "Target Zero" has a vision to reduce traffic fatalities and serious injuries to zero by 2030. WSDOT is pursuing this goal along with partners such as Washington State Patrol (WSP) and Washington Traffic Safety Commission (WTSC). WSDOT recognizes that risk exists in all modes of transportation. The universal objective is to reduce the number of fatal and serious injury crashes within the limits of available resources, science, technology, and legislatively mandated priorities.

The Secretary's Executive Order E 1085, Sustainable Highway Safety Program, sets the policy for the Washington State Department of Transportation (WSDOT) to embark on a targeted and scientifically-based Engineering approach for identifying and addressing crash risks that is multimodal and coordinated with the other three "E"s, Education, Enforcement, and Emergency Services. Sustainable Safety employs a "5th E", Evaluation, this is the analysis and diagnosis of crashes and to target their contributing factors in addressing highway safety performance. Evaluation relies on quantifying safety performance using scientific tools and assessment techniques to determine appropriate safety countermeasures.

Sustainable Safety is the approach to transportation safety at WSDOT through the use of "…tools and procedures based on accepted science, data, and proven practice" in accordance with Secretary's Executive Order E 1096, Agency Emphasis and Expectations, to target safety needs, and "deliver the right solutions at the right time and at the right location."

Practical Solutions is an approach to making project decisions that focus on resolving the project need for the least cost without adversely impacting safety performance. Sustainable Safety is the approach for resolving safety performance within WSDOT's Practical Solutions as directed in both E 1096 and Secretary's Executive Order E 1090, Moving Washington Forward: Practical Solutions.

E 1085 directs engineers to base project-level decisions on safety analysis of specific locations and corridors and focus on proven lower-cost targeted countermeasures at specific locations that optimize the return on investment of safety dollars. These lower-cost investments allow for additional identified locations to be addressed. Sustainable Safety is therefore an essential part of successful Practical Design implementation. It provides the process and methods to incorporate safety performance assessment and peer-review into Performance-Based Practical Design. Sustainable Safety allows the planner, engineer, and decision maker, to identify and quantify the safety performance of alternatives during project development.

Implementing Sustainable Safety improves WSDOT's effectiveness in reducing the risk of fatal and serious injury crashes statewide. It focuses on the contributing factors and types of crashes through the use of state-of-the-art principles and analytical methods to diagnose, quantify, and predict safety performance. The Sustainable Highway Safety Policy directs WSDOT to use effective and efficient resources, like the AASHTO Highway Safety Manual (HSM) to achieve the goals of the Washington State Strategic Highway Safety Plan: Target Zero. This approach:

1. Optimizes the reduction in fatal and serious injury crash potential on Washington's highways.
2. Provides quantifiable assessment of crash potential.
3. Identifies locations that have a higher potential for crash reduction.
4. Provides reliable and accurate assessment of potential crash reduction benefits.
5. Identifies and deploys solutions with optimal benefit/cost within the WSDOT priority array or through low cost operational improvements.
6. Reduces waste by focusing on design elements that provide a reduction in crash potential.
7. Addresses locations that will result in a higher crash risk reduction potential for a given investment level.
8. Provides an accurate assessment of project and program performance.
9. Provides scientific and engineering tools to continually improve and refine safety analyses.

Sustainable Safety is a critical, integral part of Practical Solutions that supports Washington in reaching its Target Zero goal.

321.02 HQ Safety Technical Group

The HQ Safety Technical Group is comprised of experts in safety analysis. The team has several duties including maintaining the Safety Analysis Guide, safety analysis training, review of complex safety analysis, review of Collision Analysis Reports, and approve the use of crash modification factors. The team can also provide assistance to a project office as they conduct safety analysis.

321.03 Project Related Safety Analysis

All projects are required to have a safety analysis for Design Approval (see Chapter 300). The safety analysis is intended to be scalable. The HQ Safety Technical Group has written the Safety Analysis Guide to provide direction on the scope and scale of safety analysis for each funding subprogram (i.e. I-1, I-2, P-3) and each document needing a safety analysis (i.e. Design Analyses, IJRs, ICAs). Contact the HQ Safety Technical Group if your project is not covered by the Safety Analysis Guide or if you have questions regarding how to use the guide.

321.04 Safety Analysis

The *Safety Analysis Guide* contains guidance on the content of stand-alone safety analyses for Design Analyses, Crash Analysis Reports, Intersection Control Analyses, Transportation Management Plans, Road Safety Audits, Environmental Impact Statements, and Interchange Justification Reports. Contact the HQ Safety Technical Group if you have any questions or need to develop a stand-alone safety analysis that is not covered in the Safety Analysis Guide.

321.05 Reports and Documentation

The Crash Analysis Report (CAR), Intersection Control Analysis (ICA), and Basis of Design (BOD) utilize safety analysis. They are described in the following subsections. For approval requirements, refer to Chapter 300.

321.05(1) Crash Analysis Report (CAR)

A CAR is developed during the scoping phase for I-2 Collision Reduction projects and is required for funding to be released. A template of the Crash Analysis Report with instructions is available here: http://wwwi.wsdot.wa.gov/Planning/CPDMO/PlanningProgrammingSafety_I-2.htm

If a CAR was developed using the template for the 2019-21 biennium or newer, the project does not need a BOD.

321.05(2) Intersection Control Analysis (ICA)

Projects that require an ICA need to do a safety analysis on the alternatives. If a project has a completed CAR, the ICA may reference this CAR. If not, the safety analysis for the ICA should have a scale and scope associated with its funding source as noted in the Safety Analysis Guide.

321.05(3) Basis of Design (BOD)

The BOD utilizes metrics and targets in the baseline and contextual needs. If the chosen metric is safety related utilize a safety analysis to determine the potential for crash reduction for various alternatives. The safety analysis may also be used as a component in the Alternative Comparison Table (ACT) to allow easier comparison across alternatives. The scale and scope of a safety analysis for a BOD is associated with its program type and is explained in the Safety Analysis Guide.

321.06 References

321.06(1) Federal/State Directives, Laws, and Codes

23 United States Code (USC) 148 – Federal requirements for the Highway Safety Improvement Program (HSIP)

Revised Code of Washington (RCW) 47.05.010 – The statement of purpose for priority programming of transportation projects

Secretary's Executive Order 1085 – Sustainable Highway Safety Program

Secretary's Executive Order 1090 – Moving Washington Forward: Practical Solutions

Secretary's Executive Order 1096 – WSDOT 2015-17: Agency Emphasis and Expectations

321.06(2) Design Guidance

Safety Analysis Guide, WSDOT; See Sustainable Highway Safety Tools here:
http://www.wsdot.wa.gov/Design/Support.htm

Highway Safety Manual (HSM), AASHTO, 2010

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2011

321.06(3) Supporting Information

Strategic Highway Safety Plan: Target Zero – Washington State´s strategic traffic safety plan developed by the Washington Traffic Safety Commission: 🖰 http://www.targetzero.com/

Sustainable Highway Safety Internal Web Page – Contains all of the procedures and tools to implement highway safety: 🖰 http://wwwi.wsdot.wa.gov/HighwaySafety/

Washington Transportation Plan – Washington State Transportation Commission´s recommended strategic transportation plan; includes a highway safety element: 🖰 http://www.wstc.wa.gov/wtp/documents/wtp2030_201012.pdf

Chapter 560 Fencing

560.01 General

Fencing is provided primarily to discourage encroachment onto Washington State Department of Transportation (WSDOT) highway right of way from adjacent property, to delineate the right of way, and to replace fencing that has been disrupted by construction.

Encroachment onto the right of way is discouraged to limit the presence of people and animals that might disrupt the efficient flow of traffic on the facility. Although not the primary intent, fencing does provide some separation between people, animals, traffic flow, and other features.

560.02 Design Criteria

560.02(1) General

Fencing on a continuous alignment usually has a pleasing appearance and is the most economical to construct and maintain. The recommended practice is to locate fencing on or, depending on the terrain, 12 inches inside the right of way line.

Where the anticipated or existing right of way line has abrupt irregularities over short distances, coordinate with Maintenance and Real Estate Services personnel to dispose of the irregularities as excess property (where possible) and fence the final property line in a manner acceptable to Maintenance.

Whenever possible, preserve the natural assets of the surrounding area and minimize the number of fence types on any particular project.

560.02(2) Limited Access Highways

On highways with full and partial limited access control, fencing is mandatory unless it has been established that such fencing may be deferred. Fencing is not required for modified limited access control areas, but may be installed where appropriate. Fencing is required between frontage roads and adjacent parking or pedestrian areas (such as rest areas and flyer stops) and highway lanes or ramps unless other barriers are used to discourage access violations.

On new alignment, fencing is not provided between the frontage road and abutting property unless the abutting property was enclosed prior to highway construction. Such fencing is normally part of the right of way negotiation.

Unless there is a possibility of access control violation, fencing installation may be deferred until needed at the following locations:

- In areas where rough topography or dense vegetation provides a natural barrier.
- Along rivers or other natural bodies of water.
- In sagebrush country that is sparsely settled.
- In areas with high snowfall levels and sparse population.
- On long sections of undeveloped public or private lands not previously fenced.

When in doubt about fencing installation, consult the Headquarters (HQ) Access and Hearings Manager.

560.02(3) Managed Access Highways

Fencing is not required for managed access highways. When highway construction will destroy the fence of an abutting property owner (which was originally constructed on private property), the cost of replacement fencing may be included in the right of way payment. When the fences of several property owners will be impacted, it may be cost-effective to replace the fences as part of the project.

If fencing is essential to the safe operation of the highway, it will be constructed and maintained by the state. An example is the separation of traveled highway lanes from adjacent facilities with parking or pedestrian areas (such as rest areas and flyer stops).

560.02(4) Special Sites

Fencing may be needed at special sites such as pit sites, stockpiles, borrow areas, and stormwater detention facilities.

Fencing is not normally installed around stormwater detention ponds. Evaluate the need to provide fencing around stormwater detention facilities when pedestrians or bicyclists are frequently present. Document your decision in the Design Documentation Package.

The following conditions suggest a need to evaluate fencing:

- Children or persons with mobility impairments are frequently present in significant numbers in locations adjacent to the facility, such as routes identified in school walk route plans or nearby residential areas or parks.
- Water depth reaches or exceeds 12 inches for several days.
- Sideslopes into the facility are steeper than 3H:1V.

Fencing proposed at sites that will be outside WSDOT right of way requires that local ordinances be followed if they are more stringent than WSDOT's.

Wetland mitigation sites are not normally fenced. When evaluating fencing for wetland mitigation sites, balance the need to restrict human access for safety considerations (such as the presence of children) with the need to provide animal habitat.

Other special sites where fencing may be required are addressed in the following chapters:

- Chapter 720, Bridges (refers to protective screening)
- Chapter 1510, Pedestrian Design Considerations

- Chapter 1520, Bicycle Facilities

The fencing types and designs for special sites are determined by the requirements of each situation.

560.03 Fencing Types

560.03(1) Chain Link

Installation of chain link fence is appropriate for maximum protection against right of way encroachment on sections of high-volume highways in the following locations:

- Along existing business districts adjacent to a freeway.
- Between freeways and adjacent parallel city streets.
- Where existing streets have been cut off by freeway construction.
- In industrial areas.
- At large residential developments.
- On military reservations.
- At schools and colleges.
- In recreational and athletic areas.
- In developed areas at the intersection of two limited access highways.
- At any other location where a barrier is needed to protect against pedestrian, bicyclist, or livestock encroachment in limited access areas.

For roadway sections in rock cuts, see Chapter 1239.

The *Standard Plans* contains details for the approved types of chain link fence. The recommended uses for each type of fence are as follows:

560.03(1)(a) Type 3

This is a high fence for areas of intensified use, such as industrial areas or school playgrounds. Use this fence for new installations of high fencing. It may be used within the Design Clear Zone.

560.03(1)(b) Type 4

This is a lower fence for special use, such as between the traveled highway lanes and a rest area or flyer stop or as a rest area boundary fence if required by the development of the surrounding area. This fence may be used along a bike path or hiking trail to separate it from an adjacent roadway.

Justify why corrective action is not taken when existing fencing with a rigid top rail will be left in place within the limits of a proposed project. For cases where a more rigid fence is needed, contact the HQ Design Office.

Coated galvanized chain link fence is available in various colors and may be considered in areas where aesthetic considerations are important. Coated ungalvanized chain link fence is not recommended.

560.03(2) Wire Fencing

The *Standard Plans* and the *Standard Specifications* contain details for the two approved types of wire fence. The recommended uses for each type of fence are as follows:

560.03(2)(a) Type 1

This fence is used in urban and suburban areas where improvements along the right of way are infrequent and future development is not anticipated. It may also be used adjacent to livestock grazing areas. The lower portion of this fence is wire mesh and provides a barrier to children and small animals.

560.03(2)(b) Type 2

This fence is used in farming areas to limit highway crossings by farm vehicles to designated approaches. These areas include irrigation districts to prevent ditch riders, maintenance personnel, and farmers from making unauthorized highway crossings, and where new alignment crosses parcels previously enclosed by barbed wire.

560.03(3) Other Considerations

Extremely tall fences (7 to 10 feet high) may be used in areas where there are exceptional conditions such as large concentrations of deer or elk. (See the region Environmental Services Office and the *Roadside Manual* concerning wildlife management.)

Metal fencing can interfere with airport traffic control radar. When locating fencing in the vicinity of an airport, contact the Federal Aviation Administration to determine whether metal fence will create radar interference at the airport. If so, use nonmetallic fencing.

Do not straddle or obstruct surveying monuments with any type of fencing.

560.04 Gates

Keep the number of fence gates along limited access highways to a minimum. On limited access highways, all new gates must be approved as described in Chapter 550.

Usually such gates are necessary only to allow highway maintenance personnel and operating equipment to reach the state right of way without using the highway or freeway main line. Gates may be needed to provide access to utility supports, manholes, and so on, located within the right of way.

Use gates of the same type as each fence, and provide locks to deter unauthorized use.

In highly developed and landscaped areas where maintenance equipment is parked outside the fence, provide the double gate shown in the Standard Plans.

Where continuous fencing is not provided on limited access highways (see Chapter 530), approaches are normally gated and locked, with a short section of fence on both sides of the gate.

560.05 Procedure

Fencing is addressed in the access report (see Chapter 530) and the Plans, Specifications, and Estimates, in accordance with the *Plans Preparation Manual*.

560.06 Documentation

Refer to Chapter 300 for design documentation requirements.

560.07 References

560.07(1) Design Guidance

Plans Preparation Manual, M 22-31, WSDOT

Roadside Manual, M 25-30, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (*Standard Plans*), M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (*Standard Specifications*), M 41-10, WSDOT

The level of work in the Project Definition phase for unstable slopes is conceptual in nature, not a final design. The geotechnical investigation generally consists of a field review, a more detailed assessment of the unstable slope, review of the conceptual mitigation developed during the programming phase of the project, and proposed modification (if any) to the original conceptual-level unstable slope mitigation. The design phase geotechnical services cost and schedule, including any required permits, are determined at this time. A brief conceptual-level report is provided to the designer that summarizes the results of the Project Definition investigation.

610.04(11)(b) Project Design

Geotechnical information and field data necessary to complete the unstable slope mitigation design is compiled during this design phase. This work includes, depending on the nature of the unstable slope problem, test borings, rock structure mapping, geotechnical field instrumentation, laboratory testing, and slope stability analysis. The purpose of this design effort is to provide design-level geotechnical recommendations to stabilize the known unstable slope.

The designer requests a geotechnical report from the HQ Geotechnical Office through the RME. The site data given in 610.04(4), as applicable, is provided along with the following information:

- A plan sheet showing the station and location of the proposed unstable slope mitigation project.
- If requested, the Digital Terrain Model (DTM) files necessary to define the on-ground topography of the project site (the limits of the DTM will have been defined during the Project Definition phase).

It is important that the request for the geotechnical report be made as early as possible in the design phase. Cost and schedule requirements to generate the report are project-specific and can vary widely. Unstable slope design investigations might require geotechnical monitoring of ground movement and groundwater over an extended period of time to develop the required field information for the unstable slope mitigation design. The time required to obtain rights of entry and other permits, as well as the long-term monitoring data, must be considered when establishing schedule requirements for the geotechnical report.

In addition to the geotechnical report requirements specified in the *Geotechnical Design Manual*, the HQ Geotechnical Office provides the following information as part of the project geotechnical report (as applicable):

- Unstable slope design analysis and mitigation recommendations.
- Constructibility issues associated with the unstable slope mitigation.
- Appropriate special provisions for inclusion in the contact plans.

The region Project Office uses the geotechnical report to finalize the design decisions for the project and the completion of the PS&E design.

610.04(11)(c) PS&E Development

Adequate geotechnical design information to complete the PS&E is typically obtained during the project design phase. Additional geotechnical work might be needed when right of way cannot be acquired, restrictions are included in permits, or other requirements are added that result in changes to the design.

Special provisions, special project elements, and design details, if not received as part of the design phase geotechnical report, are developed with the assistance of the RME and the HQ Geotechnical Office. The designer uses this information in conjunction with the design phase geotechnical report to complete the PS&E document. The RME and the HQ Geotechnical Office can review the contract plans before the PS&E review begins, if requested. Otherwise, they will review the contract plans during the normal PS&E review process.

610.04(12) Rockslope Design

610.04(12)(a) Project Definition

The region Project Office provides the RME with a description and location of the proposed rock excavation work. For widening of existing rock cuts, the anticipated width and length of the proposed cut in relationship to the existing cut are provided. For new alignments, the approximate location and depth of the cut are provided. Location of the proposed cut(s) can be milepost limits or stationing. The designer meets at the project site with the RME and the HQ Geotechnical Office to conduct a field review, discuss project requirements, and identify any geotechnical issues associated with the proposed rock cuts. The RME requests that the HQ Geotechnical Office participate in the field review and Project Definition reporting.

The level of rockslope design work for the Project Definition phase is conceptual in nature. The geotechnical investigation generally consists of the field review, review of existing records, an assessment of existing rockslope stability, and preliminary geologic structure mapping. The focus of this investigation is to assess the feasibility of the rock cuts for the proposed widening or realignment, not final design. A brief conceptual-level report that summarizes the result of the Project Definition investigation is provided to the designer.

610.04(12)(b) Project Design

Detailed rockslope design is done once the roadway geometrics have been established. The rockslope design cannot be finalized until the roadway geometrics have been finalized. Geotechnical information and field data necessary to complete the rockslope design are compiled during this design phase. This work includes rock structure mapping, test borings, laboratory testing, and slope stability analysis. The purpose of this design effort is to determine the maximum stable cut slope angle and any additional rockslope stabilization measures that could be required.

The designer requests a geotechnical report from the HQ Geotechnical Office through the RME. The site data given in 610.04(4), as applicable, is provided.

It is important that the request for the geotechnical report be made as early as possible in the design phase. Cost and schedule requirements to generate the report are project-specific and can vary widely. The time required to obtain permits and rights of entry must be considered when establishing schedule requirements.

In addition to the geotechnical report requirements specified in the *Geotechnical Design Manual*, the HQ Geotechnical Office provides the following information as part of the project geotechnical report pertaining to rockslope design analysis and recommendations:

- Type of rockslope design analysis conducted and limitation of the analysis. Also included will be any agreements with the region and other customers regarding the definition of “acceptable risk.”
- The slope(s) required for stability.
- Additional slope stabilization requirements (such as rock bolts or rock dowels).
- Rockslope ditch criteria (see Chapter 1239).
- Assessment of rippability.

Chapter 710 Site Data for Structures

710.01 General

The Washington State Department of Transportation (WSDOT) Headquarters (HQ) Bridge and Structures Office provides preliminary site data reviews to determine the applicability of, and requirements surrounding, proprietary structural solutions, or the need for specific structural design strategies, as well as structural design services to the regions. This chapter describes the information required by the HQ Bridge and Structures Office to perform these functions.

710.02 Required Data for All Structures

Structure site data provides information about the type of crossing, topography, type of structure, and potential future construction. Submit structure site data to the HQ Bridge and Structures Office for all structures meeting the Chapter 720 definition of a bridge: essentially all structures of with an interior span equal to 20 feet or greater measured along the overcrossing alignment. This includes all buried structures such as precast concrete arch structures, reinforced concrete arch structures, precast reinforced concrete three-sided structures, precast reinforced concrete box culverts, and precast reinforced concrete split box culverts with an interior span of 20 feet or greater. Site data can also provide information on nonstandard retaining walls requiring project-specific design by the HQ Bridge and Structures Office.

Provide a cover memo that gives general information on the project, describes the attachments, and transmits the forms and data included in the submittal. Submit site data as a CAD file, supplemental drawings, and a report. (See Exhibit 710-1 for items to include in a structure site data submittal). Direct any questions relating to the preparation of structure site data to the HQ Bridge and Structures Office. The *Bridge Design Manual* shows examples of required WSDOT forms.

710.02(1) Scour

At any location where a structure can be in contact with water (such as culvert outfall, lake, river, or floodplain), there is a risk of scour. This risk is to be analyzed. Contact the HQ Geotechnical Office and the HQ Hydraulics Office to determine whether a scour analysis is required.

710.02(2) CAD Files and Supplemental Drawings

CAD files prepared for use as structure site data will be accepted in DGN (preferred) or DWG (acceptable) format.

Prepare plan, profile, and section drawings for all structures. Include copies of the CAD site data and supplemental drawings in the 11 x 17 plan sheet format with the submittal.

Use a complete and separate CAD file for each structure. Create the base map in 2D expanded level format only at 1:1 scale, with only one model per DGN or DWG file, and all base map levels in accordance with the *Electronic Engineering Data Standards* manual. Create a separate base map in 3D with the alignment and contour lines only—no contour text. Turn on all levels (existing and proposed) and merge all reference files, leaving the reference file list empty. Put the new and existing alignments in the same file.

The *Bridge Design Manual* contains examples of completed bridge preliminary plans. These plans show examples of the line styles and drawing format for site data in CAD.

Structure site data is used to prepare the layout plan, which is to be used in the contract plans. Include the following information in the CAD files or in the supplemental drawings.

710.02(2)(a) Plan

- Vertical and horizontal datum control (see Chapters 400 and 410).
- Contours of the existing ground surface (index and intermediate). Use intervals of 2 feet. Show contours beneath an existing or proposed structure and beneath the water surface of any waterway. Do not partially delete contour lines that cover index contour text.
- Alignment of the proposed highway and traffic channelization in the vicinity.
- Location by section, township, and range.
- Type, size, and location of all existing or proposed sewers, telephone and power lines, water lines, gas lines, traffic barriers, culverts, bridges, buildings, and walls.
- Location of right of way lines and easement lines.
- Distance and direction to nearest state highway intersections along the main alignment in each direction.
- Location of all roads, streets, and detours.
- Stage construction plan and alignment.
- Type, size, and location of all existing and proposed sign structures, light standards, and associated conduits and junction boxes. Provide proposed signing and lighting items when the information becomes available.
- Location of existing and proposed drainage.
- Horizontal curve data. Provide the Inroads report for each alignment. Include coordinates for all control points.

710.02(2)(b) Profile

- Profile view showing the grade line of the proposed or existing alignment and the existing ground line along the alignment line.
- Vertical curve data. Provide the Inroads report for each alignment along with the CAD detail.

- Superelevation transition diagram for each alignment as applicable.

710.02(2)(c) Section

- Channelization roadway sections on the structure and at structure approaches. Indicate the lane and shoulder widths, cross slopes and side slopes, ditch dimensions, and traffic barrier requirements.
- Stage construction roadway geometrics with the minimum lane and roadway widths specified.

710.02(3) Report

Submit DOT Form 235-002, Bridge Site Data-General. Supplement the CAD drawings with the following items:

- Vicinity maps
- Class of highway
- Design speed
- Special requirements for replacing or relocating utility facilities
- ADT and DHV counts
- Truck traffic percentage
- Requirements for road or street maintenance during construction

710.02(4) Video and Photographs

Submit a video of the site. Show all the general features of the site and details of existing structures. Scan the area slowly, spending extra time showing existing bridge pier details and end slopes. A “voice over” narrative on the video is necessary for orientation.

Color photographs of the structure site are desirable. Include detailed photographs of existing abutments, piers, end slopes, and other pertinent details for widenings, bridge replacements, or sites with existing structures.

710.03 Additional Data for Waterway Crossings (Bridges and Buried Structures)

Coordinate with the HQ Hydraulics Section and supplement the structure site data for all waterway crossings with the DOT Form 235-001, Bridge Site Data for Stream Crossings, and the following:

- Show riprap or other slope protection requirements at the structure site (type, plan limits, and cross section) as determined by the HQ Hydraulics Section.
- Show a profile of the waterway. The extent will be determined by the HQ Hydraulics Section.
- Show cross sections of the waterway including new streambed design, defining the bankfull width and the bank shelf widths and slopes. The extent will be determined by the HQ Hydraulics Section. The requirements for waterway profile and cross sections

may be less stringent if the HQ Hydraulics Section has sufficient documentation (FEMA reports, for example) to make a determination. Contact the HQ Hydraulics Section to verify the extent of the information needed. Coordinate any rechannelization of the waterway with the HQ Hydraulics Section.

- Many waterway crossings require a permit from the U.S. Coast Guard (see *Bridge Design Manual* Chapter 2.2.4 and the *Environmental Manual*). Generally, ocean tide-influenced waterways and waterways used for commercial navigation require a Coast Guard permit. These structures require the following additional information:
    - Names and addresses of the landowners adjacent to the bridge site.
    - Quantity of new embankment material within the floodway. This quantity denotes, in cubic yards, the material below and the material above normal high water.

For all waterway crossings, where the structure parallel to the centerline of roadway width is less than 20 feet, the Region's designer shall contact the Coast Guard for permit requirements. For all waterway crossings, where the structure parallel to the centerline of roadway width is 20 feet or greater, the Bridge and Structure's Coast Guard Liaison shall contact the Coast Guard for permit requirements.

The region is responsible for coordination with the HQ Bridge and Structures Office, U.S. Army Corps of Engineers, and U.S. Coast Guard for waterways that may qualify for a permit exemption. The HQ Bridge and Structures Office is responsible for coordination with the U.S. Coast Guard for waterways that require a permit.

710.04 Additional Data for Grade Separations

710.04(1) Highway-Railroad Separation

Supplement structure site data for structures involving railroads with the following:

710.04(1)(a) Plan

- Alignment of all existing and proposed railroad tracks.
- Center-to-center spacing of all tracks.
- Angle, station, and coordinates of all intersections between the highway alignment and each track.
- Location of railroad right of way lines.
- Horizontal curve data. Include coordinates for all circular and spiral curve control points.

710.04(1)(b) Profile

- For proposed railroad tracks: profile, vertical curve, and superelevation data for each track.
- For existing railroad tracks: elevations accurate to 0.1 foot taken at 10-foot intervals along the top of the highest rail of each track. Provide elevations to 50 feet beyond the extreme outside limits of the existing or proposed structure. Tabulate elevations in a format acceptable to the HQ Bridge and Structures Office.

710.04(2) Highway-Highway Separation

Supplement structure site data for structures involving other highways by the following:

710.04(2)(a) Plan

- Alignment of all existing and proposed highways, streets, and roads.
- Angle, station, and coordinates of all intersections between all crossing alignments.
- Horizontal curve data. Include coordinates for all curve control points.

710.04(2)(b) Profile

- For proposed highways: profile, vertical curve, and superelevation data for each.
- For existing highways: elevations accurate to 0.1 foot taken at 10-foot intervals along the centerline or crown line and each edge of shoulder, for each alignment, to define the existing roadway cross slopes. Provide elevations to 50 feet beyond the extreme outside limits of the existing or proposed structure. Tabulate elevations in a format acceptable to the HQ Bridge and Structures Office.

710.04(2)(c) Section

- Roadway sections of each undercrossing roadway indicating the lane and shoulder widths, cross slopes and side slopes, ditch dimensions, and traffic barrier requirements.
- Falsework or construction opening requirements. Specify minimum vertical clearances, lane widths, and lateral clearances.

710.05 Additional Data for Widenings

Bridge rehabilitations and modifications that require new substructure are defined as bridge widenings.

710.05(1) Bridge Widenings

Submit DOT Form 235-002A, Supplemental Bridge Site Data-Rehabilitation/ Modification. Supplement structure site data for structures involving bridge widenings by the following:

710.05(1)(a) Plan

- Stations for existing back of pavement seats, expansion joints, and pier centerlines based on field measurements along the survey line and each curb line.
- Locations of existing bridge drains. Indicate whether these drains are to remain in use or be plugged.

710.05(1)(b) Profile

- Elevations accurate to 0.1 foot taken at 10-foot intervals along the curb line of the side of the structure being widened. Pair these elevations with corresponding elevations (same station) taken along the crown line or an offset distance (10-foot minimum from the curb line). This information will be used to establish the cross slope of the existing bridge. Tabulate elevations in a format acceptable to the HQ Bridge and Structures Office.

Take these elevations at the level of the concrete roadway deck. For bridges with concrete overlay, elevations at the top of the overlay will be sufficient. For bridges with a nonstructural overlay, such as an asphalt concrete overlay, take elevations at the level of the concrete roadway deck. For skewed bridges, take elevations along the crown line or at an offset distance (10-foot minimum from the curb line) on the approach roadway for a sufficient distance to enable a cross slope to be established for the skewed corners of the bridge.

710.06 Documentation

Refer to Chapter 300 for design documentation requirements.

710.07 References

Bridge Design Manual, M 23-50, WSDOT

Electronic Engineering Data Standards, M 3028

Environmental Manual, M31-11

Hydraulics Manual, M 23-03

Exhibit 710-1 Structure Site Data Checklist

PLAN (in CAD file)

_____ Survey Lines and Station Ticks
_____ Survey Line Intersection Angles
_____ Survey Line Intersection Stations
_____ Survey Line Bearings
_____ Roadway and Median Widths
_____ Lane and Shoulder Widths
_____ Sidewalk Width
_____ Connection/Widening for Traffic Barrier
_____ Profile Grade and Pivot Point
_____ Roadway Superelevation Rate (if constant)
_____ Lane Taper and Channelization Data
_____ Traffic Arrows
_____ Mileage to Towns Along Main Line
_____ Existing Drainage Structures
_____ Existing Utilities: Type/Size/Location
_____ New Utilities: Type/Size/Location
_____ Light Standards, Junction Boxes, Conduits
_____ Bridge-Mounted Signs and Supports
_____ Contours
_____ Bottom of Ditches
_____ Test Holes (if available)
_____ Riprap Limits
_____ Stream Flow Arrow
_____ R/W Lines and/or Easement Lines
_____ Exist. Bridge No. (to be removed, widened)
_____ Section, Township, Range
_____ City or Town
_____ North Arrow
_____ SR Number
_____ Scale

TABLES (in tabular format in CAD file)

_____ Curb Line Elevations at Top of Existing Bridge Deck
_____ Undercrossing Roadway Existing Elevations
_____ Undercrossing Railroad Existing Elevations
_____ Curve Data

OTHER SITE DATA (may be in CAD file or on supplemental sheets or drawings)

_____ Superelevation Diagrams
_____ End Slope Rate
_____ Profile Grade Vertical Curves
_____ Coast Guard Permit Status
_____ Railroad Agreement Status
_____ Highway Classification
_____ Design Speed
_____ ADT, DHV, and % Trucks
_____ InRoads reports

FORMS (information noted on the form or attached on supplemental sheets or drawings)

Bridge Site Data General

_____ Slope Protection
_____ Pedestrian Barrier/Pedestrian Rail Height Requirements
_____ Construction/Falsework Openings
_____ Stage Construction Channelization Plans
_____ Bridge (before/with/after) Approach Fills
_____ Datum
_____ Video of Site
_____ Photographs of Site
_____ Control Section
_____ Project Number
_____ Region Number
_____ Highway Section

Bridge Site Data for Stream Crossings

_____ Water Surface Elevations and Flow Data
_____ Riprap Cross Section Detail
_____ Bankfull width
_____ Bank shelf width

Supplemental Bridge Site Data: Rehabilitation/ Modification

BRIDGE, CROSSROAD, AND APPROACH ROADWAY CROSS SECTIONS (may be in CAD file or on separate drawings)

_____ Bridge Roadway Width
_____ Lane and Shoulder Widths
_____ Profile Grade and Pivot Point
_____ Superelevation Rate
_____ Survey Line
_____ PB/Pedestrian Rail Dimensions
_____ Stage Construction Lane Orientations
_____ Locations of Temporary Barrier
_____ Conduits/Utilities in Bridge
_____ Location and Depth of Ditches
_____ Shoulder Widening for Barrier
_____ Side Slope Rate

Chapter 720 Bridges

720.01 General

The National Bridge Inspection Standards (NBIS), published in the Code of Federal Regulations (23 CFR 650, Subpart C), defines a bridge as:

> *A structure including supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between undercopings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening.*

The term "bridge" as used in this chapter applies to all structures conforming to the above definition. This includes all buried structures of a span greater than 20 feet measured along the overcrossing alignment, such as precast reinforced concrete three-sided structures, precast reinforced concrete box culverts, and precast reinforced concrete split box culverts.

Bridge design is the responsibility of the Washington State Department of Transportation (WSDOT) Headquarters (HQ) Bridge and Structures Office, which develops a preliminary bridge plan for a new or modified structure in collaboration with the region. This chapter provides basic design considerations for the development of this plan. Unique staging requirements, constructability issues, and other considerations are addressed during plan development. Contact the HQ Bridge and Structures Office early in the planning stage regarding issues that might affect the planned project (see Chapter 700).

720.02 Bridge Locations

Bridge locations are chosen to conform to the alignment of the highway. Conditions that can simplify design efforts, minimize construction activities, and reduce structure costs are:

- A perpendicular crossing.
- The minimum required horizontal and vertical clearances.
- A constant bridge width (without tapered sections).
- A tangential approach alignment of sufficient length not to require superelevation on the bridge.
- A crest vertical curve profile that will facilitate drainage.
- An adequate construction staging area.

720.03 Bridge Site Design Elements

720.03(1) Structural Capacity

The structural capacity of a bridge is a measure of the structure's ability to carry vehicle loads. For new bridges, the bridge designer chooses the design load that determines the structural capacity. For existing bridges, the structural capacity is calculated to determine the "load rating" of the bridge. The load rating is used to determine whether or not a bridge is "posted" for legal weight vehicles or "restricted" for overweight permit vehicles.

720.03(1)(a) New Structures

All new structures that carry vehicular loads are designed to HL-93 notional live load in accordance with AASHTO's LRFD Bridge Design Specifications.

720.03(1)(b) Existing Structures

When the structural capacity of a bridge will be affected by the project, the Region requests a Structural Capacity Report from the Risk Reduction Engineer in the HQ Bridge and Structures Office. Permanent redistribution of traffic, introduction of median barrier, and widening or deck rehabilitation are among the triggers for evaluation of a bridge's structural capacity. The report will state:

- The structural capacity status of the structures within the project limits.
- What action, if any, is appropriate.

The Region requests the Bridge and Structures Asset Manager to provide status about whether a bridge is included in the 6-year or 20-year plans for replacement or rehabilitation under the P2 program and, if so, in which biennium the P2 project is likely to be funded.

The criteria used by the Bridge and Structures office to evaluate the structural capacity of a bridge are as follows:

1. On National Highway System (NHS) routes (including Interstate routes):
   - The operating load rating is at least 36 tons (which is equal to HS-20).
   - The bridge is not permanently posted for legal weight vehicles.
   - The bridge is not permanently restricted for vehicles requiring overweight permits.
2. On non-NHS routes:
   - The bridge is not permanently posted for legal weight vehicles.
   - The bridge is not permanently restricted for vehicles requiring overweight permits.

Include the Structural Capacity Report in the Project File (see Chapter 300).

720.03(2) Bridge Widths

The Design Manual contains multiple chapters that provide geometric cross section criteria and procedures relevant to determining design element widths. See Chapter 1230 for a guide to chapters that provide geometric cross section element widths.

While it is preferred not to alter the continuity of a roadway, there may be situations where providing a structure width more or less than the roadway approaching the structure is appropriate.

All structures on city or county routes crossing over a state highway must conform to the Local Agency Guidelines.

For structures involving railroads, contact the HQ Design Office Railroad Liaison.

720.03(3) Horizontal Clearance

Horizontal clearance for structures is the distance from the edge of the traveled way to bridge piers and abutments, traffic barrier ends, or bridge end embankment slopes. Minimum distances for this clearance vary depending on the type of structure. (See Chapters 1239, 1600, and 1610 and the *Bridge Design Manual* for guidance on horizontal clearance.)

For structures involving railroads, contact the HQ Design Office Railroad Liaison.

720.03(4) Bridge Medians

Designs for bridges on divided multilane highways often include the decision to join parallel bridges as one or build them as independent structures. There are several factors in this decision, such as in new corridor construction, phased construction of corridors, and the general median width of the divided highway. This section covers some common design considerations related to bridge medians.

Advances in crash barriers and their applications have resulted in an expanded set of choices for bridge medians on divided highways.

Modern barrier designs and applications have allowed for longer runs of traffic barrier, different barrier types, and bullnose guardrail designs for shielding the gap between parallel structures. These tools have reduced collisions with abrupt bridge ends as well as shielded the opening between bridges.

Some highway corridors are initially planned as multilane divided highways but may be developed in logical, affordable phases and individual projects. This could result in an initial phase where a corridor may open as a two-lane rural highway used by both travel directions. A later phase could convert the facility to a divided highway, bringing with it the need for median separation. Consider the long-range plans when determining median widths for bridges. The photos in Exhibit 720-1 show a completed multilane highway where two separate bridges were ultimately constructed years apart and a new corridor underway where one bridge is now built.

Joining two structures may not be the most cost-effective or sustainable solution for all projects. Coordinate with the Bridge and Structures Office and the local Maintenance Office when discussing options and concerns. For bridges on parallel horizontal and vertical alignments, practical considerations for joining two structures as one include, but are not limited to:

- Phased development where one structure exists and another is planned.

- Old and new structure types and compatibility (with phased corridor construction).
- Median width.
- Median barrier treatment options.
- Environmental contexts and regulations.
- Seismic conditions and load ratings.
- Bridge maintenance and inspection techniques: accessibility options and equipment for terrain in specific contexts. An open area between structures may be needed for bridge inspection.
- Skew angles and/or curvature of waterways or roadways beneath the structures.
- Economics.
- Historical/aesthetic value of existing bridges to remain in place.

If structures will not be joined, evaluate the median as described here:

When there is a median gap between bridges of 6 inches or more, the Region PEO will evaluate whether or not the median gap needs to be screened. Address the potential for pedestrians on the bridge and if closing the median gap to less than 6 inches, or installing fencing, netting, or other elements to enclose the area between the bridges would be beneficial. Document this evaluation in the Basis of Design and Alternatives Comparison Table.

Exhibit 720-1 Phased Development of Multilane Divided Highways

720.03(5) Vertical Clearance

Vertical clearance is the critical height under a structure that will accommodate vehicular and rail traffic based on its design characteristics. This height is the least height available from the lower roadway surface (including usable shoulders) or the plane of the top of the rails to the bottom of the bridge. Usable shoulders are the design shoulders for the roadway and do not include paved widened areas that may exist under the structure.

In addition to the following vertical clearance guidance, consider whether the corridor experiences overheight loads. Consider a vertical clearance such that it will not create a new "low point" in the corridor.

720.03(5)(a) Vertical Falsework Clearance for Bridges Over Highways

Construction of new bridges and the reconstruction or widening of existing structures often requires the erection of falsework across the traveled way of a highway. The erection of this falsework can reduce the vertical clearance for vehicles to pass under the work area. The potential for collisions to occur by hitting this lower construction stage falsework is increased.

1. On all routes that require a 16.5-foot vertical clearance, maintain this same clearance for falsework vertical clearance.
   - On structures that currently have less than a 16.5-foot vertical clearance for the falsework envelope, maintain existing clearance.
   - On new structures, maintain the falsework vertical clearance at least to those of the minimum vertical clearances referenced below.
2. Any variance from the above must be approved by the Regional Administrator or designee in writing and made a part of the Project File.

720.03(5)(b) Minimum Clearance for New Structures

For new structures, the minimum vertical clearances are as follows:

720.03(5)(b)(1) Bridge Over a Roadway

The minimum vertical clearance for a bridge over a roadway is 16.5 feet.

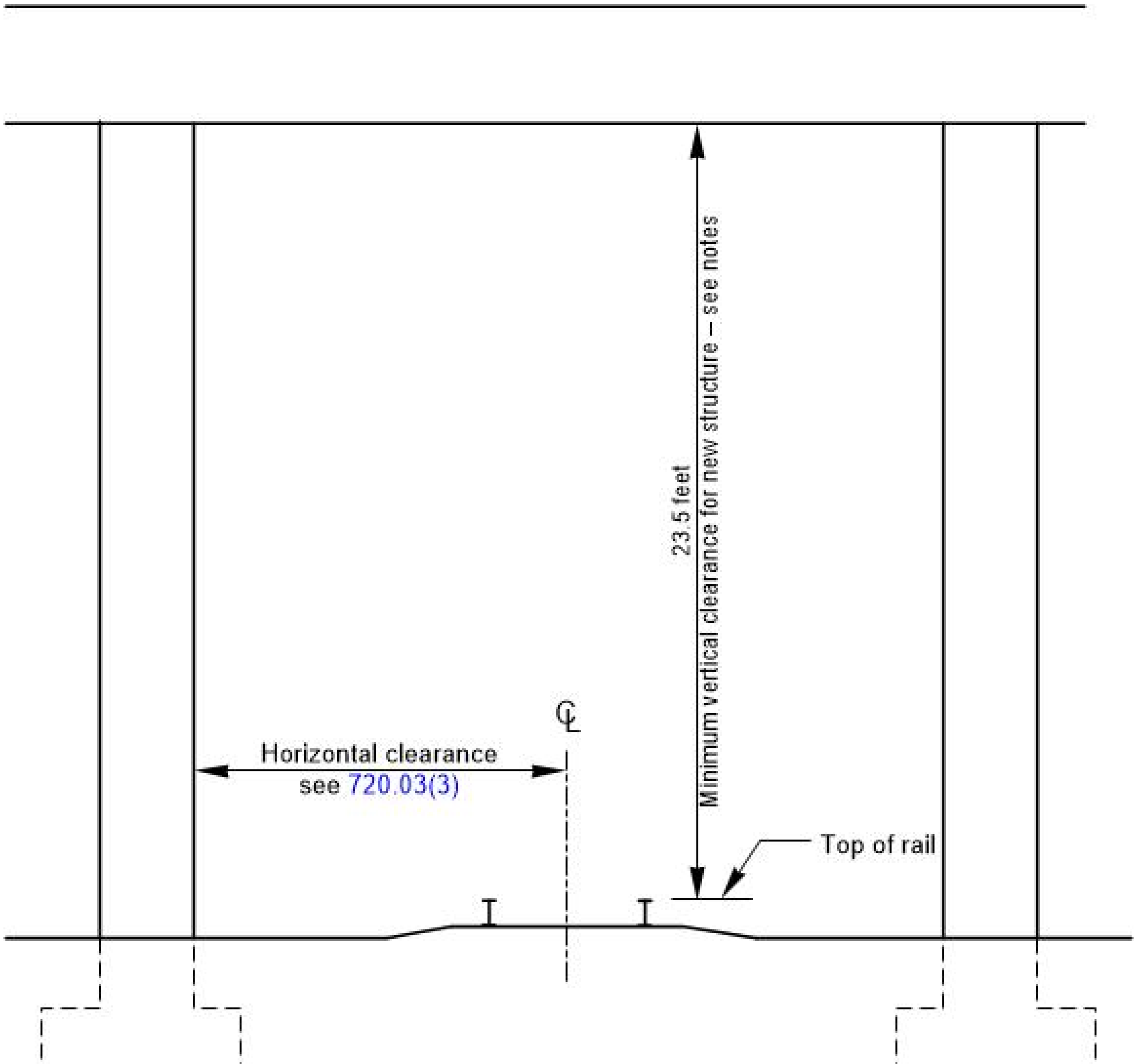
720.03(5)(b)(2) Bridge Over a Railroad Track

The minimum vertical clearance for a bridge over a railroad track is 23.5 feet (see Exhibit 720-2). A lesser clearance may be negotiated with the railroad company based on certain operational characteristics of the rail line; however, any clearance less than 22.5 feet requires the approval of the Washington State Utilities and Transportation Commission (WUTC) per WAC 480-60. Vertical clearance is provided for the width of the railroad clearance envelope. Coordinate railroad clearance issues with the HQ Design Office Railroad Liaison.

720.03(5)(b)(3) Pedestrian Bridge Over a Roadway

The minimum vertical clearance for a pedestrian bridge over a roadway is 17.5 feet.

Exhibit 720-2 Highway Structure Over Railroad



Notes:

- Use 22.5-foot vertical clearance for existing structures.
- Lesser vertical clearance may be negotiated (see 720.03(5)).
- Increase horizontal clearance when the track is curved.
- Coordinate railroad clearance issues with the HQ Design Office Railroad Liaison.

720.03(5)(c) Minimum Clearance for Existing Structures

The criteria used to evaluate the vertical clearance for existing structures depend on the work being done on or under that structure. When evaluating an existing structure on the Interstate System, see 720.03(5)(e), Coordination. This guidance applies to bridge clearances over state highways and under state highways at interchanges. For state highways over local roads and streets, city or county vertical clearance requirements may be used as minimum design criteria. (See Exhibit 720-3 for bridge vertical clearances.)

720.03(5)(c)(1) Bridge Over a Roadway

For a project that will widen an existing structure over a highway or where the highway will be widened under an existing structure, the vertical clearance can be as little as 16.0 feet on the Interstate System or other freeways or 15.5 feet on nonfreeway routes. An approved design analysis is required for clearance less than 16.0 feet on Interstate routes or other freeways and 15.5 feet on nonfreeway routes.

For a planned resurfacing of the highway under an existing bridge, if the clearance will be less than 16.0 feet on the Interstate System or other freeways and 15.5 feet on nonfreeway routes, evaluate the following options and include in a design analysis request:

- Pavement removal and replacement
- Roadway excavation and reconstruction to lower the roadway profile
- Providing a new bridge with the required vertical clearance

Reducing roadway paving and surfacing thickness under the bridge to achieve the minimum vertical clearance can cause accelerated deterioration of the highway and is not recommended. Elimination of the planned resurfacing in the immediate area of the bridge might be a short-term solution if recommended by the Region Materials Engineer (RME). Solutions that include milling the existing surface followed by overlay or inlay must be approved by the RME to ensure adequate pavement structure is provided.

For other projects that include an existing bridge where no widening is proposed on or under the bridge, and the project does not affect vertical clearance, the clearance can be as little as 14.5 feet. For these projects, document the clearance in the Design Documentation Package. For an existing bridge with less than a 14.5-foot vertical clearance, an approved design analysis request is required.

720.03(5)(c)(2) Bridge Over a Railroad Track

For an existing structure over a railroad track (see Exhibit 720-2), the vertical clearance can be as little as 22.5 feet. A lesser clearance can be used with the agreement of the railroad company and the approval of the Washington State Utilities and Transportation Commission. Coordinate railroad clearance issues with the HQ Design Office Railroad Liaison.

Exhibit 720-3 Bridge Vertical Clearances

Project Type	Vertical Clearance [8]	Documentation Requirement (see notes)
Interstate and Other Freeways [1]		
New Bridge	> 16.5 ft	[2]
Widening Over or Under Existing Bridge	> 16 ft	[2]
	< 16 ft	[4]
Resurfacing Under Existing Bridge	> 16 ft	[2]
	< 16 ft	[4]
Other With No Change to Vertical Clearance	> 14.5 ft	[3]
	< 14.5 ft	[4]
Nonfreeway Routes		
New Bridge	> 16.5 ft	[2]
Widening Over or Under Existing Bridge	> 15.5 ft	[2]
	< 15.5 ft	[4]
Resurfacing Under Existing Bridge	> 15.5 ft	[2]
	< 15.5 ft	[4]
Other With No Change to Vertical Clearance	> 14.5 ft	[3]
	< 14.5 ft	[4]
Bridge Over Railroad Tracks [7]		
New Bridge	> 23.5 ft < 23.5 ft	[2] [4][5]
Existing Bridge	> 22.5 ft < 22.5 ft	[2] [4][5]
Pedestrian Bridge Over Roadway		
New Bridge	> 17.5 ft	[2]
Existing Bridge	17.5 ft	[6]

Notes:

[1] Applies to all bridge vertical clearances over highways and under highways at interchanges.

[2] No documentation required.

[3] Document to Design Documentation Package.

[4] Approved design analysis required.

[5] Requires written agreement between railroad company and WSDOT and approval via petition from the WUTC.

[6] Maintain 17.5-ft clearance.

[7] Coordinate railroad clearance with the HQ Design Office Railroad Liaison.

[8] See 720.03(5).

720.03(5)(d) Signing

Low-clearance warning signs are necessary when the vertical clearance of an existing bridge is less than 15 feet 3 inches. Refer to the *Manual on Uniform Traffic Control Devices* and the *Traffic Manual* for other requirements for low-clearance signing.

720.03(5)(e) Coordination

The Interstate System is used by the Department of Defense (DOD) for the conveyance of military traffic. The Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) represents the DOD in public highway matters. The MTMCTEA has an inventory of vertical clearance deficiencies over the Interstate System in Washington State. Contact the MTMCTEA, through the Federal Highway Administration (FHWA), if either of the following changes is proposed to these bridges:

- A project would create a new deficiency of less than a 16.0-foot vertical clearance over an Interstate highway.
- The vertical clearance over the Interstate is already deficient (less than 16.0 feet) and a change (increase or decrease) to vertical clearance is proposed.

Coordination with MTMCTEA is required for these changes on all rural Interstate highways and for one Interstate route through each urban area.

720.03(6) Liquefaction Impact Considerations

To determine the amount of settlement and the potential for the soil to flow laterally during the design level earthquake due to liquefaction, an analysis performed by the HQ Geotechnical Office is needed for each bridge project site location. The information collected is used by bridge engineers to determine the bridge's capability to withstand the movement and loading in a seismic event and to explore other foundation mitigation options not necessitating total bridge replacement.

The HQ Bridge and Structures Office, in collaboration with the HQ Geotechnical Office, evaluates bridge-widening projects involving liquefiable soils and recommends appropriate liquefaction mitigation.

See the *Bridge Design Manual LRFD* for further information.

720.03(7) Pedestrian and Bicycle Facilities

When pedestrians or bicyclists are anticipated on bridges, provide facilities consistent with guidance in Chapters 1510, 1515, and 1520.

Evolving programs and technologies such as incident response, personal cell phones, and ITS cameras have further reduced the probability of motorists becoming pedestrians. Investigate other methods of treatment such as pedestrian scale signing or other low-cost safety improvement measures. Document decisions in the Basis of Design.

720.03(8) Bridge Approach Slab

Bridge approach slabs are reinforced concrete pavement installed across the full width of the bridge ends. They provide a stable transition from normal roadway cross section to the bridge ends, and they compensate for differential expansion and contraction of the bridge and the roadway.

Bridge approach slabs are provided on all new bridges. If an existing bridge is being widened and it has an approach slab, slabs are required on the widenings. The region, with the concurrence of the State Geotechnical Engineer and the State Bridge Design Engineer, may decide to omit bridge approach slabs. Document decisions in the DDP.

720.03(9) Traffic Barrier End Treatment

Plans for new bridge construction and bridge traffic barrier modifications include provisions for the connection of bridge traffic barriers to the longitudinal barrier approaching and departing the bridge. Indicate the preferred longitudinal barrier type and connection during the review of the bridge preliminary plan.

720.03(10) Bridge End Embankments

The design of embankment slopes at bridge ends depends on several factors. The width of the embankment is determined not only by the width of the roadway, but also by the presence of traffic barriers, curbs, and sidewalks, all of which create the need for additional widening. Examples of the additional widening required for these conditions are shown in the Standard Plans.

The end slope is determined by combining the recommendations of several technical experts within WSDOT. Exhibit 720-4 illustrates the factors taken into consideration and the experts involved in the process.

720.03(11) Bridge Slope Protection

Slope protection provides a protective and aesthetic surface for exposed slopes under bridges. Slope protection is normally provided under:

- Structures over state highways.
- Structures within an interchange.
- Structures over other public roads unless requested otherwise by the public agency.
- Railroad overcrossings if requested by the railroad.

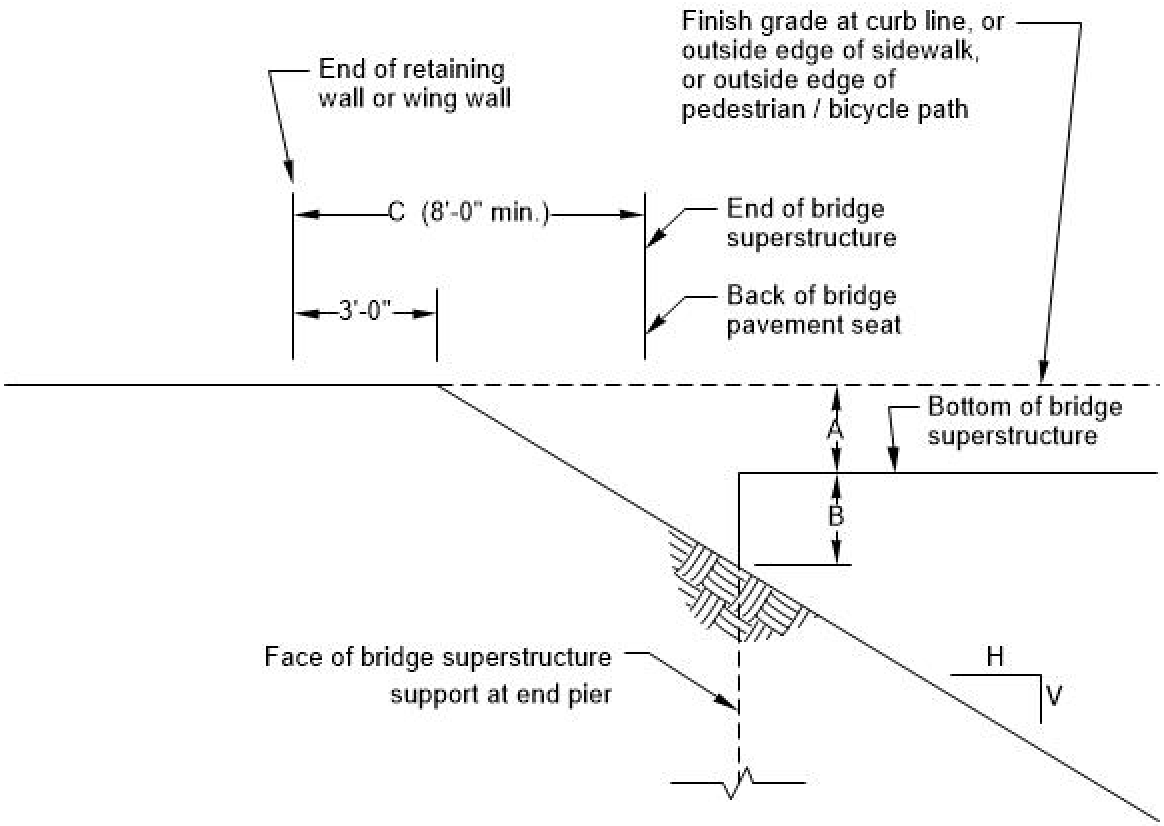
Slope protection is usually not provided under pedestrian structures.

The type of slope protection is selected at the bridge preliminary plan stage. Typical slope protection types are concrete slope protection, and rubble stone.

720.03(12) Slope Protection at Water Crossings

The HQ Hydraulics Section determines the slope protection requirements for structures that cross waterways. The type, limits, and quantity of slope protection are shown on the bridge preliminary plan.

Exhibit 720-4 Embankment Slope at Bridge Ends



Bridge End Elevation

Applies to retaining wall or wing wall (or combination) extending beyond bridge superstructure (barrier omitted for clarity)

Legend

A = Superstructure depth: recommended by HQ Bridge and Structures Office

B = Vertical clearance from bottom of superstructure to embankment: recommended by Bridge Preservation Engineer

C = Distance from end of retaining wall or wing wall to back of pavement seat: recommended by HQ Bridge and Structures Office

H & V = Embankment slope: recommended by Geotechnical Engineer

720.03(13) Screening for Highway Structures

The Washington State Patrol (WSP) classifies the throwing of an object from a highway structure as an assault, not an accident or collision. Therefore, records of these assaults are not contained in WSDOT's crash databases. Contact the Region Traffic Engineer, RME's office and the WSP for the history of reported incidents.

Screening might reduce the number of incidents, but will not stop a determined individual at that location, or deter them from moving to other locations in the area. Enforcement provides the most effective deterrent and is typically the first approach used.

Installation of screening is analyzed on a case-by-case basis at the following locations:

- On existing structures where there is a history of multiple incidents of objects being dropped or thrown and where enforcement has not changed the situation.
- On new structures near schools, playgrounds, or areas frequently used by children not accompanied by adults.
- In urban areas on new structures used by pedestrians where surveillance by local law enforcement personnel is not likely.
- On new structures with walkways where experience on similar structures within a 1 mile radius indicates a need.
- On private property structures, such as buildings or power stations, subject to damage.

In most cases, the installation of a screen on a new structure can be postponed until there are indications of need.

Submit all proposals to install screening on structures to the Director & State Design Engineer, Development Division, for approval. Contact the HQ Bridge and Structures Office for approval to attach screening to structures and for specific design and mounting details.

720.04 Documentation

Refer to Chapter 300 for design documentation requirements.

720.05 References

720.05(1) Federal/State Laws and Codes

23 CFR Part 650, Subpart C – National Bridge Inspection Standards

Washington Administrative Code (WAC) 480-60, Railroad companies – Clearances

720.05(2) Design Guidance

Bridge Design Manual LRFD, M 23-50, WSDOT

Geotechnical Design Manual, M 46-03, WSDOT

Local Agency Guidelines (LAG), M 36-63, WSDOT

LRFD Bridge Design Specifications, AASHTO, Current Edition

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-10, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

Traffic Manual, M 51-02, WSDOT

720.05(3) Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition

Manual for Railway Engineering, American Railway Engineering and Maintenance-of-Way Association (AREMA)

1010.01 General

Addressing work zone impacts to all road users is an important component in the design of a project and needs to be given adequate consideration early in the design process. Most work zones create some level of traffic impacts and require additional safety features; therefore, all work areas and operations needed for construction must be identified and addressed during the project design. Planners, designers, construction engineers, maintenance personnel, and others all play a role in developing a comprehensive work zone design. Consider including Rail, Freight, and Ports, Commercial Vehicle Services, and Public Transportation Divisions for help coordinating with freight and transit industries. See the WSDOT Project Management website for information on project teams.

This chapter provides the designer with guidance to develop comprehensive work zone strategies and plans to address a project's safety and mobility benefits/improvements for all modes, as well as constructability. A systematic process for addressing work zone impacts is required by federal regulations and state policy.

For the purposes of this chapter high speed means 45 mph and above.

1010.02 Definitions

The following terms are defined in the *Design Manual* Glossary: ***transportation management area (TMA)***; ***transportation management plan (TMP)***; ***work zone; work zone impact***; ***work zone traffic control***; ***traveling public***.

1010.03 Work Zone Safety and Mobility

Washington State Department of Transportation (WSDOT) policy per Executive Order E 1001, Work Zone Safety and Mobility, is intended to support systematic consideration and management of work zone impacts across all stages of project development.

The policy states:

> *All WSDOT employees are directed to make the safety of workers and the traveling public our highest priority during roadway design, construction, maintenance, and related activities.*

Designers should be familiar with this document. The policy defines how WSDOT programs address work zone safety and mobility issues during project planning, design, and construction.

1010.04 Transportation Management Plans and Significant Projects

1010.04(1) Transportation Management Plan (TMP)

A transportation management plan is a set of strategies for managing the corridor-wide work zone impacts of a project. A TMP is required for all projects and is the key element in addressing all work zone safety and mobility impacts. The TMP development begins in the scoping phase of a project by assessing impacts known at the time and then selecting mitigating strategies and design solutions to manage those impacts. It is very important to continue the development of the TMP throughout the project development process.

Not all work zone impacts have to be addressed with traffic control plans only. Many work zone impacts can be reduced or eliminated through project design elements like alignment choice, materials selection, structure types, overbuilding, and phased construction. Work zone impacts related to work duration may be resolved or reduced through innovative bidding and contract administration.

The three major components of a TMP are described below.

1010.04(1)(a) Temporary Traffic Control (TTC)

The TTC components are those strategies for directing traffic through the work zone and minimizing the duration of the impacts. These components are to be included in the Plans, Specifications, and Estimates (PS&E) as traffic control plans (TCPs) and contract provisions. The TTC components may include but are not limited to the following strategies:

- TTC strategies such as lane closures or shifts, one-lane two-way operations (flagging and or pilot car), staged construction, or full road closures and detours.
- Traffic Control Devices such as temporary signing, channelizing devices (cones, drums), changeable message signs, arrow boards, temporary signals, and temporary pavement markings.
- Corridor Project Coordination, Contracting Strategies, and Innovative Construction Strategies such as A+B bidding, incentives/disincentives, and precast members or rapid cure materials.

1010.04(1)(b) Transportation Operations (TO)

The TO components are those strategies for improving traffic flow and safety through the work zone. Some of these strategies may be included in the PS&E, but could also be WSDOT-managed elements outside the contract. The TO components may include but are not limited to the following strategies:

- Demand Management Strategies such as Transit service improvements, transit incentives, and park & ride promotion.
- Corridor/Network Management (traffic operations) Strategies such as Signal timing/coordination improvements, temporary signals, bus pullouts, reversible lanes, and truck/heavy-vehicle restrictions.
- Work Zone Safety Management Strategies such as Positive protective device use, speed limit reductions, and automated flagger assistance devices.
- Traffic/Incident Management and Enforcement Strategies such as Work Zone Intelligent Transportation Systems (ITS), Washington State Patrol, tow service, WSDOT Incident Management vehicle(s), and traffic screens.

1010.04(1)(c) Public Information (PI)

The PI components are those strategies for raising awareness of the upcoming project impacts or current restrictions. Public awareness strategies may be developed and implemented by WSDOT through the region or Headquarters (HQ) Communications offices and implemented before and during construction. Motorist information strategies may be WSDOT-managed elements with state equipment outside the contract or identified on plans in the PS&E. The PI components may include, but are not limited to, the following strategies:

- Public Awareness Strategies such as Brochures or mailers, press releases, paid advertisements, and project website (consider providing information in other languages if appropriate).
- Motorist Information Strategies such as Highway advisory radio (HAR), changeable message signs, and transportation management center (TMC).

It is very important to continue the development of the TMP throughout the project development process. Not all work zone impacts have to be addressed with traffic control plans only. Many work zone impacts can be reduced or eliminated through project design elements like alignment choice, materials selection, structure types, overbuilding, and phased construction. Work zone impacts related to work duration may be resolved or reduced through innovative bidding and contract administration.

The TMP Checklist in Exhibit 1010-3 will help identify and organize TMP components. Include the completed checklist in the Project File. For significant projects, develop this checklist and the supporting plans, data, impacts assessment, strategies, capacity/delay analysis and endorsements into a formal TMP document to be included in the Project File. For TMP examples, see:
http://www.ops.fhwa.dot.gov/wz/resources/final_rule/tmp_examples/sample_tmps.htm
http://www.ops.fhwa.dot.gov/wz/resources/publications/trans_mgmt_plans/trans_mgmt_plans.pdf

1010.04(2) Significant Projects

The FHWA definition of a “significant project” is as follows:

A significant project is one that, alone or in combination with other concurrent projects nearby, is anticipated to cause sustained work zone impacts that are greater than what is considered tolerable based on state policy and/or engineering judgment.

All Interstate system projects within the boundaries of a designated Transportation Management Area (TMA) that occupy a location for more than three days with either intermittent or continuous lane closures shall be considered as significant projects.

Note: Significant projects require a Transportation Management Plan document addressing safety and mobility impacts with strategies or elements from all three TMP components. The size and scale of the TMP document will depend on the project’s complexity and impacts. For examples of WSDOT TMP’s see: http://www.wsdot.wa.gov/Safety/WorkZones/resources.htm

For projects not identified as significant, the Temporary Traffic Control components included in the PS&E will be considered the TMP. Transportation Operations and Public Information components may also be required to properly address the impacts as many projects can have significant work zone safety and mobility impacts, but are not necessarily a significant project as defined under the federal requirements stated above. Consider developing a TMP document for these types of projects as well.

The Project Summary must include a Work Zone Strategy Statement and indicate whether the project is significant in regard to work zone impacts.

Significant projects may require a Value Engineering (VE) study (see Chapter 310) and a Cost Risk Assessment (CRA) or Cost Estimate Validation Process (CEVP) that could help define strategies or identify risks: www.wsdot.wa.gov/projects/projectmgmt/riskassessment/

1010.05 Developing TMP Strategies

1010.05(1) Key Considerations

The following list is intended to alert the designer to actions and issues that need to be addressed as part of a TMP. Addressing these items is required per WSDOT’s work zone policy and federal regulations, and they are key to the successful development of a project’s TMP.

- Determine work zone impacts through an impact assessment process.
- Minimize, mitigate, and manage work zone impacts.
- Integrate work zone impacts strategies early, during planning, programming, and design.
- Develop an accurate scoping estimate based on the work zone strategies.
- Hold a Work Zone Design Strategy Conference early in the design process. (Include bridge, construction, traffic, maintenance, freight, transit, local agency, and law enforcement personnel.)
- Utilize the Work Zone TMP Checklist/TMP document (required for significant projects).
- Emphasize flagger safety.

- Assess work zone mobility through a capacity analysis.
- Integrate project constructability, work efficiency and cost containment into the work zone strategy.
- Attend work zone training.
- Address Washington State traffic and safety regulations as provided for by state law.
- Use the legally adopted *Manual on Uniform Traffic Control Devices* (MUTCD), with Washington State modifications as the minimum standard.
- Provide an appropriate level of traffic control plans (TCPs).
- Consider work zone ITS elements.
- Use established design criteria in work zone roadway and roadside design.
- Accommodate pedestrian access (including ADA requirements) and maintenance of existing transit stops and bicycle traffic.
- Consider maintenance issues and needs through the duration of the project.
- Consider school, hospital, emergency services, and postal delivery, impacts.
- Consider economic impacts (business access) due to traffic delay or restricted access.
- Consider freight mobility; total roadway widths to less than 16 feet should be avoided if possible. Truck routes can be found here:
  http://www.wsdot.wa.gov/Freight/EconCorridors.htm
- Address traffic impacts extending beyond the project limits and impacting other roads.
- Identify seasonal or special event impacts that affect recreation or business due to work zone impacts.
- Consider risk management and tort liability exposure.
- Approach the work zone design from the road user's perspective.
- Incorporate worker safety needs (positive protection) in your work zone designs.
- Account for all needed work areas, operations and possible staging areas.
- Address work vehicle ingress and egress to each work area.
- Use of law enforcement

1010.05(2) Impacts Assessment

One of the most important tasks in developing a TMP is assessing all of the project impacts to mobility and safety. Impacts that are not identified and addressed in the TMP will undoubtedly become issues during the construction phase of the project. A designer needs to possess a clear understanding of how project features will be constructed, including work methods, equipment, materials, and duration, to complete the work. Involve the construction PE when making decisions on assessing and addressing impacts.

A complete and accurate impacts assessment will allow for the development of an effective TMP that should only need minor modifications to address construction issues.

An early and ongoing impacts assessment allows time to:

- Develop TTC, TO, and PI strategies to address identified impacts as needed to effectively manage the project.
- Resolve potential work zone impacts within the design features of the project. Decisions that consider work zone impacts during bridge type selection, materials selection, advertisement dates, and others have the potential to resolve or minimize work zone impacts.

- Consider innovative mitigation strategies that may involve many stakeholders.

Some impacts may be difficult to completely solve and may ultimately need a management decision to determine the level of mitigation or impact that is acceptable. These types of impacts need to be clearly addressed in the TMP with documentation supporting and explaining the decision.

The following are some examples of impacts that need to be managed during the design of a project:

1. Bridge construction sequence or falsework opening plans need to match the TCC staging or channelization plans. Coordination with the HQ Bridge and Structures Office is essential as the bridge design schedule may differ than the project schedule. Maintain the legal height of 16 feet 6 inches as the minimum falsework opening whenever possible; anything less than this must consider overheight vehicle impacts, possible additional signing needs, and temporary bypass routes. Impacts to shoulder widths due to barrier or bridge staging may impact bicycle or pedestrian access and must be addressed in TCC plans. Refer to Chapter 720 for additional requirements and approvals. Coordination with the Permits Office may be needed.
2. If existing signal and illumination systems are not able to be maintained during the construction phases, plans for temporary systems or connections need to be included in the project.
3. Temporary relocation of existing signing (including overhead signing) may be required and should be detailed in the plans.
4. Permanent traffic loop installation (such as advance loops, turn pockets, and stop bars, and ITS loops) and pavement marking installations (crosswalks, arrows, and so on) may require specific TTC plans.
5. What type of temporary marking is most appropriate for the installation, work duration, and the pavement surface? Will the final pavement surface have a "ghost stripe" potential?
6. Lane shifts onto existing shoulders:
    - Is the depth of the existing shoulder adequate to carry the extra traffic and are there rumble stripe that need to be removed?
    - Are there any existing catch basins or junction boxes located in the shoulder that cannot accept traffic loads over them?
    - What is the existing side slope rate? If steeper than 4H:1V, does it need mitigation? Are there existing roadside objects that, when the roadway is shifted, are now within the clear zone limits?
    - Shifting of more than one lane in a direction is only allowed with temporary pavement markings. Shifting lanes by using channelizing devices is not allowed due to the high probability that devices used to separate the traffic will be displaced.
    - Signal head alignment: When the lane is shifted approaching the intersection, is the signal head alignment within appropriate limits?
7. Roundabout construction at an existing intersection requires site-specific staging plans. Roundabouts create many unique construction challenges and each roundabout has very site-specific design features.

1010.05(3) Work Duration

The duration of work is a major factor in determining a strategy and the amount and types of devices to use in traffic control work zones. A project may have work operations with durations that meet several or all of the following conditions:

1010.05(3)(a) Long-Term Stationary Work Zone

This is work that occupies a location continuously for more than three days. Construction signs should be post-mounted and larger; more stable channelizing devices should be used for increased visibility. Temporary barriers, pavement markings, illumination, and other considerations may be required for long-term stationary work. Staged construction or temporary alignment/channelization plans are required with this type of work.

1010.05(3)(b) Intermediate-Term Stationary Work Zone

This is work that occupies a location for up to three days. Signs may still be post-mounted if in place continuously. Temporary pavement markings, in addition to channelization devices, may be required for lane shifts. Barrier and temporary illumination would normally not be used in this work zone duration.

1010.05(3)(c) Short-Term Stationary Work Zone

This is work that occupies a location for more than one hour within a single day. At these locations, all devices are placed and removed during the single period.

1010.05(3)(d) Short-Duration Work Zone

This is work that occupies a location for up to one hour. Because the work time is short, the impact to motorists is usually not significant. Simplified traffic control set-ups are allowed, to reduce worker exposure to traffic. The time it may take to set up a full complement of signs and devices could approach or exceed the amount of time required to perform the work. Short-duration work zones usually apply to maintenance work and are not used on construction projects. (See Work Zone Traffic Control Guidelines for more information.)

1010.05(3)(e) Mobile Work Zone

This is work that moves intermittently or continuously. These operations often involve frequent stops for activities such as sweeping, paint striping, litter cleanup, pothole patching, or utility operations, and they are similar to short-duration work zones. Truck-mounted attenuators, warning signs, flashing vehicle lights, flags, and channelizing devices are used, and they move along with the work. When the operation moves along the road at low speeds without stopping, the advance warning devices are often attached to mobile units and move with the operation.

Pavement milling and paving activities are similar to mobile operations in that they can progress along a roadway several miles in a day. These operations, however, are not considered mobile work zones, and work zone traffic control consistent with construction operations is required.

1010.05(4) TMP Strategies

With a completed impacts assessment, strategy development can begin. There are often several strategies to address a work zone impact, and engineering judgment will be needed in selecting the best option. Constructability, along with addressing safety and mobility, is the goal. Selecting a strategy is often a compromise and involves many engineering and non-engineering factors. Work closely with bridge, construction, maintenance and traffic office personnel when selecting and developing strategies for the TMP and PS&E.

Do not assume that strategies chosen for past projects will adequately address the impacts for similar current projects. There may be similarities with the type of work, but each project is unique and is to be approached in that manner. Always look for other options or innovative approaches; many projects have unique features that can be turned to an advantage if carefully considered. Even a basic paving project on a rural two-lane highway may have opportunities for detours, shifting traffic, or other strategies.

For a list of work zone analysis tools, see:
http://ops.fhwa.dot.gov/wz/traffic_analysis/index.htm#tools

1010.05(5) Temporary Traffic Control (TTC) Strategies

1010.05(5)(a) Lane Closure

One or more traffic lanes are closed. A capacity analysis is necessary to determine the extent of congestion that may result. Night work or peak hour restrictions may be required. Use traffic safety drums and truck-mounted attenuators for freeway or expressway lane closures. Channelization devices should not encroach on the open freeway lanes; an additional lane should be closed if encroachment is necessary. Consider closing additional lanes to increase the lateral buffer space for worker safety.

1010.05(5)(b) Shoulder Closure

A shoulder closure is used for work areas off the traveled way. On high-volume freeways or expressways, they should not be allowed during peak traffic hours. Channelization devices should not encroach on the open lanes of high-speed roadways.

1010.05(5)(c) Alternating One-Lane Two-Way Traffic

This strategy involves using one lane for both directions of traffic. Flaggers are used to alternate the traffic movements.

If flaggers are used at an intersection, a flagger is required for each leg of the intersection. Only law enforcement personnel are allowed to flag from the center of an intersection. Close lanes and turn pockets so only one lane of traffic approaches a flagger station. When a signal is present, it shall be turned off or set to red flash mode when flagging.

Law enforcement personnel may be considered for some flagging operations and can be very effective where additional driver compliance is desired. The *Traffic Manual* contains information on the use of law enforcement personnel at work zones.

Flagger safety is a high emphasis area. Do not include alternating traffic with flaggers as a traffic control strategy until all other reasonable means of traffic control have been considered. Flagging stations need to be illuminated at night. Flaggers need escape routes in case of errant vehicles. Provide a method of alerting them to vehicles approaching from behind. Two-way radios or cellular phones are required to allow flaggers to communicate with one another. The flagger's location, escape route, protection, signing, and any other safety-related issues all need to be incorporated into the traffic control plan for the flagging operation. Flaggers are not to be used on freeways or expressways. Using flaggers solely to instruct motorists to proceed slowly is an unacceptable practice.

Removing flaggers from the roadway during alternating traffic operations can be done with portable temporary traffic control signals or automated flagging assistance devices (AFAD). Portable signals work best when the length between signals will be 1,500 feet maximum and no accesses lie between the temporary signals. Each AFAD unit will need a flagger operating the device from a safe location off the roadway. A traffic control plan should show the advance signing and the AFAD or signal locations. Temporary stop bars, and lighting at the stop bars is required for signal use. For assistance on using these devices, contact the region Traffic Office.

Refer to WAC 296-155-305 for flagging requirements.

1010.05(5)(d) Temporary Alignment and Channelization

Temporary alignments and/or channelization may be an option for long-term work zones or staged traffic control. The following are guiding principles for the design of temporary alignment and channelization plans:

- Use site-specific base data to develop site-specific traffic control plans.
- Use permanent geometric design criteria.
- Provide beginning and ending station ties and curve data.
- Include lane and shoulder widths.
- Provide temporary roadway sections.
- To avoid confusion, do not show existing conflicting or unnecessary details on the plan.
- Do not use straight line tapers through curves; use circular alignment.
- Be aware of existing crown points, lane/shoulder cross slope breaks, and super-elevation transitions that may affect a driver's ability to maintain control of a vehicle.
- If the project has multiple stages, from one stage to the next, show newly constructed features as existing elements. For example, if an edge line is removed in one stage, the following stage would show the change by indicating where the new edge line is located.
- Consider the time needed for removal of existing markings and placement of the new markings and possibly placement of barriers and attenuators. In urban areas where work hours for lane closures are limited, special consideration may be necessary to allow time to implement the plan, or an interim stage may be necessary.
- Use shoulder closure signing and channelizing devices to close a shoulder prior to a temporary impact attenuator and run of temporary concrete barrier.
- Existing signing may need to be covered or revised, and additional construction warning signs may be needed for the new alignment.
- Temporary pavement marking types and colors should be specified. Long-duration temporary markings should be installed per the Standard Plans for permanent markings.
- For better guidance through shifting or taper areas, consider solid lane lines. Return to broken lane lines between shift areas.

- Provide a list of the approved temporary impact attenuators that may be used for the plan if applicable.
- The plans must provide all the layout information for all the temporary features just as a permanent pavement marking plan would.

1010.05(5)(d)(1) Staged Construction

Staged construction entails combining multiple work areas into a logical order to provide large protected work areas for long durations, which maximizes work operations and minimizes daily impacts to traffic. Temporary alignment and channelization plans must be designed to place traffic in these semi-permanent locations. Minimum geometric design criteria are to be used when developing these plans. Design strategies such as overbuilding for future stages or the use of temporary structures are often part of staged construction on significant impact projects or mega projects. Develop detailed capacity analysis and traffic modeling for each stage.

1010.05(5)(d)(2) Lane Shift/Reduced Lane Width

Traffic lanes may be shifted and/or width-reduced in order to accommodate a long-duration work area when it is not practicable, for capacity reasons, to reduce the number of available lanes. Shifting more than one lane of traffic requires the removal of conflicting pavement markings and the installation of temporary markings; the use of channelization devices to delineate multiple lanes of traffic is not allowed. Use advanced warning signs to show the changed alignment when the lateral shifting distance is greater than one-half of a lane width, and consider the use of solid lane lines through the shift areas.

Utilizing the existing shoulder may be necessary to accommodate the shifting movement. First, determine the structural capacity of the shoulder to ensure its ability to carry the proposed traffic. Remove and inlay existing shoulder rumble strips prior to routing traffic onto the shoulder.

1010.05(5)(d)(3) Traffic Split or Island Work Zone

This strategy separates lanes of traffic traveling in one direction around a work area. On higher-speed roadways, temporary barriers are provided to prevent errant vehicles from entering the work area. Some drivers have difficulty understanding "lane split" configurations, which sometimes results in poor driving decisions such as unnecessary or late lane changes. Braking and erratic lane changes decrease the traffic capacity through the work zone, which results in an unstable traffic flow approaching the lane split. Evaluate other strategies, such as overbuilding, to keep traffic on one side of the work area to avoid a traffic split if possible.

Consider the following guidance for traffic split operations:

- Define the work operation and develop the traffic control strategy around the specific operation.

- Limit the duration the traffic split can be in place. Consider incentives and disincentives to encourage the contractor to be as efficient as possible. A higher level of traffic impacts may be acceptable if offset with fewer impacted days.
- Advance warning signs advising drivers of the approaching roadway condition are required. Consider the use of Portable Changeable Message Signs (PCMS), portable Highway Advisory Radio (HAR), and other dynamic devices. Overhead signing and in-lane pavement markings also may be necessary to give additional driver notice of the traffic split.
- Consider how the operation will impact truck traffic. If the truck volumes are high, additional consideration may be prudent to control in which lane the trucks drive. If the trucks are controlled, it eliminates much of the potential for truck/car conflicts and sorts out undesirable truck lane changes through the work zone. For questions concerning truck operations, contact the HQ Freight Systems Division.
- To discourage lane changing, consider the use of solid lane line markings to delineate traffic approaching the split or island. Refer to the MUTCD for additional details.
- Consider the use of STAY IN LANE (black on white) signs, or set up a "no pass" zone approaching the lane split and coordinate with the Washington State Patrol (WSP).
- Supplement the existing roadway lighting with additional temporary lighting to improve the visibility of the island work area (see exhibit in Chapter 1040).
- Coordinate with the region Traffic Office for signing and pavement marking details when designing island work zones.

1010.05(5)(d)(4) Temporary Bypass

This strategy involves total closure of one or both directions of travel on the roadway. Traffic is routed to a temporary bypass usually constructed within the highway right of way. An example of this is the replacement of an existing bridge by building an adjacent temporary structure and shifting traffic onto the temporary structure. A temporary channelization plan will show pavement markings, barrier and attenuators, sign and device placement.

1010.05(5)(d)(5) Median Crossover

This strategy involves placing all multilane highway traffic on one side of the median. Lanes are usually reduced in both directions and one direction is routed across the median. The design for elements of temporary crossovers needs to follow the same guidance as permanent design for alignment, barriers, delineation, and illumination.

- Design crossovers for operating speeds not less than 10 mph below the posted speed limit unless unusual site conditions require a lower design speed.
- Median paving may be required to create crossover locations (consider drainage for the added pavement).

- Use temporary barrier to separate the two directions of traffic normally separated by a median barrier,
- Temporary illumination at the crossover locations (see exhibit in Chapter 1040)
- Straight line crossover tapers work best for highways with narrow paved medians.
- Temporary pavement markings, removal of conflicting existing markings, and construction signs are also required.
- A good array of channelizing devices and properly placed pavement markings is essential in providing clear, positive guidance to drivers.
- Provide a clear roadside recovery area adjacent to the crossover. Consider how the roadway safety hardware (guardrail, crash cushions, and so on) may be impacted by the traffic using the crossover if the traffic is going against the normal traffic flow direction. Avoid or mitigate possible snagging potential. Avoid placing crossover detours near structures.

1010.05(5)(e) Total Closures and Detours

Total closures may be for the project duration or for a critical work operation that has major constructability or safety issues. The main requirement for total closures is the availability of a detour route and if the route can accommodate the increased traffic volumes and trucks turning movements. Local roads may have lower geometric criteria than state facilities. Placing additional and new types of traffic on a local road may create new safety concerns, especially when drivers are accustomed to the geometrics associated with state highways. Pavement integrity and rehabilitation may need to be addressed when traffic is detoured to specific local roadways.

For the traveling public, closing the road for a short time might be less of an inconvenience than driving through a work zone for an extended period of time (see the Traffic Manual and RCW 47.48). Advance notification of the closure is required, and a signed detour route may be required.

Consider the following road closure issues:

- Communication with all stakeholders, including road users, adjoining property owners, local agencies, transit agencies, the freight industry, emergency services, schools, and others, is required when considering a total closure strategy. This helps determine the level of support for a closure and development of an acceptable closure. Include Rail, Freight, and Ports; Commercial Vehicle Services; and Public Transportation Divisions to help coordinate.
- Analyze a closure strategy and compare it to other strategies, such as staged work zones, to determine which is overall more beneficial. This information helps stakeholders understand the impacts if a closure is not selected.
- A closure decision (other than short-term, minor-impact closures) will require stakeholder acceptance and management approval once impacts and benefits have been analyzed.

- Closures that reopen to a new, completed roadway or other noticeable improvements are generally more accepted by the public.
- Route-to-route connections and other strategic access points may have to be maintained or a reasonable alternative provided.
- Material selection, production rates, and work operation efficiencies have a direct tie to the feasibility of the closure strategy. A strong emphasis has been placed on this area and several successful strategies have been implemented, such as weekend-long closures or extended-duration single-shift closures. These strategies use specific materials such as quick-curing concrete, accelerated work schedules, prefabricated structure components, on-site mix plants, and so on, and are based on actual production rates. The WSDOT Materials Laboratory and the HQ Construction Office are good resources for more information on constructability as a component of an effective work zone strategy.
- Interstate or interstate ramp closures (including interstate closures with interchange ramps as detours) lasting more than 7 days require FHWA 60-day advance notice. (See the Stewardship and Oversight Agreement for closure notification requirements.)
- Short-duration closures of ramps or intersecting streets during off-peak hours do not require extensive approval if advance notice is provided and reasonable alternate routes are available.
- Detailed, project-specific traffic control plans, traffic operation plans, and public information plans are required.
- Depending on the duration of the closure/detour and the anticipated amount and type of traffic that will use the route, consider upgrades to the route such as signal timing, intersection turning radius for large vehicle, structural pavement enhancements, or shoulder widening.
- An approved detour agreement with the appropriate local agency is required for detour routes using local roadways and must be completed prior to project advertisement.
- Document road closure decisions and agreements in the Project File.

1010.05(5)(f) Intermittent Closure

This involves stopping all traffic for a short time to allow the work to proceed. Traffic volumes will determine the allowed duration of the closures. Typically, the closure would be limited to a ten-minute maximum and would occur in the lowest traffic volume hours. Equipment crossing and material delivery are where this type of closure may work well. Traffic is reduced to a single lane on a multilane highway, and a flagger or law enforcement is used to stop traffic.

1010.05(5)(g) Rolling Slowdown

Rolling slowdowns are commonly practiced by the Washington State Patrol (WSP) for emergency closures. They are a legitimate form of traffic control for contractors or utility and highway maintenance crews for very specific short-duration closures (to move large equipment across the highway, to pull power lines across the roadway, to switch traffic onto a new alignment, and so on). They are not to be used for routine work that can be addressed by lane closures or other formal traffic control strategies. Traffic control vehicles, during off-peak hours, form a moving blockade, which reduces traffic speeds and creates a large gap (or clear area) in traffic, allowing very short-term work to be accomplished without completely stopping the traffic.

Consider other forms of traffic control as the primary choice before the rolling slowdown. A project-specific traffic control plan (TCP) must be developed for this operation. The TCP or contact provisions should list the work operations in which a rolling slowdown is allowed. The gap required for the work and the location where the rolling slowdown begins needs to be addressed on the TCP. Use of the WSP is encouraged whenever possible. Refer to the Standard Specifications and Work Zone Traffic Control Guidelines for additional information on rolling slowdown operations.

1010.05(5)(h) Pedestrian and Bike Detour Route

When existing pedestrian access routes and bike routes are disrupted due to construction activities, address detour routes with a traffic control plan. The plan must show enough detail and be specific enough to address the conflicts and ensure the temporary route is reasonably safe and adequate to meet the needs of the user. Also, consider the impacts to transit stops for pedestrians: Will the bus stops be able to remain in use during construction or will adjustments be necessary? (See Chapter 1510 for pedestrian work zone design requirements.)

1010.05(5)(i) Alternative Project Delivery

To reduce construction times and minimize impacts to the traveling public, consider alternative delivery techniques to accomplish this. For more information, see:
http://www.wsdot.wa.gov/projects/delivery/alternative/

1010.05(5)(j) Innovative Design/Construction Methods

- Overbuild beyond normal project needs to maintain additional traffic or facilitate staged construction.
- Replace bridges using new alignments so they can be built with minimal impacts.
- Bring adjacent lifts of hot mix asphalt (HMA) to match the latest lifts (lag up), and require a tapered wedge joint to eliminate drop-off and abrupt lane edges to improve motorist safety.
- Require permanent pavement markings at intervals during multi-season projects to limit the duration temporary markings are needed and to avoid temporary marking issues during winter shut-down.

1010.05(6) Transportation Operations (TO) Strategies

1010.05(6)(a) Demand Management

- Provide transit service improvements and possible incentives to help reduce demand.
- For long-term freeway projects, consider ramp metering.
- Provide a shuttle service for pedestrians and bicyclists.
- Provide local road improvements (signals modifications, widening, and so on) to improve capacity for use as alternate routes.
- Provide traffic screens to reduce driver distraction.

1010.05(6)(b) Corridor/Network Management

- Provide a temporary express lane with no access through the project.
- Consider signal timing or coordination modifications.
- Provide emergency pullouts for disabled vehicles on projects with long stretches of narrow shoulders and no other access points.
- Use heavy-vehicle restrictions and provide alternate routes or lane use restrictions.

1010.05(6)(c) Work Zone Safety Management

- Provide temporary access road approaches for work zone access.
- Use positive protective devices (barrier) for long-term work zones to improve the environment for workers and motorists.
- Install intrusion alarms or vehicle arresting devices.
- Use speed limit reductions when temporary conditions create a need for motorist slow-downs. Refer to the *Traffic Manual* for additional information, guidance and approval requirements for speed limit reductions in work zones.

1010.05(6)(d) Traffic/Incident Management and Enforcement

- Provide law enforcement patrols to reduce speeding and aggressive drivers.
- Provide incident response patrols during construction to reduce delays due to collisions in the work zone.
- Include work zone ITS elements in the project or coordinate with TMC to use existing equipment.
- Provide a dedicated tow service to clear incidents.

1010.05(7) Public Information (PI) Strategies

1010.05(7)(a) Public Awareness

One PI strategy is a public awareness campaign using the media, project websites, public meetings, e-mail updates, and mailed brochures. This gives regular road users advance notice of impacts they can expect and time to plan for alternate routes or other options to avoid project impacts. Involve the region or HQ Communications Office in developing and implementing these strategies. Coordinate transit travel information and restrictions with the Public Transportation Division. 🖱 http://wwwi.wsdot.wa.gov/PubTran/

Coordinate freight travel information and restrictions with the Rail, Freight, and Ports Division.

🖱 http://www.wsdot.wa.gov/freight/

🖱 http://www.wsdot.wa.gov/Freight/Trucking/default

1010.05(7)(b) Driver Information

In addition to work zone signs, provide driver information using highway advisory radio (HAR) and changeable message signs (existing or portable). Provide additional work zone ITS features that could include traffic cameras or queue detection along with changeable message signs to

provide drivers with real time information on delays and traffic incidents. Involve the region TMC in the development and implementation of these strategies. Additional information on work zone ITS can be found on the Work Zone Safety web page:
www.wsdot.wa.gov/safety/workzones/

The Freight Alert system should be used to communicate information with freight industry on work zones. Each region has the capability to send alerts with this system.

http://www.wsdot.wa.gov/freight/

Work zone strategy development is a fluid process and may be ongoing as project information and design features are developed during the design process. There may be many factors involved with strategy development, and it is necessary to be well organized to make sure all the relative factors are identified and evaluated.

1010.05(7)(c) Pedestrian and Bicycle Information

Include pedestrian and bicycle access information and alternate routes in the public awareness plans. Pedestrian and bicyclist information signing, including alternate route maps specifically for these road users, could be considered.

1010.06 Capacity Analysis

Work zone congestion and delay is a significant issue for many highway projects. At high-volume locations with existing capacity problems, even shoulder closures will increase congestion.

All work zone traffic restrictions need to be analyzed to determine the level of impacts. Short-term lane closures may only require work hour restrictions to address delays; long-term temporary channelization, realignments, lane shifts, and more will require a detailed capacity analysis to determine the level of impact. Demand management and public information strategies may be required to address delays. Traffic capacity mitigation measures are important since many projects cannot effectively design out all the work zone impacts. Include a Work Zone & Traffic Analysis in the TMP.

Work zone mobility impacts can have the following effects:

- **Crashes:** Most work zone crashes are congestion-related, usually in the form of rear-end collisions due to traffic queues. Traffic queues beyond the advance warning signs increase the risk of crashes.
- **Driver Frustration:** Drivers expect to travel to their destinations in a timely manner. If delays occur, driver frustration can lead to aggressive or inappropriate driving actions.
- **Constructability:** Constructing a project efficiently relies on the ability to pursue work operations while maintaining traffic flow. Delays in material delivery, work hour restrictions, and constant installation and removal of traffic control devices all detract from constructability.
- **Local Road Impacts:** Projects with capacity deficiencies can sometimes cause traffic to divert to local roadways, which may impact the surrounding local roadway system and community.
- **Public Credibility:** Work zone congestion and delay can create poor credibility for WSDOT with drivers and the surrounding community in general.

- **Restricted Access:** Severe congestion can effectively gridlock a road system, preventing access to important route connections, businesses, schools, hospitals, and so on.
- **User Cost Impacts:** Traffic delays have an economic impact on road users and the surrounding community. Calculated user costs are part of a work zone capacity analysis and may be used to determine liquidated damages specifications.

WSDOT has a responsibility to maintain traffic mobility through and around its projects. The goal is to keep a project’s work zone traffic capacity compatible with existing traffic demands. Maintaining the optimum carrying capacity of an existing facility during construction may not be possible, but an effort must be made to maintain existing traffic mobility through and/or around the work zone.

Maintaining mobility does not rule out innovative strategies such as roadway closures. Planned closures can accelerate work operations, reducing the duration of impacts to road users. These types of traffic control strategies must include demand management and public information plans to notify road users and mitigate and manage the impacts as much as possible.

A capacity analysis helps determine whether a work zone strategy is feasible. Mitigation measures that provide the right combination of good public information, advance signing and notification, alternate routes, detours, and work hour restrictions, as well as innovations such as strategic closures, accelerated construction schedules, or parallel roadway system capacity improvements, can be very effective in reducing mobility impacts.

Some of the impact issues and mitigating measures commonly addressed by traffic analyses include:

- Work hour time restrictions
- Hourly liquidated damage assessment
- Use of staged construction
- Working day assessment
- Public information campaign
- User cost assessment
- Local roadway impacts
- Special event and holiday time restrictions
- Closure and detour options
- Mitigation cost justification
- Level of service
- Queue lengths
- Delay time
- Running speed
- Coordination with adjoining projects (internal and local agency)

Many projects will have several potential work zone strategies, while other projects may only have one obvious work zone strategy. It is possible that a significant mobility impact strategy may be the only option. TMP strategies still need to be considered. An analysis will help show the results of these mitigating measures.

There is no absolute answer for how much congestion and delay are acceptable on a project; it may ultimately become a management decision.

Reductions in traffic capacity are to be mitigated and managed as part of the TMP. The traffic analysis process helps shape the TMP as the work zone strategies are evaluated and refined into traffic control plans and specifications. Maintain analysis documents in the Project File.

1010.06(1) Collecting Traffic Volume Data

Current volume data in the project vicinity is required for accurate traffic analysis results. Seasonal adjustment factors may be needed depending on when the data was collected and when the proposed traffic restrictions may be in place. Assess existing data as early as possible to determine whether additional data collection may be required. The region Traffic Office and the HQ Transportation Data & GIS Office can assist with collecting traffic volume data. Coordination with local agencies may be needed to obtain data on affected local roads.

1010.06(2) Short-Term Lane Closure Work Zone Capacity

For short-term lane closures on multilane highways or alternating one-way traffic on two-lane highways, see Exhibit 1010-1. It provides information for a quick analysis when compared to current hourly volumes on the highway. The basic traffic analysis programs QUEWZ 98, along with hourly volume input, the number of lanes to be closed, the hours of closure, and other default information, will output queue length, delay time, user costs, and running speed.

Exhibit 1010-1 General Lane Closure Work Zone Capacity

Roadway Type	Work Zone Capacity
Multilane Freeways/Highways	1300 VPHPL*
Multilane Urban/Suburban	600 VPHPL*
Two-Lane Rural Highway	400 VPHPL/ 800 VPH total*

*These are average capacity values. The actual values would be dependent on several factors, which include the existing number of lanes, number of lanes closed, traffic speed, truck percentage, interchanges/intersections, type of work, type of traffic control, and seasonal factors (among others). For further information, consult the *Highway Capacity Manual*.

1010.06(3) Long-Term Work Zone Capacity

For complex strategies that change traffic patterns, a more detailed analysis is required using advanced traffic modeling software. These strategies could include reducing lane and shoulder widths for extended lengths, reducing the number of lanes for extended durations, moving all lanes of traffic onto a temporary alignment, changing access locations to and from the highway, or closures with detours (including public information and traffic operation plans with anticipated reduction in demand). Work with the region Traffic Office for assistance with this level of analysis.

The following resources are also available to assist with the actual analysis and mitigation strategy development upon request:

- HQ Transportation Data & GIS Office

- HQ Traffic Offices
- Region Work Zone Specialist
- Region Public Information Office

Training is also available to obtain further knowledge and expertise in traffic analysis (see 1010.12).

1010.07 Work Zone Design

Part 6 of the MUTCD mostly addresses short-duration temporary traffic control standards. Some long-duration work zones may require temporary alignments and channelization, including barrier and attenuator use, temporary illumination and signals, and temporary pedestrian and bicycle routes. Refer to the *Design Manual*'s chapters for permanent features for design guidance.

1010.07(1) Lane Widths

Maintain existing lane widths during work zone operations whenever practicable.

For projects that require lane shifts or narrowed lanes due to work area limits and staging, consider the following before determining the work zone lane configurations to be implemented:

- Overall roadway width available
- Posted speed limit
- Traffic volumes through the project limits
- Number of lanes
- Existing lane and shoulder widths
- Crown points and shoulder slope breaks
- Treat lane lines and construction joints to provide a smooth flow
- Length and duration of lane width reduction (if in place)
- Roadway geometry (cross slope, vertical and horizontal curves)
- Vertical clearances
- Transit and freight vehicles, including over-sized vehicles

Work zone geometric transitions should be minimized or avoided if possible. When necessary, such transitions should be made as smoothly as the space available allows. Maintain approach lane width, if possible, throughout the connection. Design lane width reductions prior to any lane shifts within the transition area. Do not reduce curve radii and lane widths simultaneously.

When determining lane widths, the objective is to use lane geometrics that will be clear to the driver and keep the vehicle in the intended lane. In order to maintain the minimum lane widths, temporary widening may be needed.

1010.07(2) Buffer Space

Buffer spaces separate road users from the work space or other areas off limits to travel. Buffer spaces also might provide some recovery space for an errant vehicle.

- A lateral buffer provides space between the vehicles and adjacent work space, traffic control device, or a condition such as an abrupt lane edge or drop-off. As a minimum, a 2-foot lateral buffer space is used. Positive Protective Devices may be required if workers are within one lane width of traffic. When temporary barriers are used, place a temporary edge line 2-foot laterally from the barrier.
- When feasible, a longitudinal buffer space is used immediately downstream of a closed or shifted traffic lane or shoulder. This space provides a recovery area for errant vehicles as they approach the work space.

Devices used to separate the driver from the work space should not encroach into adjacent lanes. If encroachment is necessary, it is recommended to close the adjacent lane to maintain the lateral buffer space.

In order to achieve the minimum lateral buffer, there may be instances where pavement widening or a revision to a stage may be necessary. In the case of short-term lane closure operations, the adjacent lane may need to be closed or traffic may need to be temporarily shifted onto a shoulder to maintain a lateral buffer space. During the design of the traffic control plan, the lateral buffer needs to be identified on the plan to ensure additional width is available; use temporary roadway cross sections to show the space in relation to the traffic and work area.

1010.07(3) Work Zone Clear Zone

The contractor's operations present opportunities for errant vehicles to impact the clear area adjacent to the traveled way. A work zone clear zone (WZCZ) is established for each project to ensure the contractor's operations provide an appropriate clear area. The WZCZ addresses items such as storage of the contractor's equipment and employee's private vehicles and storage or stockpiling of project materials. The WZCZ applies during working and nonworking hours and applies only to roadside objects introduced by the contractor's operations. It is not intended to resolve preexisting deficiencies in the Design Clear Zone or clear zone values established at the completion of the project. Those work operations or objects that are actively in progress and delineated by approved traffic control measures are not subject to the WZCZ requirements.

Minimum WZCZ values are presented in Exhibit 1010-2. WZCZ values may be less than Design Clear Zone values due to the temporary nature of the construction and limitations on horizontal clearance. To establish an appropriate project-specific WZCZ, it may be necessary to exceed the minimum values. The following conditions warrant closer scrutiny of the WZCZ values, with consideration of a wider clear zone:

- Outside of horizontal curves or other locations where the alignment presents an increased potential for vehicles to leave the traveled way.
- The lower portion of long downgrades or other locations where gradient presents an increased potential for vehicles to exceed the posted speed.

- Steep fill slopes and high traffic volumes. (Although it is not presented as absolute guidance, the Design Clear Zone exhibit in Chapter 1600 may be used as a tool to assess increases in WZCZ values.)

Exhibit 1010-2 Minimum Work Zone Clear Zone Distance

Posted Speed	Distance From Traveled Way (ft)
35 mph or less	10
40 mph	15
45 to 55 mph	20
60 mph or greater	30

1010.07(4) Abrupt Lane Edges and Drop-offs

Minimize, mitigate, or eliminate abrupt lane edges and drop-offs whenever practicable. When unavoidable, traffic control plans should provide a protection method. Consider temporary barriers for long duration drop off protection and contract provisions limiting the duration of edges from daily paving operations. Abrupt edges up to 0.20 foot may remain exposed with appropriate warning signs alerting motorists of the condition. Edges or drop-offs more than 0.20 foot are not allowed in the traveled way or auxiliary lane.

The best long duration protection method for drop-offs more than 0.20 feet is Temporary Barrier. Place barrier on the traffic side of the drop-off with 2 feet between the drop-off and the back of the barrier and a provide a new edge line on the traffic side of the barrier with a 2-foot lateral buffer space minimum. The space behind the barrier can be reduced if the barrier is anchored. Barrier end attenuators may be required.

Open trenches within the traveled way or auxiliary lane shall have a steel-plate cover placed and anchored over them. A wedge of suitable material, if required, shall be placed for a smooth transition between the pavement and the steel plate. Warning signs shall be used to alert motorists of the presence of the steel plates.

Abrupt lane edges, and drop-offs and steel plates require additional warning and considerations for motorcyclists, bicyclists, and pedestrians, including pedestrians with disabilities. Adequate signing to warn the motorcycle rider, bicyclists and pedestrians, including pedestrians with disabilities of these conditions is required. (See RCW 47.36.200 and WAC 468-95-305.) See *Design Manual* Chapter 1510 for work zone pedestrian accommodation guidance.

See *Standard Specifications* section 1-07.23(1) for the contract requirements for drop off protection and address project specific protection if necessary.

1010.07(5) Vertical Clearance

In accordance with Chapter 720, the minimum vertical clearance over new highways is 16.5 feet. Anything less than the minimum must follow the reduced clearance criteria discussed in Chapter 720 and be included in the temporary traffic control plans. Maintain legal height on temporary falsework for bridge construction projects. Anything less than this must consider over-height vehicle impacts and possible additional signing needs and coordination with permit offices. Widening of existing structures can prove challenging when the existing height is at or less than legal height, so extra care is required in the consideration of over-height vehicles when temporary falsework is necessary. Coordination with the HQ Bridge and Structures Office is essential to ensure traffic needs have been accommodated. Vertical clearance requirements associated with local road networks may be different than what is shown in Chapter 720. Coordinate with the local agency.

1010.07(6) Reduced Speeds in Work Zones

Drivers tend to reduce their speed only if they perceive a need to do so. Reduced speed limits should only be used to address an altered geometry when not able to meet design standards for the existing speed, when the roadway will be narrowed with minimal shy distance to barriers, when roadway conditions warrant a reduction like BST operations, and when there will be workers on foot within a lane width of high-speed high-volume traffic without positive protection devices in place. Speed reductions are not applied as a means for selecting lower work zone design criteria (tapers, temporary alignment, device spacing, and so on).

Speed limit reductions are categorized as follows:

- Continuous Regulatory Speed Limit Reduction: A speed reduction in place 24 hours a day for the duration of the project, stage, or roadway condition.
- Variable Regulatory Speed Limit Reduction: A speed reduction in place only during active work hours (Class B construction signs may be used). This is a good option when positive protection devices are not used.
- Advisory Speed Reduction: In combination with a warning sign, an advisory speed plaque may be used to indicate a recommended safe speed through a work zone or work zone condition. Refer to the MUTCD for additional guidance.

Refer to the *Traffic Manual* for additional information, guidance and approval requirements for speed limit reductions in work zones. Include approval documents in the Project File.

1010.07(7) Accommodation for Pedestrians and Bicyclists

Many public highways and streets accommodate pedestrians and bicyclists, predominately in urban areas. During construction, access must be maintained through or around the work zones. When existing pedestrian routes that are accessible to pedestrians with disabilities are closed, the alternate routes must be designed and constructed to meet or exceed the existing level of accessibility. Temporary pedestrian facilities within the work zone must meet accessibility criteria to the maximum extent feasible. (See Chapter 1510 for pedestrian circulation path and pedestrian access route accessibility criteria.) Covered walkways are to be provided where there is a potential for falling objects.

In work areas where the speeds are low (25 mph), or the ADT is 2,000 or less, bicyclists can use the same route as motorized vehicles. For work zones on higher-speed facilities, bicyclists will need a minimum 4-foot shoulder or detour route to provide passage through or around a work zone. Bicyclists may be required to dismount and walk their bikes through a work zone on the route provided for pedestrians.

It may be possible to make other provisions to transport pedestrians and bicyclists through a work zone or with a walking escort around the active work area. Roadway surfaces are an important consideration for pedestrian and bicycle use. Unacceptable conditions such as loose gravel, uneven surfaces, milled pavement, and asphalt tack coats endanger the bicyclist and restrict access to pedestrians with disabilities.

Information can be gathered on bike issues by contacting local bike clubs. Coordination with local bike clubs goes a long way to ensuring their members are notified of work zone impacts, and it helps maintain good public relations. (See Chapter 1520 for more bicycle design requirements and Chapter 1510 and MUTCD Chapter 6D for pedestrian work zone design requirements.)

1010.07(8) Motorcycles

The same road surfaces that are a concern for bicyclists are also a concern for motorcyclists. Stability at high speed is a far greater concern for motorcycles than cars on grooved pavement, milled asphalt, and transitions from existing pavement to milled surfaces. Contractors must provide adequate warning signs for these conditions to alert the motorcycle rider. For regulations on providing warnings to motorcyclists, see RCW 47.26.200.

1010.07(9) Oversized Vehicles

The region Maintenance offices and the HQ Commercial Vehicle Services Office issue permits to allow vehicles that exceed the legal width, height, or weight limits to use certain routes. If a proposed work zone will reduce roadway width or vertical clearance, or have weight restrictions, adequate warning signs and notification to the HQ Commercial Vehicle Services Office and the appropriate region Maintenance Office is required as a minimum. When the total width of a roadway is to be reduced to less than 16 feet for more than three days, communication with these offices and any other stakeholders is required; include documentation in the Project File. The contract documents shall include provisions requiring the contractor to provide a 30-calendar-day notice prior to placing the restriction.

In the permit notification, identify the type of restriction (height, weight, or width) and specify the maximum size that can be accommodated. On some projects, it may be necessary to designate a detour route for oversized vehicles. An important safety issue associated with oversized loads is that they can sometimes be unexpected in work zones, even though warning and restriction or prohibition signs may be in place. Some oversized loads can overhang the temporary barrier or channelization devices and endanger workers. Consider the potential risk to those within the work zone. Routes with high volumes of oversized loads or routes that are already strategic oversized load routes may not be able to rely only on warning or prohibition signs. Protective features or active early warning devices may be needed. If the risk is so great that one oversized load could potentially cause significant damage or injury to workers, failsafe protection measures may be needed to protect structures and workers. The structure design, staging, and falsework openings may need to be reconsidered to safely accommodate oversized loads.

1010.08 Temporary Traffic Control Devices

FHWA regulations require that devices such as portable sign stands, barricades, traffic barriers, barrier terminals, crash cushions, and work zone hardware be compliant with the National Cooperative Highway Research Program (NCHRP) Report 350 or the Manual for Assessing Safety Hardware (MASH) crash test requirements.

1010.08(1) Channelizing Devices

Channelizing devices are used to alert and guide road users through the work zone. They are used to channelize traffic away from the work space, pavement drop-offs, or opposing directions of traffic. Traffic Safety Drums are the preferred devices on freeways and expressways as they are highly visible and are less likely to be displaced by traffic wind. 28-inch cones are also used on WSDOT projects. They are a good choice for flagging operations. Tall channelization devices are 42-inch cone-type devices and should be used in place of tubular markers to separate opposing traffic. Tubular markers are not a recommended device unless they are being used to separate traffic on low-volume low-speed roadways. Longitudinal channelizing devices are interconnected devices that provide channelization with no gaps. These devices look like a temporary barrier, but are not approved as a positive protective device. Barricades are a channelization device mostly used to supplement other channelization devices in traffic control operations involving road, ramp, or sidewalk closures.

1010.08(2) Construction Signs

Portable and temporary signs (Class B Construction Signs) are generally used in short-term work zones. They are set up and removed daily or frequently repositioned as the work moves along the highway. These signs are mounted on crashworthy, collapsible sign supports. The minimum mount height is 1 foot above the roadway, but there are temporary sign supports that will provide 5- to 7-foot mounting heights. This may be useful when temporary signs are mounted behind channelizing device or in urban areas with roadside parking that may obstruct sign visibility and multilane facilities. Temporary signs need to be placed such that they do not obstruct pedestrian facilities. Warning signs in place longer than three days at one location must be post-mounted.

Fixed signing (Class A Construction Signs) are the signs mounted on conventional sign supports along or over the roadway. This signing is used for long-term stationary work zones. Details for their design are in Chapter 1020 and the *Standard Plans*. Sign messages, color, configuration, and usage are shown in the MUTCD and the *Sign Fabrication Manual*. Existing signs may need to be covered, removed, or modified during construction.

1010.08(3) Warning Lights

Warning lights are either flashing or steady burn and can be mounted on channelizing devices, barriers, and signs. Secure crashworthy mounting of warning lights is required.

- **Type A:** Low-intensity flashing warning light used on a sign or barricade to warn road users during nighttime hours that they are approaching a work zone.
- **Type B:** High-intensity flashing warning light used on a sign or barricade to warn road users during both daytime and nighttime hours.
- **Type C and Type D 360 degree:** Steady-burn warning lights designed to operate 24 hours a day to delineate the edge of the roadway.

1010.08(4) Arrow Board

The arrow board (Sequential Arrow Sign) displays either an arrow or a chevron pointing in the direction of the intended route of travel. Arrow board displays are required for lane closures on multilane roadways. When closing more than one lane, use an arrow board display for each lane reduction. Place the arrow board at the beginning of the transition taper and out of the traveled way. The caution display (four corner lights) is only used for shoulder work. Arrow boards are not used on two-lane two-way roadways.

1010.08(5) Portable Changeable Message Signs (PCMS)

PCMS have electronic displays that can be modified and programmed with specific messages and may be used to supplement other warning signs. These signs are usually trailer mounted with solar power and batteries to energize the electronic displays. A two-second display of two messages is the recommended method to ensure motorists have time to read the sign's message twice. These devices are not crashworthy and should be removed when not in use, or placed behind barrier or guardrail. PCMS are best used to provide notice of unexpected situations like the potential for traffic delays or queuing and to provide a notice of future closures or restrictions. They should not be used in place of required signs or to provide redundant information.

1010.08(6) Portable Temporary Traffic Control Signals

These versatile trailer-mounted portable signals are battery powered, with the ability to be connected to AC power. They can operate on fixed timing or be traffic actuated. They are typically used on two-lane two-way highways to alternate traffic in a single lane for extended durations.

1010.08(7) Portable Highway Advisory Radio (HAR)

HAR can be used to broadcast AM radio messages about work zone traffic and travel-related information. The system may be a permanently located transmitter or a portable trailer-mounted system that can be moved from location to location as necessary. Contact the region Traffic Office for specific guidance and advice on the use of these systems.

1010.08(8) Automated Flagger Assistance Device (AFAD)

An AFAD is a flagging machine that is operated remotely by a flagger located off the roadway and away from traffic. This device could be used to enhance safety for flaggers on highways with reduced sight distance or limited escape routes. A traffic control plan is required for use of the AFAD. A flagger is required to operate each device.

Refer to the MUTCD for additional guidance on temporary traffic control zone devices.

1010.09 Positive Protection Devices

Channelizing devices will not provide adequate worker and road user protection in some work zones. Positive protective devices are required for the following conditions unless an engineering study determines otherwise:

- To separate opposing high-speed traffic normally separated by a median or existing median barrier.
- Where existing traffic barriers or bridge railings are to be removed.
- For drop-off protection during widening or excavations (see *Standard Specification* 1-07.23(1)).

- When temporary slopes change clear zone requirements.
- For bridge falsework protection.
- When equipment or materials must remain in the work zone clear zone.
- When newly constructed features in the clear zone will not have permanent protection until later in the project.
- Where temporary signs or light standards are not crashworthy.
- To separate workers from motorized traffic when work zone offers no means of escape for the worker, such as tunnels, bridges, and retaining walls, or for long-duration worker exposure within one lane-width of high-speed high-volume traffic.

1010.09(1) Temporary Barriers

Providing temporary barrier protection may become the key component of the work zone strategy. Barrier use usually requires long-term stationary work zones with pavement marking revisions, and will increase the traffic control costs of a project. The safety benefit versus the cost of using barrier requires careful consideration, and cost should not be the only or primary factor determining the use of barrier. (See Chapter 1610 for guidance on barriers.)

1010.09(1)(a) Temporary Concrete Barriers

These are the safety-shape barriers shown in the Standard Plans. Lateral displacement from impacts is usually in the range of 2 to 4 feet. (See Chapter 1610 for detailed information on deflection.) When any barrier displacement is unacceptable, these barriers are anchored to the roadway or bridge deck. Some deflection with anchored systems is still expected.) Anchoring systems are also shown in the Standard Plans.

1010.09(1)(b) Movable Barriers

Movable barriers are specially designed segmental barriers that can be moved laterally one lane width or more as a unit with specialized equipment. This allows strategies with frequent or daily relocation of a barrier. The ends of the barrier must be located out of the clear zone or fitted with an impact attenuator. Storage sites at both ends of the barrier will be needed for the barrier-moving machine.

1010.09(1)(c) Portable Steel Barriers

Portable steel barriers have a lightweight stackable design. They have options for gate-type openings and relocation without heavy equipment. Lateral displacement from impacts is in the range of 6 to 8 feet. Steel barriers can be anchored according to the manufacturer's specifications. Some deflection with anchored systems is still expected.

1010.09(2) Impact Attenuators

Within the Design Clear Zone, the approach ends of temporary barriers shall be fitted with impact attenuators. The information in Chapter 1620 provides all the needed impact attenuator performance information, but the actual work zone location may require careful consideration by the designer to ensure the correct application is used. Consider the dynamic nature of work operations where work zone ingress and egress, work area protection, worker protection, and traffic protection all factor into the final selection as well as the placement surface available.

Contract plans showing temporary impact attenuator placement need to include a list of the approved attenuators that a contractor may use for that installation.

1010.09(3) Transportable Attenuators

A transportable attenuator (TA) is a positive protection device that will provide protection for the work area only a short distance in front of the device. An impact attenuator device is attached to the rear of a large truck the weighs 15,000 lbs. total weight or more to minimize the roll-ahead distance when impacted by an errant vehicle. A TA should be used on all high-speed roadway operations.

1010.10 Other Traffic Control Devices or Features

1010.10(1) Delineation

Temporary pavement markings will be required when permanent markings are eliminated because of construction operations or when lane shifts or temporary alignments are needed for long-term work zone strategies. Temporary pavement markings can be made using paint, tape, or raised pavement markers. Short-duration temporary pavement markings are made with materials intended to last only until permanent markings can be installed on paving and BST projects, or for short durations between construction stages. Broken line patterns consist of a 4 foot line with a 36-foot gap. Temporary edge lines are usually not required on paving/BST projects and must be specified in the plans if desired. Long-duration temporary pavement markings are made with materials intended to last for staged construction on high-volume highways, for use between construction seasons, or for long-duration lane shifts. Existing contradictory pavement markings must be removed. These markings are installed in accordance with the Standard Plans for permanent markings. Long-duration markings need to be detailed in the contract plans for installation and material type. Removable tapes work well for broken lines and can be removed by hand, leaving no scar on the pavement surface. Complex projects will most likely require both long- and short-duration temporary markings.

Lateral clearance markers are used at the angle points of barriers where they encroach on or otherwise restrict the adjacent shoulder. Barrier delineation is necessary where the barrier is less than 4 feet from the edge of traveled way.

Guideposts may be considered to aid nighttime driving through temporary alignments or diversions. (See Chapter 1030 for delineation requirements.)

1010.10(2) Screening

Screening devices can be used to reduce motorists' distraction due to construction activities adjacent to the traveled way. Consider screening when a highway operates near capacity during most of the day. Screening should be positioned behind traffic barriers to prevent impacts by errant vehicles and should be anchored or braced to resist overturning when buffeted by wind. Commercially available screening or contractor-built screening can be used, provided the device meets crashworthy criteria if exposed to traffic and is approved by the Engineer prior to installation.

Glare screening may be required on concrete barriers separating two-way traffic to reduce headlight glare from oncoming traffic. Woven wire and vertical blade-type screens are commonly used in this installation. This screening also reduces the potential for motorist confusion at nighttime by shielding construction equipment and the headlights of other vehicles on adjacent roadways. Make sure that motorists' sight distance is not impaired by these glare screens. Contact the HQ Design Office and refer to AASHTO's Roadside Design Guide for additional information on screening.

1010.10(3) Illumination

Illumination might be justified if construction activities take place on the roadway at night for an extended period of time. Illumination might also be justified for long-term construction projects at the following locations:

- Road closures with detours or diversions.
- Median crossovers on freeways.
- Complex or temporary alignment or channelization.
- Haul road crossings (if operational at night).
- Temporary traffic signals.
- Temporary ramp connections.
- Projects with lane shifts and restricted geometrics.
- Projects with existing illumination that needs to be removed as part of the construction process.

Illumination is required when:

- Traffic flow is split around or near an obstruction.
- Flaggers are necessary for nighttime construction activities (supplemental lighting of the flagger stations by use of portable light plants or other approved methods). Refer to *Standard Specification* 1-10.3(1)A.

For information on light levels and other electrical design requirements, see Chapter 1040.

1010.10(4) Signals

A permanent signal system can be modified for a temporary configuration such as temporary pole locations during intersection construction, span wire systems, and adjustment of signal heads and alternative detection systems to accommodate a construction stage (see Chapter 1330).

1010.10(5) Work Zone Intelligent Transportation Systems (ITS)

Intelligent Transportation Systems apply advanced technologies to optimize the safety and efficiency of the existing transportation network. Many permanent systems already exist throughout Washington State and provide the opportunity to greatly enhance construction projects that fall within the limits of the ITS network. Temporary portable ITS applications in work zones can be used to provide traffic monitoring and management, data collection, and traveler information.

ITS can provide real-time work zone information and associated traffic conditions such as queue detection for "slowed or stopped traffic ahead" before motorists see brake lights, or they can advise of alternate routes, giving motorists options to avoid delays and warn drivers of haul vehicles entering or leaving a work area.

Work zone ITS technology is an emerging area that can provide the means to better monitor and manage traffic flow through and around work zones. Equipment used in work zones, such as portable camera systems, highway advisory radios, variable speed limits, ramp metering systems, and queue detection sensors, helps ensure a more efficient traffic flow with a positive impact on safety, mobility, access, and productivity.

Identify work zone ITS elements early in the strategy development process and include them in the preliminary estimate so they can be designed along with the other traffic control elements. For large mobility projects that have existing freeway cameras already in place, temporary ITS features (such as temporary poles and portable systems) may be necessary to ensure the network can be maintained during construction, especially if existing camera locations are in conflict with construction activities. In locations that do not have existing camera locations, but have significant construction projects planned, work zone ITS may be a good opportunity to bring ITS technology to the route.

Refer to Chapter 1050 and the work zone safety web page for additional ITS information and guidance.

1010.11 Traffic Control Plan Development and PS&E

WSDOT projects need to include plans and payment items for controlling traffic based on a strategy that is consistent with the project construction elements, even though there may be more than one workable strategy. A constructable and biddable method of temporary traffic control is the goal. The contractor has the option of adopting the contract plans or proposing an alternative method.

1010.11(1) Traffic Control Plans (TCPs)

"Typical" traffic control plans are generic in nature and are not intended to address all site conditions. They are intended for use at multiple work locations and roadways with little or no field modifications necessary. Typical plans may be all that are needed for basic paving projects. Some typical plans are located at: www.wsdot.wa.gov/design/standards/plansheet.htm

"Project-specific" traffic control plans are typical-type plans that have been modified to fit a specific project or roadway condition. Dimension lines for signs and device placement have the distances based on the project highway speed limit, and spacing charts have been removed; the lane and roadway configuration may also be modified to match the project conditions.

"Site-specific" traffic control plans are drawn for a specific location. Scaled base data drawn plans will be the most accurate as device placement and layout issues can be resolved by the designer. These types of plans should be used for temporary alignment and channelization for long-duration traffic control. Making a "project-specific" plan applicable for a site-specific location is another option, but the designer must ensure the device layout will match the site-specific location since it will not be a scaled plan.

The following plans, in addition to the TCP types above addressing the TTC strategies, may be included in the PS&E.

1010.11(1)(a) Construction Sign Plan

Show Class A Construction Signs that will remain in place for the duration of the project located by either station or milepost. Verify the locations to avoid conflicts with existing signing or other roadway features. These locations may still be subject to movement in the field to fit specific conditions. For simple projects these sign are often shown on the vicinity map sheet.

1010.11(1)(b) Construction Sign Specification Sheet

Provide a Class A Construction Sign Specifications sheet on complex or staged projects. Include location, post information, and notes for Standard Plans or other specific sign information and sign details.

1010.11(1)(c) Quantity Tabulation Sheets

Quantity Tabulation sheets are a good idea for barrier and attenuator items and temporary pavement markings on projects with large quantities of these items or for staged construction projects.

1010.11(1)(d) Traffic Control Plan Index

An Index sheet is a useful tool for projects that contain a large quantity of traffic control plans and multiple work operations at various locations throughout the project. The Index sheet provides the contractor a quick referencing tool indicating the applicable traffic control plan for the specific work operation.

1010.11(1)(e) Construction Sequence Plans

Sequence plans are placed early in the plan set and are intended to show the proposed construction stages and the work required for each stage. They should refer to the corresponding TCPs for the traffic control details of each stage.

1010.11(1)(f) Temporary Signal Plan

The temporary signal plan will follow conventions used to develop permanent signals (as described in Chapter 1330), but will be designed to accommodate temporary needs and work operations to ensure there will be no conflicts with construction operations. Ensure opposing left-turn clearances are maintained as described in Chapter 1310 if channelization has been temporarily revised, or adjust signal timing to accommodate. Some existing systems can be maintained using temporary span wires for signal heads and video, microwave actuation, or timed control.

1010.11(1)(g) Temporary Illumination Plan

Full lighting is normally provided through traffic control areas where power is available. The temporary illumination plan will follow conventions used to develop permanent illumination (as described in Chapter 1040), but will be designed to accommodate temporary needs and work operations to ensure there will be no conflicts with construction operations.

1010.11(2) Contract Specifications

Work hour restrictions for lane closure operations are to be specifically identified for each project where traffic impacts are expected and liquidated damages need to be applied to the contract. Refer to the Plans Preparation Manual for additional information on writing traffic control specifications.

1010.11(3) Cost Estimating

Temporary traffic control devices and traffic control labor can be difficult to estimate. There is no way of knowing how many operations a contractor may implement at the same time. The best method is to follow the working day estimate schedule and the TCPs that will be used for each operation. Temporary signs and devices will be used on many plans, but the estimated quantity reflects the most used at any one time. To use the lump sum item to pay for all temporary traffic control, be certain how the contractor's work operations will progress and that the traffic control plans fully define the work zone expectations.

1010.12 Training and Resources

Temporary traffic control-related training is an important component in an effective work zone safety and mobility program. Federal regulations require that those involved in the development, design, implementation, operation, inspection, and enforcement be trained at a level consistent with their responsibilities.

1010.12(1) Training Courses

The following work zone related courses are available through the Talent Development office and the State Work Zone Training Specialist can assist with the availability and scheduling of classes:

- **Work Zone Traffic Control Plan Design Course:** This course, taught by the HQ Traffic Office, focuses on work zone safety and mobility through transportation management plan and temporary traffic control PS&E development.
- **Traffic Control Supervisor (TCS) Course:** The same course taught by the Evergreen Safety Council, NW Laborers Union, and ATSSA, for contractors is also taught by the HQ Traffic Office for WSDOT employees. Field personnel who have TCS related responsibilities or designers wanting basic temporary traffic control design and implementation training should attend this course. This course may be taken without the intention of becoming a certified TCS.
- **Flagger Certification Course:** This course is for employees who may have flagging duties or want to become a certified Traffic Control Supervisor. The safety offices can assist with class scheduling.

Traffic analysis, traffic engineering, pedestrian facilities design and other courses may also be available and apply to work zone safety and mobility.

The American Traffic Safety Services Association (ATSSA) offers free or low-cost training through an FHWA work zone safety grant.

1010.12(2) Resources

The responsibility of the designer to fully address all work zone traffic control impacts is very important because the level of traffic safety and mobility will be directly affected by the effectiveness of the transportation management plan (TMP). The following resources are available to assist the designer with various aspects of the work zone design effort.

1010.12(2)(a) Region Work Zone Resources

Each region has individuals and offices with various resources that provide work zone guidance and direction beyond what may be available at the project Design Office level. They include:

- Region Traffic Office
- Region Work Zone Specialist
- Region Construction and Design Offices

1010.12(2)(b) Headquarters (HQ) Work Zone Resources

The HQ Traffic Office has a work zone team available to answer questions, provide information, or otherwise assist. The HQ Design and Construction offices may also be able to assist with some work zone issues. They include:

- State Assistant Traffic Design Engineer
- State Work Zone Engineer
- State Work Zone Training Specialist
- WSDOT Work Zone Web Page

1010.12(2)(c) FHWA Work Zone Resources

The FHWA Washington Division Office and Headquarters (HQ) Office may be able to provide some additional information through the WSDOT HQ Traffic Office. The FHWA also has a work zone web page: www.ops.fhwa.dot.gov/wz/

1010.13 Documentation

Refer to Chapter 300 for design documentation requirements.

1010.14 References

1010.14(1) Federal/State Laws and Codes

23 Code of Federal Regulations (CFR) Part 630 Subpart J and Subpart K – Work Zone Safety and Mobility and Temporary Traffic Control Devices

See Chapter 1510 for Americans with Disabilities Act policy and references.

"Final Rule on Work Zone Safety and Mobility," Federal Highway Administration (FHWA), Published on September 9, 2004
www.ops.fhwa.dot.gov/wz/resources/final_rule.htm

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

1010.14(2) Design Guidance

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO

Executive Order E 1001, Work Zone Safety and Mobility
http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1001.pdf

Executive Order E 1060, Speed Limit Reductions in Work Zones
http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1060.pdf

Executive Order E 1033, WSDOT Employee Safety
http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1033.pdf

Plans Preparation Manual, M 22-31, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-10, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

Traffic Manual, M 51-02, WSDOT

Work Zone Traffic Control Guidelines, M 54-44, WSDOT

1010.14(3) Supporting Information

Construction Manual, M 41-01, WSDOT

"Crashworthy Work Zone Traffic Control Devices," Report 553, NCHRP, 2006

Environmental Manual, M 31-11, WSDOT

Highway Capacity Manual, 2010, TRB

ITE Temporary Traffic Control Device Handbook, 2001

ITS in Work Zones www.ops.fhwa.dot.gov/wz/its/

"Recommended Procedures for the Safety Evaluation of Highway Features," Report 350, NCHRP, 1993

Roadside Design Guide, AASHTO, 2011

Manual for Assessing Safety Hardware, AASHTO, 2009

Work Zone & Traffic Analysis, FHWA www.ops.fhwa.dot.gov/wz/traffic_analysis.htm

Work Zone Operations Best Practices Guidebook, FHWA, 2007
www.ops.fhwa.dot.gov/wz/practices/practices.htm

Work Zone Safety and Mobility, FHWA www.ops.fhwa.dot.gov/wz/index.asp

Work Zone Safety Web Page, WSDOT www.wsdot.wa.gov/safety/workzones/

WSDOT Project Management website: http://www.wsdot.wa.gov/Projects/ProjectMgmt/

Exhibit 1010-3 Transportation Management Plan Components Checklist

Use the following checklist to develop a formal TMP document on significant projects.

TMP Component	✓
1. Introductory Material	
Cover page	
Licensed Engineer stamp page (if necessary)	
Table of contents	
List of figures	
List of tables	
List of abbreviations and symbols	
Terminology	
2. Executive Summary	
3. TMP Roles and Responsibilities	
TMP manager	
Stakeholders/review committee	
Approval contact(s)	
TMP implementation task leaders (public information liaison, incident management coordinator)	
TMP monitors	
Emergency contacts	
4. Project Description	
Project background	
Project type	
Project area/corridor	
Project goals and constraints	
Proposed construction phasing/staging	
General schedule and timeline	
Adjacent projects	
5. Existing and Future Conditions	
Data collection and modeling approach	
Existing roadway characteristics (history, roadway classification, number of lanes, geometrics, urban/suburban/rural)	
Existing and historical traffic data (volumes, speed, capacity, volume-to-capacity ratio, percent trucks, queue length, peak traffic hours)	
Existing traffic operations (signal timing, traffic controls)	
Incident and crash data	
Local community and business concerns/issues	
Traffic growth rates (for future construction dates)	
Traffic predictions during construction (volume, delay, queue)	
6. Work Zone Impacts Assessment Report	
Qualitative summary of anticipated work zone impacts	
Impacts assessment of alternative project design and management strategies (in conjunction with each other)	
• Construction approach/phasing/staging strategies	
• Work zone impacts management strategies	

Exhibit 1010-3 Transportation Management Plan Components Checklist (continued)

TMP Component	✓
Traffic analysis results (if applicable)	
• Traffic analysis strategies	
• Measures of effectiveness	
• Analysis tool selection methodology and justification	
• Analysis results	
Traffic (volume, capacity, delay, queue, noise)	
Safety	
Adequacy of detour routes	
Business/community impact	
Seasonal impacts	
Cost-effectiveness/evaluation of alternatives	
Selected alternative	
• Construction approach/phasing/staging strategy	
• Work zone impacts management strategies	
7. Selected Work Zone Impacts Management Strategies	
Temporary Traffic Control (TTC) strategies	
• Control strategies	
• Traffic control devices	
• Corridor Project coordination, contracting, and innovative construction strategies	
Public Information (PI)	
• Public awareness strategies	
• Motorist information strategies	
Transportation Operations (TO)	
• Demand management strategies	
• Corridor/network management strategies	
• Work zone safety management strategies	
• Traffic/incident management and enforcement strategies	
8. TMP Monitoring	
Monitoring requirements	
Evaluation report of successes and failures of TMP	
9. Contingency Plans	
Trigger points	
Decision tree	
Contractor's contingency plan	
Standby equipment or personnel	
10. TMP Implementation Costs	
Itemized costs	
Cost responsibilities/sharing opportunities	
Funding source(s)	
11. Special Considerations (as needed)	
12. Attachments (as needed)	

Chapter 1030 Delineation

1030.01 General

The primary function of delineation is to provide the visual information needed by a driver to operate a vehicle in a variety of situations. Delineation includes the marking of highways with painted or more durable pavement marking lines and symbols, guideposts, and other devices such as curbs. These devices can use retroreflectance, which is the reflecting of light from a vehicle's headlights back to the driver, to enhance an object's visibility at nighttime.

Delineation is a required design element (see Chapter 1105) on most projects. A decision to omit delineation is possible if the existing delineation is unaffected by construction and a safety performance evaluation (see Chapter 321) clearly shows that delineation is not a contributing factor to crashes. The Washington State Department of Transportation (WSDOT) uses the latest edition of the *Manual on Uniform Traffic Control Devises* (MUTCD) as a guide for the design, location, and application of delineation.

Consult with the region Traffic Office early in the design process to ensure the proposed delineation is compatible with current WSDOT policy and guidance regarding types of markings and material selection.

1030.02 Definitions

The following terms are defined in the *Design Manual* Glossary:

Delineation; *extrude*; *mcd/m2/lux*; *pavement marking*; *pavement marking beads*; *pavement marking durability*; *retroreflection, coefficient of* (R_L); *traffic paint*; and *wet film thickness*.

1030.03 Pavement Markings

1030.03(1) Pavement Marking Types

Pavement markings have specific functions: they guide the movement of traffic and they promote increased safety performance. In some cases, they are used to supplement the messages of other traffic control devices. In other cases, markings are the only way to convey a message without distracting the driver. Pavement markings are intended to provide adequate performance year round. Guidelines for the application of various pavement markings are provided in the *Standard Plans* and the MUTCD.

1030.03(1)(a) Longitudinal Pavement Markings

Longitudinal pavement markings define the boundary between opposing traffic flows, and they identify the edges of traveled way, multiple traffic lanes, turn lanes, and special-use lanes. The *Standard Plans* shows the dimensions of longitudinal pavement markings. Longitudinal pavement markings are as follows:

barrier centerline A very wide—18 inches minimum, usually 20 inches: five 4 inch lines—solid yellow line or a combination of two single 4-inch solid yellow lines with yellow crosshatching between the lines, with a total width not less than 18 inches, used to separate opposing traffic movements where all movements over the line are prohibited. Barrier centerline locations require the approval of the region Traffic Engineer and Access Engineer.

centerline A broken yellow line used to separate lanes of traffic moving in opposite directions, where passing in the opposing lane is allowed.

dotted extension line A broken white or yellow line that is an extension of an edge line or centerline used at exit ramps, intersections on horizontal curves, multiple turn lanes, and other locations where the direction of travel for through or turning traffic is unclear.

double centerline Two parallel solid yellow lines used to separate lanes of traffic moving in opposite directions where passing in the opposing lane is prohibited.

double lane line Two solid white lines used to separate lanes of traffic moving in the same direction where crossing the lane line marking is prohibited.

double wide lane line Two solid wide white lines used to separate a concurrent preferential lane of traffic where crossing is prohibited.

drop lane line A wide broken white line used in advance of a wide line to delineate a lane that ends at an off-ramp or intersection.

edge line A solid white or yellow line used to define the outer edges of the traveled way. Edge lines are not required where curbs or sidewalks are 4 feet or less from the traveled way.

lane line A broken white line used to separate lanes of traffic moving in the same direction.

no-pass line A solid yellow line used in conjunction with a centerline where passing in the opposing lane is prohibited.

reversible lane line Two broken yellow lines used to delineate a lane where traffic direction is periodically reversed.

solid lane line A solid white line used to separate lanes of traffic moving in the same direction where crossing the lane line marking is discouraged.

two-way left-turn centerline Two yellow lines, one solid and one broken, used to delineate each side of a two-way left-turn lane.

wide broken lane line A wide broken white line used to designate a portion of a high-occupancy vehicle (HOV) lane located on a divided highway where general-purpose vehicles may enter to make an exit.

wide dotted lane line A wide broken white line used to designate a portion of a high-occupancy vehicle (HOV), or business access and transit (BAT) lane located on an arterial highway where general-purpose vehicles may enter to make a turn at an intersection.

wide lane line A wide solid white line used to separate lanes of traffic moving in the same direction, at ramp connections, storage lanes at intersections, and high-occupancy vehicle (HOV) lanes, or at business access and transit (BAT) lanes, bike lanes, and other preferential lanes where crossing is discouraged.

See MUTCD Chapter 3B for further information for these markings.

1030.03(1)(b) Transverse Pavement Markings

Transverse pavement markings define pedestrian crossings and vehicle stopping points at intersections. They are also used to warn motorists of approaching conditions, required vehicular maneuvers, or lane usage. See the *Standard Plans* for details of these pavement markings. Typical transverse pavement markings are as follows:

access parking space symbol A white marking used to designate parking stalls provided for motorists with disabilities. The marking may have an optional blue background and white border.

aerial surveillance marker White markings used at one-mile and one-half-mile intervals on sections of highways where the State Patrol uses airplanes to enforce speed limits.

bicycle lane symbol A white marking consisting of a symbol of a bicyclist and an arrow used in a marked bike lane. The bicycle lane symbol is to be placed immediately after an intersection and at other locations as needed (see the MUTCD). Typical spacing is 500 feet, with a maximum distance of 1,500 feet.

crosswalk line A series of parallel solid white lines used to define a pedestrian crossing.

drainage marking A white line used to denote the location of a catch basin, grate inlet, or other drainage feature in the shoulder of a roadway.

HOV symbol A white diamond marking used for high-occupancy vehicle lanes. The spacing of the markings is an engineering judgment based on the conditions of use. Typical spacing is 1000 feet for divided highways and 500 feet for arterial highways.

railroad crossing symbol A white marking used in advance of a railroad crossing where grade crossing signals or gates are located or where the posted speed of the highway is 40 mph or higher.

stop line A solid white line used to indicate the stopping point at an intersection or railroad crossing.

traffic arrow A white marking used in storage lanes and two-way left-turn lanes to denote the direction of turning movement. Arrows are also used at ramp terminals and intersections on divided highways to discourage wrong-way movements.

traffic letters White markings forming word messages, such as “ONLY,” used in conjunction with a traffic arrow at drop-lane situations. Traffic letters are not required for left- and right-turn storage lanes where the intended use of the lane is obvious.

wide line A wide solid line used for traffic islands, hash marks, chevrons, and other applications. A wide line used in conjunction with a centerline marking shall be yellow. A wide line used in conjunction with a lane line or right edge line marking shall be white.

Yield line markings A series of white triangular markings indicating that the lane yields.

1030.03(2) Pavement Marking Materials

Pavement markings are applied using various materials. These materials are divided into two categories: paint and plastic. When selecting the pavement marking material to use in a project, consider the initial cost of the material and its durability; the location; the traffic conditions; the snow and ice removal practices of the particular maintenance area; and the region's ability to maintain the markings.

Both painted and plastic pavement markings can accomplish the goal of providing a visible (daytime) and retroreflective (nighttime) pavement marking at the completion of a contract. The difference between the two marking materials is the projected durability of the markings. Paint used on sections of highway subjected to high traffic volumes and/or snow-removal operations might have a durability of only two to three months. Maintenance crews cannot restripe a highway during winter months; therefore, if a painted marking wears out prematurely, the highway will not have a stripe until maintenance crews can restripe in April or May. When these conditions are encountered in a highway project, consider a more durable plastic marking material and application type that will provide the desired durability for the marking.

Check with your region Traffic Office for any specific pavement marking policy. For the recommended pavement marking material for different highway types and snow-removal practices, see Exhibit 1030-1. Consult with the region's Traffic and Maintenance offices to select the best material for the project.

1030.03(2)(a) Paint

Paint is the most common pavement marking material. It is relatively easy to apply and dries quickly (30–90 seconds in warm, dry weather) after application. This allows the application to be a moving operation, which minimizes traffic control costs and delays to the roadway users. On construction contracts, paint is applied with two coats: the first coat is 10 mils thick, followed by a second coat 15 mils thick. The disadvantage of using paint as a pavement marking material is its limited durability when subjected to traffic abrasion, sanding, or snow-removal activities. Specify paint only where it will have a durability that will provide a retroreflective stripe until maintenance crews can repaint the line and extend its usefulness until the next repainting.

Paint is one of two material types dependent upon the solids carrier: solvent or water. The designer is encouraged to specify waterborne paint. Solvent paint is subject to a monetary penalty because it contains a high level of volatile organic compounds (VOCs). There is an Environmental Protection Agency (EPA) Clean Air Act penalty assessed on solvent paint that is passed on to those who purchase solvent paint in quantity.

Durable waterborne paint or high-build waterborne paint is formulated to allow application thicknesses greater than 15 mils. It is more durable than standard waterborne paint and provides additional service life. The additional thickness permits the use of larger beads that enhance wet night retroreflectivity.

Low-temperature waterborne paint is intended to extend the paint season later into the fall, although it may also be used earlier in the spring. The paint is formulated for application temperatures of 35° Fahrenheit and rising, though durability can be affected when applied during conditions where standard waterborne paint could have been used.

1030.03(2)(b) Plastic

Plastic markings have a higher installation cost than paint. They can, however, be a more cost-effective measure than paint because of their longer service life. Plastic marking materials may provide a year-round retroreflective pavement marking, while paint may not last until the next restriping. Plastic marking materials currently listed in the *Standard Specifications* include the following:

1. **Type A: Liquid Hot Applied Thermoplastic**

   Thermoplastic material consists of resins and filler materials in solid form at room temperature. The material is heated to a semiliquid, molten state (400° Fahrenheit) and is then applied to the roadway by spray or extrusion methods. This material can be used for both transverse and longitudinal line applications. Special equipment is required for both the initial application and subsequent maintenance renewal. Sprayed material can be applied at a thickness of 30 mils and dries in 30 to 60 seconds. The durability of material applied in this manner is slightly longer than that of paint. Extruded material is applied at a thickness of 125 mils and has a drying time of 15 minutes. This material can be applied as a flat line or applied with ridges or profiles (bumps) that enhance wet night visibility. These profiles produce a rumble effect similar to raised pavement markers when a vehicle crosses over the marking. (Profiles come in the shape of a raised bar at set intervals and are formed simultaneously with the extruded baseline.)

2. **Type B: Preformed Fused Thermoplastic**

   This material consists of a mixture of pigment, fillers, resins, and beads that are factory produced in sheet form, 125 mils thick. The material is applied by heating (drying) the pavement and top heating the material. The heating process fuses the preformed thermoplastic material to the pavement surface. These materials, which are used for transverse markings, are available in white, red, blue, and other colors.

3. **Type C: Cold Applied Preformed Tape**

   Preformed tape is composed of thermoplastic or other materials that are fabricated under factory conditions. After curing, the material is cut to size and shipped to the work site in rolls or in flat pieces. The material is then applied to the roadway with an adhesive on the underside of the tape. Preformed tape is available in 60, 90, or 125 mils (WSDOT does not currently specify 125 mil tape.) The most durable application of preformed tape is achieved when the tape is either inlaid (rolled) into hot asphalt with the top of the tape flush with the surface of the pavement, or placed in a groove cut into the pavement surface with the top of the tape slightly below the surface of the pavement.

ASTM has classified preformed tape into two categories: Type 1 and Type 2. Type 1 tape has a profiled surface and a requirement to have a retroreflectivity of over 500 mcd/m2/lux. Type 1 tape has proven to be very durable. It is used on high-volume, high-speed highways. Type 2 tape has a flat surface and a requirement to have a retroreflectivity of over 250 mcd/ m2/lux. Field tests show that Type 2 tape has a shorter durability than Type 1 tape.

4. **Type D: Liquid Cold Applied Methyl Methacrylate (MMA)**

Methyl methacrylate can be applied by either spraying or extrusion. Sprayed applications can be one or two coats, 30 to 45 mils thick. Extruded applications are 90 mils thick for asphalt concrete pavement or Portland cement concrete pavement, or 120 mils thick for open-graded asphalt pavement. MMA can also be extruded using specialized equipment to produce a textured line 150 mils thick. The material is not heated and can be applied within an approximate temperature range of 40° to 105° Fahrenheit, provided the pavement surface is dry. The material can be used for both transverse and longitudinal applications. The material can also be applied with profiles (bumps) that slightly enhance wet night retroreflectivity. The profiles also produce a rumble effect similar to raised pavement markers.

1030.03(2)(c) Beads

Glass beads are small glass spheres used in highway markings to provide the necessary retroreflectivity. The beads are dropped onto the wet marking material immediately after it is applied (drop-on beads), or premixed into the wet marking material.

Proper installation of glass beads is critical to achieving good pavement marking retroreflectivity. Each glass bead works like a light-focusing lens, reflecting light back to the driver. Glass beads are embedded into the pavement marking material; for optimum performance, the bead is embedded between 55% and 60% of its diameter.

Large glass and composite beads are effective when roads are wet. Large glass or composite beads are not appropriate for standard mil paint as the paint is too thin to properly embed the large glass or composite beads; therefore, WSDOT specifies small glass or composite beads for such paint applications. The use of large glass or composite beads is limited to high-build waterborne paint and other materials with a thickness of at least 22 mils.

1030.03(3) Pavement Marking Application Types

There are five application types used for pavement markings. Most pavement marking applications are applied directly to the pavement surface. In steel bit snow plowing areas, the pavement markings may be inlaid or grooved to protect the markings.

Because they are higher than the surrounding pavement surface, pavement markings are subject to rapid wear caused by traffic and snowplows. As they wear, they lose visibility and retroreflectivity, particularly in wet weather. Wear on the stripes can be greatly reduced and their durability considerably increased by placing them in a shallow groove in the surface of the pavement.

1030.03(3)(a) Application Types

The five application types for pavement markings are:

1. Flat Lines

Flat lines are pavement marking lines with a flat surface.

2. Profiled Marking

A profiled pavement marking consists of a baseline thickness and a profiled thickness, which is a portion of the pavement marking line that is applied at a greater thickness than the baseline thickness. Profiles are applied using the extruded method in the same application as the baseline. The profiles may be slightly rounded if the minimum profile thickness is provided for the entire length of the profile. (See the *Standard Plans* for the construction details.)

3. Embossed Plastic Line

Embossed plastic lines consist of a flat line with transverse grooves. An embossed plastic line may also have profiles. (See the *Standard Plans* for the construction details.)

4. Inlaid Plastic Line

Inlaid plastic line is constructed by rolling Type C tape into hot mix asphalt (HMA) with the finish roller. This application is used infrequently by WSDOT and is not in the *Standard Specifications*.

5. Grooved Plastic Line

Grooved plastic line is constructed by cutting a groove into the pavement surface and spraying, extruding, or gluing pavement marking material into the groove. The groove depth is dependent upon the material used, the pavement surface, and the location. The groove is typically in the range of 20 to 250 mils deep and 4 inches wide. Coordinate with the region Traffic Office on the use and dimensions of grooved plastic line marking.

1030.03(4) Raised Pavement Markers

Raised pavement markers (RPMs) are installed as positioning guides with long line pavement markings. They can also be installed as a complete substitution for certain long line markings. RPMs have a durability of two years, and they provide good wet night visibility and a rumble effect. RPMs are made from plastic materials and are available in three different types:

- Type 1 markers are 4 inches in diameter, ¾ inch high, and non-reflectorized.
- Type 2 markers are 4 inches wide, 4 inches long, ¾ inch high, and reflectorized.
- Type 3 markers are 6, 8, 10, or 12 inches wide, 4 inches long, ¾ inch high, and non-reflectorized.

Type 2 RPMs are not used as a substitute for right edge lines. They may be used to supplement the right edge line markings at lane reductions, at sections with reduced lane widths such as narrow structures, and at the gore of exit ramps. All other applications supplementing right edge line markings require the approval of the region Traffic Engineer.

Red-backed RPMs are not desired and thus are only used at the discretion of the Region Traffic Engineer for specific locations. Research regarding their effectiveness for addressing wrong-way driving has been inconclusive to date.

Type 3 RPMs are used in locations where additional emphasis is desired, including vehicle separations and islands. Obtain approval by the region Traffic Engineer for all installations of Type 3 RPMs. Retain approval in the Design Documentation Package.

Reflectorized RPMs are not required for centerline and lane line applications in continuously illuminated sections of highway. However, if illumination policies (see Chapter 1040) affect a section of limited access roadway, coordinate with the region Traffic Engineer for RPM placement details. If reflectorized RPMs are used at an intersection within an illuminated section, they are also to be used throughout that section.

For raised pavement marker application details, see the *Standard Plans*.

1030.03(5) Recessed Raised Pavement Markers

Recessed raised pavement markers (RRPMs) are raised pavement markers (RPMs) installed in a groove ground into the pavement in accordance with the *Standard Plans*. RRPMs provide guidance similar to RPMs in ice chisel and steel blade snow-removal areas. RRPMs can also be used in rubber or Cooper-style blade snow-removal areas in accordance with region policy.

Designers should be aware that the performance of RRPMs can be compromised, especially on curves, because the groove can block motorists' view of the markers. Also, the groove for RRPMs installed on flat grades can fill with water during rain events and cause the RRPM to be non-reflective.

RRPMs, when specified, are installed at the locations shown in the *Standard Plans* for Type 2W RPMs on multilane one-way roadways and Type 2YY RPMs on two-lane two-way roadways.

Do not recess side-to-side RPMs on wide dotted lane lines.

For recessed pavement marker application details, see the *Standard Plans*.

1030.04 Guideposts

1030.04(1) General

Guideposts are retroreflective devices installed at the side of the roadway to indicate alignment. They are guidance devices rather than warning devices. Guideposts are used as an aid to nighttime driving primarily on horizontal curves; multilane divided highways; ramps; tangent sections where they can be justified due to snow, fog, or other reduced-visibility conditions; and at intersections without illumination.

1030.04(1)(a) Types of Guideposts

The retroreflective device may be mounted on either a white or brown post. The types of guideposts and their application are as follows:

1. **Type W**

   Type W guideposts have silver-white reflective sheeting, are facing traffic, and are used on the right side of divided highways, ramps, right-hand acceleration and deceleration lanes, intersections, and ramp terminals.

2. **Type WW**

   Type WW guideposts have silver-white reflective sheeting on both sides and are used on the outside of horizontal curves on two-way undivided highways.

3. **Type Y**

   Type Y guideposts have yellow reflective sheeting, are facing traffic, and are used on the left side of ramps, left-hand acceleration and deceleration lanes, ramp terminals, intersections on divided highways, median crossovers, and horizontal curves on divided highways.

4. **Type YY**

   Type YY guideposts have yellow reflective sheeting on both sides and are used in the median on divided highways.

5. **Type IC1**

   Type IC1 guideposts have silver-white reflective sheeting on both sides and an additional silver-white piece of reflective sheeting below the standard silver-white sheeting on the side facing traffic. They are used at intersections of undivided highways without illumination.

6. **Type IC2**

   Type IC2 guideposts have silver-white reflective sheeting on both sides and an additional silver-white piece of reflective sheeting below the standard silver-white reflective sheeting on the back side. They are used at intersections of undivided highways without illumination.

1030.04(2) Placement and Spacing

Guideposts are placed not less than 2 feet and not more than 8 feet outside the outer edge of the shoulder. Place guideposts at a constant distance from the edge of the roadway. When an obstruction intrudes into this space, position the guideposts to smoothly transition to the inside of the obstruction. Guideposts are not required along continuously illuminated divided or undivided highways. (See Exhibit 1030-2 for guidepost placement requirements and the *Standard Plans* for information on the different types and placement of guideposts.)

1030.05 Barrier Delineation

Traffic barriers are delineated where guideposts are required, such as bridge approaches, ramps, and other locations on unilluminated roadways (see Exhibit 1030-2). At these locations, the barrier delineation has the same spacing as that of guideposts. Barrier delineation is also required when the traffic barrier is 4 feet or less from the traveled way. Use a delineator spacing of no more than 40 feet at these locations.

Beam guardrail can be delineated by either mounting flexible guideposts behind the rail or by attaching shorter flexible guideposts to the wood guardrail posts.

Concrete barrier can be delineated by placing retroreflective devices on the face of the barrier about 6 inches down from the top. Consider mounting these devices on the top of the barrier at locations where mud or snow accumulates against the face of the barrier.

1030.06 Object Markers

Object markers are used to mark obstructions within or adjacent to the roadway. The MUTCD details three types of object markers. The Type 3 object marker with yellow and black sloping stripes is the most commonly used object marker.

The MUTCD contains criteria for the use of object markers to mark objects in and/or adjacent to the roadway. Follow these criteria in project design.

The terminal ends of impact attenuators are delineated with modified Type 3 object markers. These are the impact attenuator markers in the *Sign Fabrication Manual*. When the impact attenuator is used in a roadside condition, the marker with diagonal stripes pointing downward toward the roadway is used. When the attenuator is used in a gore where traffic will pass on either side, the marker with chevron stripes is used.

End of Roadway markers are similar to Type 1 object markers and are detailed in the MUTCD. They are used to alert users about the end of the roadway. Follow the MUTCD criteria in project design.

1030.07 Documentation

Refer to Chapter 300 for design documentation requirements.

1030.08 References

1030.08(1) Federal/State Laws and Codes

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

1030.08(2) Design Guidance

Roadway Delineation Practices Handbook, FHWA report, Washington, DC, 1994

Standard Plans for Road, Bridge, and Municipal Construction (*Standard Plans*), M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (*Standard Specifications*), M 41-10, WSDOT

Exhibit 1030-1 Pavement Marking Material Guide – Consult Region Striping Policy

Roadway Classification	Marking Type [3]				
	Centerlines [5]	Lane Lines [5]	Edge Lines	Wide Lines	Transverse Markings
Ice Chisel Snow Removal Areas					
Interstate	N.A.	Grooved Plastic [1]	Paint	Paint	Paint
Major Arterial	Paint & RRPMs[4] or Plastic[2] & RRPMs[4]	Paint	Paint	Paint	Paint
Minor Arterial	Paint	Paint	Paint	Paint	Paint
Collector	Paint	Paint	Paint	Paint	Paint
Steel Blade Snow Removal Areas					
Interstate-Urban	N.A.	Plastic [2]	Paint or Plastic[2]	Paint or Plastic[2]	Paint or Plastic[2]
Interstate-Rural	N.A.	Paint	Paint or Plastic[2]	Paint or Plastic[2]	Paint or Plastic[2]
Major Arterial	Paint & RRPMs[4] or Plastic[2] & RRPMs[4]	Paint	Paint or Plastic[2]	Paint or Plastic[2]	Paint or Plastic[2]
Minor Arterial	Paint	Paint	Paint	Paint or Plastic[2]	Paint or Plastic[2]
Collector	Paint	Paint	Paint	Paint or Plastic[2]	Paint or Plastic[2]
Rubber Blade Snow Removal Areas					
Interstate-Urban	N/A	PMMA [6] only or PMMA & RPMs	Paint or Plastic[2]	Plastic	FMMA [7]
Interstate-Rural	N/A	PMMA [6] only or PMMA & RPMs	Paint	Plastic [2]	FMMA [7]
Major Arterial	Paint & RPMs or Plastic [2] & RPMs		Paint	Plastic [2]	Plastic [2]
Minor Arterial	Paint & RPMs	Paint & RPMs	Paint	Plastic [2]	Plastic [2]
Collector	Paint & RPMs	Paint	Paint	Plastic [2]	Plastic [2]

Notes:

[1] Grooved Plastic is a line constructed by cutting a groove into the pavement surface and spraying, extruding, or gluing pavement marking material into the groove.

[2] Plastic refers to methyl methacrylate (MMA), thermoplastic, or preformed tape.

[3] For RPM substitute applications and RPM applications supplementing paint or plastic, see the *Standard Plans*, Section M.

[4] RRPMs refer to RPMs installed in a groove ground into the pavement. RRPMs are identified as "Recessed Pavement Markers" in the *Standard Specifications* and the *Standard Plans*.

[5] Type 2 RPMs are not required with painted or plastic centerline or lane line in continuously illuminated sections.

[6] PMMA refers to profiled methyl methacrylate.

[7] FMMA refers to flat methyl methacrylate.

Exhibit 1030-2 Guidepost Placement

Location	Guideposts on Tangents [1][3]	Guideposts on Horizontal curves [1][3]
Divided Highways With Continuous Illumination		
Main Line	None	None
Bridge Approaches	None	None
Intersections	None	None
Lane Reductions	[4]	[4]
Median Crossovers	None	None
Ramps	[4]	[4]
Divided Highways Without Continuous Illumination		
Main Line with RPMs	None	[4]
Main Line without RPMs	Right Side Only (0.10 mile spacing)	[4]
Bridge Approaches	[4]	[4]
Intersections	[4]	[4]
Lane Reductions	[4]	[4]
Median Crossovers	[4]	[4]
Ramps	[4]	[4]
Undivided Highways With Continuous Illumination		
Main Line	None	None
Bridge Approaches	None	None
Intersections	None	None
Lane Reductions	[4]	[4]
Undivided Highways Without Continuous Illumination		
Main Line	[2]	*Standard Plans*, Section M[2]
Bridge Approaches	[4]	[4]
Intersections with Illumination	None	None
Intersections without Illumination	[4]	[4]
Lane Reductions	[4]	[4]

Notes:

[1] For lateral placement of guideposts, see the *Standard Plans*, Section M.

[2] Installation of guideposts on tangents and on the inside of horizontal curves is allowed at locations approved by the region Traffic Engineer.

[3] Barrier delineation is required when the traffic barrier is 4 feet or less from the traveled way. Use delineator spacing of 40 feet or less.

[4] *Standard Plans*, Section M

Chapter 1040 Illumination

1040.01 General

Illumination is provided along highways, in parking lots, and at other facilities to enhance the visual perception of conditions or features that require additional motorist, cyclist, or pedestrian alertness during the hours of darkness.

The Washington State Department of Transportation (WSDOT) is responsible for illumination on state highways and crossroads (WAC 468-18-040 and WAC 468-18-050) with partial limited access control, modified limited access control, or full limited access control, regardless of the location. WSDOT is responsible (WAC 468-18-050) for illumination on state highways and crossroads with managed access control located outside the corporate limits of cities. Cities are responsible for illumination on managed access state highways within their corporate limits.

For the definitions of limited access control and managed access control, see Chapter 520. For a listing (by milepost) of the limited access or managed access status of all state highways, refer to the Access Control Tracking System Limited Access and Managed Access Master Plan, under the "More Information" heading: www.wsdot.wa.gov/design/accessandhearings. For further information, refer to the WSDOT/Association of Washington Cities agreement "City Streets as Part of State Highways": www.wsdot.wa.gov/localprograms/lag/construction.htm

1040.02 Definitions

The following terms are defined in the Glossary: *adaptive lighting system, average light level, complex ramp alignment and grade, continuous load, footcandle (fc), lamp lumens, light emitting diode(LED), long tunnel, lumen, luminaire, luminance, luminous flux, maximum uniformity ratio, maximum veiling luminance ratio, minimum average light level, minimum light level, mounting height – luminaire, multimodal connection, negative illumination, nighttime, pedestrian crossing, pole height (H1), positive illumination, roadway luminance, security lighting, short tunnel, SIgnal Maintenance Management System (SIMMS), slip base, spacing, transit flyer stop, transit stop, uniformity ratio,* and *veiling luminance*.

1040.03 Design Considerations

An illumination system is built from many separate components. The simplest illumination system contains the following:

- A power feed from the local utility company.

- An electrical service cabinet containing a photocell and circuit breaker for each illumination circuit.
- Runs of conduit with associated junction boxes leading to each luminaire.
- Conductors routed from the service cabinet breaker to each luminaire.
- A concrete light standard foundation.
- A light standard with a slip base or a fixed base.
- A luminaire (light) over or near the roadway edge line.

There are design considerations that need to be addressed when performing even the most minimal work on an existing illumination system. An existing electrical system is acceptable for use under the design requirements and National Electric Code (NEC) rules that were in effect at the time of installation. When modifying an existing electrical service or transformer, the designer is responsible for bringing the whole system up to current NEC design standards. Retrofitting an existing fixed base light standard with a slip base feature requires the installation of quick disconnect fittings and fuses in the circuit, at the luminaire only. The existing conductor configuration for a fixed base luminaire is not acceptable for use on a breakaway (slip base) installation. Existing conductors and components that no longer meet current NEC requirements are to be replaced and the whole circuit is to be designed to current standards. This may mean replacing the whole circuit back to the nearest overcurrent protection device (circuit breaker). Address the following when modifying an existing illumination system:

- Whether the existing circuit is in compliance with current NEC standards (deficient electrical component).
- Whether existing luminaire system components, such as conductors, conduit, junction boxes, foundation, and pole comply with current standards.
- Whether conductors meet NEC requirements for temperature rating (deficient electrical component).
- Conductor material: aluminum conductors or copper conductors (deficient electrical component).
- Whether the existing bonding and grounding system is adequate: cabinets, poles, junction boxes, including lids, and other appurtenances are bonded and grounded per NEC requirements.
- The condition and adequacy of the existing conduit running between the luminaire and the nearest junction box (deficient electrical component).
- The condition of the junction box next to the luminaire (deficient electrical component).
- The suitability of the existing foundation to meet current design requirements.
- The suitability of the location to meet current design standards for illumination.
- The location and bolt pattern of the existing foundation to meet current design standards.
- The design life remaining for the existing light standard (deficient electrical component).
- The condition of the existing light standard (deficient electrical component).

- Maintenance personnel assessment of the electrical safety of the installation.

Involve appropriate Headquarters (HQ) and region Traffic Office design personnel early in the process. Ensure potential system deficiencies are reflected in the estimate of work.

Maintain required illumination during all construction activities, except when shutdown is permitted to allow for alterations or final removal of the system per the Engineer. Site preparation, widening, drainage, guardrail installation, or other work can easily impact existing conduit runs or luminaire locations. Also, changed conditions such as merging, weaving, or unusual alignment due to traffic control often require additional temporary illumination.

Note: The same lighting requirements apply whether a condition is temporary or permanent.

Illumination is not required for minor operational enhancement projects, unless that is the specific reasoning for the project.

1040.04 Required Illumination

The following items are to be considered for each project:

- Replace standard duty junction boxes that are located in paved areas with heavy-duty junction boxes, and bring electrical components to current standards. Relocate/remove junction boxes that are located in the travel way when practical.
- Review the age of the equipment as listed in SIMMS and consider replacing components that have reached the end of their design life. Replace poles, foundations, heads, and other equipment, that have reached their design life.
- Locate components so that they can be safely accessed from the right of way.
- Ensure existing slip base features are in accordance with current design standards.
- Consider additional illumination in accordance with 1040.05, if warranted, or design additional illumination if it is called for in the Project Definition.
- When it is necessary to relocate existing light standard foundations, evaluate the entire conduit run serving those light standards and replace deficient components to current (NEC) standards.

Exhibits 1040-1a through 1040-21 show examples of illumination for roadway, transit flyer stops, parking lots, truck weigh stations, tunnels, bridges, work zones, and detour applications.

A minimum of two light standards of standard pole height are required at all design areas, with the exception of ramp terminals and entrance/exit points at minor parking lots.

1040.04(1) Freeway Off-Ramps and On-Ramps

Provide the necessary illumination for the design area of all freeway off-ramp gore areas and on-ramp acceleration tapers (see 1040.06(2) and Exhibits 1040-1a, 1b, and 1c).

1040.04(2) Freeway Ramp Terminals

Provide the necessary illumination for the design area (see Exhibit 1040-2).

1040.04(3) Freeway On-Ramps With Ramp Meter Signals

Provide the necessary number of light standards to illuminate freeway on-ramps with ramp meters, from 150’ before the ramp meter stop bar to 50’ past the ramp meter stop bar. When there is an HOV bypass lane or a two-lane merge beyond the ramp meter, then also provide illumination from the point where the merging lane width is 10’ to 200’ downstream of that point (see Exhibit 1040-3). Illumination for the ramp merge with mainline is to be done per Exhibit 1040-1b.

1040.04(4) HOT (High-Occupancy Toll) Lane Enter/Exit Zones and Access Weave Lanes

Provide the necessary number of luminaires to illuminate the design area of the enter/exit zones and access weave lanes of the HOT lane (see Exhibits 1040-4a and 4b).

1040.04(5) Lane Reduction

Provide the necessary number of light standards to illuminate the design area of all highway lane reduction areas within the urban boundary (see Exhibit 1040-5). This requirement does not apply to:

- The end of slow-moving vehicle turnouts.
- The end of the area where driving on shoulders is allowed.

1040.04(6) Intersections With Left-Turn Lane Channelization

Illumination of the intersection area is required for intersections with painted or other low-profile pavement markings such as raised pavement markings. When the channelization is delineated with curbs, raised medians, or islands, illuminate the raised channelization on the State Route from 25’ before the raised channelization begins (see Exhibits 1040-6a, 6b, and 6c).

1040.04(7) Intersections With Traffic Signals

Illuminate intersections with traffic signals on state highways (see Exhibit 1040-7). In cities with a population under 25,000, the state may assume responsibility for illumination installed on signal standards.

1040.04(8) Roundabouts

Provide the necessary number of light standards to illuminate the design areas of roundabouts (see Chapter 1320 and Exhibit 1040-9).

1040.04(9) Railroad Crossings with Gates or Signals

Railroad crossings with automated gates or signals on state highways are illuminated if there is nighttime train traffic. Within the corporate limits of a city, and outside limited access control, illumination is the responsibility of the city. Install luminaires beyond the railroad crossing, on the side of the roadway opposite the approaching traffic, to backlight the train (see Exhibit 1040-10).

1040.04(10) Midblock Pedestrian Crossings

Illuminate the entire midblock pedestrian crossing, including the crosswalks, the refuge area in the roadway, and the sidewalks or shoulders adjacent to the crosswalk. When a raised median pedestrian refuge design is used, illuminate the raised channelization (see Exhibit 1040-11).

1040.04(11) Transit Flyer Stops

Illuminate the pedestrian-loading areas of transit flyer stops located within the limited access boundaries (see Exhibit 1040-12).

1040.04(12) Major Parking Lots

All parking lots with usage exceeding 50 vehicles during the nighttime peak hour are considered major parking lots. Provide an illumination design that will produce the light levels shown in Exhibit 1040-22. (See Exhibit 1040-13 for the parking design area and bus loading zone design area.) During periods of low usage at night, security lighting is required only in the parking area and bus loading zone. Provide an electrical circuitry design that allows the illumination system to be reduced to approximately 25% of the required light level.

1040.04(13) Minor Parking Lots

Minor parking lots have a nighttime peak hour usage of 50 or fewer vehicles. Provide security-level lighting for those lots owned and maintained by the state. Security lighting for a minor parking lot consists of lighting the entrance and exit to the lot (see Exhibit 1040-14).

1040.04(14) Truck Weigh Sites

Provide illumination of the roadway diverge and merge sections, scale platforms, parking areas, and inspection areas of weigh sites (see Exhibit 1040-15).

1040.04(15) Safety Rest Areas

Provide illumination within rest areas at the roadway diverge and merge sections, the walkways between parking areas and rest room buildings, and the parking areas the same as for a major parking lot (see Exhibit 1040-16).

1040.04(16) Chain-Up/Chain-Off Parking Areas

Provide the necessary number of luminaires to illuminate the design area of the chain-up/chain-off parking areas (see Exhibit 1040-17) on State Routes 2, 12, and 90 where a power distribution point is within a half mile and power is readily accessible. Illumination is to be installed in the median and on the right shoulder to provide lighting on both sides of the stopped vehicles. Luminaires should only be energized during periods when traction tires are required and vehicles over 10,000 pounds are required to use chains.

1040.04(17) Tunnels, Lids, and Underpasses

For the purposes of this chapter, a tunnel is a structure over a roadway, which restricts the normal daytime illumination of a roadway section such that the driver's visibility is substantially diminished. Tunnels cover roadways and produce a shadow that limits the ability of the driver to see objects or obstructions within the tunnel. In most locations, no supplemental daytime lighting is required for underpasses or structures less than 80 feet in length. Provide both nighttime and daytime lighting for long tunnels. (See ANSI/IES publication RP-22-11 for tunnel lighting design criteria.) Provide vandal-resistant daytime and nighttime security lighting in pedestrian tunnels. Short tunnels and underpasses where the exit portal is not visible from the entrance portal due to curvature of the roadway are to be considered long tunnels.

1040.04(18) Bridge Inspection Lighting

Provide the necessary number of light fixtures and electrical outlets to illuminate the interior inspection areas of floating bridges, steel box girder bridges and concrete box girder bridges where access is provided (see Exhibit 1040-18). Separate circuits are to be used for lighting and electrical outlets. Each electrical outlet is to be powered by 2 Duplex receptacles on two separate circuits. All electrical outlets are to be labeled with circuit identifications. Coordinate bridge illumination requirements with the HQ Bridge and Structures Office.

1040.04(19) Same Direction Traffic Split Around an Obstruction

Provide the necessary number of light standards to illuminate the design area where traffic is split around an obstruction. This requirement applies to permanent and temporary same-direction split channelization. For temporary work zones, illuminate the obstruction for the duration of the traffic split (see Exhibit 1040-19).

1040.04(20) Diverging Diamond Interchange

Provide the necessary number of light standards to illuminate the design area shown in Exhibit 1040-21. The design area starts 25’ before the raised channelization as you approach the interchange and continues through the interchange until 25’ past the raised channelization as you exit the interchange.

1040.05 Additional Illumination

At certain locations, additional illumination is desirable to provide better definition of nighttime driving conditions or to provide consistency with local agency goals and enhancement projects. For Improvement projects on state highways, additional illumination could be reviewed as a crash countermeasure under certain circumstances, which are listed in this section.

1040.05(1) Conditions for Additional Illumination

Following are some conditions used in making the decision to provide additional illumination:

1040.05(1)(a) Crash Analysis

The following conditions have to be met when making the decision to provide additional illumination:

- During the last full five calendar years, the site has experienced nighttime crashes that are correctable with illumination, AND
- The benefit-cost analysis for the proposed illumination exceeds 1, AND
- Alternative lower-cost countermeasures have been evaluated and did not address the particular nighttime crash history.

Nighttime crashes are defined as crashes occurring between half an hour after sunset and half an hour before sunrise. Correctable nighttime crashes are crashes that (a) meet the nighttime definition in this chapter, (b) have contributing factors related to a lack of lighting, and (c) where lighting, if installed, would directly address the contributing factor(s) to the crashes.

Collision reporting forms and the crash data are not adequate means to distinguish between day and nighttime conditions: the crash location, the reported crash times, and seasonal variations should be used to determine which crashes qualify as nighttime crashes. Also:

- For sites where the number of nighttime crashes equals or exceeds the number of daytime crashes, the above-mentioned crash and benefit-cost analysis should be performed.
- For sites where these nighttime crashes involve pedestrians, refer to 1040.05(11).

1040.05(1)(b) Locations With Nighttime Pedestrian Crashes

The mitigation of nighttime pedestrian crashes requires different lighting strategies than vehicular crash locations. Provide light levels to emphasize crosswalks and adjacent sidewalks by using positive lighting of the pedestrians.

Multilane highways with two-way left-turn lanes, in areas transitioning from rural land use to urban land use, or areas experiencing commercial growth or commercial redevelopment, are typically high-speed facilities with numerous road approaches and driveways. These approaches allow numerous vehicle entry and exit points and provide few crossing opportunities for pedestrians; consider additional illumination.

1040.05(2) Highways

Proposals to provide full (continuous) illumination require the approval of the Region and State Traffic Engineers. Regions may choose to develop (regional or corridor-specific) system plans for providing full (continuous) illumination. The State Traffic Engineer’s approval of a system plan will eliminate the need for a project-specific approval from the State Traffic Engineer. Continuous illumination can be provided inside city limits at the city’s request provided the city takes on the maintenance and operational costs and responsibilities of maintaining and operating the system.

The decision whether to provide full (continuous) illumination is to be made during the scoping stage and communicated to the designers as soon as possible.

Continuous illumination should be considered when the crash analysis requirements in 1040.05(1) are met and a benefit/cost analysis between the required and full (continuous) illumination exceeds 1.

On the main line of highways without full limited access control, consider full (continuous) illumination if the segment of highway is in a commercial area and the crash analysis requirements in 1040.05(1) are met, has raised channelization, has medium or high pedestrian activity during night time hours, and an engineering study indicates that nighttime driving conditions will be improved.

1040.05(3) Ramps

Consider additional illumination at ramps where the alignment or grade is complex.

1040.05(4) Crossroads

Consider additional illumination if the crossroad is in a short tunnel, an underpass, or a lid.

1040.05(5) Intersections Without Turn-Lane Channelization

Refer to Exhibit 1040-8.

1040.05(6) Short Tunnels, Underpasses, or Lids

Consider illumination of the sidewalk, walkway, or shared-use path if it is included as part of the short tunnels, underpasses, or lids.

1040.05(7) Work Zones and Detours

Consider temporary illumination of the highway through work zones and detours when changes to the highway alignment or grade remain in place during nighttime hours. Exhibit 1040-20 illustrates considerations for temporary illumination, such as reduced roadway widths, work zone lane shifts, and median cross overs.

For further information on illumination in work zones, see Chapter 1010.

1040.05(8) Transit Stops

The responsibility for lighting at transit stops is shared with the transit agency. Consider illuminating transit stops with shelters as they usually indicate greater passenger usage. Negotiation with the transit agencies is required for the funding and maintenance of this illumination. Negotiating a memorandum of understanding (MOU) with each transit agency is preferred over spot negotiations. If the transit agency is unable or unwilling to participate in the funding and maintenance of the illumination, consider a single light standard positioned to illuminate both the transit pullout area and the loading area.

1040.05(9) Bridges

Justification for illuminating the roadway/sidewalk portion of bridges is the same as that for highways on either end of the bridge with or without full limited access control, as applicable. Justification for illuminating the architectural features of a bridge structure requires the approval of the State Traffic Engineer. For justification for illuminating pedestrian walkways or bicycle trails under a bridge, see 1040.05(11).

1040.05(10) Railroad Crossing Without Gates or Signals

Consider the illumination of railroad crossings without gates or signals when:

- The crash history indicates that motorists experience difficulty in seeing trains or control devices.
- There are a substantial number of rail operations conducted during nighttime hours.
- The crossing is blocked for long periods due to low train speeds.
- The crossing is blocked for long periods during the nighttime.

For further information, see the MUTCD.

1040.05(11) Sidewalks, Walkways, and Shared-Use Paths

Consider illumination of a pedestrian walkway if the walkway is a connection between two highway facilities. This could be between parking areas and rest room buildings at rest areas; between drop-off/pick-up points and bus loading areas at flyer stops; or between parking areas and bus loading areas or ferry loading zones. Consider illuminating existing sidewalks, walkways, and shared-use paths if security problems have been reported or are anticipated. Under these conditions, these facilities are illuminated to the level shown in Exhibit 1040-22.

1040.06 Design Criteria

1040.06(1) Light Levels

Light levels vary with the functional classification of the highway, the development of the adjacent area, and the level of nighttime activity. Light level requirements for highways and other facilities are shown in Exhibit 1040-22. These levels are the minimum average light levels required for a design area at the end of rated lamp life for applications requiring a spacing calculation. Light level requirements are not applicable for single light standards or security lighting installations where:

- The light level is reduced to approximately 25% of the required light level in parking lots and parking lot loading areas during periods of low usage at night.
- Walkway or path illumination is installed only at areas where shadows and horizontal and vertical geometry obstruct a pedestrian's view.
- Light level requirements are applicable when:
- The complete walkway or path is to be illuminated for public safety.

The access areas used for interior inspection of floating bridges or steel box/concrete box girder bridges are exempt from lighting level and lighting ratio design requirements.

For functional classifications of highways, see:
www.wsdot.wa.gov/mapsdata/travel/hpms/functionalclass.htm

1040.06(1)(a) Activity Areas

The types of activity areas (shown below) are related to the number of pedestrian crossings through the design area. These crossings need not occur within a single crosswalk and can be at several locations along the roadway in an area with pedestrian generators. Land use and activity classifications are as follows:

1040.06(1)(a)(1) High Activity

Areas with over 100 pedestrian crossings during nighttime peak hour pedestrian usage. Examples include downtown retail areas; near outdoor stage theaters, concert halls, stadiums, and transit terminals; and parking areas adjacent to these facilities.

1040.06(1)(a)(2) Medium Activity

Areas with pedestrian crossings that number between 11 and 100 during nighttime peak hour pedestrian usage. Examples include downtown office areas; blocks with libraries, movie theaters, apartments, neighborhood shopping, industrial buildings, and older city areas; and streets with transit lines.

1040.06(1)(a)(3) Low Activity

Areas with pedestrian crossings that number less than 11 during the nighttime peak hour pedestrian usage. Examples include suburban single-family areas, low-density residential developments, and rural or semirural areas.

1040.06(2) Design Areas

The design area is that portion of the roadway, parking lot, or other facility subject to the minimum light level, minimum average light level, uniformity ratio, and maximum veiling luminance ratio design requirements. This encompasses the area between the edges of the traveled way along the roadway; the outer edges of the stopping points at intersections; and, when present, a bike lane adjacent to the traveled way. When the roadway has adjacent sidewalks <u>and is located in a medium or high pedestrian activity area</u>, the design area includes these features; however, sidewalks adjacent to the traveled way are exempt from maximum veiling luminance ratio requirements.

1040.06(2)(a) Design Area Requirements

Design area requirements for various applications are shown in Exhibits 1040-1a through 1040-21 and are described in the following:

1040.06(2)(a)(1) Single-Lane Off-Ramp

Two main line through lanes and the ramp lane, including gore area, from the gore point (beginning of wide line) to a point 200 feet (minimum) downstream of the gore point. A 100 foot longitudinal tolerance either way from the gore point is allowed.

1040.06(2)(a)(2) Two-Lane Off-Ramp

Two main line through lanes and both ramp lanes, including gore area, from a point 200 feet upstream of the gore point (beginning of wide line) to a point 200 feet downstream of the gore point. A 100-foot longitudinal tolerance either way from the gore point is allowed.

1040.06(2)(a)(3) Single-Lane On-Ramp

Two main line through lanes and the ramp lane, from a point where the ramp lane is 10 feet wide to a point 200 feet downstream. A 100-foot longitudinal tolerance either way is allowed; this includes auxiliary lane on-connections and lane reductions.

1040.06(2)(a)(4) Two-Lane On-Ramp

Two main line through lanes and the ramp lanes from a point where the ramp width is 22 feet wide to a point 200 feet upstream and 200 feet downstream. A 100-foot longitudinal tolerance either way is allowed.

1040.06(2)(a)(5) Intersections Channelized With Pavement Markings

When the leg of an intersection is two lanes wide or less, the design area starts at the stop bar and encompasses the intersection area. When the leg of an intersection is three or more lanes wide, the design area starts 25’ before the stop bar and encompasses the intersection area.

1040.06(2)(a)(6) Intersections With Raised Channelization

The design area has two components: the intersection area and the approach areas. When the leg of an intersection is two lanes wide or less, the intersection design area starts at the stop bar and encompasses the intersection area. When the leg of an intersection is three or more lanes wide, the intersection design area starts 25 feet before the stop bar and encompasses the intersection area on both the main road and the minor road, including marked or unmarked crosswalks. The approach areas are the areas on the main roadway between the intersection design area and where the left-turn taper begins.

1040.06(2)(a)(7) Unchannelized Intersection

The area between the stopping points on both the main road and the minor road, including marked or unmarked crosswalks.

1040.06(2)(a)(8) Railroad Crossing

The roadway width from a point 50 feet on either side of the track (the approach side only for one-way roadways).

1040.06(2)(a)(9) Transit Loading Area

The lane width and length designated for loading.

1040.06(2)(a)(10) Major Parking Lot

The entire area designated for parking, including internal access lanes.

1040.06(2)(a)(11) Scale Platform at Weigh Site

The approach width from the beginning of the scale platform to the end of the platform.

1040.06(2)(a)(12) Inspection Area at Weigh Site

The area dedicated to inspection as agreed upon with the Washington State Patrol.

1040.06(2)(a)(13) Bridge Inspection Lighting System

Fixtures are to be ceiling mounted. For steel box girders bridges, the spacing shall not be greater than the smaller of 4 times the web depth or 25 ft. For concrete box girder bridges, the spacing shall not be greater than the smaller of 8 times the web depth or 50 ft. Illumination is to consists of a 100 watt incandescent (or fluorescent equivalent) fixture. The bulb should have a minimum of 1600 lumens. Each fixture is to be designed with a 20 amp rated ground fault circuit interrupt (GFCI) receptacle. A light switch is needed at each entrance to any common inspection area. For inspection areas with two or more entrances, three-way or four-way switches are required.

1040.06(3) Daytime Light Levels for Tunnels, Lids, and Underpasses

It is important to provide sufficient illumination inside a tunnel. When driving into and through a tunnel during the day, a driver’s eyes have to adjust from a high light level (daylight) to a lower lighting level inside the tunnel. Motorists require sufficient time for their eyes to adapt to the lower light level of the tunnel itself. When sufficient lighting is not provided in the threshold, transition, or interior zones of a tunnel, a motorist’s eyes may not have enough time to adapt and may experience a “black hole” or “blackout” effect. This “black hole” effect may cause a motorist to slow down, reducing the efficiency of the roadway. When leaving the tunnel, the driver's eyes have to adjust from a low lighting level back to daytime conditions. The full design considerations for tunnel lighting are covered in 1040.08(2) in the Design Guidance section.

- All designs for illuminating tunnels are to be reviewed and approved by the State Traffic Engineer.
- Long tunnels are divided into zones for the determination of daytime light levels. The zones are Threshold Zone, Transition Zone(s), and Interior Zone. Each zone length is calculated using the method described in ANSI/IES RP-22-11.
- The designer of a long tunnel shall perform a Lseq (Equivalent Veiling Luminance) calculation. Lseq values obtained from this calculation shall be used to reduce (or increase) the Suggested Daytime Maintained Average Pavement Luminance Levels where indicated.
- Tunnel wall illumination is required.
- The approach and exit roadways shall have a nighttime luminance level of no less than one third of the tunnel interior level for one safe stopping sight distance (SSSD).
- Provide illumination of fire protection equipment, alarm pull boxes, phones, and emergency exits in long tunnels. (See NFPA 502 for additional information.)
- Short tunnels and underpasses in rural areas or with low pedestrian usage normally do not have daytime illumination. Short tunnels and underpasses in urban areas with high pedestrian usage may require daytime and nighttime illumination. Consultation with the affected local agency is recommended. Short tunnels and underpasses are treated the same as an entrance zone on a long tunnel to establish daytime light levels.
- Nighttime light level requirements for short tunnels on continuously illuminated roadways are the same as the light level required on the roadway outside the tunnel.

1040.06(4) Light Standards

1040.06(4)(a) Light Standards on State Highway Facilities

Light standards are the most common supports used to provide illumination for highway facilities. The 40-foot light standard with a slip bases and Type 1 mast arm is predominantly used on state highways. In areas with continuous illumination, 50-foot light standards may be used. Use Type 1 mast arms on all new systems and when modifying existing systems. Cities and counties may elect to use different mounting heights to address factors unique to their environments. On state highways, alternative colored light standards may be considered if requested by the city or county, provided they agree to pay any additional costs associated with this change.

The typical location for a light standard is on the right shoulder. When considering designs for light standards mounted on concrete barrier in the median, consider the total life cycle cost of the system, including the user costs resulting from lane closures required for relamping and repair operations, and higher maintenance costs since the work will most likely be done during night time hours due to decreased traffic volumes. Region Signal Maintenance approval is required for all median mounted luminaires except chain on/off areas. Light standards located in the vicinity of overhead power lines require a minimum 10 foot circumferential clearance from the power line (including the neutral conductor) to any portion of the light standard or luminaire. Depending on the line voltage, a distance greater than 10 feet may be required (WAC

296-24-960). Consult the HQ Bridge and Structures Office when mounting light standards on structures such as retaining walls and bridge railings.

It is preferable to locate a light standard as far from the traveled way as possible to reduce the potential for impacts from errant vehicles. The typical luminaire position is mounted directly over the edge line plus or minus 4 feet. However, some flexibility is acceptable with the luminaire position to allow for placement of the light standard provided light levels, uniformity, and maintenance considerations are also addressed and with the Region Traffic Engineer's approval. On Type III signal standards, luminaires may be placed more than 4 feet from the edge line.

Standard mast arm lengths are available in 2-foot increments between 6 and 16 feet. The preferred design for a single-arm light standard is a 16-foot mast arm installed on a 40-foot standard. The maximum allowable mast arm length for a single-arm light standard is 16 feet. The preferred design for a double mast arm light standard has mast arms between 6 feet and 12 feet in length, installed on a 40-foot standard. The maximum allowable mast arm length for a double luminaire light standard is 12 feet.

When light standards are located within the Design Clear Zone, breakaway and slip base features are used to reduce the severity of an impact. (See Chapter 1600 for additional guidance on clear zone issues.)

In curb and sidewalk sections, locate the light standard behind the sidewalk. In locations where the light standard cannot be placed behind the sidewalk and still have the luminaire mounted within 4' of the edge line, the luminaire should be located in the sidewalk. Slip bases on light standards are a safety requirement for roadways where the posted speed is 35 mph or higher. They are not always desirable at other locations. Fixed bases are installed in the following locations:

- Roadway with speeds below 35 mph.
- Parking lots.
- Medians where the light standard is mounted on median barrier.
- Behind traffic barrier, beyond the barrier's deflection design value (see Chapter 1610).
- Along pedestrian walkways, bike paths, and shared-use paths outside of the roadway clear zone.

1040.06(4)(b) Light Standard Heights

Standard pole heights (20-foot, 30-foot, or 40-foot) are readily available from local distributors and manufacturers. Light standards can also be supplied with other lengths. However, WSDOT Maintenance offices cannot stock poles with nonstandard lengths for use as replacements in the event of a knockdown. Nonstandard lengths in 5-foot increments (25-foot, 35-foot, or 45-foot) will require a longer delivery time. Other nonstandard lengths (for example, 27-foot, 33-foot, or 37-foot) will not only require a longer delivery time, they will also be more expensive.

In almost all cases, use a standard pole heights of 40 feet for roadway illumination. Structure-mounted light standards may need to be shorter than the standard 40-foot grade-mounted pole. It is acceptable to use 20-foot or 30-foot light standards on bridges, retaining walls, or other structures to compensate for top-of-structure elevation above the roadway surface. Luminaires with a mounting height over 40 feet should only be used in continuously illuminated areas that are not in residential areas. Use of these standard pole heights will result in variable mounting heights for the luminaires. Luminaire mounting height is defined as the actual distance from the roadway surface directly under the luminaire to the luminaire itself. Use the actual mounting height at each location when calculating light standard spacing. Luminaires with a mounting height over 50 feet require lowering devices.

High mast light supports may be considered for complex interchanges where continuous lighting is justified. High mast lighting may be considered for temporary illumination areas during construction. Initial construction costs, long-term maintenance, clear zone mitigation, spillover light onto adjacent properties, and negative visual impacts are important factors when considering high mast illumination.

Shorter light standards of 30 feet or less may be used for minor parking lots, trails, pedestrian walkways, and locations with restricted vertical clearance.

1040.06(4)(c) Standard Luminaire

The standard luminaire in use now for roadway lighting is a cobra head style type III LED fixture. The list of LED fixtures approved for use on WSDOT projects can be found at:
http://www.wsdot.wa.gov/Design/Traffic/ledluminaires.htm

For continuously illuminated area a type V distribution pattern can be used for the interior areas with type III distribution on the perimeters.

1040.06(4)(d) Electrical Design

For an example of circuit layout, conductor sizing, conduit sizing, overcurrent protection device sizing, and other electrical design calculations, see the Power Supply Design material located at:
http://www.wsdot.wa.gov/design/traffic/electrical/training.htm

An example of illumination design grid layouts and calculations is located in the Illumination Design for Transportation Applications material located in the link above.

The illumination circuitry is to be laid out so that if four or more luminaires are installed, it should have a minimum of two circuits. The intent is to make sure that if a circuit fails, there will still be partial lighting from the other circuits.

The maximum allowable junction box spacing is as follows:

1. 360 feet allowed between in grade junction boxes with a straight pull.
2. 180 feet when conduit run is along a curve or when the conduit makes a 30 degree or greater change in direction.
3. 180 feet between NEMA junction boxes in traffic barrier, retaining wall, or structure.
4. A junction box is required within 5 feet minimum (preferred) & 10 feet maximum of the luminaire base, regardless of the luminaire spacing.
5. 360 feet between NEMA junction boxes when fiber optic cable is run through conduit in traffic barrier, retaining wall, or structure.
6. Pull Box interconnect to Traffic Signal – spacing is 500 feet maximum. Disclaimer: This would only apply to a single fiber optic cable.
7. 1,000 feet between cable vaults or pull boxes – main line fiber optic cable.

1040.06(5) Adaptive Lighting

Adaptive Lighting Systems may be used at select locations where changing traffic conditions allow for lowering of light levels or the changing of a required design area. Some examples would be: the Pedestrian/Area Classification changes requiring different levels; traffic volumes drop sharply; or chain up/chain off areas. Region and State Traffic Engineers' approval is required for adaptive lighting systems.

1040.07 Documentation

Justify and document any additional illumination in the Design Documentation Package (DDP).

The approval from maintenance to install median mounted luminaires can be an email or memo from the area maintenance superintendent and is kept in the design file.

Any areas in this section that says to "consider" a design element should have the logic of the consideration and decision documented in the design file for future reference.

Refer to Chapter 300 for design documentation requirements.

1040.08 References

1040.08(1) Federal/State Laws and Codes

National Electrical Code (NEC), NFPA, Quincy, MA

Revised Code of Washington (RCW) 47.24.020, Jurisdiction, control

Washington Administrative Code (WAC) 296-24-960, Working on or near exposed energized parts

WAC 468-18-040, Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings

WAC 468-18-050, Policy on the construction, improvement and maintenance of intersections of state highways and city streets

1040.08(2) Design Guidance

American National Standard Practice for Roadway Lighting, IES RP-8-00, New York, NY 2000

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

NFPA 502: Standard for Road Tunnels, Bridges, and Other Limited Access Highways, NFPA, Quincy, MA 2011

Recommended Practice for Tunnel Lighting, IESNA RP-22-05, New York, NY 2011

Roadway Lighting Design Guide, AASHTO, October 2005

Roadway Lighting Handbook, Addendum to Chapter Six: Designing the Lighting System Using Pavement Luminance, Federal Highway Administration, Addendum to Implementation Package 78-15, Washington, DC 1983

Roadway Lighting Handbook, Federal Highway Administration, Implementation Package 78-15, Washington, DC 1978 (Reprinted April 1984)

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

1040.08(3) Supporting Information

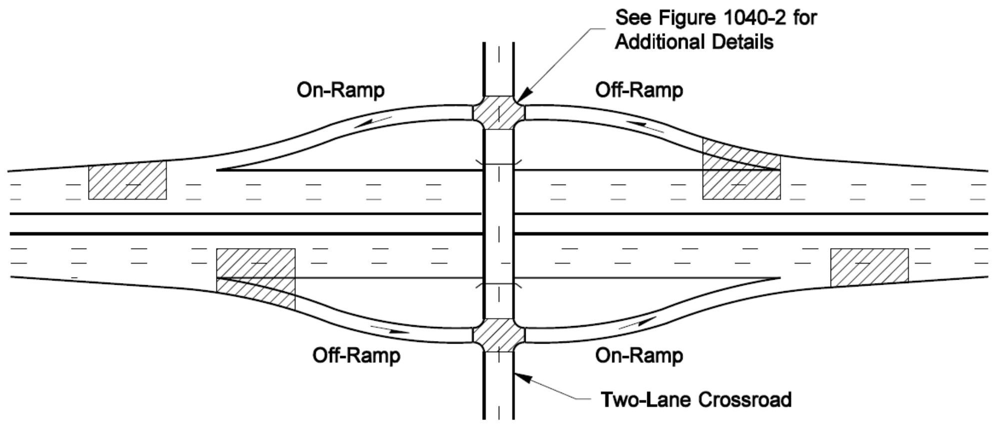
A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, Current Edition

An Informational Guide for Roadway Lighting, AASHTO, Washington, DC 1984

City Streets as Part of State Highways Guidelines Reached by the Washington State Department of Transportation and the Association of Washington Cities on Interpretation of Selected Topics of RCW 47.24 and Figures of WAC 468-18-050 for the Construction, Operations and Maintenance Responsibilities of WSDOT and Cities for such Streets, 4-30-1997 amended 4-2-2013

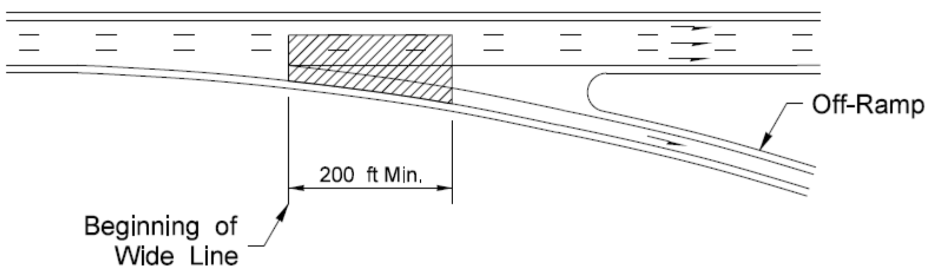
Light Trespass: Research Results and Recommendations, IES TM-11-00, New York, NY 2000

Exhibit 1040-1a Freeway Lighting Applications



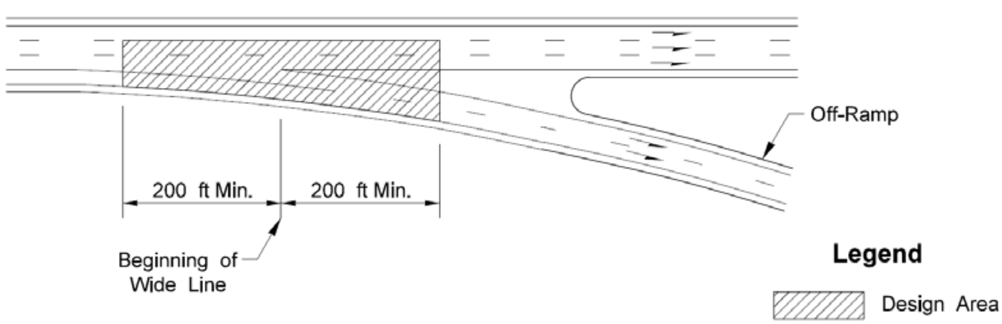
Required Illumination for a Typical Diamond Interchange

Shown for single-lane ramp connection and a two-lane crossroad without channelization.



Single-Lane Off-Connection

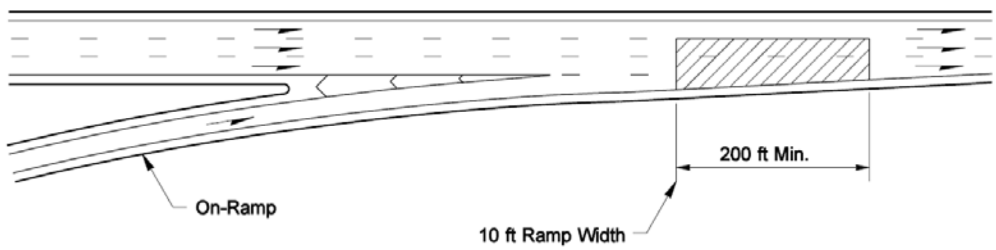
The design area may be shifted up to 100 ft from the beginning of the wide line; a minimum of two light standards of standard pole height required for design area.



Two-Lane Off-Connection: One Exit Only Lane; One Optional Lane

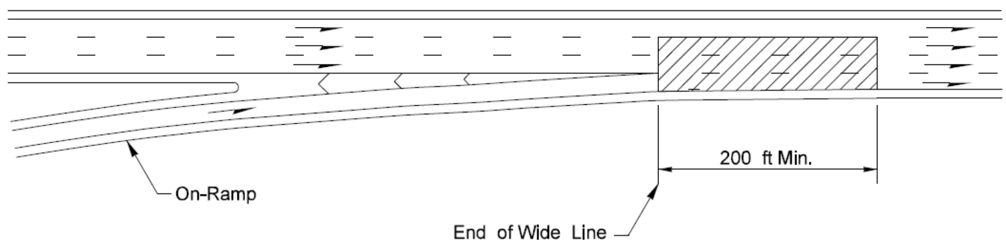
The design area may be shifted up to 100 ft from the beginning of the wide line; a minimum of three light standards of standard pole height required for design area.

Exhibit 1040-1b Freeway Lighting Applications



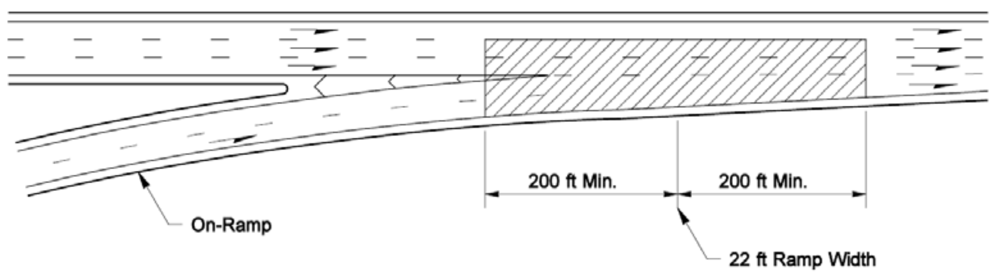
Single-Lane On-Connection

The design area may be shifted up to 100 ft from the 10-ft-wide ramp point; a minimum of two light standards of standard pole height required for design area.



Auxiliary Lane at On-Connection

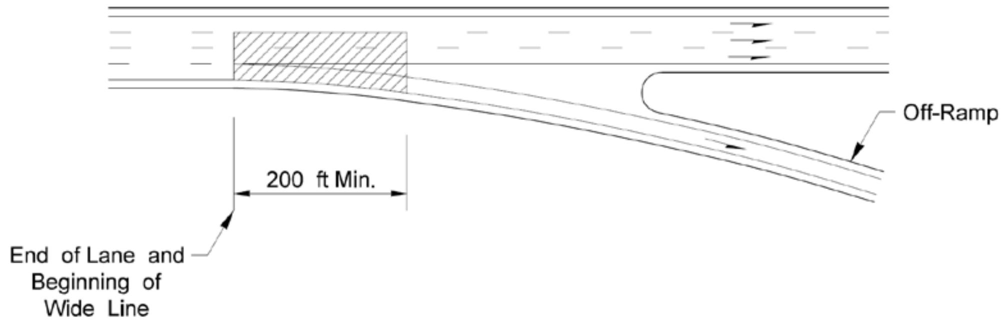
The design area may be shifted up to 100 ft from the end of wide line; a minimum of <u>two</u> light standards of standard pole height required for design area.



Two-Lane On-Connection: One Auxiliary Lane; One Merge Lane

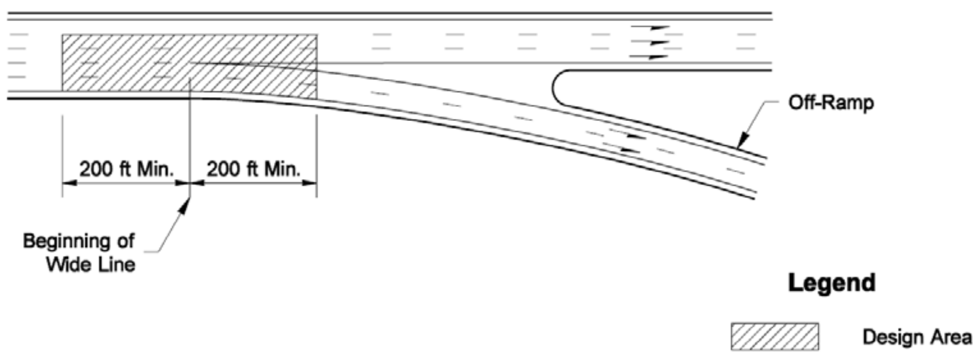
The design area may be shifted up to 100 ft from the 22-ft-wide ramp point; a minimum of three light standards of standard pole height required for design area.

Exhibit 1040-1c Freeway Lighting Applications



Single Exit-Only Lane

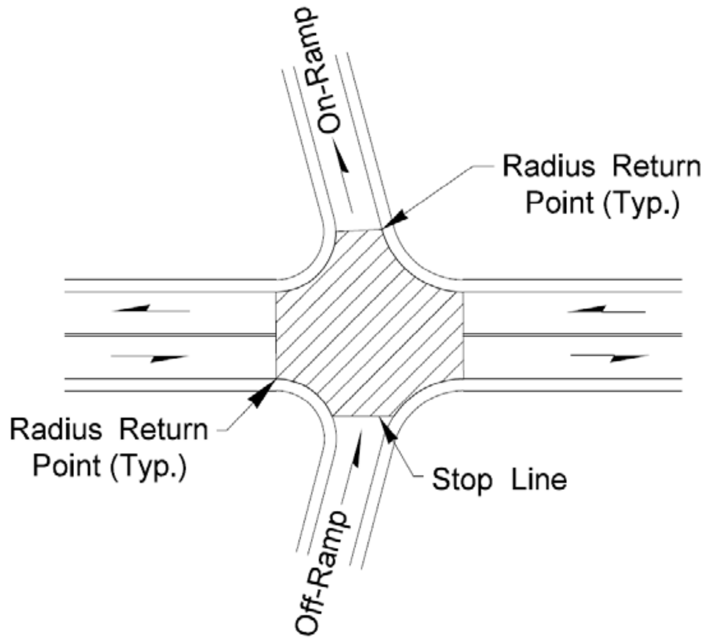
The design area may be shifted up to 100 ft from the end of lane and the beginning of wide line; a minimum of two light standards of standard pole height required for design area.



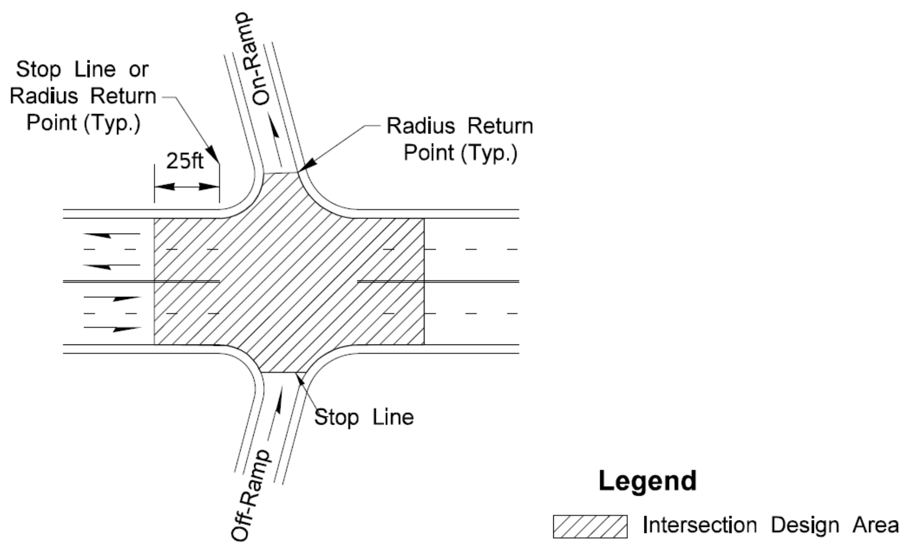
Two Exit-Only Lanes

The design area may be shifted up to 100 ft from the end of lane and the beginning of wide line; a minimum of three light standards of standard pole height required for design area.

Exhibit 1040-2 Freeway Ramp Terminals

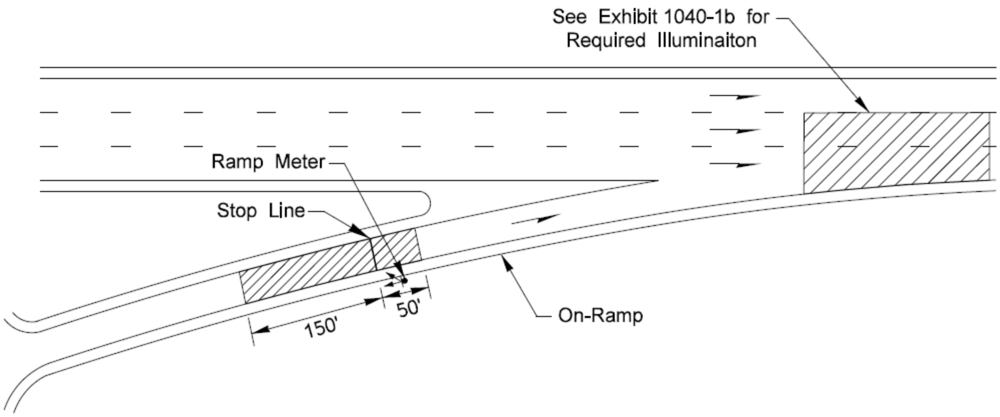


Off Ramp with Single-Lane Crossroad

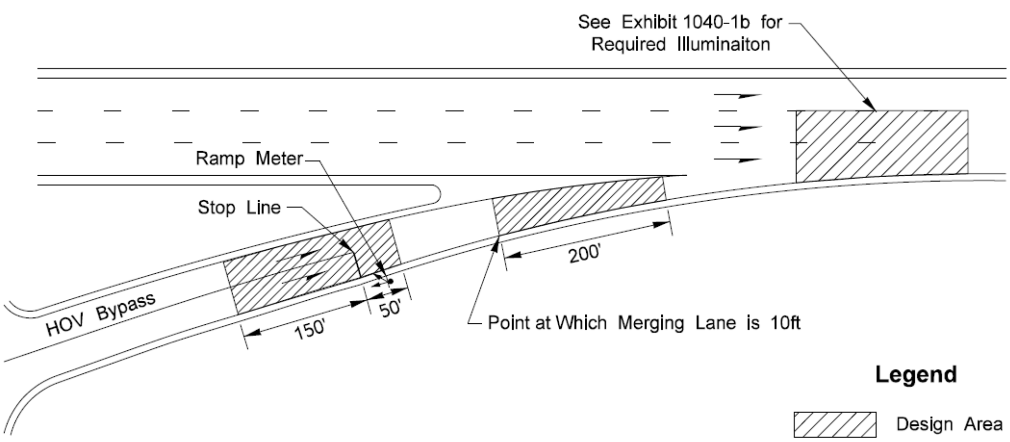


Off-Ramp with Multilane Crossroad

Exhibit 1040-3 Ramp with Meter

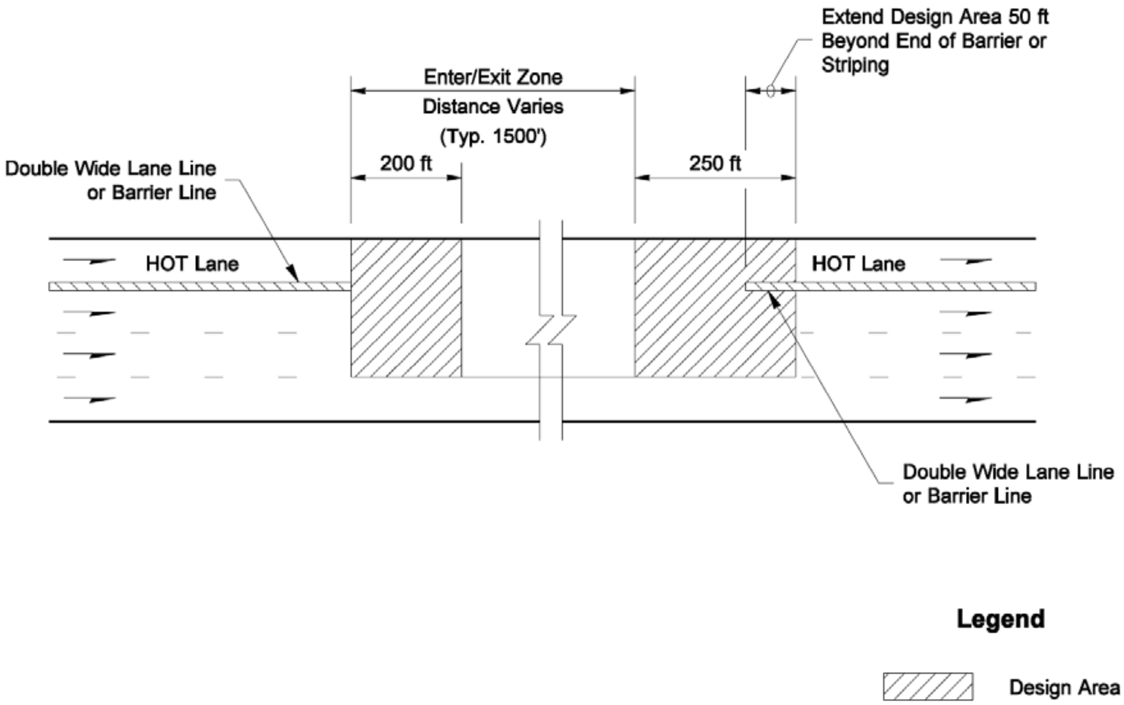


Single-Lane On-Ramp



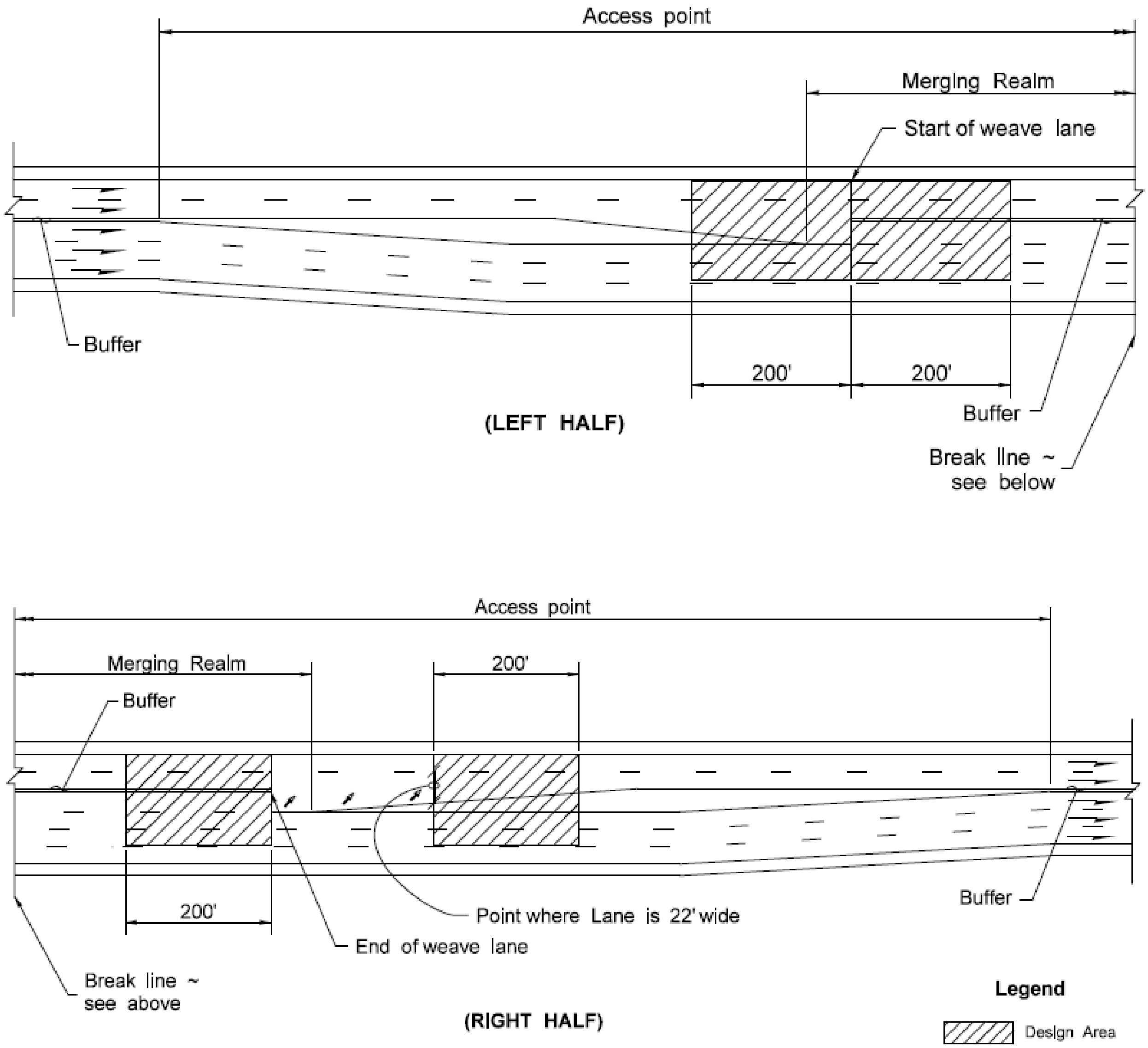
Multilane On-Ramp with HOV Bypass Lane

Exhibit 1040-4a HOT (High-Occupancy Toll) Lane Enter/Exit Zone



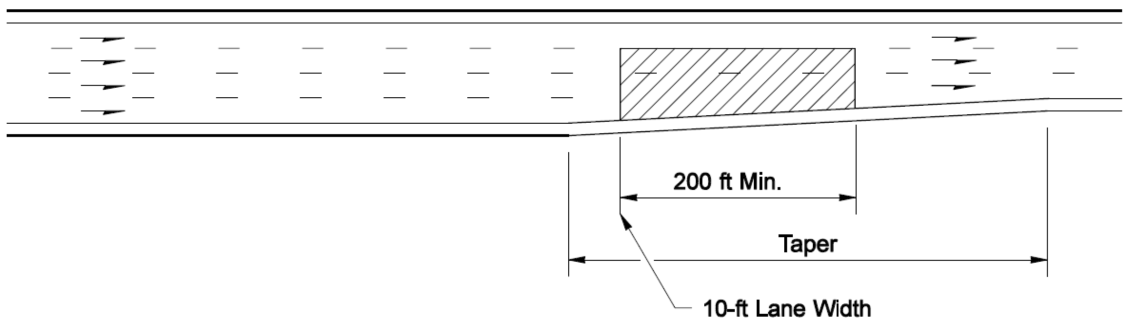
A minimum of two light standards of standard pole height required for each design area.

Exhibit 1040-4b HOT (High-Occupancy Toll) Lane ACCESS WEAVE LANE



TOLL LANE ACCESS WEAVE LANE

Exhibit 1040-5 Lane Reduction



A minimum of two light standards of standard pole height required for design area;

design area may be shifted 100 ft.

Exhibit 1040-6a Intersection with Left-Turn Channelization: Divided Highway

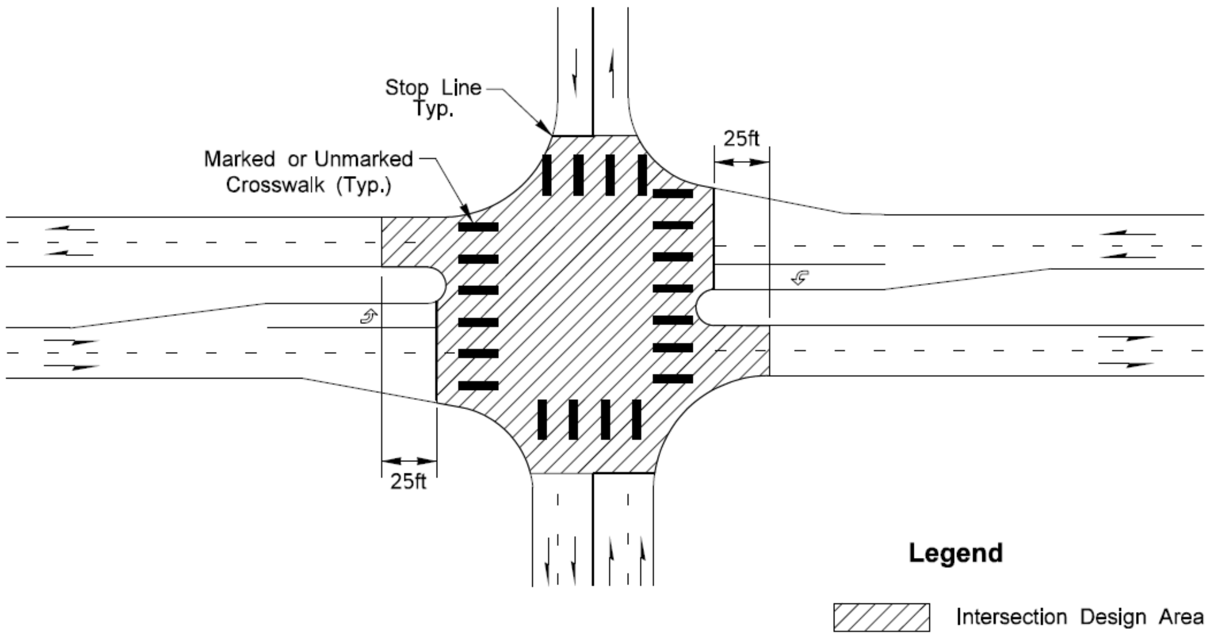
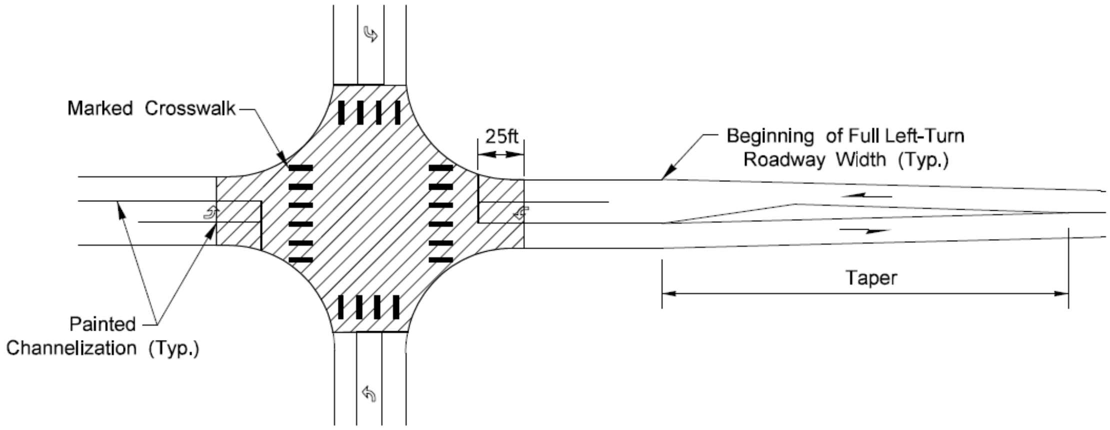
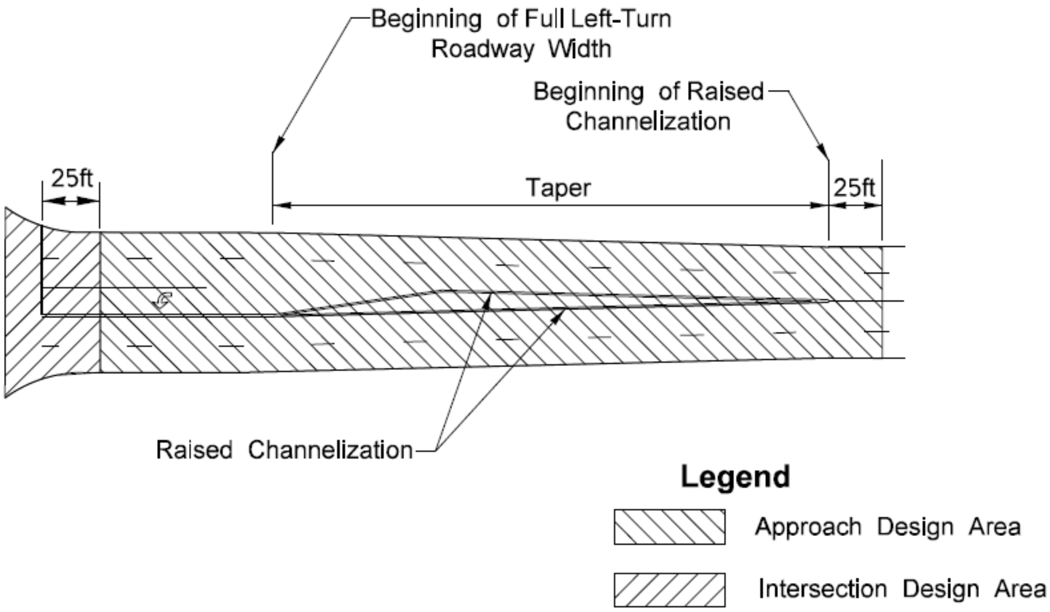


Exhibit 1040-6b Intersections with Left-Turn Channelization



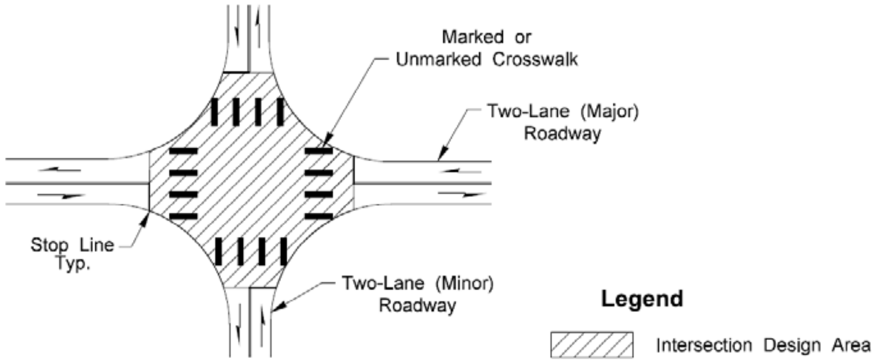
Intersection with Low-Profile Left-Turn Channelization Pavement Markings

Exhibit 1040-6c Intersections with Raised Left-Turn Channelization

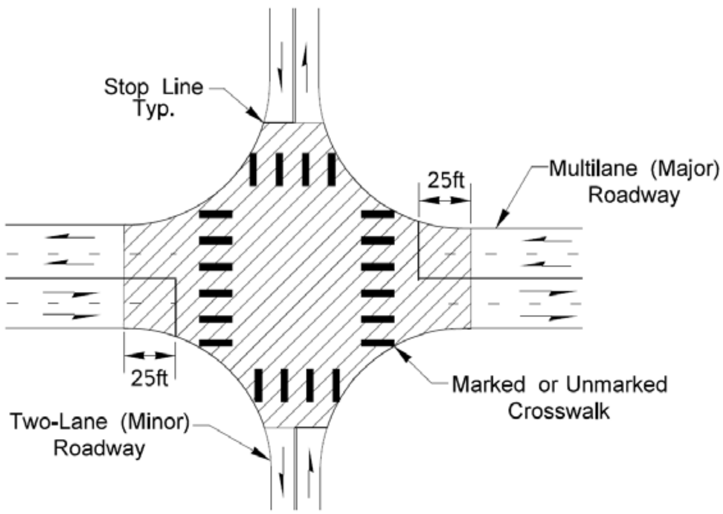


Intersection with Raised Left-Turn Channelization

Exhibit 1040-7 Intersections with Traffic Signals

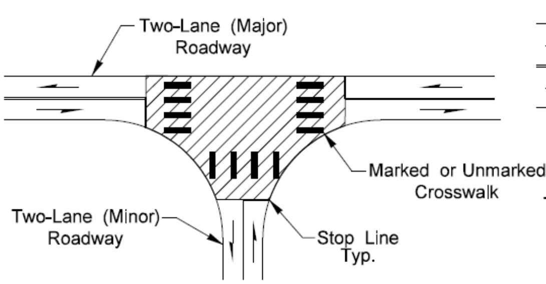


Four-Way Intersection with Single-Lane Approaches

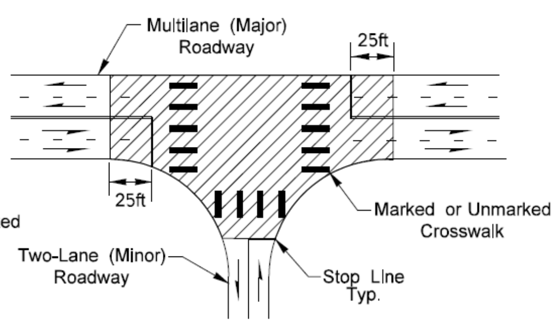


Four-Way Intersection with Multilane Major Approaches

A minimum of two light standards required for design area.



Minor Tee Intersection



Major Tee Intersection

A minimum of two light standards is required for design area.

Exhibit 1040-8 Intersection without Channelization

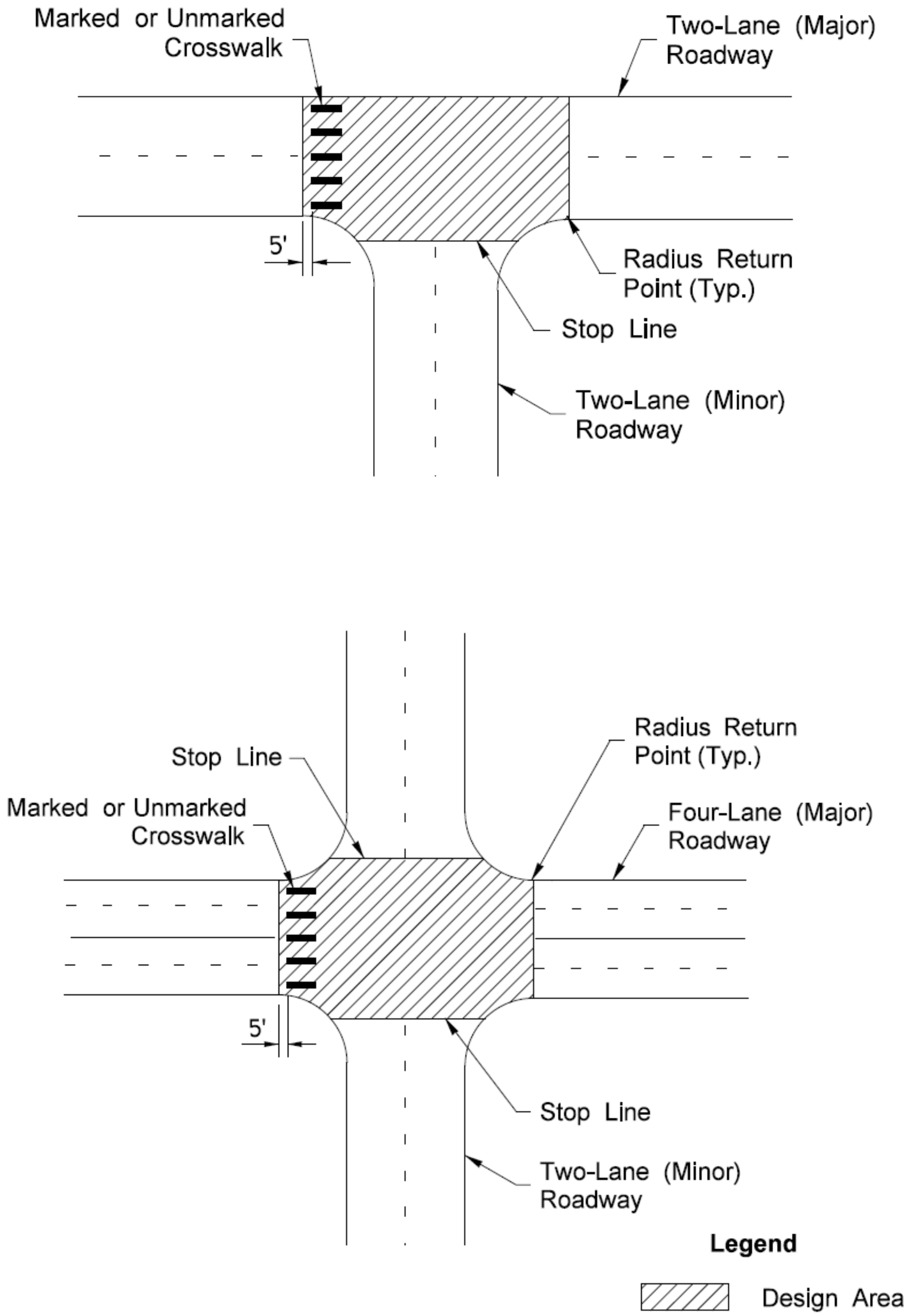
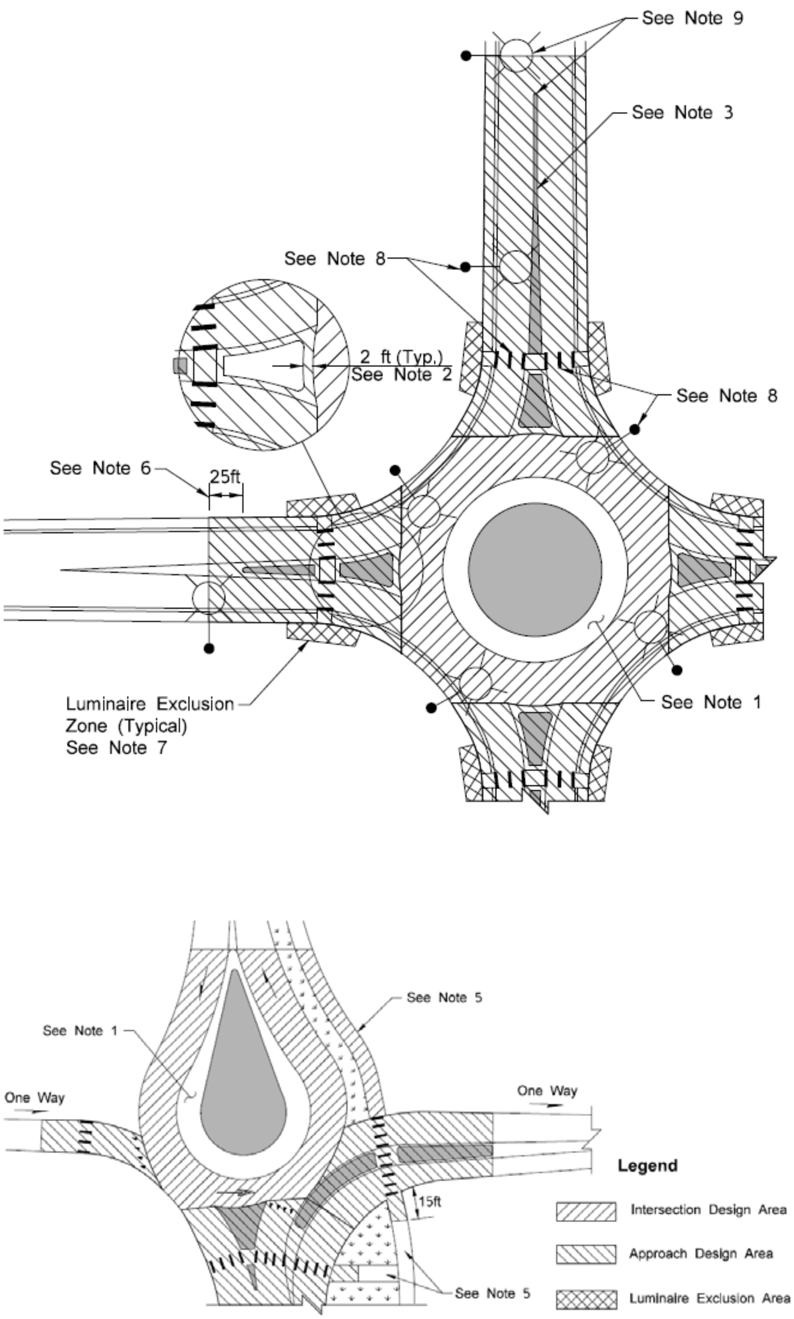


Exhibit 1040-9 Roundabout



Notes

1. Exclude Truck Apron from lighting calculations.
2. Exclude the portion inside the 2ft offset areas of the raised channelization islands from calculation.
3. All channelization 2ft wide or less is included in the Approach Design Area calculation.
4. When a leg of the roundabout is a one-way roadway, the Approach Design Area starts at the beginning of the raised channelization, or 50ft from the outside edge of the circulating roadway, or 50ft beyond a sidewalk, whichever is further.
5. A sidewalk is included in the Intersection Design Area calculation when a planting strip is less than 15ft wide.
6. Install luminaire to provide positive illumination of raised channelization. The preferred luminaire location would be from 20' to one mounting height's distance in front of the raised channelization.
7. Do not install luminaire in the area from 20' in front of the crosswalk to 20' past the crosswalk.
8. Install luminaire to provide positive illumination of the crosswalk for approaching vehicles. The preferred luminaire location would be one mounting height's distance in front of the crosswalk.
9. If approach intersection area requires more than one luminaire, the last luminaire on that approach chain can be replaced with a ground-mounted, internally illuminated bollard with sign in place of 2nd luminaire.

Exhibit 1040-10 Railroad Crossing with Gates or Signals

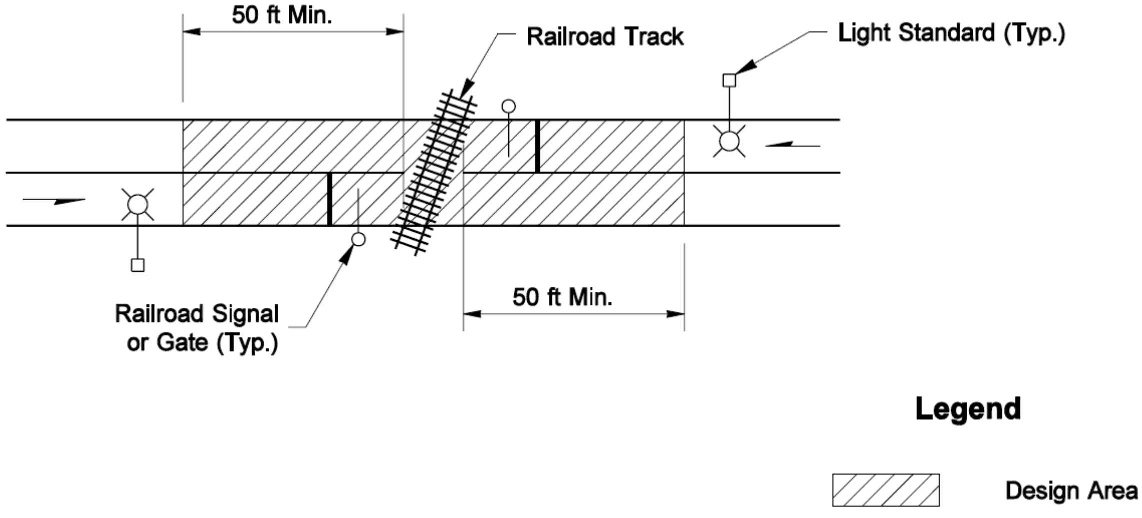
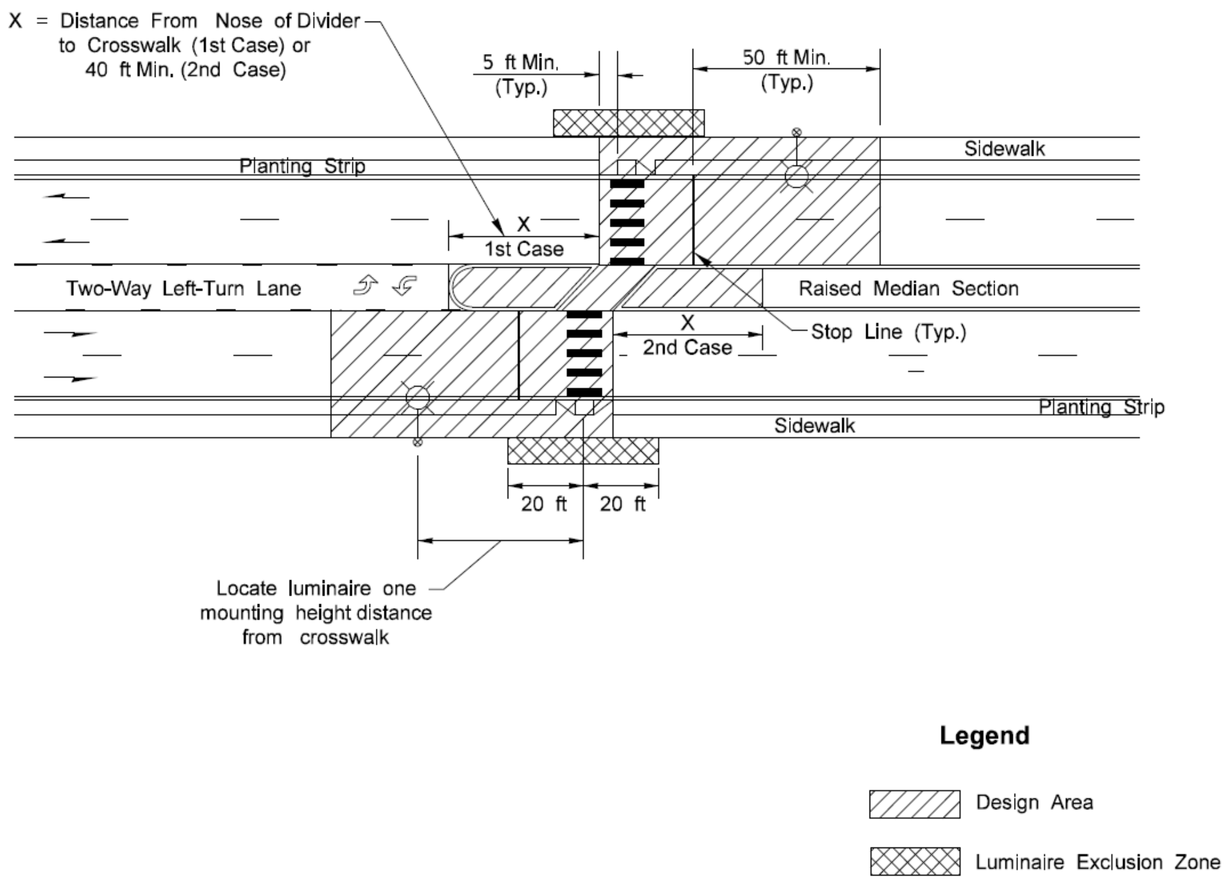


Exhibit 1040-11 Midblock Pedestrian Crossing



A minimum of two light standards of standard height is required for the design area.

Exhibit 1040-12 Transit Flyer Stop

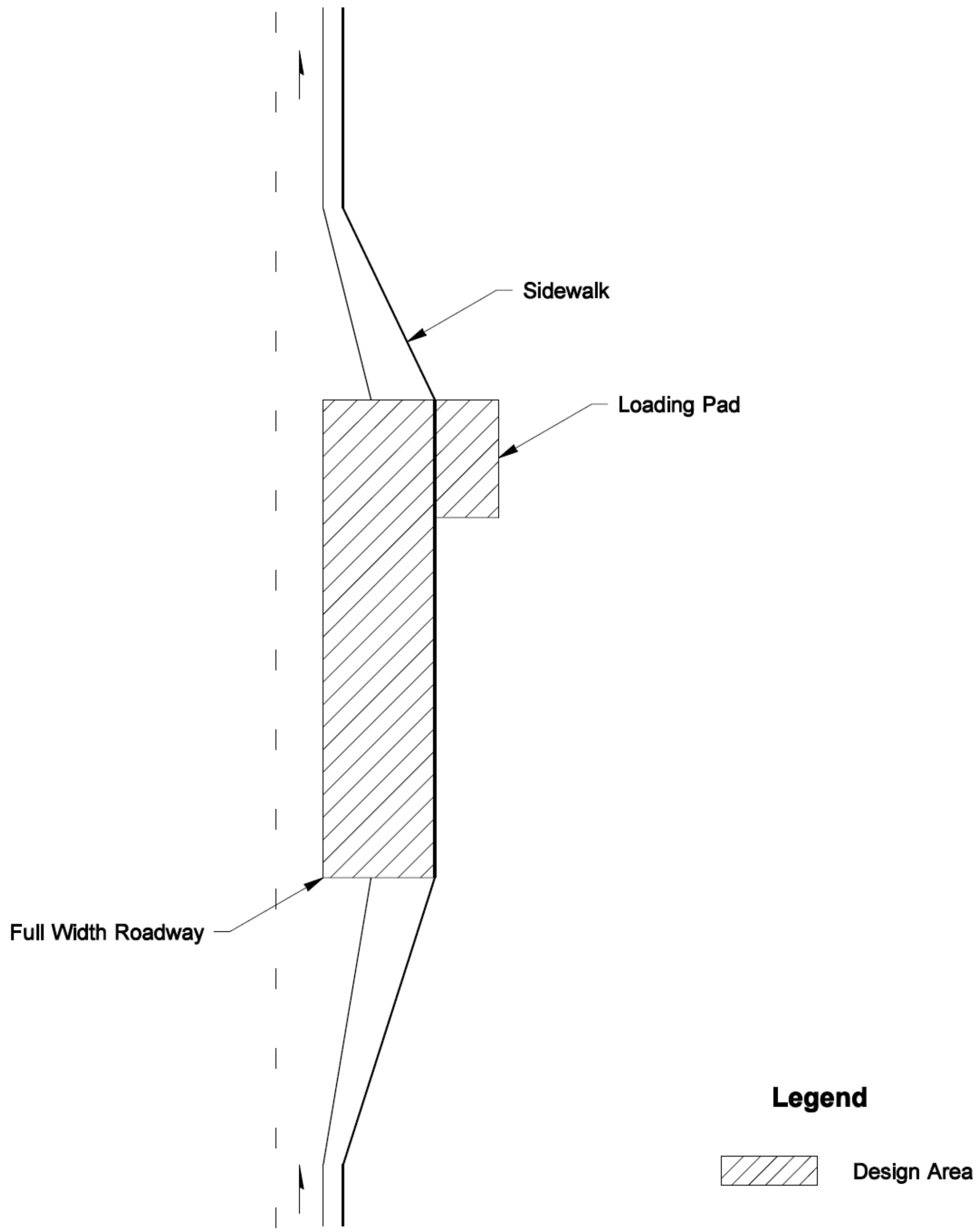


Exhibit 1040-13 Major Parking Lot

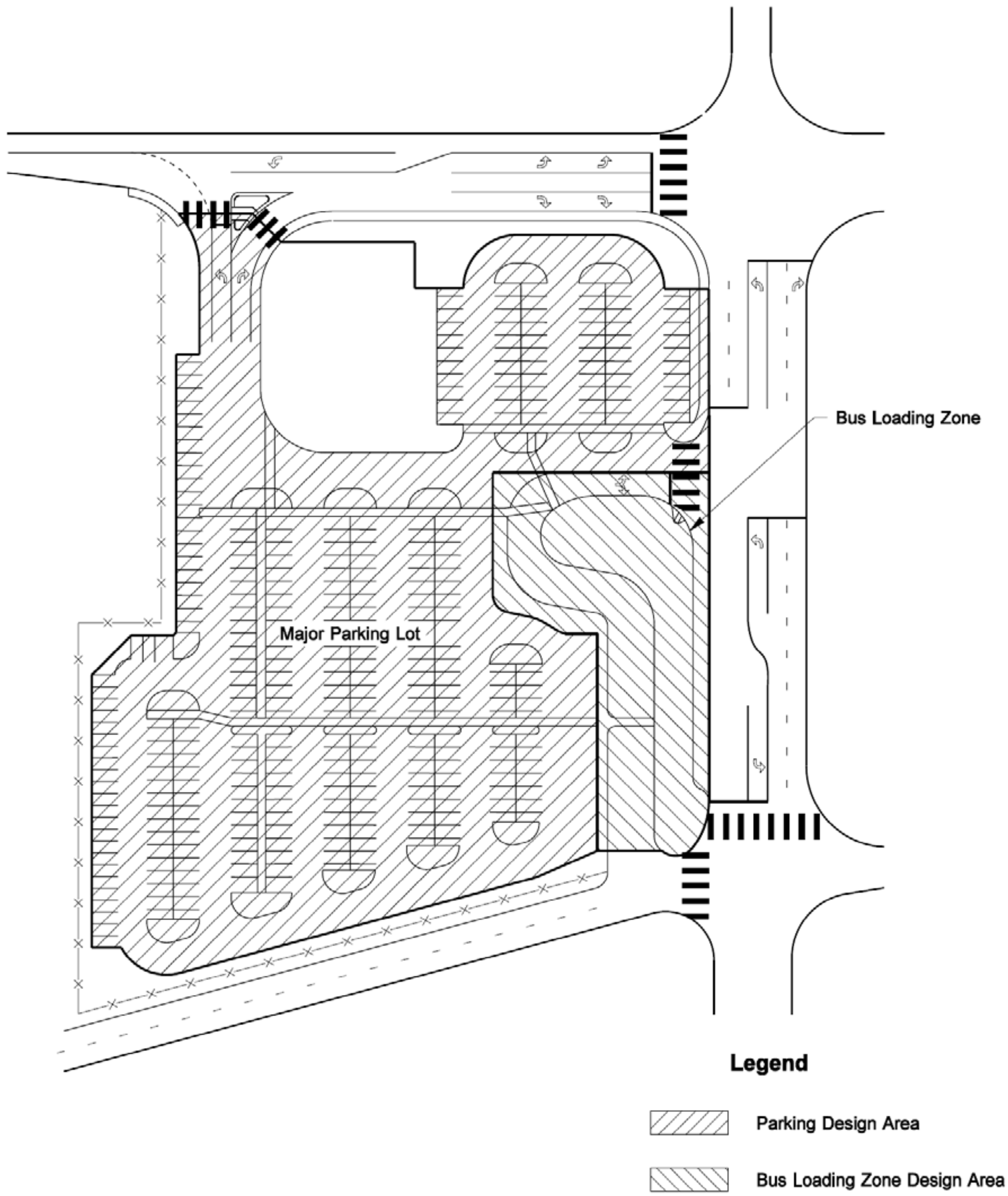


Exhibit 1040-14 Minor Parking Lot

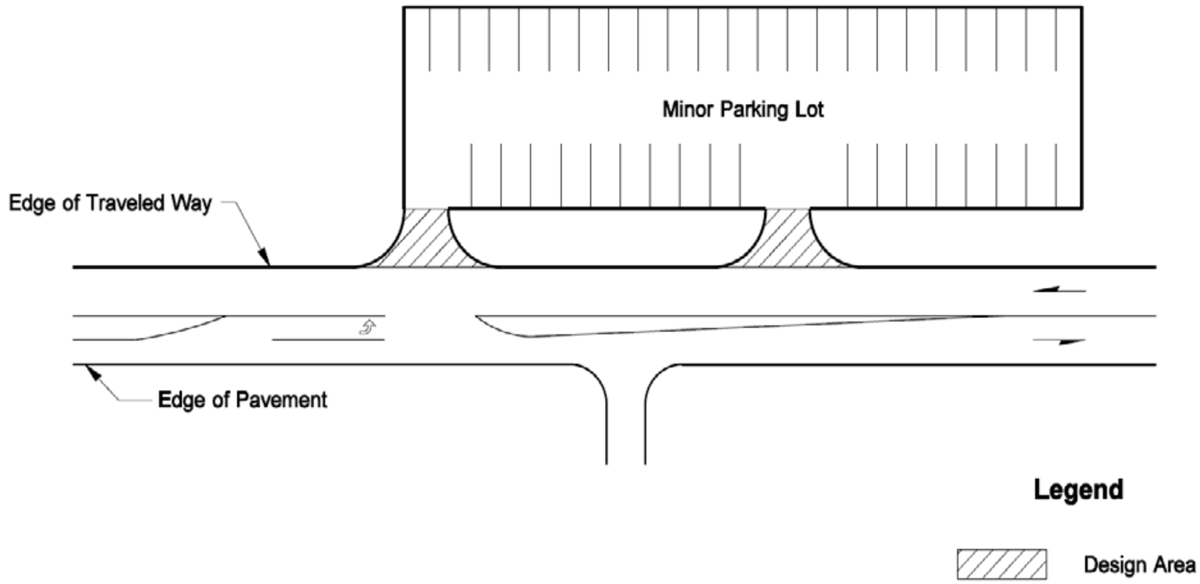


Exhibit 1040-15 Truck Weigh Site

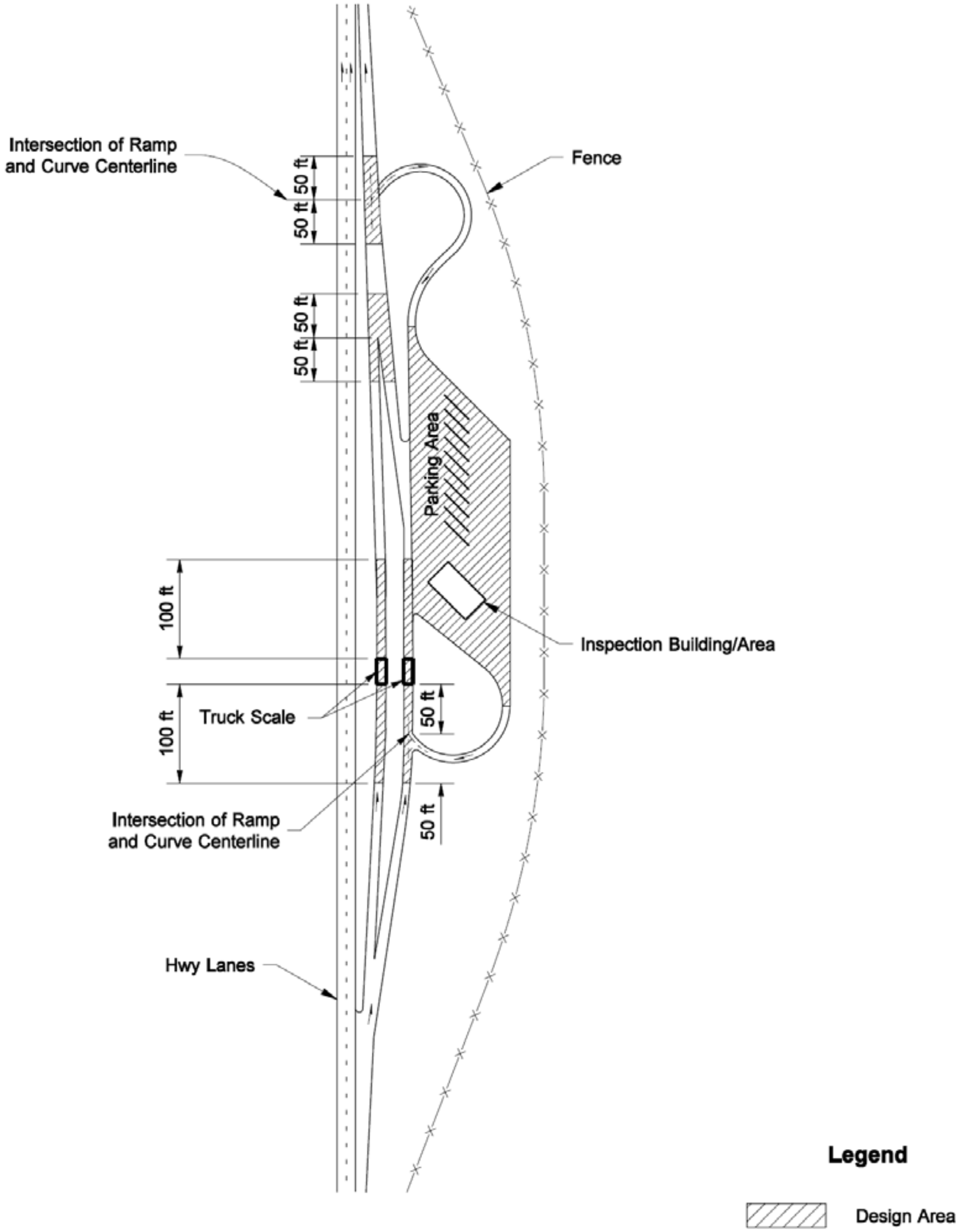


Exhibit 1040-16 Safety Rest Area

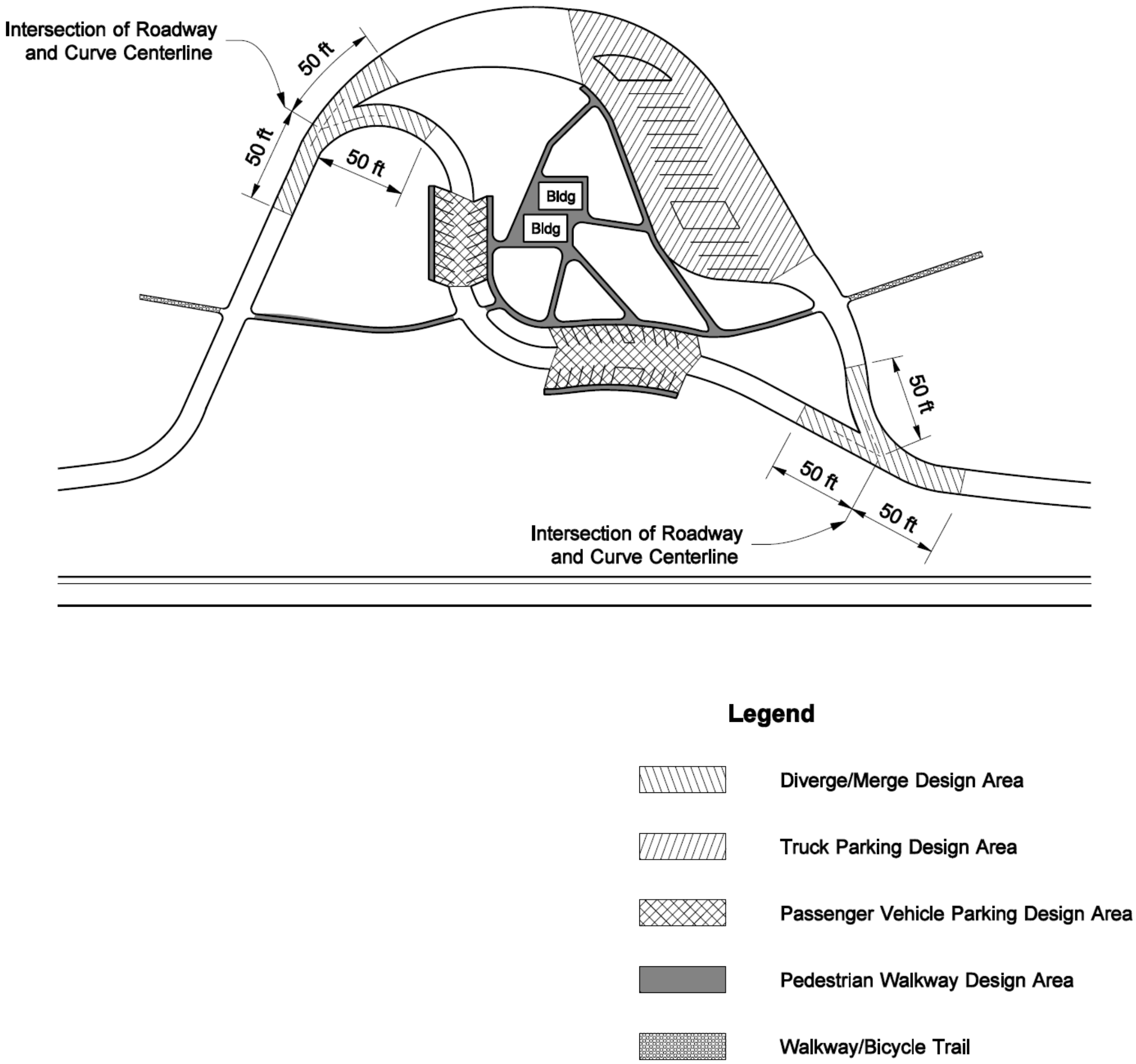


Exhibit 1040-17 Chain-Up/Chain-Off Parking Area

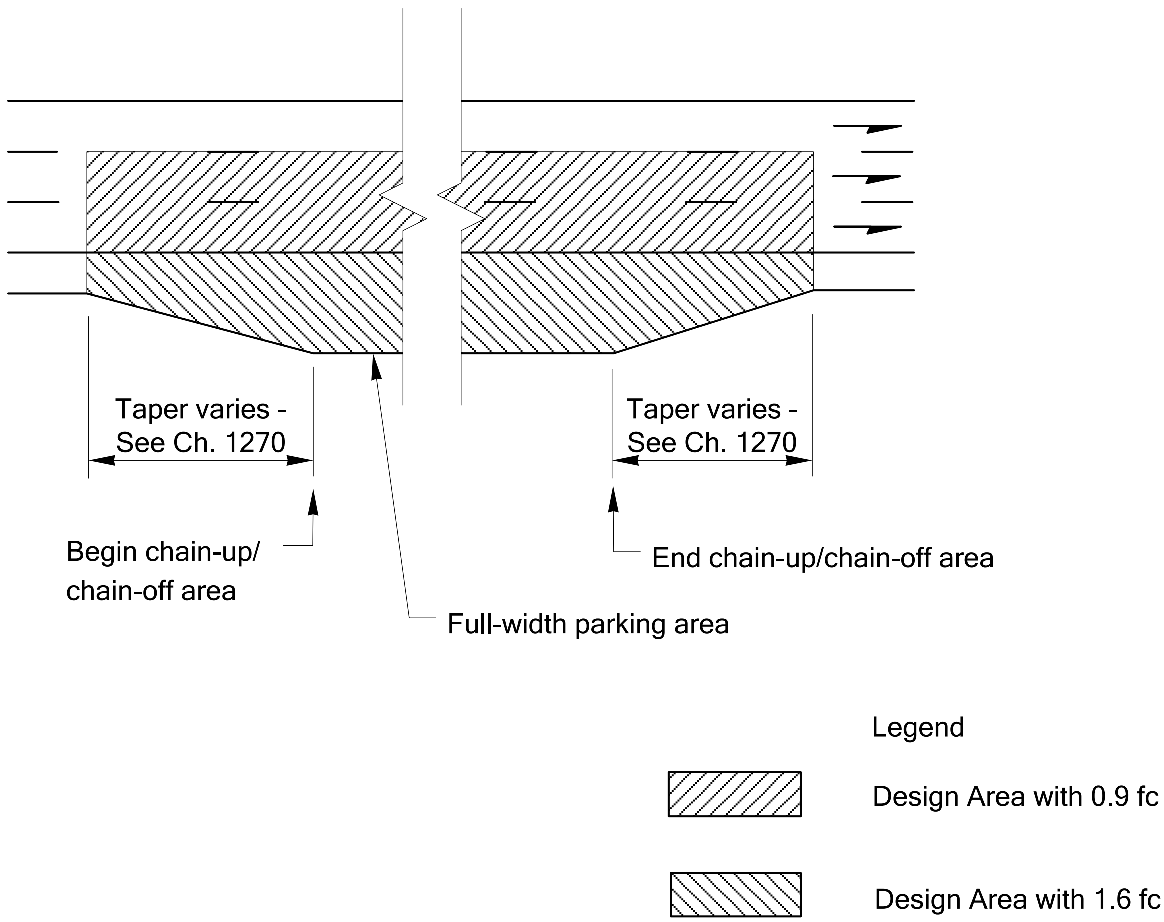
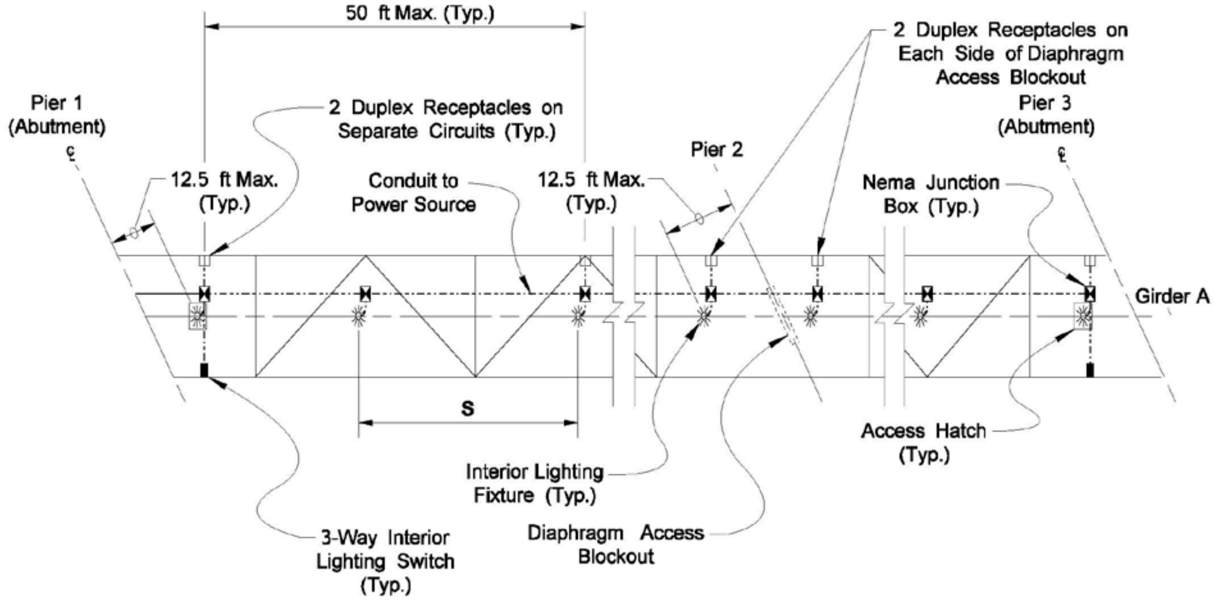


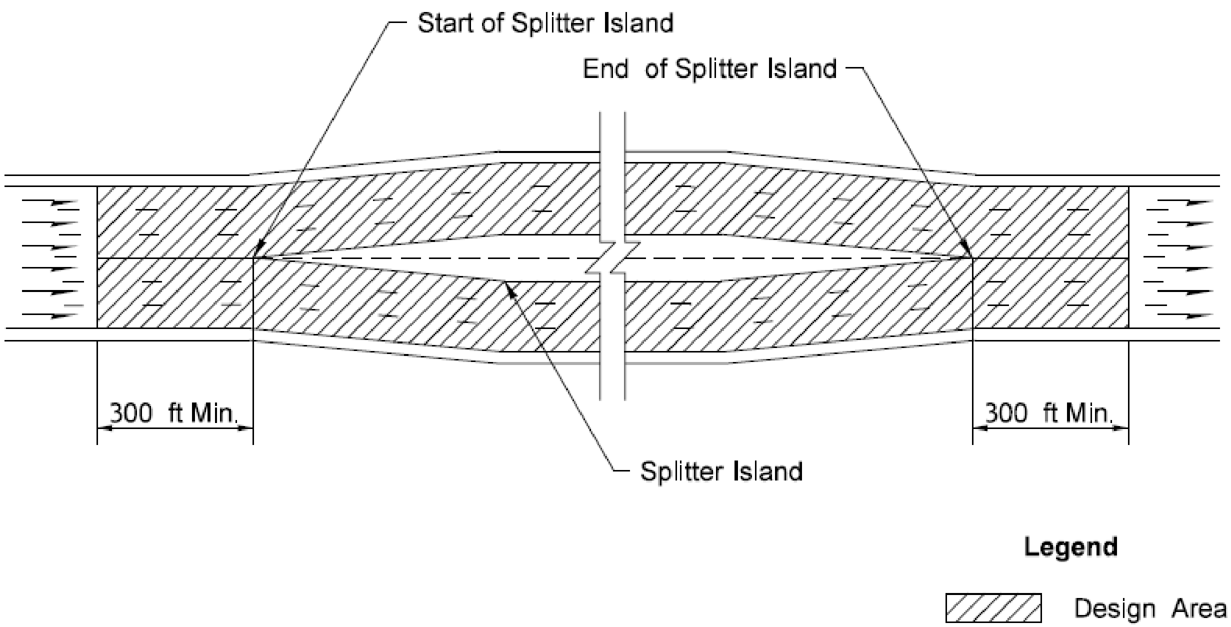
Exhibit 1040-18 Bridge Inspection Lighting System



Maximum Lighting Fixture Spacing (S):

Steel Box Girder Bridge S= 4 x (WEB DEPTH) ≤ 25 FT
Conrecte Box Girder Bridge S = 8 x (WEB DEPTH) ≤ 50 FT

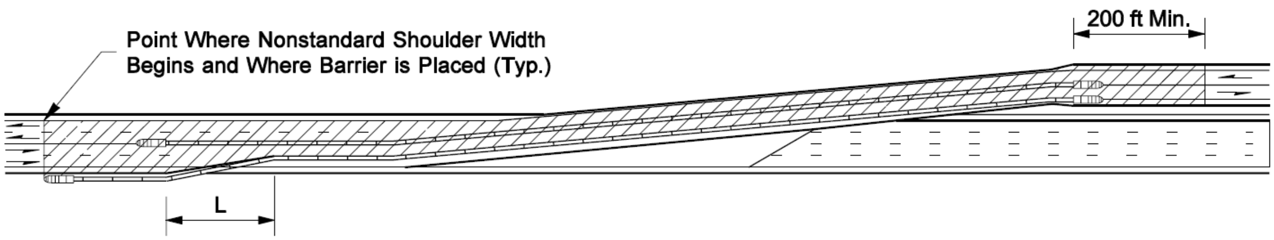
Exhibit 1040-19 Traffic Split Around an Obstruction



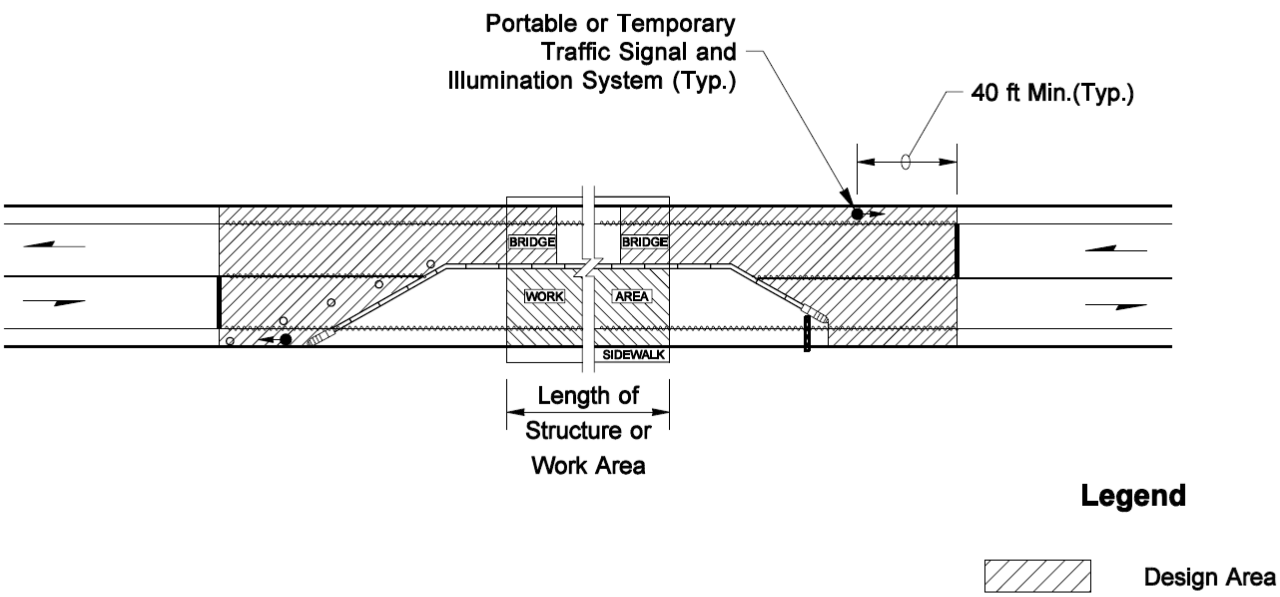
Note:

For temporary work zone plan applications, a site-specific traffic control plan is required. Refer to Chapters 1610 and 1620 for traffic barrier and attenuator information, Chapter 1010 for work zone information, and Chapter 1020 for signing information.

Exhibit 1040-20 Construction Work Zone and Detour



Detour Traffic



Lane Closure with Barrier and Signals without Flaggers or Spotters

One-direction closure shown/other direction closure typical.

Note:

For temporary work zone plan applications, a site-specific traffic control plan is required. Refer to Chapters 1610 and 1620 for traffic barrier and attenuator information, Chapter 1010 for work zone information, and Chapter 1020 for signing information. Refer to the MUTCD Typical Application 12 for additional details.

Exhibit 1040-21 Diverging Diamond Interchange

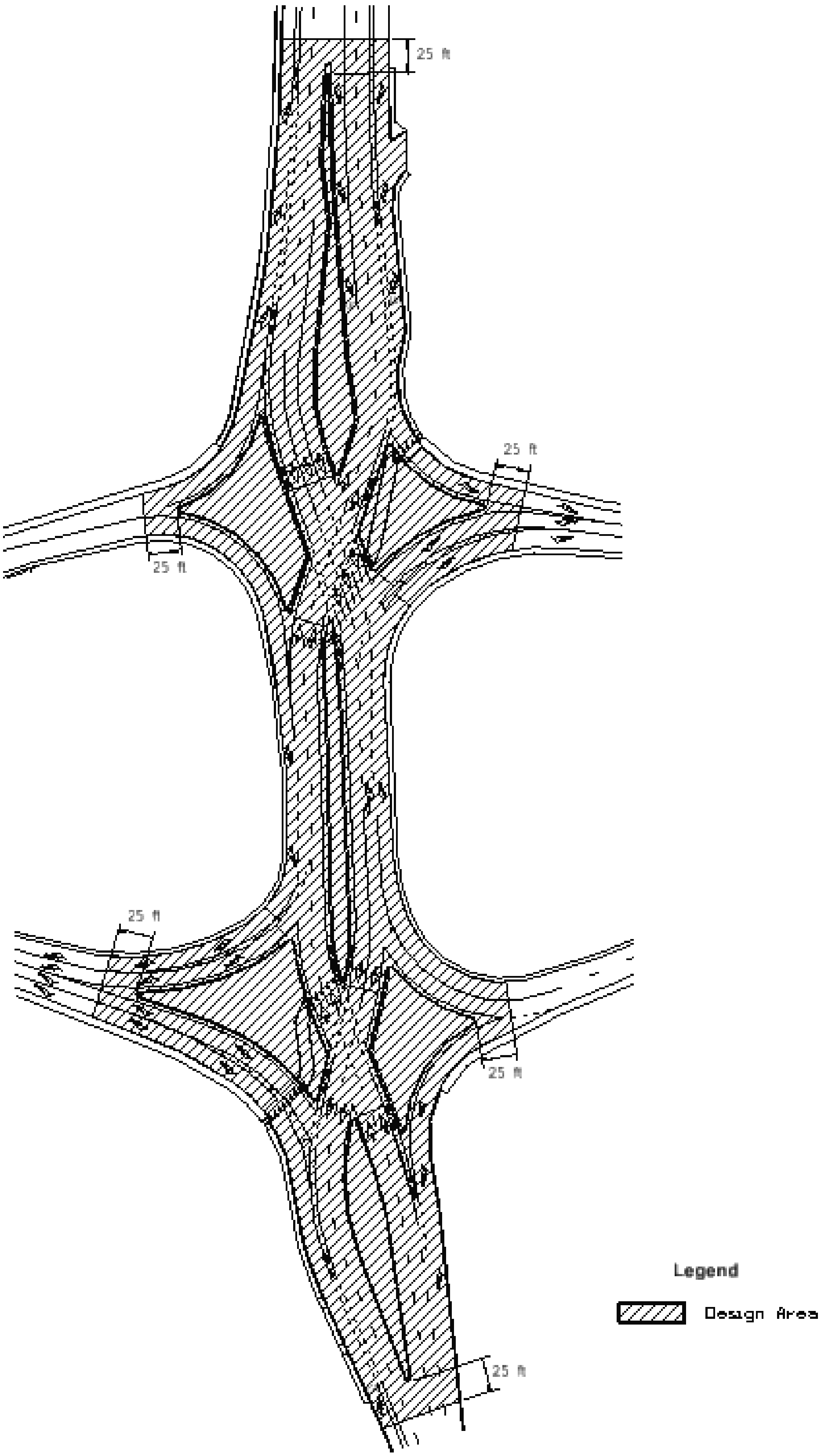


Exhibit 1040-22 Light Levels and Uniformity Ratios

Light Level and Uniformity Ratio Chart					
Highway Design Class	Minimum Average Maintained Horizontal Light Level [2] — Pedestrian/Area Classification			Maximum Uniformity Ratio [5]	Maximum Veiling Luminance Ratio [6]
	High (footcandles)	Medium (footcandles)	Low (footcandles)		
Highways With Full Access Control [1][8]					
Main Line	0.6	0.6	0.6	4:1	0.3:1
Ramps	0.6	0.6	0.6	4:1	0.3:1
Crossroads	0.6	0.6	0.6	4:1	0.3:1
Ramp Intersections	0.9	0.9	0.9	4:1	0.3:1
Highways Without Full Access Control [3][8]					
Main Line	1.2	0.9	0.6	4:1	0.3:1
Intersections	1.2	0.9	0.9	4:1	0.3:1
Other Illuminated Features					
Construction Lanes and Detours	1.0	1.0	1.0	4:1	0.3:1
Major Parking Lots/Rest Areas	0.8	0.8	0.8	4:1	0.3:1
Vehicle Inspection Areas	2.0	2.0	2.0	4:1	0.3:1
Sidewalks, Walkways & Shared Use Paths	0.8	0.8	0.8	4:1	0.3:1
Weigh Scales	0.8	0.8	0.8	4:1	0.3:1
Transit Stops [4]	2.0	2.0	2.0	NA [7]	0.3:1
Midblock Ped X-ing	2.0	2.0	2.0	4:1	0.3:1

Notes:

[1] The minimum light level is 0.2 footcandle (fc) for any application with a minimum average maintained horizontal light level of 0.6 fc. The minimum light levels for all other applications are controlled by the uniformity ratio.

[2] Light level and uniformity ratio apply only when installation of more than one light standard is justified.

[3] Light levels shown also apply to modified and partial limited access control.

[4] For single light standard installations, provide the light level at the location where the bus stops for riders (see Exhibit 1040-12).

[5] Minimum Average Maintained Light Level/Minimum Light Level = Maximum Uniformity Ratio.

[6] Maximum Veiling Luminance/Average Luminance = Maximum Veiling Luminance Ratio.

[7] The Maximum Uniformity Ratio is 4:1 when more than one light standard is justified.

[8] Roundabout illumination shall meet intersection lighting requirements for the associated roadway classification.

Chapter 1100 Practical Design

1100.01 General

The Washington State Department of Transportation (WSDOT) is committed to context-appropriate, multimodal, performance-based designs. WSDOT's goal is to optimize existing system capacity and safety through better interconnectivity of all transportation modes. Community engagement is an essential element.

This chapter provides an overview of the practical design approach that WSDOT uses to make project decisions. The remaining chapters in Division 11 provide specific design policy details for each procedural step. WSDOT's practical design approach is context-appropriate, multi-modal and performance-based. Practical design utilizes a collaborative approach, design flexibility, and a high likelihood of variable solutions. As a result, WSDOT's practical design finds consistency through the procedural process applied rather than pre-determined outcomes for projects.

This chapter provides:

- An overview of the WSDOT Practical Solutions initiative.
- An overview of the practical design process.
- Information regarding the importance of design control selection.

1100.01(1) Practical Solutions

Practical Solutions includes practical solutions planning and practical design, as described in Executive Order (EO) E 1090.

Practical Solutions enables more flexible and sustainable transportation investment decisions. It encourages this by: (1) increasing the focus on addressing identified performance needs throughout all phases of development, and (2) engaging local partners and stakeholders at the earliest stages of scope definition to account for their input at the right stage of the development process. Practical Solutions includes one or a combination of strategies, including, but not limited to, operational improvements, off-system solutions, transportation demand management, and incremental strategic capital solutions.

1100.01(1)(a) Practical Solutions Planning

Practical Solutions planning is an approach to making planning decisions that considers a variety of conceptual strategies to achieve the desired system performance targets for the lowest cost.

Central to practical solutions planning is a process that identifies regional and corridor performance areas, engages communities to ascertain local contexts and needs, and applies methods to evaluate and implement short- and long-term solutions.

The outcome of practical solutions planning is a recommended set of multimodal strategies that are cost-effective and balance the goals and objectives of state and local needs. WSDOT's corridor sketch initiative and planning studies inform practical solutions through the following:

- Identify performance gaps for a corridor segment, now and in the future.
- Identify potential strategies to address the gaps.
- Integrate inputs from partners that support corridor segment performance.
- Define context and corridor variables.

Identify and rank demand management and operational improvements first, then consider capital solutions. Note that Executive Order (EO) E 1090 instructs that the solution may or may not be on a state corridor.

1100.01(1)(b) Practical Design

Practical design focuses on the specific problem or problems identified during the planning and scoping process. This performance-based approach looks for lower-cost solutions that meet outcomes that WSDOT, collaborating agencies, communities, and stakeholders have identified. Practical design is a fundamental component to the Vision, Mission, Values, Goals, and Reforms identified in Results WSDOT, the department's Strategic Plan. The primary objectives of the practical design approach are: (1) focusing on project need(s), and (2) seeking the most reasonable low-cost solution to meet that need(s).

Practical design allows flexibility and encourages innovation. Practical design considers incremental solutions to address uncertainties in future scenarios. Practical design can be applied at all phases of project development; however, it is most effective at the scoping level or earlier, where key decisions are made as to what design controls and elements are affected by alternatives and how they can best be configured to meet the project objectives.

With practical design, decision-making focuses on the maximum benefit to the system, rather than the maximum benefit to the project.

1100.02 Practical Design Procedure

Practical design begins when a location under evaluation moves from a discussion of strategies to one of potential solutions within those strategies. The beginning of the practical design approach occurs when the scoping phase requires a Basis of Design (BOD), or when the preliminary engineering phase for a funded project initiates. In each of these situations, practical design procedures apply whether or not practical solutions planning has occurred.

WSDOT's practical design process consists of seven primary procedural steps:

1. Assemble a project advisory team as needed (see 1100.04).
2. Clearly identify the baseline need. Define it in terms of performance, contributing factors, and underlying reasons for the baseline need (see Chapter 1101).
3. Identify the land use and transportation context (which includes environmental use and constraints) for the location (see Chapter 1102).

4. Select design controls compatible with the context (see Chapter 1103).
5. Formulate and evaluate potential alternatives that resolve the baseline need for the selected context and design controls (see Chapter 1104).
6. Select design elements that will be included in the alternatives (see Chapter 1105).
7. Determine design element dimensions consistent with performance needs, context, and design controls (see Chapter 1106).

The Basis of Design (BOD) documents the outcomes of applying these procedural steps. It also serves as a management tool throughout the design phase, to keep a project team focused on the baseline performance need and agreed performance trade-offs in order to prevent scope creep. During the design phase, a BOD is required on all projects unless design elements are not changed (see exceptions in 1100.10). During the scoping phase, a BOD is only required as determined by the Capital Program Development and Management (CPDM) Office. See 1100.10(1) for further information about the BOD.

1100.03 Community Engagement

WSDOT has a strategic goal of engaging the community in order to strengthen partnerships, increase credibility, drive priorities, and inform decision-making. Community input informs the project development process from planning to design. Engaging with the community helps us more fully understand:

- Performance issues and gaps
- Context identity
- Local environmental issues
- Modal priorities and needs

WSDOT encourages recognition of individual community contexts, values, and needs in developing transportation solutions. We do so in order to enhance public trust and develop targeted designs that meet the performance needs of the state, regional, and local transportation systems. – Executive Order 1096

Use the *WSDOT Community Engagement Plan* and document the findings of community engagement efforts (see 1100.10(5)).

1100.04 Advisory Team

Teams deliver projects. Collaborative decisions contribute to successful project delivery. Collaboration emphasizes context sensitive design as part of WSDOT's approach. The practical design approach is a team approach that involves external and internal stakeholders providing consent-based outcomes early in project development. This is consistent with WSDOT Executive Order 1096 - *WSDOT 2015-17: Agency Emphasis and Expectations* and Executive Order 1028 – *Context Sensitive Solutions*. The advisory team is a collaborative body that provides recommendations to the WSDOT project manager and engineer of record, specifically in these areas:

- Need identification (including performance metrics and targets)
- Context identification
- Design control selection
- Alternative formulation

- Performance trade-off decision preferences (including weighing environmental constraints and regulatory issues)
- Alternative evaluation

The Engineer of Record, or project manager, convenes an advisory team that has the skills, knowledge, and responsibilities needed for design decision-making; including planning, project development, environment, active transportation, and context sensitive design. Include WSDOT members on the advisory team who have positional or delegated authority to make decisions associated with the areas outlined in this chapter.

The project manager and project team consider recommendations offered by the advisory team. The project manager decides which recommendations, if any, will be included in the project and informs the advisory team, providing an opportunity for feedback. Document recommendations and their treatment to the Basis of Design prior to its approval.

The project manager has discretion in how to work with internal and external stakeholders in documenting decisions. For more information on organizing, managing, and collaborating with advisory teams, see the WSDOT Project Management Guide:
www.wsdot.wa.gov/projects/projectmgmt/onlineguide/preconstructioninitiatealign

1100.05 Need and Performance Identification

The most fundamental function of practical design is to focus on the primary reason a location is under evaluation. Ask why there is a project under consideration at this location, and identify the specific need. If it is a mobility project, why is there a mobility need and what is specifically contributing to that need?

WSDOT's practical design approach requires that the need be translated into specific performance metrics and that targets be selected to be achieved by the design. A contributing factors analysis (see Chapter 1101) refines focus in order to resolve the specific performance problems and helps define the potential scope of project alternatives.

Chapter 1101 provides guidance for identifying project performance needs. Understanding performance and associated performance terms is critical to the application of Chapter 1101. See the guidance document *Performance Based Design* before proceeding with application of Chapter 1101. Direct link to guidance document:
www.wsdot.wa.gov/publications/fulltext/design/ASDE/Practical_Design.pdf

1100.06 Context Identification

Context identification refers to understanding the characteristics, activities, and functions within a geographical area. WSDOT is committed to providing context sensitive solutions (see E 1028), and context identification is key to implementing this goal. WSDOT's context identification process involves two interrelated context facets: land use and transportation. Context identification also considers existing and future contexts. Chapter 1102 provides guidance for determining context.

1100.07 Design Control Selection

Design controls create significant boundaries and have significant influence on design. WSDOT uses five primary design controls:

1. Design Year
2. Modal Priority
3. Access Control
4. Design Speed
5. Terrain Classification

Chapter 1103 presents guidance related to choosing design controls.

1100.08 Alternative Formulation and Evaluation

Under practical design, the goal is to develop a solution for the baseline need at the lowest cost. However, it is critical to understand how the solution affects other known or identified needs, termed "contextual needs." This requires consideration of multimodal solutions. Chapter 1101 provides a discussion on baseline and contextual performance needs, and Chapter 1104 discusses using these needs to develop and evaluate alternatives.

Practical Solutions requires consideration of operational and demand management strategies prior to implementing a capital strategy. The intent is to find low-cost solutions before making large capital investments.

In some cases, the planning phase will have identified a strategy based on practical solutions planning. Focusing on the preferred strategy can help guide the development of alternative solutions. The guidance document *Alternative Strategies and Solutions* discusses primary strategies and examples of solutions within those strategies.

Design Support guidance document: http://www.wsdot.wa.gov/Design/Support.htm
Direct link to guidance document:
www.wsdot.wa.gov/publications/fulltext/design/ASDE/Practical_Design.pdf

1100.09 Design Element Selection and Dimensions

Design element selection is based entirely on the alternative selected to resolve the baseline need and balance performance trade-offs. Chapter 1105 provides instruction for design element selection. Chapter 1106 provides information related to choosing dimensions for design elements.

1100.10 Documentation Tools

Basis of Design (BOD), Basis of Estimate (BOE), Design Parameter Sheets, and Alternative Comparison Tables are all documentation tools used to record decisions and analyses needed in development of a solution that is consistent with WSDOT's practical design approach. The tools can be found at: http://www.wsdot.wa.gov/Design/Support.htm

1100.10(1) Basis of Design

The BOD organizes information around the practical design procedural steps (see 1100.02) necessary to support WSDOT's practical design approach. It provides a template for documenting each step in the process. The BOD includes the following information and sections:

- Planning Document Summary
- General Project Information
- Section 1 – Project Needs
- Section 2 – Context
- Section 3 – Design Controls
- Section 4 – Alternatives Analysis
- Section 5 – Design Element Selection

Exhibit 1100-1 shows the major activities associated with WSDOT's practical design approach and corresponding Design Manual chapters and Basis of Design sections.

When using a BOD, start as early as possible. During planning or scoping, a BOD may be only partially completed. Information documented on the BOD provides an opportunity for greater consistency between strategies developed in planning and solutions developed in scoping and design. Information documented in the BOD comes through use of consent-based recommendations (see Section 1100.04).

Contact the region Program Management regarding the need to initiate a BOD during the project-scoping phase. Since the BOD is ultimately a document that supports design decisions, the approval of a BOD, which ideally takes place at 30% design level or earlier, is a part of, and included in, the project Design Approval process (see Chapter 300).

Basis of Design: www.wsdot.wa.gov/Design/Support.htm

1100.10(1)(a) Basis of Design Exemptions

See 1100.02 for guidance regarding when a BOD is required for scoping projects. For design-phase projects, a BOD supports design decisions and is required on all projects where one or more design elements are changed (see Chapter 1105). Exceptions are listed below.

1100.10(1)(a)(1) All Projects

If the only design elements changed by the project are listed in Exhibit 1105-1, a Basis of Design (BOD) may not be required. The Assistant State Design Engineer (ASDE) shall concur with the request to exempt the BOD requirement. Submit a request, by email, for an exemption from the BOD requirement. The request should explain the unique circumstances that make use of the BOD unnecessary. Each request is evaluated on a case-by-case basis. If a BOD has been prepared for the project and no design elements were changed, an ASDE approval of the BOD is not required.

1100.10(1)(a)(2) Preservation Projects

A Basis of Design form is not required for Preservation projects if the only design elements changed are listed in Chapter 1120, and the criteria/guidance provided in Chapter 1120 is followed.

1100.10(1)(a)(3) Safety Projects

Safety projects (developed under the I-2 funding program) may not require a BOD even though design elements are changed. The Assistant State Design Engineer (ASDE) shall provide concurrence to exempt the project from the BOD requirement. Submit exemption requests to the ASDE by email explaining why an exemption is applicable. The request should explain the unique circumstances that make use of the BOD unnecessary. Exemption requests are evaluated on a case-by-case basis.

Circumstances that may contribute to a decision to exempt a safety project from the need to prepare a BOD include:

- A programmatic project endorsed by the WSDOT Highway Safety Panel (e.g. Intersection Improvement Program ISIP treatments, Rumble Strips, etc.)
- A Collision Analysis Report (CAR) was approved by the WSDOT Highway Safety Panel AND:
    - The CAR clearly identifies the project need.
    - The CAR compared and rated alternatives.

1100.10(2) Basis of Estimate

A Basis of Estimate is required for all project estimates, and is updated throughout all phases of project development. Refer to the *Cost Estimating Manual for WSDOT Projects* for additional information on estimating and the Basis of Estimate.

1100.10(3) Alternatives Comparison Table

The Alternative Comparison Table (ACT) provides solutions evaluated in accordance with WSDOT's Practical Solutions approach. This table allows comparison of alternatives to identify the optimum solution. The table enables discussions of performance trade-offs. The Alternative Comparison Table is supplemental documentation for Section 4 of the BOD. Alternative Comparison Table: 🖰 www.wsdot.wa.gov/Design/Support.htm.

1100.10(4) Design Parameter Sheets

The Design Parameter Sheets document the dimensions selected for the various design elements selected and noted in Section 5 of the Basis of Design. Design Parameter Sheet template: 🖰 www.wsdot.wa.gov/Design/Support.htm

1100.10(5) Documenting Community Engagement

Community engagement is a fundamental component of WSDOT's Practical Solutions strategy, and key to practical design implementation. Community engagement will be consistent with the *WSDOT Community Engagement Plan* (see 🖰 www.wsdot.wa.gov/planning/)

Document community engagement for all projects. There is no strict format for this.

1100.11 References

1100.11(1) Federal/State Directives, Laws, and Codes

Revised Code of Washington (RCW) 47.04.280 – Transportation system policy goals

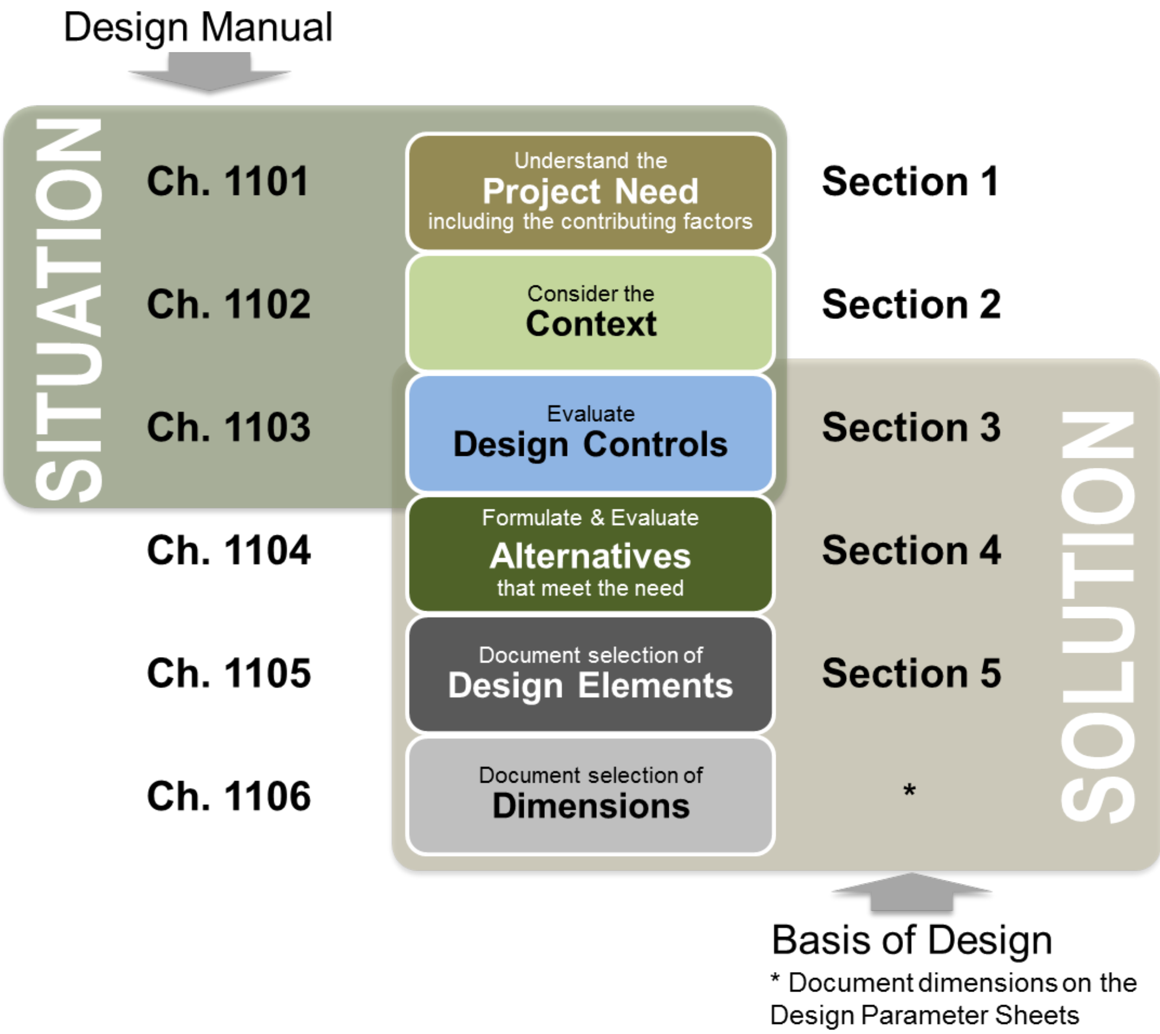
Revised Code of Washington (RCW) 47.05.010 – The statement of purpose for priority programming of transportation projects

Secretary's Executive Order 1090 – Moving Washington Forward: Practical Solutions

Secretary's Executive Order 1096 – WSDOT 2015-17: Agency Emphasis and Expectations

Secretary's Executive Order 1028 – Context Sensitive Solution

Exhibit 1100-1 Basis of Design Flowchart



Chapter 1101 Need Identification

1101.01 General

Practical design starts with identification of issues associated with the performance of a transportation facility. First, one or more project needs associated with these issues are identified. These project needs represent the gap in performance between the existing and desired state. Once they are identified, a project need statement is then developed which expresses only the most fundamental causes of these performance gaps.

This chapter provides:

- Instruction on the different types of needs—baseline and contextual.
- A method to diagnose and analyze the contributing factors of the identified need.
- Instruction on how to determine performance metrics and targets for each of the identified needs.
- How to develop project need statements.

1101.02 Baseline Needs

A baseline need is the primary reason a project has been proposed at a location. The baseline need usually evolves from a WSDOT planning and/or priority array process. There can be more than one baseline need such as when an agency partners with WSDOT on a project and the partner's need becomes another baseline need. It is important to consider the needs of all mode users.

> **Example:** A local agency desires to fund a revitalization project for a community bordering a state highway. The local agency's baseline need in this case is the local land use's economic vitality. If WSDOT also happens to have a prioritized and funded baseline need at the same location, and the two parties decide to partner in a combined project, that project will have at least two baseline needs. The two parties will work to develop solutions compatible for both baseline needs.

To determine, develop, and refine the project's baseline need(s), examine the conditions surrounding the original project identification, which was completed in the priority programming phase.

After developing and refining the baseline need(s), define the baseline performance metrics. (see 1101.02(1)) and determine the baseline need targets (see 1101.02(2)).

1101.02(1) Baseline Performance Metrics of the Baseline Need(s)

Baseline performance metrics are those “measurables” used to check that the project satisfies the need(s). Baseline performance metrics are also used in the development of the project need statement. Project alternatives must address the identified baseline performance metric(s).

Threshold performance metrics are used in the priority array programming process to screen the full state network under each performance category (for further information on threshold performance metrics and performance categories, see the guidance document Performance-Based Decisions: www.wsdot.wa.gov/Design/Support.htm). The baseline performance metric for preservation category projects is predetermined, and is the same as the threshold performance metrics determined by Subject Matter Experts (SMEs) and HQ Capital Program Development and Management (CPDM) Office.

The baseline performance metrics for a mobility or economic vitality category project may be different from the threshold performance metrics. However, the baseline metric chosen is to be consistent with the priority array performance category that identified the location to be evaluated.

> **Example:** A routinely congested corridor has been screened to identify locations with a potential mobility performance gap. Screening used a threshold performance metric of estimated operations at 70% of posted speed during the peak hour. After considering the context of the location, and the relevance of the threshold performance metric to the site specific conditions and operations, the advisory team recommends that travel time reliability is a more appropriate metric for the location.

WSDOT’s practical design approach is committed to multimodal safety as identified in Washington State’s Strategic Safety Plan (see www.targetzero.com/plan.htm). To meet this commitment, projects are required to include a baseline performance metric for evaluating the number of fatal and serious injury crashes in safety, mobility and economic vitality category projects. Other safety metrics to address the specific community or partnering agency needs may be included as contextual needs.

Safety projects are expected to continue project development as directed by the Multimodal Safety Executive Committee (MSEC), and described in the Safety Scoping Flowchart and Chapter 321.

Other projects are to coordinate up front with the HQ Safety Technical Group to determine the scale and scope of crash analyses appropriate for different types and sizes of projects. For additional information see Chapter 321.

1101.02(2) Baseline Performance Target

Performance targets are the outcome (or desired state) intended for a project. Use baseline performance metrics and targets to compare alternative designs based on how well the alternative meets the selected targets relative to their costs. Targets can be a single value or range of values.

There may be situations where the targets cannot practicably be met by any alternative or where there are unacceptable performance trade-offs in other performance categories. In these situations it may be appropriate to accept performance trade-offs, in one of the other categories during the alternatives evaluation (see Chapter 1104), in order to balance competing needs and outcomes. In other situations, it may be appropriate to refine the performance target under consideration.

1101.03 Contextual Needs

Practical design requires that designers refrain from overdesigning the project by focusing the solution on the baseline need or needs. In doing so, opportunities are provided by projects to address other needs that may be identified through community engagement and/or increased project knowledge and understanding. These other needs are classified as "contextual needs." A contextual need is any identified need that is not a baseline need. Potential sources of contextual needs include:

- Performance gaps identified through the priority array network screening, that did not prioritize under a statewide biennial prioritization and budget exercise, but still exist at the project location.
- Needs identified through community engagement or identified by a partnering agency.
- Needs based on identified environmental regulations and constraints.
- Needs identified through coordination with WSDOT maintenance (see Chapter 301 for additional information).
- Needs identified through increased knowledge of the project site and context.

Develop metrics for contextual needs to compare alternatives. Interpret and translate each issue into a statement that is measureable, to the extent feasible. Contextual need metrics can be either quantitative or qualitative.

1101.03(1) Use in Alternative Formulation and Evaluation

Contextual needs serve a different role than baseline needs. Baseline needs primarily shape the alternatives developed, while contextual needs are important to the performance trade-offs discussion (see Chapter 1104). Not all contextual needs identified need to be addressed by a project. Contextual needs present opportunities for optimizing the design, provide for partnerships and modes, and ultimately determine the most optimal project alternative (in conjunction with SEPA/NEPA processes as discussed in Chapter 1104).

Whether a design alternative achieves a particular contextual performance target is a consideration during the tradeoffs analysis. When no alternative adequately balances performance, lower-cost countermeasures can be employed to help mitigate performance issues and improve the viability of alternatives. Modifications to one or more design controls are another approach that can be used to achieve performance targets (see Chapter 1103), without significantly burdening the alternative with additional cost. If all alternatives fail to find an acceptable performance balance targets may be refined. Performance targets are documented and approved as part of the Basis of Design approval process.

1101.04 Contributing Factors Analysis

Contributing factors analysis (CFA) is a process by which subject matter experts on the advisory team evaluate the contributing factors associated with performance gaps in order to identify the root reasons for each gap. In the transportation field, contributing factors are any geometric, operational, context-based, or human factor that can reasonably be attributed to a performance need through data analysis and engineering judgment.

Practical design relies on CFA to find the root reason(s) a need exists, rather than focusing on a symptom that may only temporarily or partially resolve the need.

Note: It is recognized that completely solving a problem may not be possible by a single corrective action due to the number of contributing factors or because of constraints.

The CFA method will:

- Organize and identify multiple contributing factors and underlying root reasons.
- Formulate a number of potential countermeasures to solve the need as thoroughly and efficiently as possible.

Diagnosis of contributing factors yields the best results when data is available for the analysis. Comprehensive crash data, organized by travel mode, is important when considering safety performance. In other performance categories, where quantitative data is not available, qualitative analysis may be used to reveal the underlying contributing factor(s).

Contributing factor analysis is only required for evaluation of baseline performance needs. However, it may be relevant to perform CFA for contextual performance metrics.

Diagnosing contributing factors using CFA is not necessarily a simple linear process. It’s possible to find that a contributing factor identified by one discipline is the root cause of another discipline’s contributing factor. In some cases, mapping the contributing factors in a network or fishbone diagram can help identify these relationships more clearly (see the guidance document Contributing Factors Analysis: www.wsdot.wa.gov/Design/Support.htm).

1101.05 Project Need Statement

A project need statement (or statement of need) uses the baseline needs (see 1101.02) and results of contributing factors analysis to succinctly describe the real root project need(s). The objective is to provide a clear, accurate plain talk description of the root needs that will facilitate the development of efficient, focused project alternatives. A need statement should:

- Identify the objective, in simple, direct terms.
- Identify the performance metric(s) involved.
- Include one or more quantifiable statements.
- Exclude any description or discussion of potential solutions.

Consider other processes applicable to their projects that may require need statements such as: value engineering, NEPA/SEPA, and Interchange Justification reports. Consider timing of these processes as well as integration and alignment of the need statements with the processes required for the project.

For more information and examples of need statements, see the guidance document Writing Effective Needs Statement: www.wsdot.wa.gov/Design/Support.htm

1101.06 Documentation

Use the Basis of Design, Section 1, to document decision-making and conclusions associated with project need identification.

Download The BOD here: 🖰 www.wsdot.wa.gov/Design/Support.htm

1101.07 References

Contributing Factors Analysis, WSDOT Guidance Document:
🖰 www.wsdot.wa.gov/Design/Support.htm

Performance-Based Design, WSDOT Guidance Document:
🖰 www.wsdot.wa.gov/Design/Support.htm

Writing Effective Needs Statement, WSDOT Guidance Document:
🖰 www.wsdot.wa.gov/Design/Support.htm

Washington State's Strategic Safety Plan: 🖰 www.targetzero.com/plan.htm

WSDOT Safety Scoping Flowchart:
🖰 http://wwwi.wsdot.wa.gov/ppsc/pgmmgt/wwwi/PlanProg/Scoping/SafetyScopingProcessFlowChart.pdf

Chapter 1102 Context Determination

1102.01 General Overview

Context refers to the environmental, economic, and social features that influence livability and travel characteristics. Context characteristics provide insight into the activities, functions, and performance that can be influenced by the roadway design. Context also informs roadway design, including the selection of design controls, such as target speed and modal priority, and other design decisions.

For the purposes of transportation planning and design, WSDOT divides context into two categories: land use and transportation. Each of these contexts is further defined and categorized in this chapter. Note that context categories, and the information pertinent to deriving them, may have been documented in a planning study.

The concepts and method described in this chapter are adapted from National Cooperative Highway Research Program project 15-52 final draft report: *Developing a Context-Sensitive Classification System for More Flexibility in Geometric Design*.

1102.02 Land Use Context

This section describes the procedure for determining the land use context category on non-freeway facilities. The guidance in this section does not apply for freeways (see Chapter 1232 for the definition of a freeway). For freeways, use Section 2 of the Basis of Design to document the urban/rural designation as listed for the route on the State Route Log.

On larger projects, more than one land use category may apply within project limits.

Step 1. Determine an initial land use context category (current state)

Land use context categories are described in detail in 1102.02(1). These categories represent distinctive land use environments beyond simply “rural” and “urban” to help determine a more accurate context. These categories influence roadway design, including determining appropriate operating speeds, mobility and access demands, and modal users. The land use categories are:

- Rural
- Suburban
- Urban
- Urban Core

Use the following factors to determine your initial land use context category:

1. Land uses (primarily residential, commercial, industrial, and/or agricultural)
2. Density
3. Setbacks

Quantify these factors through an assessment of the area adjacent to the existing or planned roadway (see Exhibit 1102-1).

Step 2. Determine an initial land use context category (future state)

Using the same factors and categories, consult with local agency staff, and review state, regional, and local planning documents to consider and document potential or anticipated changes to land use context. Sources of information include the local comprehensive plan, WSDOT Highway System Plan, WSDOT corridor sketches, and WSDOT planning studies in the corridor.

Exhibit 1102-1 Factors for Determining Initial Land Use Context

Factor	Criteria
Land Use	Land uses within ½ mi of roadway
Density	Housing units / acre
Density	Jobs / acre
Density	Intersections per sq. mi.
Density	Typical building height
Setback	Typical building setback
Setback	Parking (on street or off street)

Specific metrics guiding the use of these criteria in determining the initial land use context category (both current and future) are provided on the WSDOT Design Office website.

Step 3. Select final land use context category (current and future state)

Once an initial land use category is determined, additional (primarily qualitative) considerations are used to verify that the selected category is appropriate. Because data used in the initial determination may be incomplete, conflicting, or difficult to interpret, it's expected that professional judgment is used to confirm the context result. Even when the overall assessment is clear, discontinuities or transitions between categories may exist and require further interpretation.

Confirm or make adjustments to the initial context category based on a qualitative analysis. Use information gathered from consultations with local agency staff, as well as the project's community engagement processes, to validate a final determination about current and future context. Information about topography, soil type, land value, population density, average building square footage, visual assessments, aerial photos, zoning, and other local agency land use data and/or maps may also be used in this step.

Document the process used to make this final context determination. Include the data used, interdisciplinary input, and issues encountered and resolved in the process. Conclude with a final land use context determination that confirms, or adjusts, the initial category(s) for the project, and seek the endorsement of this final determination from the project advisory team (see Chapter 1100).

1102.02(1) Land Use Categories

The land use categories used to inform project design are described below.

1102.02(1)(a) Rural

The rural category ranges from no development (natural environment) to some light development (structures), with sparse residential and other structures mostly associated with farms. The land is primarily used for outdoor recreation, agriculture, farms, and/or resource extraction. Occasionally non-incorporated communities will include a few residential and commercial structures. Rural characteristics also include:

- No or very few pedestrians – except those locations used for outdoor recreation and modal connections, and where socioeconomic factors suggest that walking is likely to serve as an essential form of transportation
- Bicycle use mostly recreational– except for tourist destinations, modal connection locations and between communities where bicycle commuters may be expected or where socioeconomic factors suggest that bicycling is likely to serve as an essential form of transportation.
- Low development density
- Isolated residential or commercial activities
- Commercial uses include general stores, restaurants, and gas stations, normally at crossroads
- Setbacks for structures are usually large, except in the immediate vicinity of small settlements
- Transit service availability is often absent or highly limited, but varies widely depending on the jurisdiction. On-demand service is typically found to provide specialized transportation services

1102.02(1)(b) Suburban

Locations classified as suburban include a diverse range of commercial and residential uses that have a low or often, medium density. Suburban areas are usually (but not always) connected and closely integrated with an urban area. The buildings tend to be multi-story with off-street parking. Sidewalks are usually present and bicycle lanes may exist. These areas include mixed use town centers, commercial corridors, and residential areas. Big box commercial and light industrial uses are also common. The range of uses encompasses health services, light industrial (and sometimes heavy industrial), quick-stop shops, gas stations, restaurants, and schools and libraries. Suburban characteristics also include:

- Heavy reliance on passenger vehicles
- Transit may be present
- Residential areas may consist of single and/or multi-family structures
- Building and structure setbacks from the roadway vary from short to long
- May have well planned and arranged multi-uses that encourage walking and biking

- Planned multi-use clusters may integrate residential and commercial areas along with schools and parks
- Some highways that fit this category may be designated by WSDOT as "Main Street Highways" (see Appendix B: Identification of State Highways as Main Streets, http://www.wsdot.wa.gov/research/reports/fullreports/733.1.pdf.)

1102.02(1)(c) Urban

Urban locations are high density, consisting principally of multi-story and low to medium rise structures for residential and commercial use. Areas usually exist for light and sometimes heavy industrial use. Many structures accommodate mixed uses: commercial, residential, and parking. Urban areas usually include prominent destinations with specialized structures for entertainment, athletic and social events as well as conference centers and may serve as a Main Street (see 1102.03(6)). Urban characteristics also include:

- Various government and public use structures exist that are accessed regularly
- Building setbacks are both short and long
- Streets normally have on-street parking
- Wide sidewalks and plazas accommodate more intense pedestrian traffic
- Bicycle lanes and transit corridors are frequently present
- Off-street parking includes multi-level structures that may be integrated with commercial or residential uses
- Some highways that fit this category may be designated by WSDOT as "Main Street Highways" (see Appendix B: Identification of State Highways as Main Streets

Due to the differences in developmental scale among urban areas as well as growth demand urban-urban core, context boundaries change over time with the urban core area expanding in high growth situations and possibly contracting in low or no growth situations.

1102.02(1)(d) Urban Core

Urban core locations include the highest level of density with its mixed residential and commercial uses accommodated in high-rise structures. There is commonly on-street parking, although it is usually time restricted. Most parking is in multi-level structures attached or integrated with other structures. The area is accessible to automobiles, commercial delivery vehicles, biking, walking, and public transit. Urban Core characteristics also include:

- Sidewalks and pedestrian plazas are present
- Bicycle facilities and transit corridors are common
- Typical land uses are mixed commercial, residential, with some government or similar institutions present
- Commercial uses predominate, including financial and legal
- Structures (predominantly high rises) may have multiple uses
- With the highest land value of any category, setbacks from the street are small
- Some highways that fit this category may be designated by WSDOT as "Main Street Highways" (see Appendix B: Identification of State Highways as Main Streets

1102.03 Transportation Context

This section describes the procedure for determining the current and future transportation context for the roadway. On larger projects, more than one transportation context may apply within project limits. Network connections are also useful in understanding the transportation context.

Each transportation context is to be described in terms of the following categories and considerations:

- Roadway type
- Bicycle route type
- Pedestrian route type
- Freight route type
- Transit use considerations
- Complete streets and Main Street highways

Seek endorsement from the project advisory team (see Chapter 1100) for determinations of these transportation context types and considerations, including input from local agency (local jurisdictions and transit agencies) and stakeholders. Document determination of each of these transportation contexts for both current and future states in Section 2 of the Basis of Design, and carry these results forward into determination of modal compatibility and modal priority (Chapter 1103).

Additional information supporting work described in this section is provided on the WSDOT Design Office website.

1102.03(1) Roadway Type

The initial roadway type is defined by the designated functional classification on the WSDOT State Route Log for the route as listed below for non-freeway facilities. A final roadway type determination is based on an assessment of whether a different functional class description (given below) corresponds better to the current and future state of the facility, compared to the designated functional class for the facility. The future state is determined after an assessment of the future modal route types described below. Justify the selection of a final roadway type whether it is the same or different from the designated functional class.

Freeways (including Interstate freeways) are defined in Chapter 1232. These routes typically are limited access facilities. The roadway type for freeways is freeway.

Roadway types for non-freeway facilities are described as follows.

- Principal Arterial – Corridors of regional importance connecting large centers of activity. These routes may be limited access facilities.
- Minor Arterial – Corridors of regional or local importance connecting centers of activity.
- Collector – Roadways of local importance providing connections between arterials and local roads.
- Local – Roads with no regional importance for local circulation and access only

1102.03(2) Bicycle Route Type

Bicycle routes are categorized based on the purpose of the trip and the network connectivity a facility provides. Use quantitative and qualitative information about bicycle connections associated with the project location to determine the current and future bicycle route type using one of these three classifications:

- Citywide Connector (CC) — The route is part of a citywide network, provides a connection to major activity centers, or is a regional bike route stretching over several miles that attracts a high volume of use, serving a primary commute or recreational purpose. These routes are typically associated with arterials and collectors.
- Neighborhood Connector (NC) — The route provides a neighborhood or sub-area connection, making connections to higher order facilities or more local activity centers, such as neighborhood commercial centers. These routes are typically associated with minor arterials and collectors.
- Local Connector (LC) — The route provides local connections of short lengths, providing internal connections within neighborhoods, or linking neighborhoods to higher order facilities. These routes are typically associated with collectors and local roads.

1102.03(3) Pedestrian Route Type

Pedestrian use is described in terms of estimated volumes (current and potential future). The amount of pedestrian traffic impacts several factors, including pedestrian facility capacity, vehicular delays at signalized intersections, and most importantly, the level of risk associated from pedestrians in the travelled way. The four pedestrian route types are based on volume as follows:

- P-1: rare or occasional use
- P-2: low volume – best measured in pedestrians per day
- P-3: medium volume - best measured in pedestrians per hour
- P-4: high volume - best in pedestrians per hour, where sub-hour peak periods are typical

1102.03(4) Freight Route Type

Freight routes may not require significant additional facilities beyond those provided for other motorized vehicles, if mobility and speeds of vehicular routes are consistent with freight movement. Special design consideration is commonly related to the Freight and Goods Transportation System classification. Document the classification for the project area.

Contact Rail, Freight, and Ports Division for help identifying freight classifications, industry needs and truck operations.

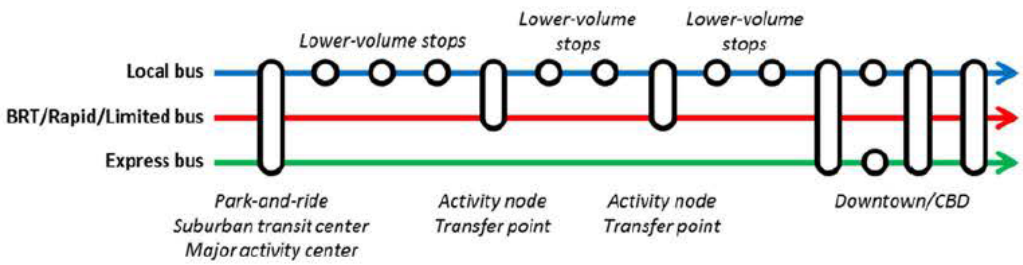
Truck route classifications can be found here:
http://www.wsdot.wa.gov/Freight/EconCorridors.htm

Additional information: http://www.wsdot.wa.gov/freight/

1102.03(5) Transit Use Considerations

Transit can provide service on any roadway type. The purposes of transit trips are similar to those of automobile trips and include commuting, work related business, shopping, personal errands, and social/recreational. The facilities and design considerations for transit uses depend on the type of transit service being provided. Note that special design consideration is required for projects that involve one or more of the following elements:

- Fixed route type: there are three primary types of fixed-route transit service, operating along designated routes at set times (Local, Limited, and Express). If one of these services exists on the project, determine the route type using criteria shown in the illustration below and the following bullets:



Source: TRPC Report 165: Transit Capacity and Quality of Service Manual.

  - Local routes serve many stops along a route and emphasize access to transit over speed.
  - Limited stop routes (also known as frequent routes, including bus rapid transit) balance transit access with speed. These routes run frequently and serve higher volume stops (e.g. major activity centers and transfer points).
  - Express routes emphasize speed over transit access, and are often used for longer distance trips.

  Note that in addition to fixed-route service, many agencies provide demand-response paratransit services that provide specialized transportation services in both rural and urban areas.

- Bus rapid transit or light rail
- Transit signal priority installation
- Planned transit facilities and routes
- In lane bus stops and/or potential bus pullouts
- Facilities for people with specialized transportation needs (e.g. hospitals, senior centers, schools, transit-dependent communities, etc.)

When evaluating transit needs and the potential for transit to improve highway performance in the project area, document relevant information or data about current transit capacity and quality of service (as defined in the Transit Capacity and Quality of Service Manual) and current and potential future use and travel markets. Include consideration for people walking and biking to/from transit connections. Contact the Public Transportation Division for help or for more information about identifying and coordinating with transit agencies and local jurisdictions that serve the project area (http://wwwi.wsdot.wa.gov/PubTran/).

1102.03(6) Complete Streets and Main Street Highways

Complete street contexts consider all transportation modes and often require differing modal priorities based on the existing land uses or may even consider multiple modes of equal priority. Complete streets may be desirable in various land use contexts including urban core, urban, suburban, small town, and even some rural contexts.

The Main Streets designation for highways is a point of reference and consideration when documenting transportation context, and should be noted on the Basis of Design. Main Street highways serve the aesthetic, social, economic, and environmental values in a larger community setting in addition to transportation. They are set up as specific state route and milepost designations.

See the *Complete Streets and Main Street Highways Program* document listed in Supporting Information at the end of this chapter for more information. For the list of designated highways see *State Highways as Main Streets: A Study of Community Design and Visioning*, Appendix B: Identification of State Highways as Main Streets,
http://www.wsdot.wa.gov/research/reports/fullreports/733.1.pdf.

1102.04 Documentation

Document the following in Section 2 of the Basis of Design:

- Land use category
- Roadway type
- Bicycle route type
- Pedestrian route type
- Freight route classification
- Transit use considerations
- Main Streets designation

Describe the process that was followed to reach these designations. If the work involved review and verification of previous work, document that process as well. If characteristics vary within project limits include the milepost ranges to which each of the designations apply.

1102.05 References

1102.05(1) Federal/State Directives, Laws, and Codes

23 Code of Federal Regulations (CFR) 450, Subpart B, Statewide Transportation Planning

23 CFR 450, Subpart C, Metropolitan Transportation Planning and Programming

23 United States Code (USC) 134, Metropolitan Planning

23 USC 135, Statewide Planning

Revised Code of Washington (RCW) 35.58.2795, Public transportation systems – Six-year transit plans

RCW 35.77.010(2) and RCW 36.81.121(2), Perpetual advanced six-year plans for coordinated transportation program expenditures – Nonmotorized transportation – Railroad right-of-way

RCW 36.70A, Growth management – Planning by selected counties and cities

RCW 43.21C, State environmental policy

RCW 47.05, Priority programming for highway development

RCW 47.06, Statewide transportation planning

RCW 47.06B, Coordinating special needs transportation

Secretary's Executive Order 1028 – Context Sensitive Solutions

Secretary's Executive Order 1090 – Moving Washington Forward: Practical Solutions

Secretary's Executive Order 1096 – WSDOT 2015-17: Agency Emphasis and Expectations

1102.05(2) Supporting Information

WSDOT References

Understanding Flexibility in Transportation Design – Washington, WA-RD 638.1, WSDOT, 2005
http://www.wsdot.wa.gov/research/reports/600/638.1.htm

Complete Streets and Main Street Highways Program, WSDOT, 2011
https://www.wsdot.wa.gov/research/reports/fullreports/780.1.pdf

State Highways as Main Streets: A Study of Community Design and Visioning, WSDOT, 2009
Appendix B: Identification of State Highways as Main Streets
http://www.wsdot.wa.gov/research/reports/fullreports/733.1.pdf

WSDOT Functional Classification map application:
http://www.wsdot.wa.gov/mapsdata/travel/hpms/functionalclass.htm

Other References

Complete Streets Planning and Design Guidelines, North Carolina Department of Transportation, July 2012. http://www.pedbikeinfo.org/pdf/PlanDesign_SamplePlans_CS_NCDOT2012.pdf

Designing Walkable Thoroughfares: A Context Sensitive Approach, Institute of Transportation Engineers, Washington D.C., 2010
http://ecommerce.ite.org/IMIS/ItemDetail?iProductCode=RP-036A-E

Evaluating Transportation Land Use Impacts, Victoria Transport Policy Institute, 2015
http://www.vtpi.org/landuse.pdf

The Innovative DOT: A Handbook of Policy and Practice, Smart Growth America, Washington D.C., 2015
http://www.smartgrowthamerica.org/the-innovative-dot

Land Use and Regional Planning: Achieving Integration Between Transport and Land Use, European Commission, 2006 http://www.transport-research.info/Upload/Documents/200608/20060831_102457_87241_Land_use.pdf

Livability in Transportation Guidebook: Planning Approaches that Promote Livability, FHWA, 2010 http://www.fhwa.dot.gov/livability/case_studies/guidebook/

Measuring Sprawl 2014, Smart Growth America, Washington D.C., 2014
http://www.smartgrowthamerica.org/measuring-sprawl

Small Town and Rural Multimodal Networks (FHWA-HEP-17-024), December 2016.
https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/small_towns/

Smart Transportation Guidebook, New Jersey Department of Transportation and Pennsylvania Department of Transportation, 2008.
http://www.state.nj.us/transportation/community/mobility/pdf/smarttransportationguidebook2008.pdf

Urban Street Design Guide, National Association of City Transportation Officials, New York, NY, 2013 http://nacto.org/

Chapter 1103 Design Control Selection

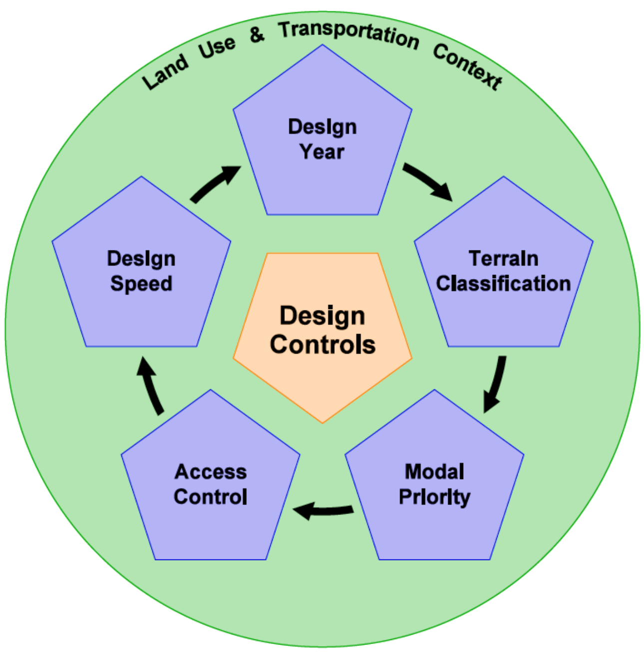
1103.01 General Overview

Design controls are specific factors that directly influence the selection of most design elements and their dimensions. Design controls establish fundamental boundaries for design alternatives. Selection of design controls is documented on the Basis of Design. This chapter provides guidance on the selection of design controls for state routes.

The five WSDOT design controls include:

- Design Year
- Modal Priority
- Access Control
- Design Speed
- Terrain Classification

Exhibit 1103-1 WSDOT Design Controls



Reciprocal connections between design controls and land use and transportation contexts

1103.02 Control: Design Year

Design year is the forecast year used for design. The year of opening is when the construction will be complete and the project location is fully operational. Design year selection is dependent on a decision to design for the year of opening, or for a future year based on forecast or planned conditions. Design year has historically been associated with a 20-year vehicle traffic forecast used in development of large mobility and capacity expansion projects. This is the origin of the term **horizon year**. Horizon year is typically considered to be 20 years from the year construction is scheduled to begin.

WSDOT policy on design year is intentionally flexible. The design year can be any interim year selected between the project year of opening year and the horizon year. Many lower-cost projects result in immediate performance improvements when construction is completed. Safety projects are an example of this where the basis of design may show design year as the year of opening.

Some projects may require horizon year analysis of an alternative regardless of the selected design year. A project may be required to evaluate alternatives based on the horizon year (20 years from the scheduled beginning of construction) if the project:

- Involves a federal nexus (federal funds involved, involves federal lands, or requires federal approvals or permits)
- Is a Project of Divisional Interest (See Chapter 300)
- Is a new/reconstruction project as defined in Chapter 300

Contact the region ASDE if there are questions.

1103.03 Control: Modal Priority

The concepts and method described in this section are adapted from National Cooperative Highway Research Program project 15-52 final draft report*: Developing a Context-Sensitive Classification System for More Flexibility in Geometric Design*.

1103.03(1) Design Users

"Design users" refers to the modes that are legally permitted to use a facility. The intent in identifying design users is to highlight all user needs, recognize modal interactions, and develop an integrated system for all users. Identifying the design users is the first step in determining which modes to accommodate and prioritize. On the Basis of Design, list design users with sufficient descriptive detail. Include consideration for all ages and abilities.

Division III of the document *Understanding Flexibility in Transportation Design – Washington* is a key resource for understanding the needs and characteristics of various design users.

1103.03(2) Modal Accommodation

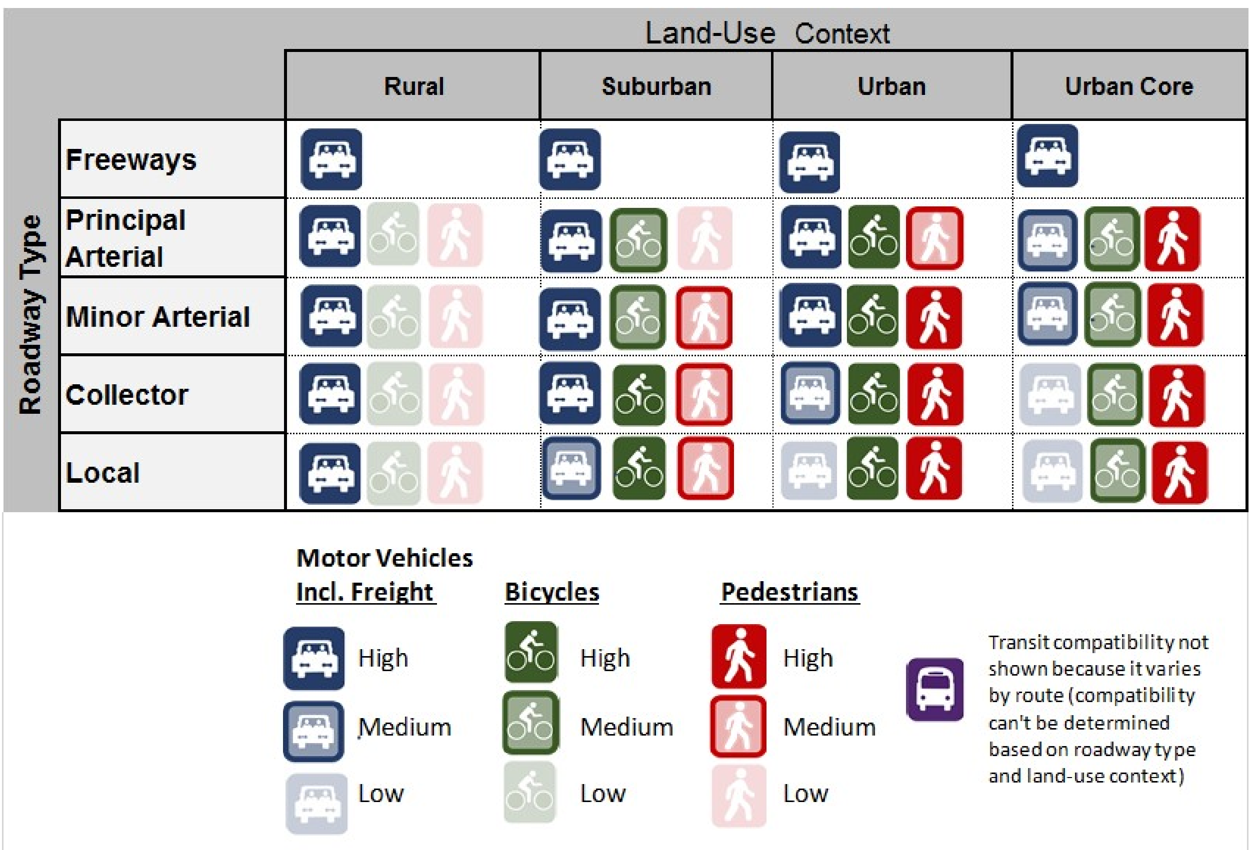
Modal accommodation refers to the level to which a travel mode will be addressed in the design. It is expressed on a scale of low, medium, and high, where a higher accommodation level is associated with the use of design features or criteria that tend to improve the performance of that mode compared to a lower level. Once established, the modal accommodation level is used to inform the decision on modal priority (See 1103.03(3)). Determine the modal accommodation level for both the current year (prior to opening) and the design year. These are referred to as existing and future conditions in the guidance that follows.

1. An **initial** modal accommodation determination, for both the current and design years, are made using Exhibit 1103-2. The initial determination uses the roadway type and land use contexts that were determined earlier and documented in Section 2 of the Basis of Design (See Chapter 1102).
2. A **final** determination for both the current and design years is made using additional information and evidence to validate or modify the initial determination.

Make the final modal accommodation determination for each mode in consultation with the project advisory team and/or subject matter expert(s), as they may recommend modifications to the initial determinations (see 1100.04 for more information about working with the project advisory team). Exhibit 1103-3 provides examples of land-use and transportation characteristics that a project advisory team or subject matter expert(s) may consider in adjusting accommodation up or down for any particular travel mode.

Exhibit 1103-2 – Initial Modal Accommodation Level

Corrected here per Technical Errata 8-8-2017



Additional guidance on the use of the following criteria in determining final modal accommodation level is provided on the Design Support site: http://www.wsdot.wa.gov/Design/Support.htm

Exhibit 1103-3 Example Characteristics Related to Modal Accommodation

Land Use Characteristic →	Increased Modal Accommodation Level
High proximity to activity centers	Pedestrian, Transit, Bicycle
Industrial and commercial land uses in surrounding area	Auto, Freight
High densities of both residential and employment	Bicycle, Pedestrian, Transit
Minimal building setbacks adjacent to roadway	Bicycle, Pedestrian
Human scale architecture present	Bicycle, Pedestrian, Transit
Transportation Characteristic →	**Increased Modal Accommodation Level**
Well-established grid network	Bicycle, Pedestrian, Transit, Auto
T-2 freight route	Auto, Freight
Streetside elements	Bicycle, Pedestrian, Transit
Frequent signalized intersections along route	Auto, Transit, Pedestrian

1103.03(2)(a) Vehicle modal accommodation level

Consider the vehicle modal accommodation level when making design decisions that address or affect needs associated with vehicle travel. Start with the initial modal accommodation level for motor vehicles per Exhibit 1103-2, and adjust it to establish the final level based on documented project specific conditions related to the quality of travel experience, and identified performance targets, that can be influenced by the project design, such as vehicle Level of Service, travel time, access classification, and other factors determined by subject matter experts or the project advisory team.

1103.03(2)(b) Bicycle modal accommodation level

Consider the bicycle modal accommodation level when making design decisions that address or affect needs associated with bicycle travel. Start with the initial modal accommodation level for bicycles per Exhibit 1103-2, and adjust it to establish the final level based on documented project specific conditions related to the quality of travel experience, and identified performance targets, that can be influenced by the project design, such as bicycle route type, efficiency of travel, range, bicyclist safety, route spacing, bicycle volumes, and other factors determined by subject matter experts or the project advisory team.

1103.03(2)(c) Pedestrian modal accommodation level

Consider the pedestrian modal accommodation level when making design decisions that address or affect needs associated with pedestrian travel. Start with the initial modal accommodation level for pedestrians per Exhibit 1103-2, and adjust it to establish the final level based on documented project specific conditions related to the quality of travel experience, and identified performance targets, that can be influenced by the project design, such as pedestrian route type, efficiency of travel, range, pedestrian safety, block length, and other factors determined by subject matter experts or the project advisory team.

1103.03(3) Modal Priority

Accommodate means that the roadway will be designed so that the chosen modes can use it, while **accommodation level** refers to the extent to which that accommodation may be required. **Priority** refers to the decision to optimize the design based on the performance of one or more travel modes. Modal priority is used as input to choosing the appropriate geometric cross section (see Chapter 1230).

Modal priority addresses all modes expected to use the facility. Determine modal priority using the accommodation level results, as well as information about freight, transit, and any other modes considered in the analysis of transportation context (see Chapter 1102).

If the modal priority is inconsistent with assumptions made about the project during a planning or scoping phase, work with program management staff to consider the need for any changes to project scoping documentation, including scope, schedule, and budget.

Document the modal priority on the Basis of Design for both the current and future conditions.

1103.03(4) Intersection Design Vehicle

WSDOT policy provides flexibility when choosing the intersection design vehicle. The purpose for this policy is to balance user needs and avoid the unnecessary expense of oversizing intersections. Considerations include frequency of the design vehicle and effects on other design users, specifically pedestrian crossing distance and times, and bicycle turning and through movements. Consider providing more protected intersection treatments for pedestrians and bicyclists to mitigate turning conflicts.

An intersection design vehicle is a specific selection made at each intersection leg. Select a design vehicle that allows the largest vehicles commonly encountered to adequately complete a required turning maneuver. The objective is not necessarily to size the specific intersection curb radius (unless there is a baseline need associated with the larger vehicles), but rather to account for a reasonable path to accommodate the large vehicle turning maneuver without conflicts (see Chapter 1310). Use turn simulation software (such as AutoTURN®) to analyze turning movements.

> **Example:** An intersection with a pedestrian modal priority experiences infrequent turning movements by a WB-67. A smaller curb radius would benefit pedestrians due to shorter crossing times and reduced exposure to vehicles. Using turn simulation software, a practicable path for the WB-67 can be identified, even though path intrusion into the second same direction lane or painted median may be necessary. The infrequent use by a WB-67, along with the pedestrian modal priority, validate the decision for selecting a smaller design vehicle for the intersection while accommodating the WB-67 vehicle.
>
> Conversely, if the crossroad was identified as being within a Freight Economic Corridor, with frequent turning movements from larger vehicles, it would be appropriate to size the intersection to prevent the second lane incursion.

Consider origins and destinations of large vehicles to understand their needs at specific intersection locations. Also, consider alternatives that may help lower turning speeds and minimize pedestrian exposure. Work with stakeholders, businesses, and service providers to understand their needs (like transit, school bus and emergency vehicle movements) and define the frequency of use at specific intersections. Municipalities may have established truck routes or restrictions that govern local freight patterns.

1103.04 Control: Access Control

Access is a critical component informed by an understanding of the land use and transportation contexts. The type of access control selected (see Chapter 520) affects accessibility and impacts the types of activities and functions that can occur on a segment. It is important for mobility and economic vitality projects to consider whether the current access classification and/or planned access classification conforms to the context selected for design (see Chapter 1102).

During development of the state highway system, access management functioned to preserve the safety and efficiency of regional highways. However, the level of access management can also significantly affect accessibility to land uses, modal mobility needs and the economic vitality of a place.

Unless access control has already been acquired by the purchase of access rights, it is necessary to select the appropriate type of limited access control or managed access control during planning and design. Appropriate access control should be considered so as not to hinder bicycle and pedestrian accessibility, mobility, and safety.

A choice to change the current or planned access control is a major decision and is to be consistent with the context, desired performance targets, and modal priorities for a location.

> **Example:** The area around a managed access Class 2 route has incurred significant development, increasing the number of local trips on a segment of the route. Over time, additional intersections and access connection permits have been granted. In this situation, it may be appropriate to consider selecting managed access Class 4 or 5 because of the changes in functions and activities along the segment over time.
>
> Conversely, a route may have a need to improve motor vehicle travel time performance, and managed access Class 1 may be appropriate.

If an alteration to current or planned access is determined necessary, consult the Headquarters Access and Hearings Manager for preliminary approval for the selection, and document on the Basis of Design (see Chapter 1100). For additional information on access control and access management, see Chapters 520, 530, and 540.

1103.05 Control: Design Speed

WSDOT uses a target speed approach for determining design speed. The objective of the target speed approach is to establish the design speed at the desired operating speed. The target speed selection is derived from other design controls, as well as transportation and land use context characteristics.

Exhibit 1103-4 shows possible (planning level) target speeds for the various roadway types and land use contexts discussed in Chapter 1102. The target speeds shown in the exhibit are suggestions only, and the target speed for the specific location may vary from those shown in the exhibit.

Exhibit 1103-4 Target Speed Based on Land Use Context and Roadway Type

Roadway Type	Land-Use Context: Rural	Suburban	Urban	Urban Core
Freeways	High	High	High	High
Principal Arterial	High	Intermediate / High	Low / Intermediate	Low
Minor Arterial	High	Low/ Intermediate	Low / Intermediate	Low
Collector	Low/ Intermediate	Low/ Intermediate	Low	Low
Local	Low/ Intermediate	Low	Low	Low

Engage the public, local agency staff and officials, and transit agencies prior to selecting the target speed. Once the target speed has been selected, it becomes the design speed for the project. The goal of the target speed approach is that the speed ultimately posted on the completed project is the same as the design, and ultimately, the operating speed. In order to achieve this outcome, consider:

- The impact of existing or proposed contextual characteristics
- Modal priorities
- Access control selection
- Performance need(s)
- Contributing factors analyses that have been developed for the project

Lowering target speed: When selecting a target speed in excess of the existing posted speed, or where excessive operating speeds were identified from contributing factors analysis of the baseline performance need, consider the use of roadway treatments that will help achieve the selected target speed (see 1103.05(2)) during alternatives formulation.

Speed management treatments are used to achieve lower vehicle speeds. When speed management treatments are proposed to accomplish a desired target speed operation concurrence of the Region Traffic Engineer is required. When a design speed is proposed for a project that is lower than the existing posted speed, the approval of the State Traffic Engineer is also required. See 1103.05(2) below for more on speed management. Careful consideration of other modal needs should be evaluated before raising target speeds.

Raising target speed: When selecting a target speed in excess of the existing posted speed, measures such as greater restriction of access control and segregation of modes may be necessary to reduce conflicts in activities and modal uses. Wider cross sectional elements like lanes and shoulders are used with higher speed facilities.

Setting the posted speed: Use caution when basing a target speed on one or more contextual characteristics that are proposed to take place after project opening, as the goal of ending up with a posted speed equal to the design speed at opening may be jeopardized.

The Region Traffic Engineer is responsible for setting the posted speed on the highway once the project is completed. Target speed is only one of the considerations used when establishing posted speed. Engage and include the Region Traffic Engineer and Traffic Office staff in key decision-making that will affect the target, design, and operating speed selection. . Incorporate consideration of traffic calming measures as needed.

1103.05(1) Low, Intermediate, and High Speeds

To provide a general basis of reference between target speed and geometric design, WSDOT policy provides three classifications of target speed as follows:

1. **Low Speed is 35 mph and below.** A low target speed is ideal for roadways with pedestrian and bicycle modal priorities. Locations that include frequent transit stops, intermodal connections, moderate to high intersection density, or moderate to high access densities may also benefit from lower speed environments. Low speed facilities in urban areas typically use narrower cross section elements.
2. **Intermediate Speeds are 40 mph and 45 mph.** An intermediate target speed is ideal for speed transitions between high and low target speed environments. Locations with low access densities and few at-grade intersections are also examples of where intermediate speed may be appropriate. In these locations consider a higher degree of separation between motor vehicles and bicycles and pedestrians.
3. **High Speed is 50 mph and above.** A high target speed is ideal for motor vehicle oriented roadways such as freeways and highways, often serving regional or longer-distance local trips. Rural connector roadways with infrequent farm or residential accesses are also consistent with the use of high target speeds. In high target speed locations consider the highest degree of separation between motor vehicles and bicycles and pedestrians. Highways with high speeds are associated with wider cross section elements.

1103.05(2) Speed Management

Speed management is necessary within many highways to achieve an optimal multimodal facility that will support the land use and transportation contexts. Speed management may also be necessary to maintain consistent or desired speeds between adjacent roadway segments. Identify speed transition segment(s) as necessary to achieve desired speeds. Identify potential speed transition segments when scoping the project.

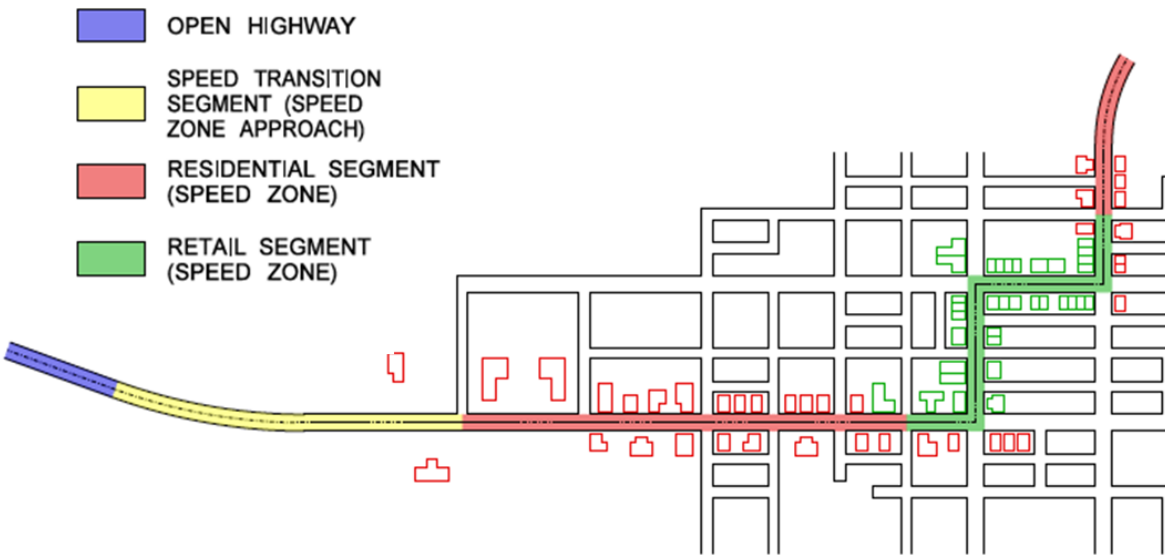
1103.05(2)(a) Speed Transition Segments

Include a speed transition segment where there is a need to obtain a target speed lower than the existing operating speed. A speed transition segment is not needed where existing operating speeds are within 5 mph of the target speed for a given location. The transition segment may not always directly precede the speed zone segment as shown in Exhibit 1103-5.

Example: A residential segment could benefit from introducing a speed transition segment farther upstream to increase the likelihood that approaching vehicles operate at the desired speed, for both segments.

The speed transition segment may incorporate a variety of treatments that alert motorists to a changing roadway environment. These treatments are intended to narrow driver focus and/or affect driver decision-making on that segment. Consider the transition segment location and length when providing multiple treatments in a short distance.

Exhibit 1103-5 Speed Transition Segment Example



1103.05(2)(b) Speed Reduction Traffic Calming Treatments

Traffic calming treatments can serve a variety of purposes, from deterring higher volumes of motorized traffic to providing speed management. This section presents traffic calming treatment options to increase the reliability of reducing vehicular speed. Speed reduction traffic calming treatments applied independently or in combination may be beneficial depending on the type and use of the treatments. Many speed management treatments have demonstrated varied effectiveness for single applications. Multiple treatments in series and parallel that build upon the context characteristics are more effective. Contact the Headquarters Design and Traffic offices for any project implementing a speed transition segment, for assistance on selection and monitoring of treatments.

Speed management techniques vary and have different results depending on the speed and types of users at a given location. The following subsections present different options for speed-reducing traffic calming treatments.

1103.05(2)(b)(1) Geometric Treatments

Geometric treatments can include overall changes of the horizontal or vertical geometry to introduce features that will support maintaining the targeted speed. Exhibit 1103-6 shows geometric traffic calming treatments and potential considerations when selecting these types of treatments.

1103.05(2)(b)(2) Roadside and Pavement Treatments

There are a number of treatments that create an environment that influences human factors and perception. Many successful roadside treatments use landscaping in an attempt to achieve the desired behavioral effect. It is important to coordinate with project partners to evaluate landscaping features and provide for traveled way operations and sight lines. The introduction of roadside features like trees, parking, and/or bicycle lanes to alert travelers to a change in conditions may be appropriate. Applying features like vegetated medians or trees is appropriate at some locations and contexts. In landscaping discussions, include Traffic Engineers, Maintenance, Urban Forestry, Landscape Architects, and Human Factors and Safety Experts. If the landscaping proposed is in a managed access segment with local jurisdiction responsibility for the roadside, coordinate to understand the jurisdictions' capabilities to sustain the landscaping and that it meets their clear zone goals.

Pavement-related treatments can also produce undesirable impacts on other users. For pavement-related treatments, include Materials Engineers, Maintenance, Traffic, and ADA Compliance Experts to review what sustainable and effective treatments can be employed.

Exhibit 1103-7 lists roadside and pavement-related traffic calming treatments and considerations to evaluate.

Exhibit 1103-6 Geometric Traffic Calming Treatments and Considerations

Treatment	Considerations
Taper for Narrow Lanes	Narrowing the lane width can be achieved by restriping lane lines. A decision to taper in or out may depend on other treatments planned, such as introducing a median or chicanes. Base taper rates on the target speed entering the context or speed transition segment, as appropriate. It is recommended that this be the first treatment employed.
Chicanes/Lane Shifts	This treatment may be achieved with curbed features, like planter strips or striping combined with additional fixed delineators. These treatment types are more appropriate when reducing speeds from an initial intermediate speed or less. When introducing this treatment with initial high speeds, the treatment should utilize paint striping, in addition to using other treatments preceding the chicane/lane shift, rather than constructing hardscape features.
Pinch Points	Applies on intermediate to low target speed situations unless completed with striping or other pavement markings. This treatment uses striping, roadside features, or curb extensions to temporarily narrow the vehicle lane. It is likely more appropriate for maintaining a desired target speed within a segment than as part of a speed transition segment. Pinch points are not appropriate for high-speed segments. Use of pinch-point treatments on intermediate speed segments requires concurrence from the Region Traffic Engineer.
Speed Cushion/Humps/Tables	On state highways, this treatment will likely have limited application, but should not be excluded from consideration. Impacts to freight, transit, and emergency service vehicles need to be evaluated prior to selecting these vertical types of treatments. These treatments may only be used when maintaining a 25 mph target speed within a segment.
Raised Intersections	Raised intersections, similar to other vertical treatments, will have limited application on state highways. This treatment typically has higher costs to construct due to the pavement needs. This treatment may be a good option when a roundabout cannot be accommodated at a narrow intersection. It can also be considered where there is a need to improve visibility of the intersection and modal conflicts, especially at problematic stop control intersections planned to remain in place. This treatment may only be used when maintaining a 25 mph target speed within a segment.
Roundabouts	Roundabouts can be a unique feature, providing reduced serious injury collision potential, traffic calming, and gateway functions (See Chapter 1320 and the Roadside Policy Manual for details on roundabout design). Roundabouts are effective from a collision reduction and operational perspective, and they provide reduced driver workload, lower speeds, and limited conflict points. They can assist with access management or when turning movements are limited or restricted on a segment. To determine if a roundabout is appropriate at a specific location, follow the Intersection Control Analysis process described in Chapter 1300.

Exhibit 1103-7 Roadside, Streetside, and Pavement-Oriented Traffic Calming Treatments

Treatment	Considerations
Landscaping	Landscaping can be used in conjunction with other treatments to reinforce the surrounding context and the driver's perception of the context. It can also provide width for modal separation. Annual maintenance impacts need to be considered, weighed, and documented prior to selecting types of vegetation to be included.
Raised Vegetated Medians	Introduce a raised vegetated median following other treatments that prepare the driver for this feature. Appropriate for low to intermediate target speed locations and transition segments.
Transverse Rumble Strips	These in-lane rumble strips are intended to alert drivers to a condition change. They are likely placed in conjunction with and prior to traffic signing revisions or in advance of other speed-reducing traffic calming treatments. Appropriate for high, intermediate, or low target speed locations and transition segments.
Optical Speed Markings	This treatment is intended to influence a driver's perception. The treatment consists of 8-inch transverse paint strips within the vehicular lane extending from lane and edge markings (or curb). The striping intervals sequentially decrease, providing the perception of increasing speed, an indication to drivers to slow their operating speed. Optical Speed Markings are ideal for speed transition segments, and are recommended to be applied in conjunction with lane narrowing for high or intermediate target speed locations.
Dynamic Warning Systems	This treatment consists of actively alerting motorists about their operating speed. There are many different systems that accomplish this, including portable radar trailers and post-mounted systems. These can be either permanent or temporary installations. Appropriate for all speeds.
Gateways	The intent of a gateway feature is to alert travelers to a context change. A gateway feature is typically found on the edge of cities or towns, but can be used to highlight specific segments within cities or towns. The gateway can be anything from a banner/structure spanning the facility, to artistic work, landscaping, and/or a roundabout at the first intersection approaching a defined environment context. The gateway feature should be developed by the community. It may be of interest to design a gateway feature fitting the cultural and historic character of the location. Consideration for potential fixed object collisions is an important aspect of gateway design. Gateway features that span or are placed within state right of way will need specific approvals, as identified in Chapter 950. Appropriate for low to intermediate target speed locations and transition segments.

1103.06 Control: Terrain Classification

Terrain may limit operational and safety performance for particular modes. While terrain impacts may be addressed at specific locations, it is not cost beneficial to modify terrain continually throughout a corridor. The type of terrain, context, and speed influence the potential operating conditions of the highway, and should be a consideration when selecting mobility performance targets (See Chapter 1101). For more information on grades, see Chapter 1220.

To provide a general reference between terrain and geometric design, three classifications of terrain have been established:

1. **Level:** Level to moderately rolling, this terrain offers few or no obstacles to the construction of a highway having continuously unrestricted horizontal and vertical alignment.
2. **Rolling:** Hills and foothills, with slopes that rise and fall gently; however, occasional steep slopes might offer some restriction to horizontal and vertical alignment.
3. **Mountainous:** Rugged foothills; high, steep drainage divides; and mountain ranges.

Designate terrain as it pertains to the general character along the alignment of a corridor. Roadways in valleys or passes in mountainous areas might have the characteristics of roads traversing level or rolling terrain and are usually classified as level or rolling, rather than mountainous. See the *Highway Log* for terrain classification.

1103.07 Documentation

Document selections for design controls in Section 3 of the Basis of Design.

1103.08 References

1103.08(1) Federal/State Directives, Laws, and Codes

Secretary's Executive Order 1090 – Moving Washington Forward: Practical Solutions

Secretary's Executive Order 1096 – WSDOT 2015-17: Agency Emphasis and Expectations

Secretary's Executive Order 1028 – Context Sensitive Solutions

1103.08(2) Supporting Information

Designing Walkable Thoroughfares: A Context Sensitive Approach, Institute of Transportation Engineers, Washington D.C., 2010 www.ite.org

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, Washington, D.C., Current Edition www.transportation.org/Pages/Default.aspx

Urban Street Design Guide, National Association of City Transportation Officials, New York, NY, 2013 www.nacto.org

Understanding Flexibility in Transportation Design – Washington, WA-RD 638.1, Washington State Department of Transportation, 2005 www.wsdot.wa.gov/research/reports/fullreports/638.1.pdf

NCHRP Report 613 – Guidelines for Selection of Speed Reduction Treatments at High Speed Intersections, Transportation Research Board, Washington D.C., 2008
🖰 http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_613.pdf

NCHRP Report 737 – Design Guidance for High-Speed to Low Speed Transition Zones for Rural Highways, Transportation Research Board, Washington D.C., 2012
🖰 http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_737.pdf

NCHRP Report 600 – Human Factors Guidelines for Road Systems, 2nd Edition, Transportation Research Board, Washington D.C., 2012
🖰 http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600Second.pdf

NCHRP Synthesis 443 – Practical Highway Design Solutions, Transportation Research Board, Washington D.C., 2012 🖰 http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_443.pdf

Measuring Sprawl 2014, Smart Growth America, Washington D.C., 2014
🖰 http://www.smartgrowthamerica.org/measuring-sprawl

Chapter 1104 Alternatives Analysis

1104.01 General

Washington State Department of Transportation practical design policy requires formulating and evaluating alternatives while considering acceptable performance trade-offs to meet the need(s) of a project at the lowest level of investment. This chapter discusses how:

- Information determined from planning phases and Chapters 1101, 1102, and 1103 is utilized in alternative solution formation
- To evaluate the alternative solutions developed

This chapter presents methods for developing alternatives. For projects requiring an Environmental Assessment (EA) or an Environmental Impact Statement (EIS), a final proposed alternative may only be determined through the National Environmental Policy Act (NEPA) process and/or the State Environmental Policy Act (SEPA) process (see Chapter 400 of the Environmental Manual for more information). If an EA or EIS has not been initiated under NEPA/SEPA, follow the procedures in this chapter. To help advance the project, consider and use appropriate NEPA/SEPA terminology. Perform public and agency outreach and document all information regarding alternatives development for use later in the NEPA/SEPA process, according to 23 CFR 168(d). Terminology used in this chapter assumes that NEPA/SEPA have not been initiated. In the event that the NEPA/SEPA process has been initiated and an EA or EIS will be required, coordinate with the region Environmental Office staff to make sure that this alternative formulation and evaluation is performed in accordance with NEPA/SEPA guidance.

1104.02 Alternative Solution Formulation

An important function of alternative solution formulation is to identify alternatives that address the baseline need while balancing the performance trade-offs identified in the process. This can include analysis of multimodal trade-offs and the formulation of multimodal/intermodal solutions. Need identification and contributing factor analysis (CFA) are critical to alternative solution formulation (see Chapter 1101 and guidance document *Contributing Factors Analysis* for more information). Conduct alternative solutions formulation according to the following principles:

- Formulate alternatives compatible with context and design controls
- Form solutions around contributing factors or the underlying root reason(s) identified from CFA. Address the underlying root reason(s) determined from CFA in at least one alternative.
- Evaluate the relative benefit between each alternative against the baseline and contextual performance metrics to determine the optimally performing solution for the least cost. (See 1104.03(3) for information on calculating the benefit/cost of alternatives.)

Planning phase corridor sketches or studies may identify WSDOT's strategy for the corridor (see the guidance document section titled *Alternative Strategies and Solutions* for more information regarding different strategies that may be considered). If this has occurred, develop at least one alternative based on that identified strategy and bring forward into the alternative evaluation process (see 1104.03).

In some cases, planning studies may have developed specific alternatives. Carry planning phase alternatives into the alternative evaluation process, unless planning phase alternatives are obsolete. In some cases, alternatives may present opportunities for phased implementation.

1104.03 Alternative Solution Evaluation

Alternative solution evaluation involves understanding the performance benefits obtained from alternative solutions in relation to the selected design year and cost. It is the intent of the alternative solution evaluation process to:

- Compare solutions that resolve the baseline need(s) in consideration with the benefits or impacts associated with the contextual needs.
- Analyze the relative value of each alternative, including associated performance trade-offs.
- Mitigate unacceptable performance trade-offs with proven countermeasures.
- Refine targets if mitigation measures applied yield unacceptable performance trade-offs.

1104.03(1) Alternatives Comparison

WSDOT's alternatives comparison process is intended to align with performance-based decision-making. The process is complementary to a practical design approach. The process centers around achieving the basic performance need, while understanding and when necessary mitigating for the potential effects to other performance areas.

Use the Alternative Comparison Table (ACT) to assist in evaluating alternatives and identified baseline and contextual performance. The intent of comparing alternatives is to:

- Obtain an alternative solution for the least cost while understanding associated performance trade-offs.
- Compare alternatives against their ability to accomplish the baseline need.
- Evaluate alternatives against their relative effects on contextual needs.
- Provide the opportunity to incorporate mitigation or countermeasures.
- Document alternative formulation and evaluation outcomes that are consistent with the environmental process and expectations.

Note that if there are a large number of contextual needs under consideration, it may be beneficial to prioritize or use a weighted evaluation of the contextual needs in order to expedite the alternative evaluation.

As discussed in 1104.02, at least one alternative based on the outcome of Contributing Factors Analysis should be compared against other alternatives.

The Alternative Comparison Table template and examples can be found at:
🖱 www.wsdot.wa.gov/Design/Support.htm

1104.03(2) Performance Trade-off Decisions

In performance trade-off decisions, the intent is to give priority to the project's baseline needs. However, there will be situations where evaluations reveal that trade-offs are too significant, and there is an inability to adequately resolve them with low-cost countermeasures, phased solutions, or general acceptance of the performance trade-off. In these situations, it is appropriate to consider alternatives that still optimize the baseline performance metric, but do not necessarily obtain initial performance targets. Document refined performance targets on the Basis of Design.

1104.03(3) Benefit/Cost Analysis

Inherent with understanding the performance trade-offs being considered, is the overall benefit/cost for the alternatives proposed. In some cases, decisions will be based on life cycle cost for maintenance items, as discussed in Chapter 301. In other cases, perceived benefits are a challenge to quantify and will need analysis such as that discussed in *NCHRP Report 642: Quantifying the Benefits of Context Sensitive Solutions*:
🖱 www.trb.org/Publications/Blurbs/162282.aspx

1104.04 Documentation

The Alternative Comparison Table (ACT) is used to assist in evaluating alternatives. Summarize the alternatives evaluated with the ACT in Section 4 of the Basis of Design (BOD). Alternative formulation and evaluation will also be documented through the NEPA process. Environmental staff will help account for consistency with the environmental process, expectations and requirements throughout any alternative formulation and evaluation that occurs within project development.

1104.05 References

1104.05(1) Federal/State Directives, Laws, and Codes

42 United States Code (USC) 4321, National Environmental Policy Act of 1969 (NEPA)

Chapter 43.21C Revised Code of Washington (RCW), State Environmental Policy Act (SEPA)

Chapter 468-12 Washington Administrative Code (WAC), WSDOT SEPA Rules

Secretary's Executive Order 1090 – Moving Washington Forward: Practical Solutions

Secretary's Executive Order 1096 – WSDOT 2015-17: Agency Emphasis and Expectations

Secretary's Executive Order 1028 – Context Sensitive Solutions

Secretary's Executive Order 1018 – Environmental Policy Statement

1104.05(2) Guidance and Resources

Environmental Manual, M 31-11, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Understanding Flexibility in Transportation Design – Washington, WA-RD 638.1, Washington State Department of Transportation, 2005
www.wsdot.wa.gov/research/reports/fullreports/638.1.pdf

1104.05(3) Supporting Information

Designing Walkable Thoroughfares: A Context Sensitive Approach, Institute of Transportation Engineers, Washington D.C., 2010.
www.ite.org

NCHRP Report 642 – Guidelines for Quantifying the Benefits of Context Sensitive Solutions, Transportation Research Board, Washington D.C., 2014
http://www.trb.org/Publications/Blurbs/162282.aspx

NCHRP Synthesis 443 – Practical Highway Design Solutions, Transportation Research Board, Washington D.C., 2013
http://www.trb.org/Main/Blurbs/168619.aspx

Chapter 1105 Design Element Selection

1105.01 General

Design elements are specific components associated with roadway design, such as lane widths, shoulder widths, alignments, clear zone, etc. Design controls (see Chapter 1103) are carefully chosen and used to determine the dimensions of design elements. The relative effect that a given design element will have on performance will depend on the selected design controls and context identification. For more information, see the guidance document section titled *The Research Summary of Different Design Elements on Performance*.

1105.02 Selecting Design Elements

Design elements that are included in a project are documented in the *Basis of Design*. Include the design elements that are changed by the project. (See Chapter 1100 for more information about Basis of Design.)

An element is **changed** if one of the following applies:

- A new element is added
- An existing element is removed or relocated
- A dimension - such as a width - is modified

A design element that is **not changed** is not documented in the Basis of Design.

The next step after selecting design elements is to choose the appropriate dimension for each element. (See Chapter 1106 for information on selecting design element dimensions.)

1105.02(1) Required Design Elements and Criteria

There are also additional legal and policy-based considerations that require a decision of whether or not to include certain design elements in a project; this depends on the program or sub-program. See Exhibit 1105-1 for additional information regarding whether or not to include these design elements in a project.

Exhibit 1105-1 Required Design Elements

Program or Sub-Program	Design Elements						
	ADA	Clear Zone [1]	Roadside Safety Hardware [3]	Signing & Delineation [4]	Illumination [7]	ITS [8]	Signal Hardware
I-1 Mobility **I-3 Economic Initiative - Trunk System** **I-6 Sound Transit**	Apply the content in Chapter 1510 (1510.05)	Apply the content in Chapter 1600	Apply the content in Chapters 1600, 1610 and 1620	Apply the content in Chapter 1020 for signing and Chapter 1030 for delineation	Apply the content in Chapter 1040	Apply the content in Chapter 1050	[5]
All Preservation (P-1, P-2, P-3)	Apply the content in Chapter 1120 (1120.03(2))	[2]	Apply the content in Chapter 1120 (1120.03(7))	[2] [6]	[2]	[2]	[5]
I-2 Safety **I-4 Environmental Retrofit** **I-3 All Other**	Apply the content in Chapter 1510 (1510.05)	[2]	[2]	[2] [6]	[2]	[2]	[5]

Notes:

[1] See Chapter 1600

[2] Only include when changed as described in 1105.02.

[3] Includes all roadside safety design elements in Chapters 1600, 1610, and 1620.

[4] See Chapter 1020 for signing and Chapter 1030 for delineation

[5] Consult the Assistant State Design Engineer (ASDE), HQ Traffic Office, and Capital Program Development and Management Office (CPDM) to determine policy requirements.

[6] Consult the ASDE for policy requirements if the roadway channelization is changed.

[7] See Chapter 1040

[8] See Chapter 1050

1105.03 Related Elements

Design elements can be interrelated. Even if a specific design element has not changed in accordance with the definition in 1105.02, consider whether or not the preferred alternative has changed the conditions in a way that may affect the performance of an unchanged element, considering all modes.

Example: A project team proposes to provide a left-turn lane along a portion of their project in order to address a baseline need related to safety for turning traffic, by reducing the width of each highway shoulder. By reducing the shoulder width, the traveled way will be closer to the roadside than in the existing condition. The project team determines whether the project would adversely affect safety performance due to roadside conditions such as steep slopes or objects in the clear zone along with considering impacts to bike and pedestrian use.

1105.04 Documentation

Document design elements that are changed in Section 5 of the Basis of Design (BOD) form unless the exemptions listed in 1100.10(1) apply.

As a design alternative matures over time, it is likely that design elements may be added or dropped through the iterative process inherent with design. It is important to update the Basis of Design documentation with these changes at the various documentation and approval milestones.

The Basis of Design is available to download here:
www.wsdot.wa.gov/Design/Support.htm

1105.05 References

The *Research Summary of Different Design Elements on Performance*, WSDOT Guidance Document:
www.wsdot.wa.gov/Design/Support.htm

Chapter 1106 Design Element Dimensions

When choosing any dimension, read the guidance for the specific facility type (for example, for ramps see Chapter 1360) and also read the guidance for the specific element (for example for side slopes see Chapter 1239).

When a range of dimensions is given, consider modal needs, required function, and desired performance (1106.03) and, where possible, use quantitative tools to help choose a dimension within the range.

1106.01 General

Practical design resolves the project need with the least investment. Flexibility in the choice of design element dimensions helps accomplish this.

For guidance related to geometric cross-section elements, first see Chapter 1230. For guidance related to all other design elements, see the appropriate chapter.

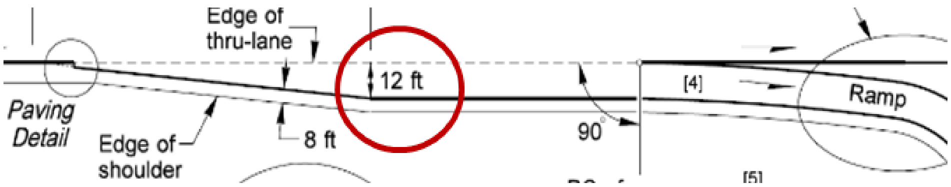
1106.02 Choosing Dimensions

Depending on the facility type, *Design Manual* guidance may come in the form of a single dimension or a range of dimensions to choose from. See Exhibit 1106-1.

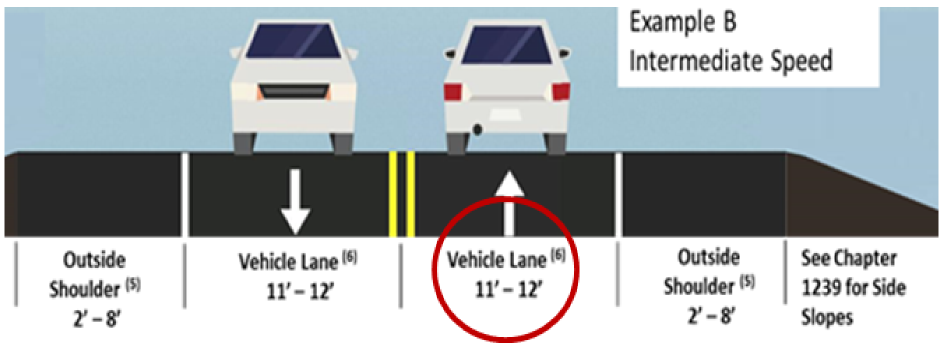
For some roadways, the optimum solution is very dependent on the location (context) of the roadway. In these cases, you will likely see a range of widths to choose from. For example, the geometric cross section guidance chapters for highways (Chapter 1231) and freeways (Chapter 1232) show cross-sections that list ranges to choose from for lane and shoulder widths.

The **mode/function/performance approach** described in 1106.03 is the tool to be used to choose the appropriate width from the range given.

Exhibit 1106-1 Dimensioning Guidance Variations



Example: *Exhibit 1360-14b calls out one specific dimension for the lane width of this section of a parallel off connection.*



Example: *Exhibit 1231-3 calls out a range of dimensions for the lane width.*

When a single dimension is given: If the decision is to use the dimension shown, no further evaluation is needed; just document the dimension choice on the Design Parameter Sheets.

If a particular roadway warrants use of a dimension that is different than the value given, the mode/function/performance approach described in 1106.03 can be used to determine the appropriate dimension. Results will need to be documented in a Design Analysis.

When a range of widths is given: Understand any width considerations specific to the design element (for example, lane width considerations are described in Chapter 1231). Use the mode/function/performance approach described in 1106.03 to choose the appropriate value within the range. If the dimension chosen is within the range given in the *Design Manual*, document the reasoning in the Design Parameter Sheets. If the value chosen is outside of the given range, document the decision in a Design Analysis.

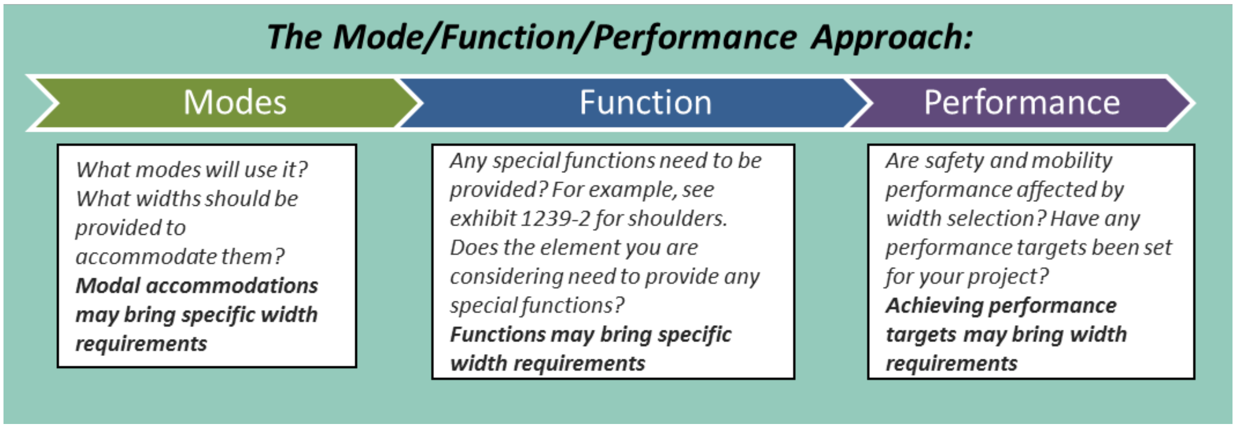
Some dimension choices can be complex, and involve trade-off evaluations, including comparisons of alternatives, benefit/cost analysis, etc. In these instances, it may be appropriate to record the dimension choice on the Design Parameter Sheets and reference any related documents that support the dimension choice.

1106.03 The Mode/Function/Performance Approach

The **mode/function/performance approach** is the primary methodology to apply when a range of dimensions is given. Utilizing this approach ensures that modal needs, the function of the design element, and safety and mobility performance have all been considered. For example, lanes and shoulders have to accommodate the modes that use the roadway, provide functions that are appropriate for the specific roadway, and provide appropriate safety and mobility performance.

Modes, function and performance overlap and are interrelated. These considerations are part of a tradeoffs discussion. Cost is always a consideration in a tradeoffs discussion. Engineering judgment and stakeholder involvement will be required.

Exhibit 1106-2 Mode/Function/Performance Approach



Modal accommodation: It is important to understand the modal needs for a roadway. Accommodating a specific mode (or modes) may influence the dimension choice.

For example, it is important to understand the vehicle mix that will be using the lanes and to understand the modes that will be using the shoulder. For lanes, a significant number of trucks and oversized vehicles may affect the lane width choice, especially if the alignment is not tangent. Read Chapter 1231 when choosing lane widths.

For shoulders, it is important to understand bicyclist and pedestrian use. The width requirements that come with accommodating various modes are discussed in Chapter 1239.

Function(s): Function is closely related to modal accommodation. Providing a specific function may drive the dimension choice.

For example, the shoulder width requirements that come with providing various functions bring a wide range of associated widths (see Exhibit 1239-2, Shoulder Function & Modal Accommodation Width Considerations).

Performance: When choosing a dimension from a range of possible choices, consider safety performance and mobility performance. Meeting safety or mobility performance targets may drive the dimension choice.

When evaluating performance, the use of quantitative engineering methods and tools is encouraged whenever possible. See 1106.05 for more information on quantitative tools and methodology for evaluating safety and mobility performance.

An important consideration of performance evaluation is whether or not the project has an identified baseline (or contextual) safety need. If safety need has been identified, performance metrics and targets may play a major role in choosing dimensions. See Chapter 1101.

For some projects, modal accommodation needs may drive lane and shoulder width decisions. In other cases, the need to provide a specific function may drive width decisions. And, in some cases, meeting established performance targets may drive width decisions. Regardless of whether modal accommodation, function, or performance drives the dimension choice, the effect of the decision on mobility and safety performance has to be considered.

Accommodating modal needs, providing specific functions, or achieving specific performance targets may require widths that can bring significant investments. Consider the cost and associated trade-offs, and document why it is worthy of the associated investment.

In addition to being the primary method to choose a dimension when a range of dimensions is given, the mode/function/performance approach can also be used in support of a Design Analysis.

1106.04 Design Up Method

When a range of dimensions is given, guidance may specifically require a "design up" approach. For example, Chapter 1231 requires a design up approach for state highways other than freeways.

Design up means considering the smallest dimension first. Increasing dimensions are then considered until the smallest dimension is identified that accommodates modal needs, provides the desired functions, and provides appropriate safety and mobility performance. Using the mode/function/performance approach described in 1106.03 is an important part of design up.

1106.05 Quantitative Analysis Methods and Tools

Currently, two primary tools exist to quantitatively evaluate performance; the *Highway Safety Manual* (HSM) for evaluating modal safety performance and the *Highway Capacity Manual* (HCM) for evaluating traffic operational mobility performance.

1106.05(1) Highway Safety Manual and Safety Modeling

Safety is and always has been a primary performance category for WSDOT. Past design policy relied on the assumption that the application of design criteria equated to a desired level of safety performance for the expenditure. This assumption may not have always been true for all locations given their operational and geometric characteristics. The strict application of criteria to achieve safety performance is known as "nominal safety." To achieve a more reliable safety performance, scientific estimation of crashes using site conditions is necessary and is termed "substantive safety." A new understanding of safety performance, crash modification factors, and roadway functions has led to a growing body of knowledge about the relationship between roadway characteristics and safety performance.

The application of the *Highway Safety Manual* (HSM) and its companion tools provides an understanding of how a particular design can perform with respect to safety. This enables analysis of safety-specific performance metrics that may be more critical to address. The HSM covers multiple transportation road types and can be a valuable tool to analyze various geometric alternatives in any program type.

For guidance regarding whether or not to include a baseline safety need see Chapter 1101. For more information on sustainable highway safety tools and analysis, see Chapter 321.

1106.05(2) Highway Capacity Manual and Traffic Modeling

The *Highway Capacity Manual* (HCM) provides quantitative methods for evaluating mobility operational performance. However, some quantitative outputs from some HCM methods are specific to free-flow speed operations or level of service, and may not be appropriate for use given the baseline mobility performance metric selected for a specific location. Traffic modeling software provides a more relevant method for understanding the mobility operational performance; however, the reliability of the outputs varies given the traffic forecasting for design years further in the future. Utilize traffic modeling to ascertain potential mobility operational performance whenever feasible.

1106.06 Documenting Dimensions

While a primary function of the Basis of Design is to document the design elements selected to be included in a project, another primary function of the Design Parameter Sheets is to document the dimensions chosen for the various design elements included in a project.

Important Note: If the dimension for an existing design element does not change, no documentation is required on the Design Parameter sheets. A Design Parameter Sheet entry left blank means that the element was not selected to be included in the project. (See Chapter 1105 for design element selection guidance.) A Design Parameter Sheet template can be found here:
🖰 http://www.wsdot.wa.gov/Design/Support.htm.

1106.07 Design Analysis

A Design Analysis is required when a dimension chosen does not meet the value, or fall within the range of values, provided for that element in the *Design Manual* (see Chapter 300.) The considerations described in 1106.03 may be useful when completing a Design Analysis.

1106.08 References

Highway Capacity Manual (HCM), latest edition, Transportation Research Board, National Research Council

Highway Safety Manual (HSM), AASHTO

Washington State's Target Zero Strategic Safety Plan

🖰 http://www.targetzero.com/plan.htm

Chapter 1120 Preservation Projects

1120.01 General

This chapter provides information specific to preservation project types.

This chapter identifies those elements and features to be evaluated and potentially addressed during the course of a preservation project. The elements listed here may be in addition to the project need identified in the Project Summary or Basis of Design (see 1120.04). Preservation projects may also provide opportunities for project partnering and retrofit options involving additional elements (see 1231.06).

Preservation projects are funded in three program areas:

- **Roadway Preservation (P1) projects** preserve pavement structure, extend pavement service life, and restore the roadway for reasonably safe operations.
- **Structures Preservation (P2) projects** preserve the state's bridge network through cost effective actions. There are numerous types of bridge preservation actions including: deck rehabilitation, seismic retrofit, painting steel bridges, scour repair, and others.
- **Other Facilities (P3)** includes guardrail and signing, major drainage, major electrical, unstable slopes and other project types.

For more information on these programs see the Planning & Programming – Scoping website:
http://wwwi.wsdot.wa.gov/Planning/CPDMO/PlanProgScoping.htm

1120.02 Structures Preservation (P2) and Other Facilities (P3)

For Structures Preservation (P2) and Other Facilities (P3) projects see the scoping instructions specific to the sub-program and type of work to determine the likely design elements to be addressed by the project.

See Chapter 300 for documentation requirements. If the project changes a geometric design element, replaces an existing bridge or installs a new bridge additional documentation may be required; contact your ASDE to discuss appropriate documentation.

1120.03 Pavement Preservation (P1)

This section applies to features and design elements to be addressed on Pavement Preservation (P1) projects.

See 1120.03(8) Documentation for instructions on using the Basis of Design to document design elements and adjusted features.

1120.03(1) Adjust existing features

- Adjust existing features such as monuments, catch basins, and access covers that are affected by resurfacing.

- Evaluate drainage grates and replace as needed to address bicycle safety (see Drainage Grates and Manhole Covers in Chapter 1520).
- For guidance on existing curb see Chapter 1239.
- Reinstall centerline and shoulder rumble strips, if present, using criteria and guidance provided in Chapter 1600.

1120.03(2) ADA requirements

- Address ADA requirements according to WSDOT policy (see Chapter 1510 and any active project delivery memorandums or design memorandums).

1120.03(3) Cross slope lane

- Rebuild the cross slope to a minimum 1.5% when the existing cross slope is flatter than 1.5% and the steeper slope is needed to provide adequate highway runoff. See Chapter 1250 for more information about cross slope.

1120.03(4) Cross slope shoulder

- When rebuilding the lane cross slope, evaluate shoulder cross slope in accordance with Chapter 1250.

1120.03(5) Vertical clearance

- Paving projects, and seismic retrofit projects, may impact vertical clearances (see Chapter 720 for bridge clearances and Chapter 1020 for overhead sign assemblies.)
- If vertical clearance will be changed by the project, evaluate this in accordance with Chapter 720 and include this design element in the Basis of Design and the Design Parameters sheets and the Design Documentation Package.
- Contact the Commercial Vehicle Services Office when changes to vertical clearance are planned.

1120.03(6) Delineation

- Install and replace delineation in accordance with Chapter 1030 (this includes only pavement markings, guideposts, and barrier delineation).
- Replace rumble strips if they are removed through project actions, or if their average depth is less than 3/8”, unless there is a documented justification for their removal (see Chapter 1600).

1120.03(7) Barriers and terminals

- When the height of a guardrail, terminal, and/or transition as measured from the ground to the top of the rail element will be affected by the project, then adjust the height in accordance with guidance provided in Chapter 1610 if it meets the following conditions:
  - The height of a Type 1 guardrail, terminal or transition will be reduced to less than 26.5 inches or increased to greater than 30 inches.

  - The height of a Type 31 guardrail, terminal or transition will be reduced to less than 28 inches or increased to greater than 32 inches.

- One terminal that was used extensively on Washington's highways was the Breakaway Cable Terminal (BCT). This system used a parabolic flare similar to the Slotted Rail Terminal (SRT) and a Type 1 anchor (Type 1 anchor posts are wood set in a steel tube or a concrete foundation). For Roadway Preservation (P1) projects replace BCTs on limited access routes and ramps. On other non-limited access routes, BCTs that have at least a 3-foot offset (measured at face of rail relative to the tangent line of the guardrail run's face of rail) may remain in place unless the guardrail run or anchor is being reconstructed or reset. Raising the rail element is not considered reconstruction or resetting.
- Evaluate the guardrail length of need accordance with Chapter 1610 for runs that need to be raised as a result of an HMA overlay. Up to 250 feet of additional run length within each run is permissible in Pavement Preservation (P1) projects.
- Note that removal is an option if guardrail is no longer needed based on validation of the original guardrail purpose from past project documentation and after consulting Chapters 1600 and 1610. Document the location of removal and the reasoning for removal in the Design Documentation Package.
- When adjusting terminals that are equipped with CRT posts, the top-drilled holes in the posts need to remain at the surface of the ground.
- Pre-cast concrete barrier sections (either New Jersey or "F" shape) are normally installed at 32" height, which includes provision for up to 3" overlay. A 29" minimum height for this type of barrier must be maintained following an overlay.
- Single slope concrete barrier may be pre-cast or cast in place, and is installed new at a height of 42", 48", or 54". A 30" minimum height must be maintained for this type of barrier following an overlay.

1120.03(8) Documentation

For Pavement Preservation (P1) projects, use the Basis of Design to document decisions when the project changes any design elements that are not listed in 1120.03(1) through 1120.03(7). Document any changes to dimensions on the Design Parameter Sheets.

Chapter 1230 Geometric Cross Section Basics

When choosing any geometric cross section dimension, including lane or shoulder width, read the guidance that is specific to the facility type. Also, read the general guidance related to common elements such as lanes, shoulders, side slopes, etc.

See Chapter 1106 for the general dimensioning guidance.

This chapter also contains guidance related to jurisdiction.

1230.01 General

The geometric cross section is composed of multiple lateral design elements such as lanes, shoulders, medians, bike facilities, and sidewalks. The designer's task is to select, size, and document these elements appropriately. There is flexibility in the selection of design element dimensioning.

All WSDOT routes, regardless of context, are referred to in the *Design Manual* as "highways." Under this definition, freeways are a subset of highways while Interstate freeways are one specific type of freeway.

Refer to the *Design Manual* Glossary for many of the terms used in this chapter. See Chapter 300 for design documentation requirements.

1230.02 Guidance for Specific Facility Types

Guidance regarding geometric cross sections is located in various *Design Manual* chapters. The chapter depends on the facility type. Examples of specific facility types include:

- Highways (general)
- Freeways
- Ramps
- Auxiliary lanes
- Collector-Distributor lanes
- Service lanes
- Frontage roads
- HOV facilities
- Median U-turns and crossovers
- Transit facilities including bus pull-outs
- Enforcement areas
- Slow vehicle turn-outs
- Truck weighing facilities
- Shared use paths
- Sidewalks
- Bicycle Facilities

Exhibit 1230-1 shows some common facility types along with the corresponding chapter that geometric cross section guidance can be found in.

Exhibit 1230-1 Geometric Cross Section - Guide to Chapters

Facility Type	Lane width	Turning roadway width	Shoulder width	Median width	Lateral clearance to curb or barrier	Side slope	Cross slope
Highways (General)	1231	1240	1231	1239	1239	1239	1250
Freeways	1232	1240	1232	1239	1239	1239	1250
Ramps	1360	1240	1360	1360	1239	1239	1360 & 1250
Auxiliary lanes	1270 or 1360 [1]	1240	1270 or 1360 [1]	N/A	1239	1239	1270
C-D roadways	1360	1240	1360	N/A	1239	1239	1360
HOV lanes, ramp bypass lanes, etc.	1410	1410	1410	N/A	1410 & 1239	1239	1410
Left-side direct HOV access (DHOV) facilities	1420	1420	1420	1420 (for DHOV)	1420 & 1239	1239	1250
Shared use path	1515	1515	1515	N/A	1515	1515	1515
Other	Geometric cross section guidance for other special purpose facilities is in various chapters. Examples include special use lanes, bridges, transit facilities, bus pull outs, median U-turns and crossovers, enforcement areas, truck weighing facilities, pedestrian bridges and tunnels, sidewalks & bicycle facilities						

Notes:

General guidance for curb design is in Chapter 1239. Guidance for curb is also found for numerous types of facilities (Chapter 1310 and others.)

[1] Passing and climbing lanes, see Chapter 1270; Auxiliary lanes between interchanges see Chapter 1360.

Exhibit 1230-1 is not a comprehensive list of guidance associated with either a facility or a design element. It is intended to be a quick reference to the chapter containing the primary guidance related to the specific element and facility type.

For guidance related to intersections see Chapter 1310. For guidance related to sidewalks see Chapter 1510. For guidance related to bicycle facilities see Chapter 1520. For guidance related to bridges see Chapter 720.

1230.03 Common Elements

In addition to the guidance specific to the facility type, also see the general guidance related to cross-sectional elements that are common to various facility types:

- Lanes — Chapter 1231
- Shoulders, side slopes, medians & curbs — Chapter 1239
- Lateral clearance to curb and barrier — Chapter 1239
- Parking & streetside (behind the curb) elements — Chapter 1238
- Cross slope and superelevation — Chapter 1250

1230.04 Jurisdiction for Design and Maintenance

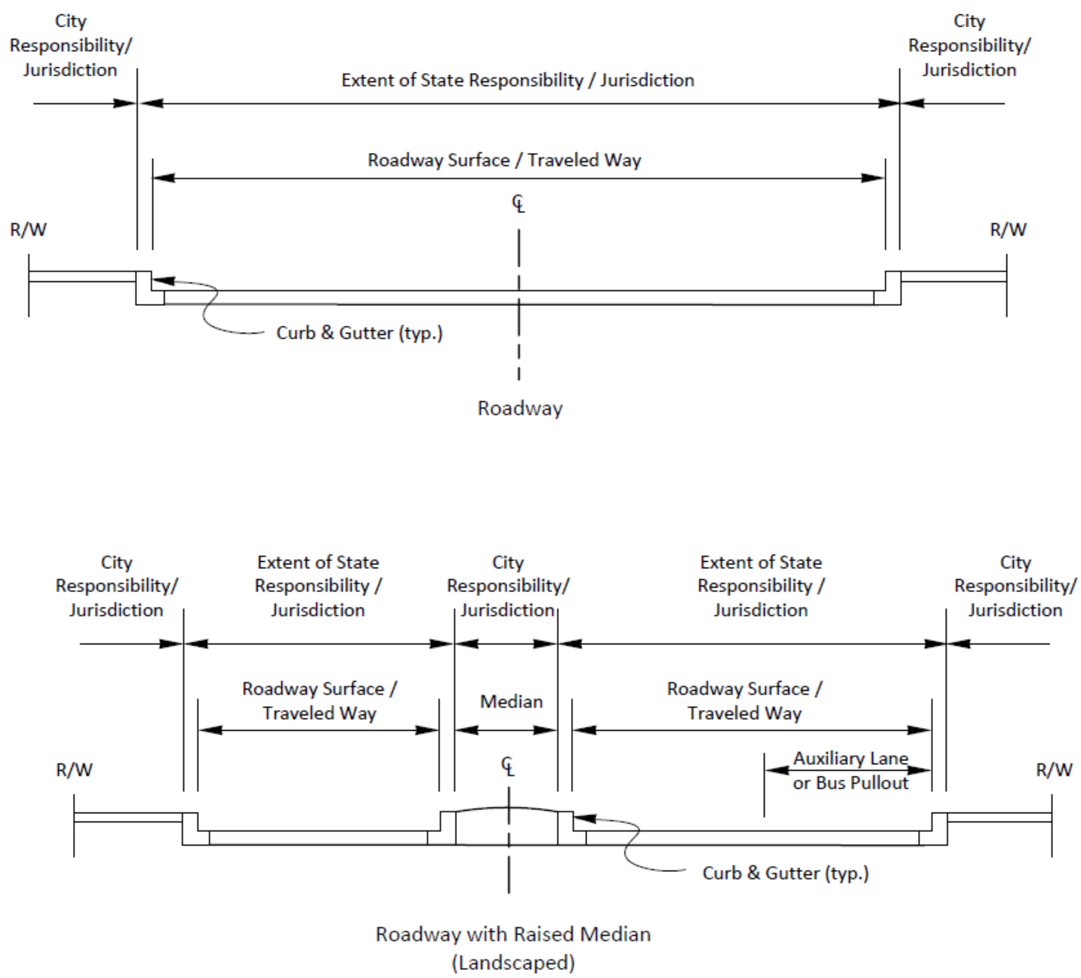
On all state highways in locations outside of cities or towns and within limited access design areas, geometric design is to be consistent with this *Design Manual*.

On state highways within an incorporated city or town, develop design features in cooperation with the local agency. For NHS routes, use the *Design Manual*. For non-NHS routes, the *Local Agency Guidelines* may be used for dimensioning design elements

Cross-sectional design within incorporated cities or towns can get complicated due to the joint-jurisdictional authority. WSDOT typically has jurisdiction between the curbs, and cities typically have jurisdiction outside the curbs (see Exhibit 1230-2). When no curb is present, the city or town holds responsibility for the roadside beyond the paved shoulder. Despite the jurisdictional differences, it is extremely important to cooperatively determine a cross-sectional design.

Refer to Chapter 301 for additional information on jurisdictional maintenance responsibilities and considerations for maintenance agreements.

Exhibit 1230-2 State and City Jurisdictional Responsibilities



1230.05 References

1230.05(1) Design Guidance

Highway Runoff Manual, M 31-16, WSDOT

Local Agency Guidelines (LAG), M 36-63, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction, M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction, M 41-10, WSDOT

1230.05(2) Supporting Information

Understanding Flexibility in Transportation Design – Washington, WA-RD 638.1, Washington State Department of Transportation, 2005
www.wsdot.wa.gov/research/reports/fullreports/638.1.pdf

Urban Street Design Guide, National Association of City Transportation Officials, New York, NY, 2013
www.nacto.org

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition
www.transportation.org/Pages/Default.aspx

Chapter 1231 Geometric Cross Section – Highways

1231.01 General

Geometric cross sections for state highways are governed by the need to balance performance metrics, the context, and selected design controls. The objective is to optimize the use of available public space while avoiding an unreasonable investment in right of way acquisition.

The term “highways” refers to all WSDOT roadways, including freeways. However, note that freeways have their own geometric cross section guidance. This chapter is not intended for freeway design. See Chapter 1232 for freeways.

1231.02 Design Up

Unless otherwise specified, use the “design up” method described in Chapter 1106 to choose a design element width when a range of widths is given in this chapter.

1231.03 Common Elements

The geometric cross sections shown in this chapter have many elements that are also common to facilities addressed in other chapters. The following chapters contain guidance related to these common geometric cross section elements:

- Lanes — Chapter 1231
- Shoulders, side slopes & ditches, medians & curbs — Chapter 1239
- Lateral clearance to curb or barrier — Chapter 1239
- Parking & streetside (behind the curb) elements — Chapter 1238
- Cross slope and superelevation — Chapter 1250

1231.04 Vehicle Lanes

1231.04(1) Type of Lanes

There are many types of lanes that may exist in a cross section, and each has its own purpose and sizing needs. General-purpose traffic lanes need to accommodate a variety of vehicle types including buses, freight vehicles, personal automotive vehicles, and bicycles. The target speed, modal priority, balance of performance needs, and transportation context are all considerations when determining size, type, and number of lanes.

Some common types of vehicle lanes include:

Through Lanes

Through lanes are the most common lane type. All highways have at least one lane in each direction to provide unimpeded traffic flow from Point A to Point B.

Turn Lanes

Dedicated turn lanes are separated from the through lanes and provide storage for turning vehicles waiting for a signal or gap in opposing traffic. There are a number of different types of turn lanes which are discussed in detail in Chapter 1310. Turn lanes are critical to meet mobility and accessibility performance for motorized and bicycle modes. Traffic analysis determines the type, storage length, and number of turn lanes that are needed to achieve the balance of multimodal performance needs.

Turn lanes present potential conflicts, particularly with bicyclists and pedestrians. See Chapters 1510 and 1520 for additional discussion on ways to mitigate for these conflicts.

Bicycle Lanes

There are several different types of bicycle lanes and many different ways to arrange bike lanes within the geometric cross section (see Chapter 1520). Shoulders designed to function for bikes are not considered bike lanes.

Transit-Only Lanes

Transit-only lanes are ideal for improving transit mobility performance and segregating heavily used or complex intermodal connections. There are many different ways to configure these within a geometric cross section. Some configurations are limited due to passenger loading needs for both the transit vehicle type and the stop locations. Develop widths for transit-only lanes with the partnering transit agency. See Chapter 1430 for additional information on Transit Facility considerations.

Auxiliary lanes

Auxiliary lanes enhance mobility performance for motor vehicles. See Chapter 1270 for design guidance and a detailed discussion on the types of auxiliary lanes.

Managed and Shared Lanes

There are many different types of managed and shared lanes. Some examples include:

- High occupancy vehicle (HOV) lanes (see Chapter 1410)
- High occupancy toll lanes (discuss with Tolling Division and see Chapter 1410)
- Hard shoulder running
- Peak hour use
- Bicycle shared lane (see Chapter 1520)
- Business access and transit (BAT) lane (see Chapter 1410, Arterial Street HOV)

1231.04(2) Lane Width

Lane width ranges for highways are listed in Exhibit 1231-1.

Exhibit 1231-1 Lane Widths for Highways

Speed	Highway Type	Lane Width Range*
High Speed	Freeway (incl. Interstate)	See Chapter 1232
	Other Highway	11' - 12'
Intermediate Speed	All	11' - 12'
Low Speed	All	10' - 12'

* The width shown is exclusive of the gutter if the gutter is a color that contrasts with the roadway.

1231.04(2)(a) Lane Width Considerations

Exhibit 1231-2 lists some considerations that may be helpful in choosing the most appropriate lane width from the range given in Exhibit 1231-1. This is not a comprehensive list. The considerations listed are meant to help understand the modal needs and function associated with different lane widths. Work with your Region Traffic Office when choosing lane widths.

Exhibit 1231-2 Lane Width Considerations

Lane Width Considerations	
General	Roadways on curves, see Chapter 1240 Turning Roadway Widths
	Narrower lanes may be used as part of a speed reduction strategy
	Two-lane, two-way rural highways: 12 ft lanes provide clearance between large vehicles traveling in opposing directions. Especially beneficial when high volumes or high truck percentages expected
	On multilane facilities with width constraints, utilizing narrower inside lanes may permit wider outside lanes for bicycles, freight, and transit
	Reduced lane widths allow more lanes to be provided in areas with constraints and allow shorter pedestrian crossing times because of reduced crossing distances
Intermediate to High Speed	12 ft lanes provide increased benefit on high speed, free-flowing principle arterials
	12 ft lanes provide increased benefit where there are higher truck volumes, especially for intermediate and high speed facilities
	Safety and mobility performance difference between 11 ft and 12 ft lanes can be negligible. Work with Region Traffic Office to evaluate performance differences for the subject roadway
Low Speed	11 ft lanes are common on urban arterials
	Lane widths of 10 ft may be appropriate in constrained areas with low truck and bus volume
	In pedestrian oriented sections, 10 ft lanes can be beneficial in minimizing crossing distance

1231.05 Modally Integrated Cross Sections

WSDOT's goal is to optimize existing system capacity through better interconnectivity of all transportation modes. Choosing the appropriate geometric cross section relies heavily on designing for the appropriate modes. See Chapter 1103 for guidance in selecting modes to accommodate and choosing modal priorities.

Once a decision is made regarding which modes to accommodate and which modes will have priority, a geometric cross section can be developed. The cross sections in this chapter are organized by modal priority for the following primary modes:


Motor Vehicles, including freight


Bicycles


Pedestrians


Transit

The cross-section examples shown in Exhibits 1231-3 through 1231-7 depict various combinations of elements that may be included in a cross section. The examples are intended to stimulate designer creativity and awareness of modal accommodations, and are not intended to be standard cross sections to be reproduced for a given modal priority. It is expected that innovative project alternatives will result in diverse configurations that best balance baseline and contextual needs (see Chapter 1101).

Since the cross-sections shown are only examples, and are really combinations of various elements, it is important to read the guidance associated with the specific elements (see 1231.03) in order to understand the considerations that may affect a choice of width, and to understand documentation requirements.

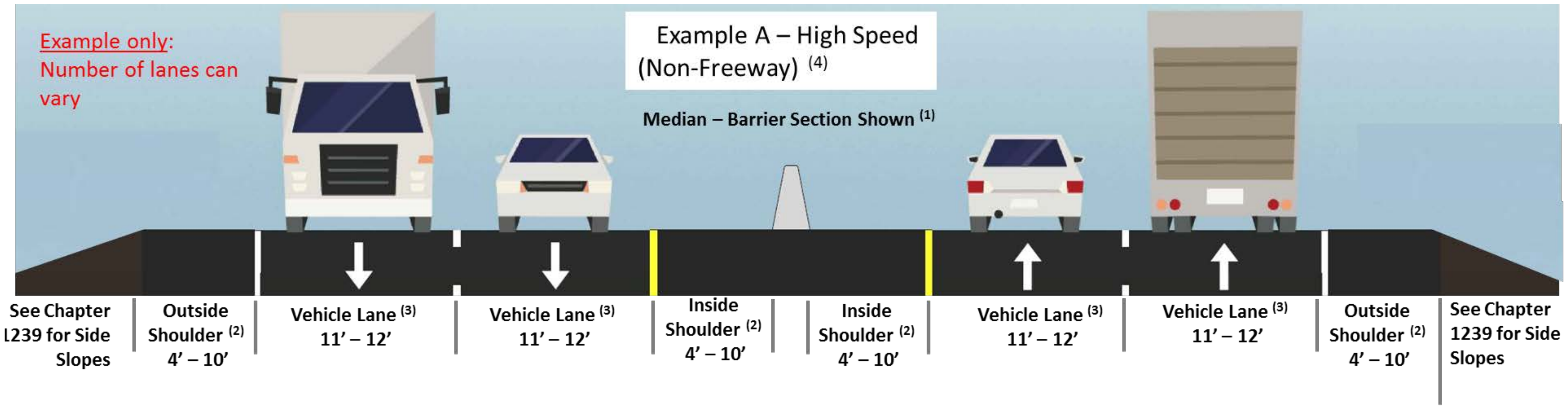
The cross section examples provide a range of dimensions for different design elements. See Chapter 1106 for guidance regarding choosing a width when a range of widths is given.

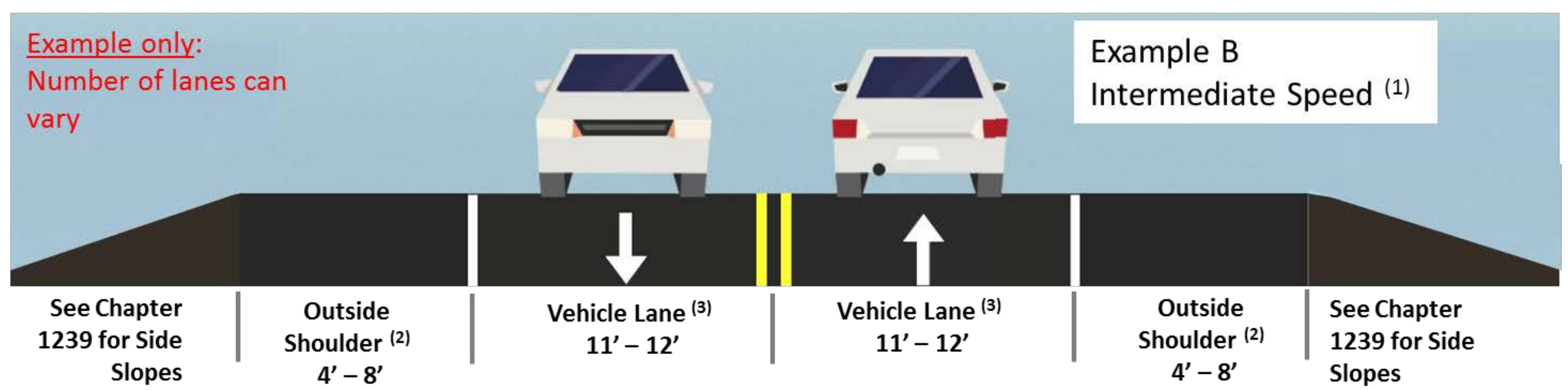
Maintaining the continuity of a roadway is an important consideration, particularly for limited access and other high-speed highways. However, it is also appropriate to change continuity as context changes in order to influence driver behavior. When designing intentional changes to the continuity of the geometric cross section, consider what is needed to enable the transition. High-speed to low-speed changes will need to transition the geometric cross section over a distance utilizing a speed transition segment (see Chapter 1103).

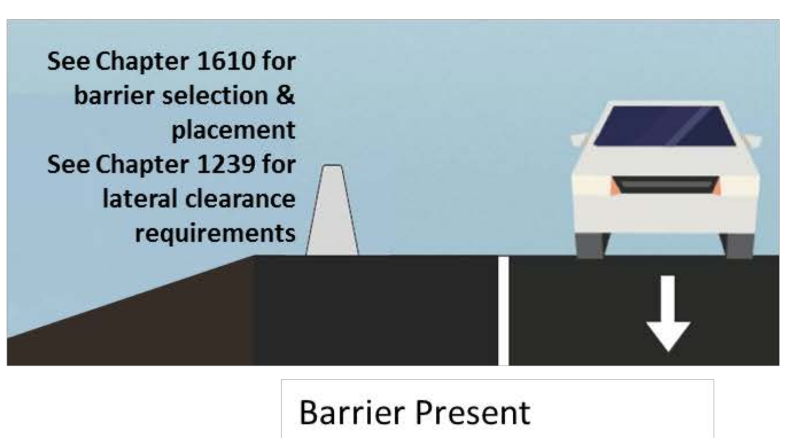
1231.05(1) Auto-and Freight Oriented Cross Sections

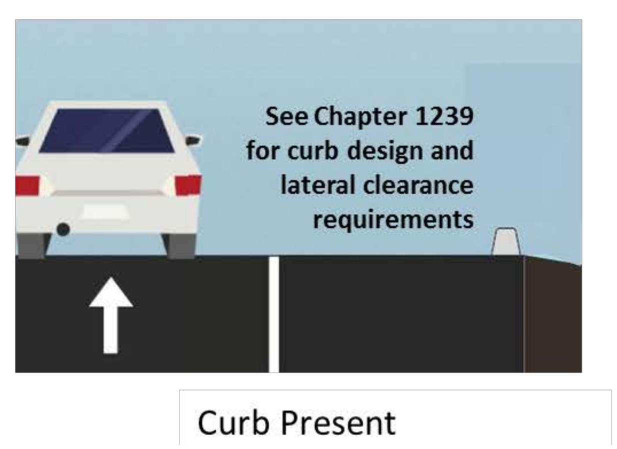
Exhibit 1231-3 shows examples of motorized vehicle-oriented designs. Motorized vehicles come in a variety of types which are operated on many vehicle lanes and parking areas. The performance needs of freight and other automotive vehicle types are often similar. However, certain truck vehicle types may require additional turning roadway width for off-tracking (see Chapter 1240), or at other locations a truck climbing lane may be needed to facilitate mobility performance (see Chapter 1270). Generally, lane width within suburban and urban contexts is less critical for mobility and safety performance than in rural and high-speed contexts. Within urban areas, placement of and sizing for loading areas within the parking areas can depend on the freight vehicle type.

Exhibit 1231-3 Motor Vehicle Oriented Cross Sections









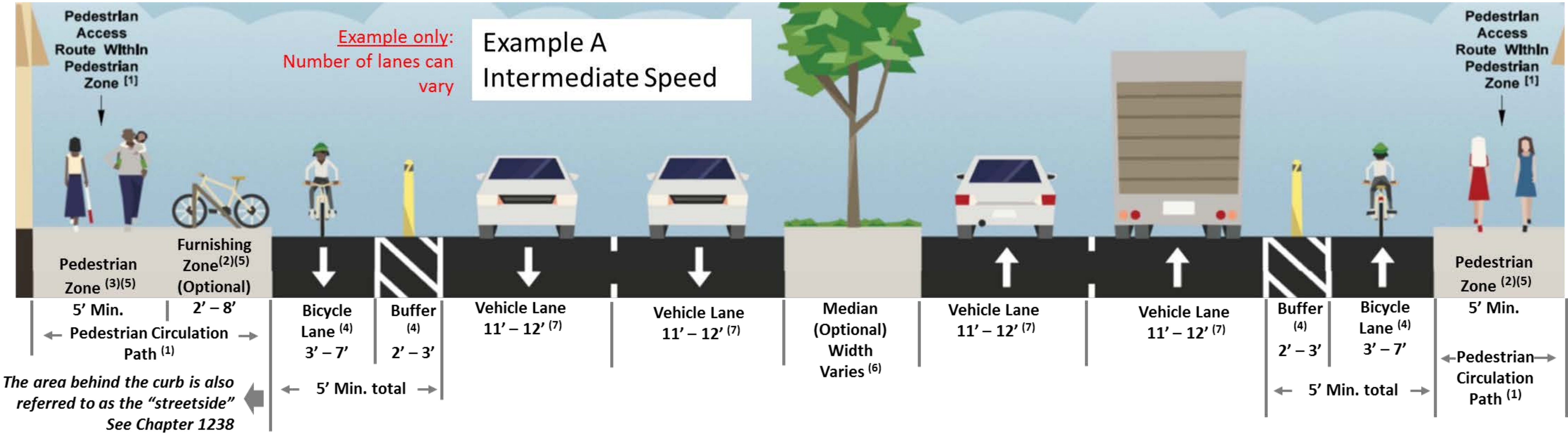
Notes:

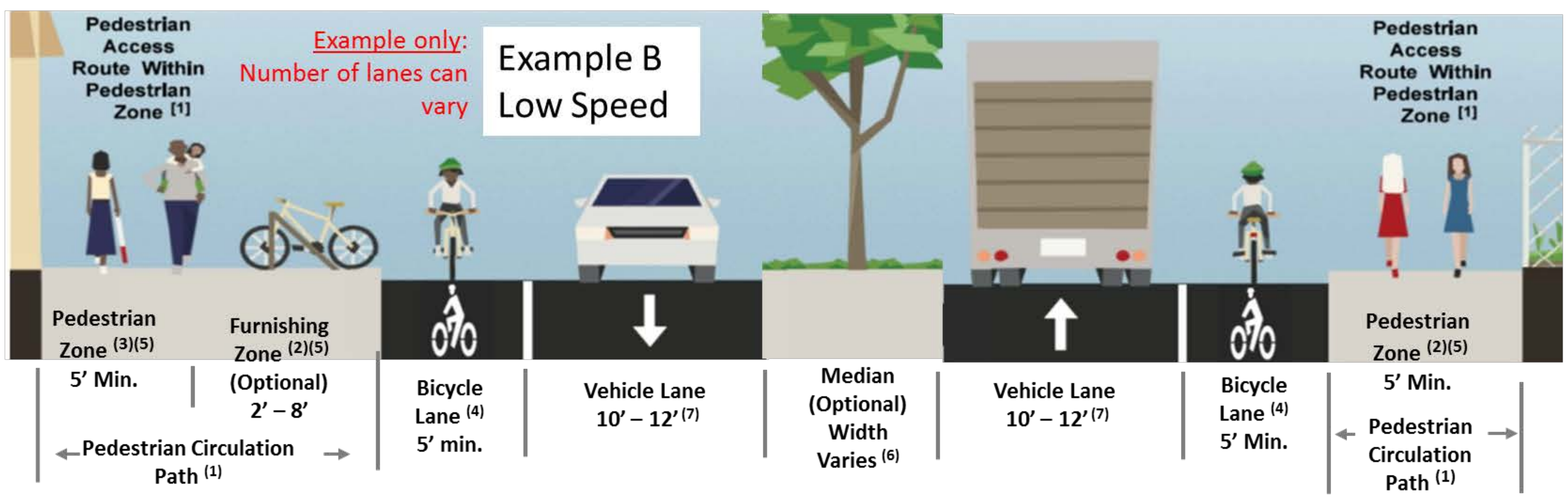
[1] Overall median width and design will vary. Some median designs include barrier and some do not. See Chapters 1239 and 1600.
[2] See Chapter 1239 for guidance on choosing a dimension from the range given.
[3] See 1231.04 for guidance on choosing a dimension from the range given. See Chapter 1410 for guidance on HOV facilities.
[4] See Chapter 1232 to see if your roadway meets the definition of a freeway.

1231.05(2) Cross Sections Featuring Bicycle Facilities

Exhibit 1231-4 Example A features bicycle facilities at an intermediate-speed location. Bike lane location within the cross section depends largely on how cyclists will interact with the land use and potential modal conflicts. Locating bike lanes on the outside of the motor vehicle lanes can improve accessibility for bicyclists. If cyclist mobility performance is a primary concern or intermodal conflicts (such as transit stop locations) are present, locating bike facilities in the center of the roadway may be more appropriate. Whether or not a bike lane buffer is needed depends mostly on the target speed and average daily traffic (ADT) of the facility; the intent of bike buffers or other protected bike facilities is to address safety performance for cyclists. Buffers and other means of modal segregation also benefit motor vehicle drivers and pedestrians by showing allocated spaces. Both roadway bike lane configurations and bike facility selection are discussed in more detail in Chapter 1520.

Exhibit 1231-4 Cross Sections Featuring Bicycle Facilities





Notes:

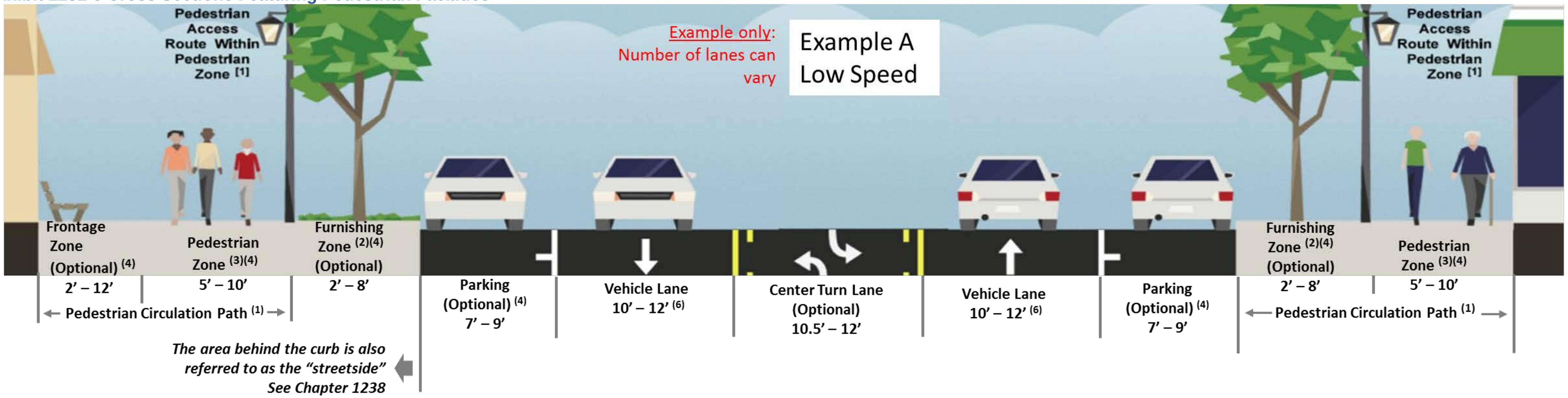
[1] See Chapter 1510.
[2] Minimum width specified is exclusive of the curb width.
[3] If no furnishing zone is provided, minimum width is exclusive of the curb width.
[4] See Chapter 1520 for bike facility options.
[5] See Chapter 1238.
[6] Overall median width and design will vary. See Chapter 1239 .
[7] See 1231.04 for guidance on choosing a dimension from the range given.

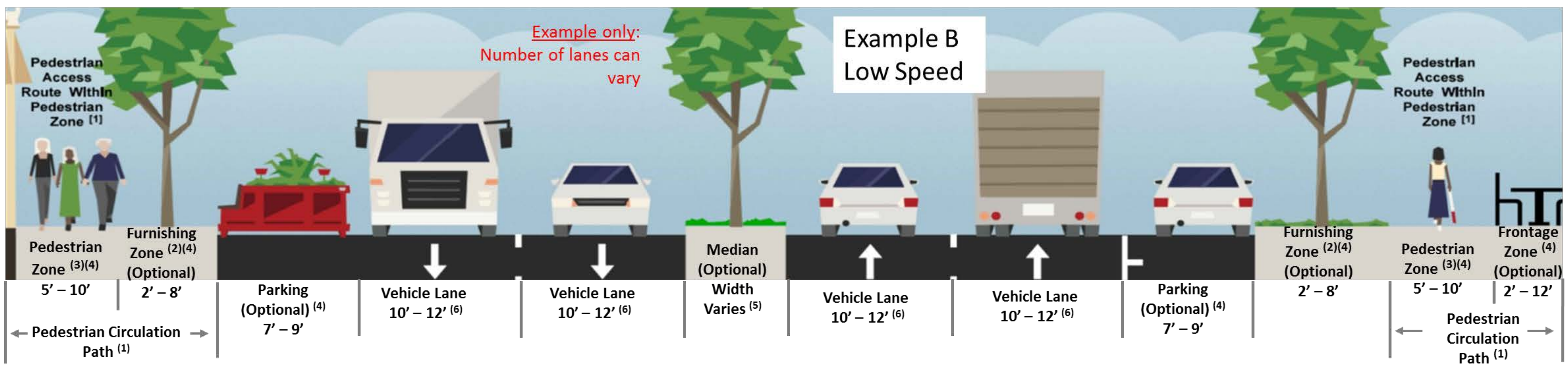
1231.05(3) Cross Sections Featuring Pedestrian Facilities

Exhibit 1231-5 shows cross-section examples featuring pedestrian facilities. The pedestrian mode is a vital transportation mode since, for most people, nearly every trip at least begins and ends by walking. Roadway facilities prioritized for pedestrians emphasize streetside elements. See Chapter 1238 for guidance regarding streetside elements.

The objective is to achieve the Pedestrian Circulation Path (PCP) necessary to support mobility, socioeconomic, and accessibility needs and provide access to intermodal connections. The configuration and dimension of streetside elements varies significantly depending on the performance needs being addressed. See Chapter 1510 for additional pedestrian design requirements and considerations.

Exhibit 1231-5 Cross Sections Featuring Pedestrian Facilities





Notes:

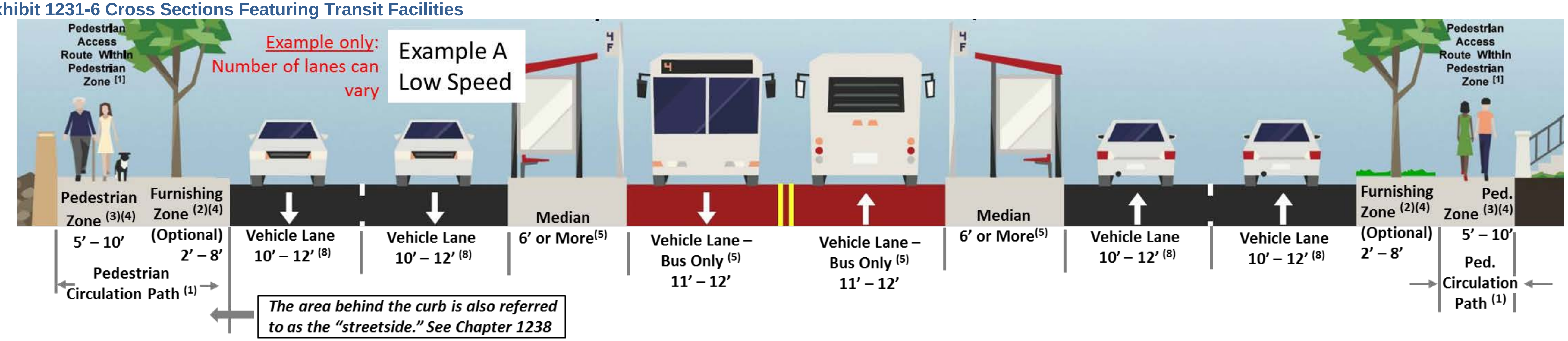
[1] See Chapter 1510.
[2] Minimum width specified is exclusive of curb width.
[3] If no furnishing zone is provided, minimum width is exclusive of the curb width.
[4] See Chapter 1238.
[5] Overall median width and design will vary. See Chapter 1239.
[6] See 1231.04 for guidance on choosing a dimension from the range given.

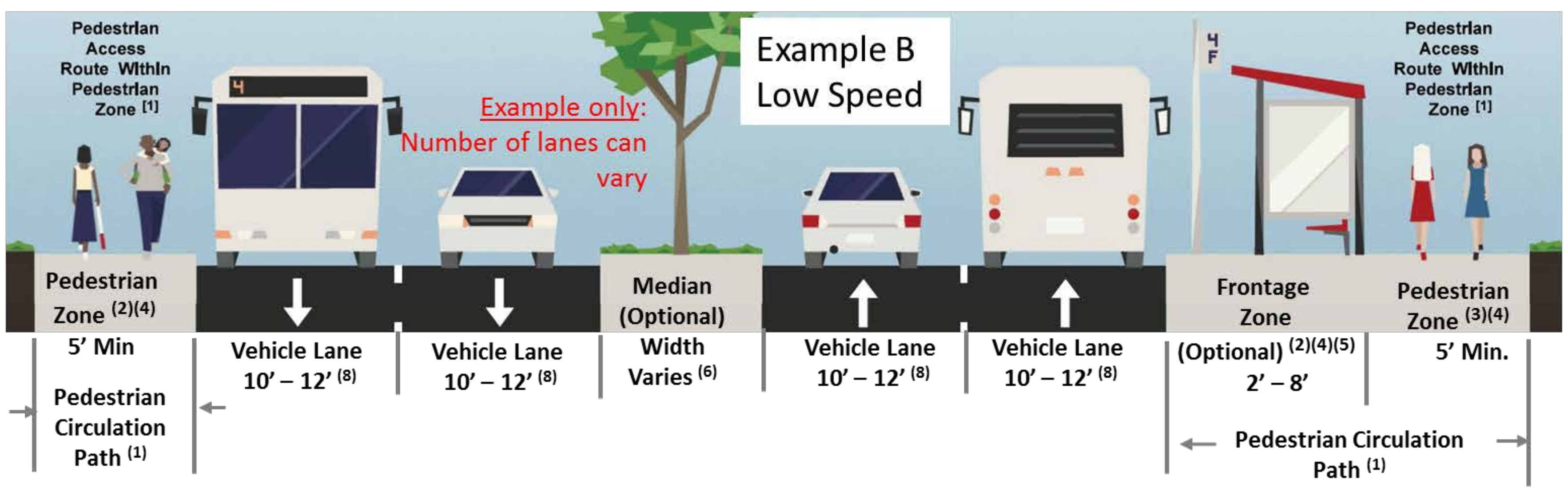
1231.05(4) Cross Sections Featuring Transit Facilities

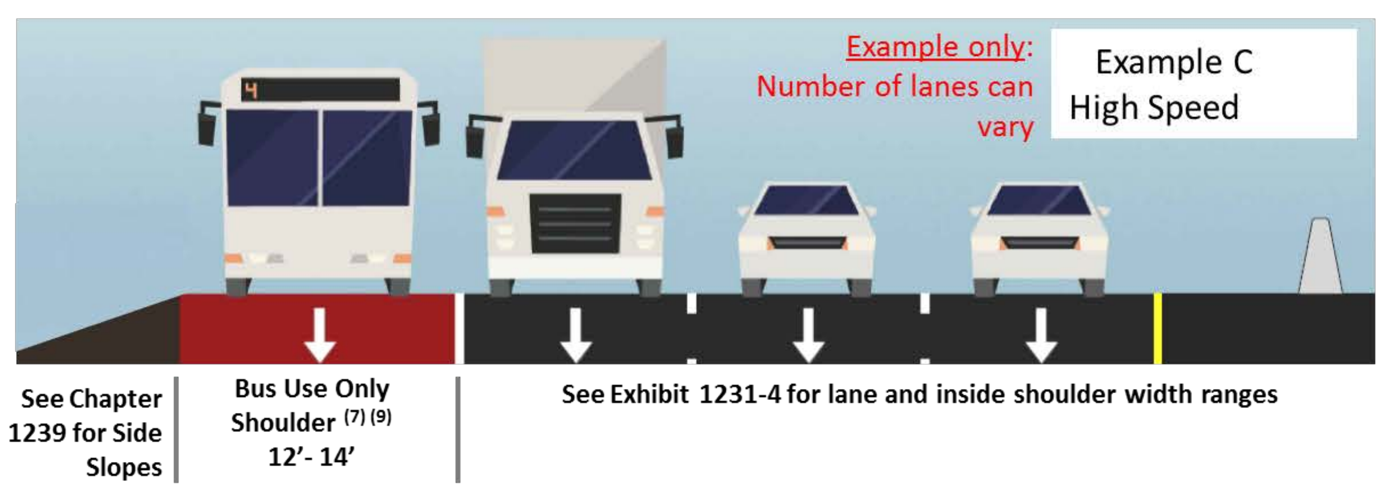
Exhibit 1231-6 provides examples of different potential configurations oriented for the transit mode. Work with the transit provider to determine their ability to operate within a given cross-sectional arrangement. In general, transit configurations can be positioned toward the side or center of a roadway. Both side and center configurations can be implemented with medians or outer separations to improve safety performance for intermodal connections, or mobility performance for the transit service.

Exhibit 1231-6 Example A shows a central configuration for transit service that provides a separated bus-only lane. Other transit vehicle types may require different widths and may also require other center cross section configurations for passenger loading. Exhibit 1231-6 Example B shows a side configuration where transit vehicles occupy the outside lane. This example can also be configured as business access and transit [BAT] lanes. Note the importance of streetside elements to assist with intermodal connections. Exhibit 1231-6 Example C is an example of a type of special use lane for high-speed routes that are routinely congested. In this example, the shoulder allows the restricted use for buses.

Exhibit 1231-6 Cross Sections Featuring Transit Facilities







Notes:

[1] See Chapter 1510.
[2] Minimum width specified is exclusive of the curb width
[3] If no furnishing zone is provided, minimum width is exclusive of the curb width.
[4] See Chapter 1238.
[5] Verify width needs with transit provider, including lift extension needs. See Chapter 1510 for Pedestrian Access Route requirements, which may be affected by presence of a shelter. See Chapter 1430 Transit Facilities.
[6] Median width and design will vary. See Chapter 1239
[7] Verify width needs with transit provider. See Chapter 1239 for bus use only shoulder, requires a Design Analysis.
[8] See 1231.04 for guidance on choosing a dimension from the range given.
[9] See Chapter 1239 for guidance on choosing a dimension from the range given.

1231.05(5) Example Cross-Sections – Complete Streets

Complete street configurations attempt to balance the performance needs of all users, regardless of age, ability, or mode. The general intent is to provide context-appropriate designs that enable safe access for all design users. It is always important to consider modal connectivity and conflicts that may occur with complete street configurations, particularly at intersections and/or transit stop locations.

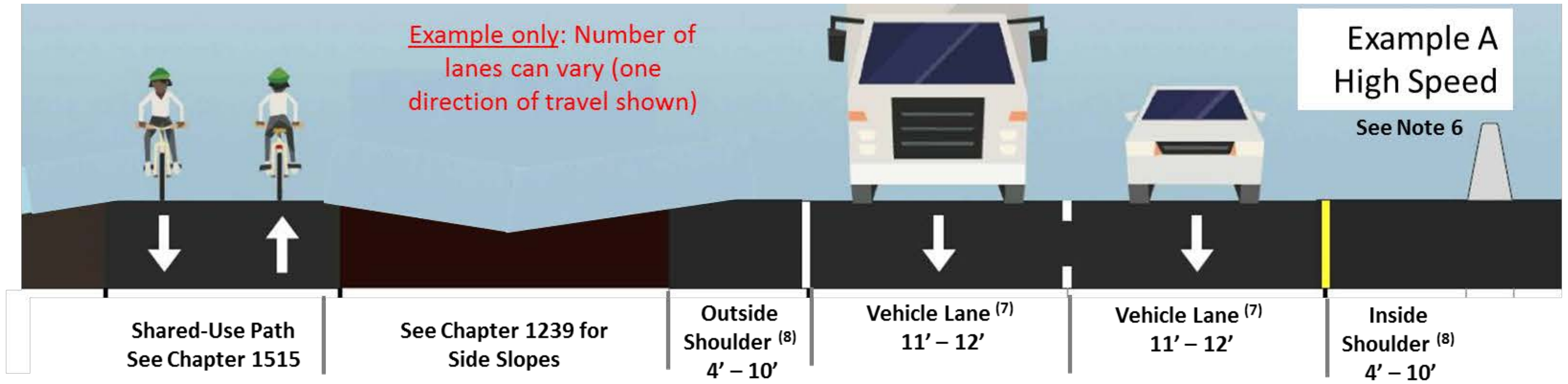
There are different potential configurations for complete streets, such as:

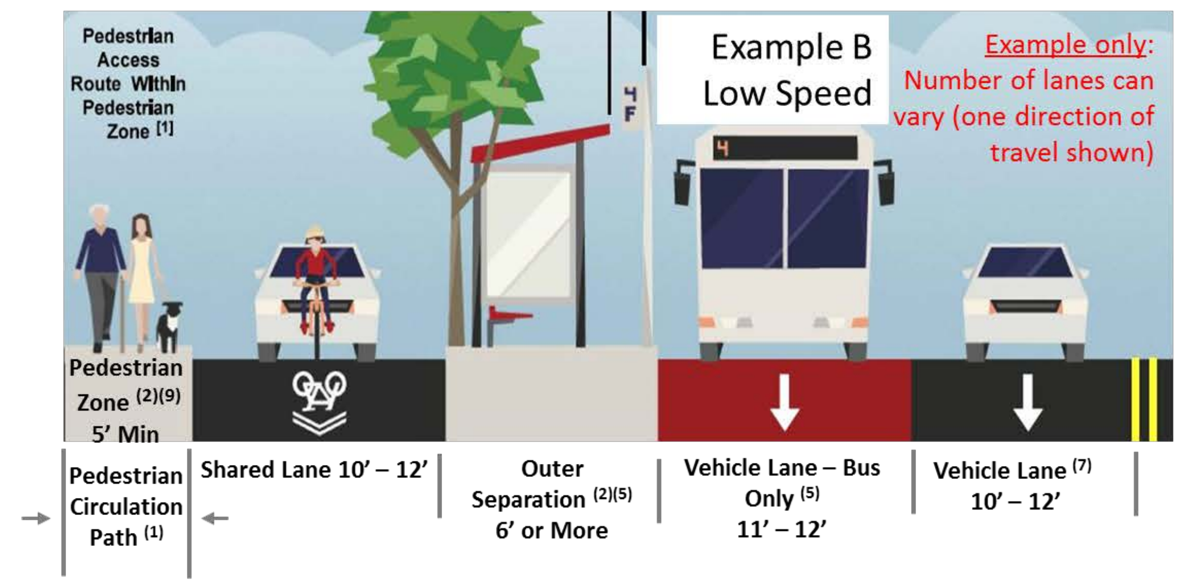
- A rural two-lane highway with wide shoulders; the shoulders can be used by motor vehicles in emergencies and by pedestrians and bicyclists.
- An urban highway or street with vehicle lanes, bike lanes, bus lanes, and sidewalks.
- Retrofitting a highway or street to clearly mark and sign a shared-use lane.
- An urban highway that undergoes a "road diet" (see 1231.06) or installation of additional pedestrian crossings.

The low speed examples in Exhibit 1231-7 illustrate roadway cross sections that:

- Separate access lanes from through traffic lanes using curbed islands.
- Reduce conflicts between pedestrian, bike, transit and auto modes by separating them.
- Provide transit stops integrated with raised islands.
- May result in improved operations for all modes.

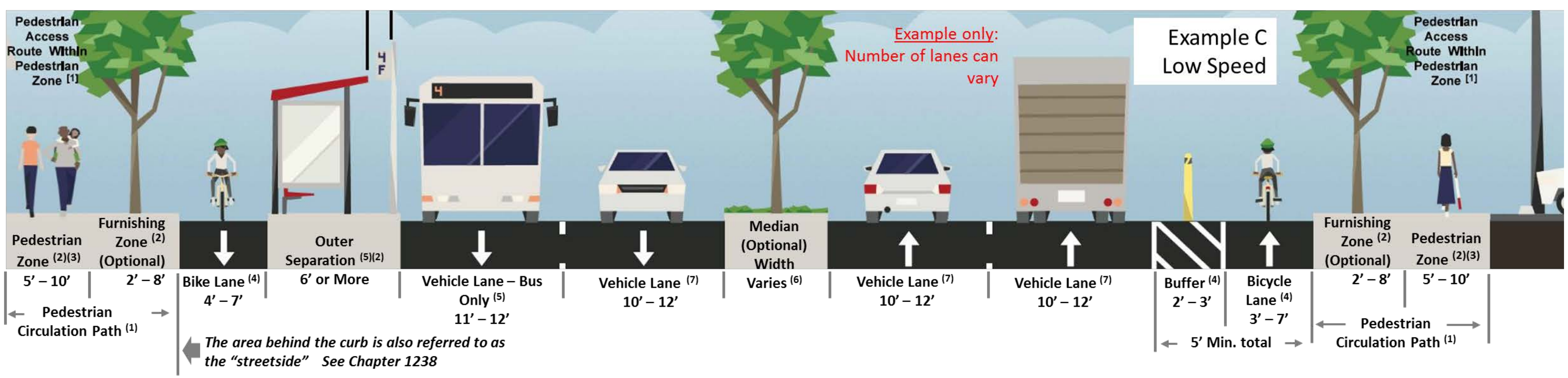
Exhibit 1231-7 Complete Street Cross Sections





Notes:

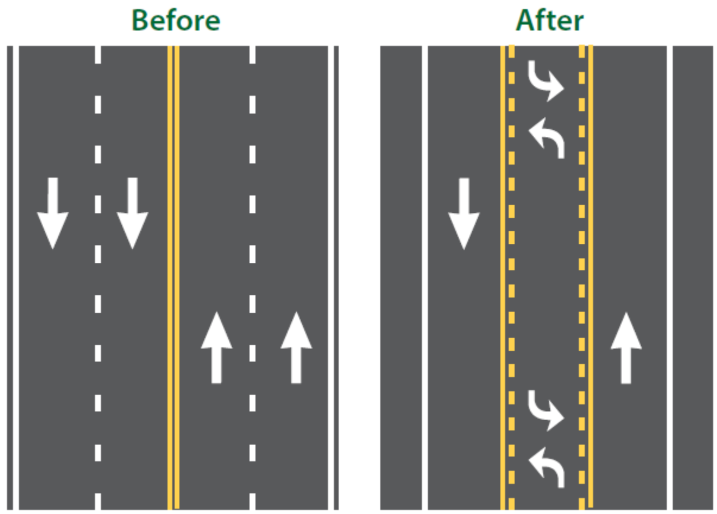
[1] See Chapter 1510.
[2] See Chapter 1238.
[3] If no furnishing zone is provided, minimum width is exclusive of the curb width.
[4] See Chapter 1520 for bike facility options.
[5] Verify width needs with transit provider. See Chapter 1430.
[6] Overall median width and design will vary. See Chapter 1239.
[7] See 1231.04 for guidance on choosing a dimension from the range given.
[8] See Chapter 1239 for guidance on choosing a dimension from the range given.
[9] Minimum width specified is exclusive of the curb width.



1231.06 Road Diets and Retrofit Options

Generally, road diets refer to converting four-lane undivided highways to three lanes with the center lane for left turning movements and the remaining outside space repurposed for bicyclists or other functions. The center lane can consist of a two-way left-turn lane (TWLTL) or can be dedicated for directional left turns either by paint or other median treatments. The choice of how to configure the center lane depends largely on balancing the resulting safety and accessibility performance of different modes and land uses.

The application of road diets also has the benefit of reallocating existing space within a cross section, which provides distinct opportunities to improve roadway bicycle facilities and/or elements of the streetside. At intersections and access points, a road diet can improve sight distance, may improve access management along the road, and in some cases, improve mobility performance for motorists.



Typical Road Diet Basic Design from FHWA Road Diet Informational Guide

The success of road diet implementation varies due to a number of factors such as signal spacing and timing, access connection density, modal priority, and average daily traffic (ADT). ADT is a reasonable indicator for implementation. FHWA recommends limiting road diet applications to roadways of 20,000 ADT or less, although road diets have been successful at locations with 25,000 ADT in various parts of the country (see Chapter 540 for additional restrictions on the use of TWLTLs). Motor vehicle mobility performance is most likely deemed the primary measure of success for the road diet configurations with higher ADT values described. However, locations with a different modal priority and higher ADT may still be candidates for road diets. The Region Traffic Engineer must approve road diet applications on state highways.

Retrofit options refer to the application of lower-cost treatments that utilize paint and other delineation devices rather than hardscape features. See Chapter 1238 for more information on retrofit options such as relocating the curb, parklets and plazas.

1231.07 References

1231.07(1) Design Guidance

Highway Runoff Manual, M 31-16, WSDOT

Local Agency Guidelines (LAG), M 36-63, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction, M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction, M 41-10, WSDOT

1231.07(2) Supporting Information

FHWA Road Diet Informational Guide, FHWA, 2014
www.safety.fhwa.dot.gov/road_diets/info_guide/

Understanding Flexibility in Transportation Design – Washington, WA-RD 638.1, Washington State Department of Transportation, 2005
www.wsdot.wa.gov/research/reports/fullreports/638.1.pdf

Urban Bikeway Design Guide, National Association of City Transportation Officials, New York, NY, 2012 revised 2013
www.nacto.org

Urban Street Design Guide, National Association of City Transportation Officials, New York, NY, 2013
www.nacto.org

Designing Walkable Thoroughfares: A Context Sensitive Approach, Institute of Transportation Engineers, Washington D.C., 2010.
www.ite.org

Guide for Geometric Design of Transit Facilities on Highways and Streets, AASHTO, Washington, D.C., 2011
www.transportation.org/Pages/Default.aspx

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition
www.transportation.org/Pages/Default.aspx

A Policy on Design Standards Interstate System, AASHTO, 2005
www.transportation.org/Pages/Default.aspx

NCHRP Synthesis 443 – Practical Highway Design Solutions, Transportation Research Board, Washington D.C., 2013
http://www.trb.org/Main/Blurbs/168619.aspx

NCHRP Report 785 – Performance-Based Analysis of Geometric Design of Highways and Streets, Transportation Research Board, Washington D.C., 2014
www.trb.org/Main/Blurbs/171431.aspx

NCHRP Report 783 – Evaluation of the 13 Controlling Criteria for Geometric Design, Transportation Research Board, Washington D.C., 2014
www.trb.org/Main/Blurbs/171358.aspx

NCHRP Report 505 – Review of Truck Characteristics as Factors in Roadway Design, Transportation Research Board, Washington D.C., 2003
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_505.pdf

Chapter 1232 Geometric Cross Section – Freeways

If your roadway fits the definition of a freeway, use the guidance in this chapter for geometric cross-section elements. If your roadway is not a freeway, see Chapter 1230.

1232.01 General

Freeways are defined as divided highways with a minimum of two lanes in each direction for the exclusive use of vehicular traffic and with full control of access. Interstate is one type of freeway.

Freeways are high-speed facilities that prioritize through travel for vehicles, freight and transit. Lanes must be wide enough for all vehicles that use them. Shoulders provide very important functions for freeways.

Freeways can be thought of as a unique context. This is reflected by the fact that design controls (Chapter 1103) are fairly consistent for all freeways:

- **Modal priority:** motor vehicles
- **Access control:** full control
- **Design speed:** high

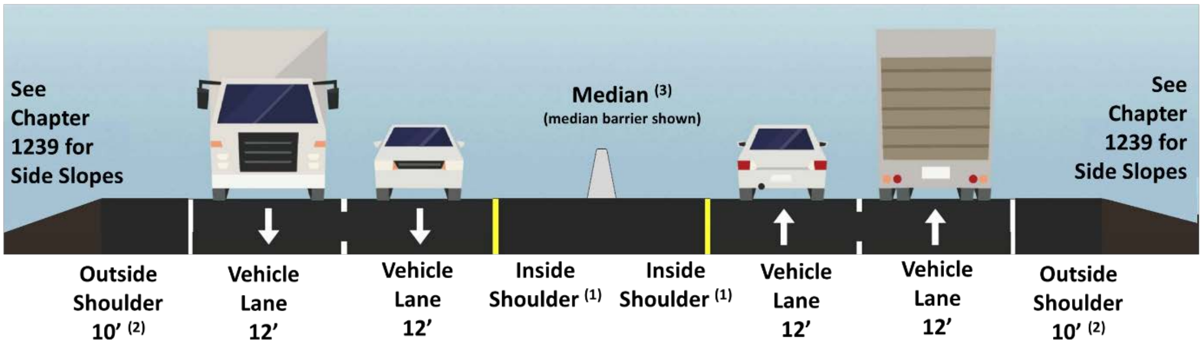
Freeways do not present the challenges of accommodating the competing needs of other modes such as pedestrians. Also, adjacent land use is generally not an issue due to freeways being limited access facilities. For these reasons, choosing cross-sectional element dimensions for freeways does not have as many complexities as for some other roadway types.

Note that there are locations where bicyclists are allowed use of the freeway shoulder.

The geometric cross-section for interstate freeways is shown in Exhibit 1232-1. The geometric cross-section for non-interstate freeways is shown in Exhibit 1232-2.

Refer to the *Design Manual* Glossary for terms used in this chapter. Refer to Chapter 300 for design documentation requirements.

Exhibit 1232-1 Geometric Cross Section - Interstate (4 lanes shown, can vary)



Notes:

See Chapter 1410 for HOV lane guidance.

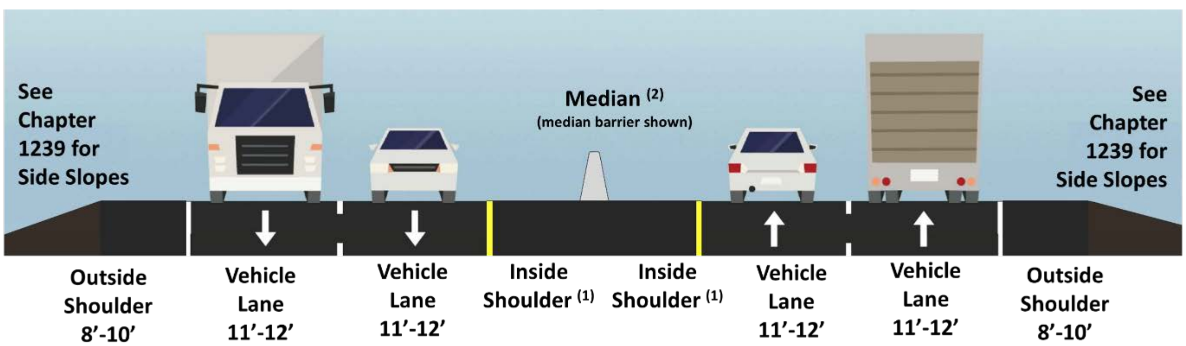
Use of the shoulder on a freeway for transit only use or as an HOV lane requires a Design Analysis.

[1] 4 ft minimum on facilities up to 4 lanes, and 10 ft minimum on 6-lane facilities.
In mountainous terrain, inside shoulder may be reduced to 4 ft on facilities up to 6 lanes.

[2] In mountainous terrain, outside shoulders may be reduced to 8 ft on facilities up to 6 lanes.

[3] Overall median width and design will vary. See Chapter 1239 and 1610.

Exhibit 1232-2 Geometric Cross Section – Non-Interstate (4 lanes shown, can vary)



Notes:

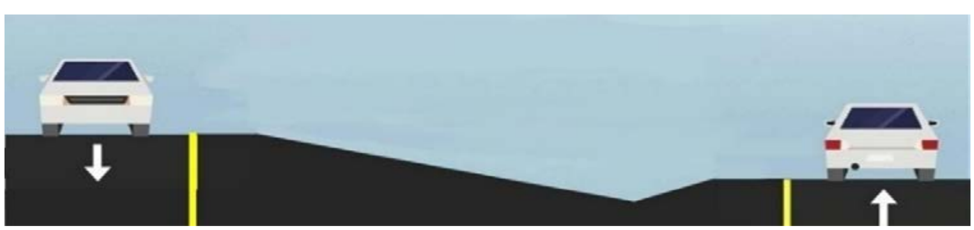
See Chapter 1410 for HOV lane guidance.

Use of the shoulder on a freeway for transit only use or as an HOV lane requires a Design Analysis.

[1] 4 ft minimum on facilities up to 4 lanes, and 8 ft minimum on 6-lane facilities.
In mountainous terrain, inside shoulder may be reduced to 4 ft on facilities up to 6 lanes

[2] Overall median width and design will vary. See Chapter 1239 and 1610.

Exhibit 1232-3 Median Section without Median Barrier



1232.02 Lane Width

For freeways, travel-through mobility and safety for motor vehicles are prioritized performance areas. Lanes must be wide enough for all vehicles that use them to travel safely at high speeds. When a range is given for lane width, use the mode/function/performance approach described in Chapter 1106 and "design up" to choose a width within the range. See Chapter 1231 for considerations for choosing a lane width.

1232.03 Shoulder Width

The prioritization of travel-through mobility and safety for motor vehicles results in placing a high priority on providing some important shoulder functions (see Chapter 1239) for freeways:

- Stopping out of traffic
- Emergency services & incidence response
- Maintenance operations

The high-speed nature of freeways reinforces the importance of providing these functions. For instance, the high speed differential between a stopped vehicle and adjacent traffic leads to a greater need to get stopped traffic out of the travelled way. Also, the limited access nature of freeways generally means that there are fewer access points to provide potential refuge.

When a range is given for shoulder width, use the mode/function/performance approach described in Chapter 1106 and "design up" to choose a width within the range. See Chapter 1239 for additional considerations for choosing a shoulder width.

1232.04 Other Elements

See the following chapters for guidance related to these other common geometric cross section elements:

- Side slopes, medians & curbs — Chapter 1239
- Lateral clearance — Chapter 1239
- Cross slope and superelevation — Chapter 1250

1232.05 Design Flexibility

There are always locations that warrant special consideration. Existing freeways may have constraints (right-of-way or environmental considerations, for example) that make the cost of widening outweigh the benefits. The optimum solution may include widths different than those shown.

If this is the case for your project, and you choose widths different than shown in the Design Manual, formulate alternative solutions that consider the tradeoffs associated with various lane and shoulder widths and document the decision in a Design Analysis. Where appropriate, include documentation of your consultation with the project advisory team (see Chapter 1100) in the Design Analysis. When compiling the Design Analysis, consider recent design resources that explore options, performance, functions, and mitigation associated with various lane and shoulder dimensions. One source is FHWA HOP-16-060 "Use of Narrow Lanes and Narrow Shoulders on Freeways." Another source is NCHRP 15-47, "Developing an Improved Highway Geometric Design Process".

1232.06 References

1232.06(1) Design Guidance

Highway Runoff Manual, M 31-16, WSDOT

Local Agency Guidelines (LAG), M 36-63, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction, M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction, M 41-10, WSDOT

1232.06(2) Supporting Information

Understanding Flexibility in Transportation Design – Washington, WA-RD 638.1, Washington State Department of Transportation, 2005
🖱 www.wsdot.wa.gov/research/reports/fullreports/638.1.pdf

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition
🖱 www.transportation.org/Pages/Default.aspx

Chapter 1238 Geometric Cross Section – Streetside and Parking

1238.01 General

The geometric cross section of a roadway is composed of different elements. The cross sections shown in Chapter 1231 include parking and various zones within the streetside (see Exhibit 1238-1). This chapter provides information on parking and streetside elements. The need to provide a particular element is dependent on the context and modal needs for a given section of roadway.

1238.02 Parking

On-street parking is typically provided in urban and rural town center areas, but is not necessarily required. On-street parking can help visually narrow the street in places to assist in conveying the surrounding context for the segment. Refer to municipal codes regarding parking requirements, and coordinate with the municipality involved. Also, if on-street parking will be either delineated or metered, the ADA has requirements on the number and configuration of parking stalls for people with disabilities. Consult with a regional ADA subject matter expert.

On-street parking can be either parallel or angled. However, angled parking on any state route requires approval from the State Traffic Engineer.

Submit a request for angled parking approval through the region Traffic Office. Include an engineering study documenting that the parking will not unduly reduce safety and that the roadway is of sufficient width that parking will not interfere with the normal movement of traffic.

Provide for vehicle overhang within the furnishing zone for all angled parking locations. Consider back-in angled parking if bike lanes are present to improve conflict management through increased visibility.

When designing parking locations for freight loading areas, it is important to consider both the delivery vehicle size and how the vehicle loading/unloading is done. Consult with business owners and freight carriers to locate and configure the freight loading areas.

Width considerations: Cross sections in the Design Manual generally show a range for parallel parking of 7 to 9 feet. AASHTO defines a passenger car width as 7 feet. Additional width can allow a buffer for car doors opening, a buffer for bike riders, or a stall that can accommodate delivery trucks.

Work with stakeholders to determine the appropriate width to provide within the site-specific constraints.

1238.03 Streetside

The area behind the curb is referred to as the "streetside" and is described in terms of "zones." Information about each zone is provided below. Note, local agency partners may have policy containing additional streetside zones to consider.

WSDOT uses the following terminology to describe the zones found within the streetside:

- Frontage Zone
- Pedestrian Zone
- Furnishing Zone

Exhibit 1238-01 Zones within the Streetside

The streetside is the interface between pedestrians and land use. A robust streetside can serve as both a pedestrian thoroughfare and a destination, which is desirable in many urban core and main street contexts to help promote economic vitality. The streetside can also reinforce the target speed. The pedestrian zone will always be present in streetside design, but other zones are optional and dependent on the modal and contextual needs and desired balance of performance needs within the available right of way.

The Americans with Disabilities Act (ADA) requires specific design element dimensions for streetside elements, depending on the configuration. In general, the pedestrian zone and frontage zone will always be part of the pedestrian circulation path (PCP). The furnishing zone may or may not be part of the PCP, depending on how it is designed. See Chapter 1510 for detailed accessibility criteria and design guidance for pedestrian facilities.

1238.03(1) Frontage Zone

The frontage zone serves the retail functions, and is the portion of the sidewalk that provides the connection to the building. The frontage zone includes the building, the façade, and the space immediately adjacent to the building. The primary purpose is access to retail space without interfering with the required pedestrian access route (PAR) within the pedestrian zone. The frontage zone may also provide space for sidewalk cafes, temporary retail product displays, advertisements, and/or outdoor seating for customers. If there is no retail or residential access need adjacent to the streetside, a frontage zone may not be necessary.

Width considerations: Cross sections in Design Manual generally show a range for the frontage zone width of 2 to 12 feet.

Narrow, 2-ft frontage zones provide for a clear area where protruding objects from the building can be located without compromising the pedestrian access route. Two feet also provides an offset from the building and minimal space for entering/exiting the building.

Wider frontage zones, such as 12-ft can provide width for a variety of possible elements, such as sidewalk café dining with tables and chairs along the building. If a frontage zone is to be provided, work with stakeholders to determine the appropriate width to provide within the site-specific constraints.

1238.03(2) Pedestrian Zone

The pedestrian zone is the space available to accommodate pedestrian travel that will:

- Create interconnectivity between different land uses
- Provide for the transfer between modes
- Separate pedestrians from vehicular traffic
- Support walking as a transportation mode

The pedestrian zone is located within the Pedestrian Circulation Path and includes the Pedestrian Access Route (PAR) needed to meet ADA accessibility criteria (see Chapter 1510). The pedestrian zone may be considerably wider than the PAR.

A generous pedestrian zone width promotes the mobility and accessibility typically anticipated within some urban and suburban contexts.

Consider wider pedestrian zones when the following are present:

- Transit facilities and passenger shelters
- Access routes to businesses
- School walking routes
- Other high pedestrian activity generators

Width considerations: The minimum pedestrian zone width of 5 feet corresponds to WSDOT’s minimum sidewalk width (see Chapter 1510). Other considerations when choosing a pedestrian zone width include:

- In many downtown environments, the focus is on multimodal transportation and, in particular, pedestrian accessibility and use. Wider streetside zones promote a greater sense of safety, and can provide a comfortable and inviting area that can attract pedestrians.

- In urban/downtown environments where store fronts/businesses are located, a larger width is recommended. Consider providing wider sidewalks to increase pedestrian comfort levels and to promote walking.
- In places with higher pedestrian volumes, a 10 foot width allows for pedestrians walking side-by-side or in groups to pass others comfortably without changing directions or walking speed.
- A 10 foot width provides sufficient width for a wheelchair user to turn around and to pass another wheelchair user (5 foot width is typically adequate to perform these maneuvers).
- The minimum sidewalk width of 5 feet is appropriate in low pedestrian volume areas, such as where there are few stores abutting the street or in residential neighborhoods.

Work with stakeholders to determine the appropriate width to provide within site-specific constraints.

1238.03(3) Furnishing Zone

The furnishing zone is the key buffer component between the active pedestrian walking area (pedestrian zone) and the roadway. The furnishing zone provides area for multiple functions. The furnishing zone is not located within the Pedestrian Access Route (PAR). However, a PAR connection is required to many features that may be found in this zone (such as street furniture, parking meters, transit shelters, and transit boarding areas.)

The Furnishing zone:

- Promotes environmental and aesthetic features that improve people's experience
- Contains street trees, street furniture, benches, planter boxes, and artwork
- Provides for the travel of the various modes through modal segregation or clearance to obstructions
- Discourages crossings at less desirable locations along the facility with use of buffers.

Traffic signs and signal cabinets; utility poles; fire hydrants; parking meters; transit boarding, queuing, and shelters; and bike racks are also generally found within the furnishing zone.

Involve the local agency, regional Landscape Architect, and safety professionals to determine optimal vegetation types.

Other width accommodations for on-street parking may be needed for vehicle overhang or entering/exiting movements when parking is present.

Coordinate with region Program Management to understand potential funding limitations for furnishing zone features described within this section. Partnerships or grants may be necessary to complete all desired features within the furnishing zone.

Width considerations: A width of 2 feet provides the minimum width to accommodate utilities and street furniture. Greater widths accommodate a larger variety of possible features within the furnishing zone. Other considerations when choosing a furnishing zone width include:

- An 8-foot width or greater generally provides sufficient space to accommodate a bus transit stop (loading/unloading) and a transit shelter (see Chapter 1430 and work with the transit provider to determine needed space.)
- In commercial areas, a minimum furnishing zone width of 4 feet is recommended.
- In areas where snow accumulation can occur, the furnishing zone can provide snow storage space that does not decrease the width of the pedestrian zone.
- When higher vehicle speeds are present, providing a larger width to act as a buffer between vehicles and pedestrians is desirable.

If a furnishing zone is to be provided, work with stakeholders to determine the appropriate width to provide in order to accommodate the expected features within the site-specific constraints.

1238.04 Retrofit Options

Retrofit options refer to the application of lower-cost treatments that utilize paint and other delineation devices rather than hardscape features. Retrofit applications are particularly useful when:

- Construction will occur in phases over a timeline greater than one year between phases where overlapping areas of work occur, or when elements or features are funded by a partnering agency.
- Implementing speed management treatments (see Chapter 1103) that, after evaluating their effectiveness, may need to be reconfigured.
- Funding is unable to adequately accomplish the identified scope of work.

Applied retrofit options may require additional maintenance over long-duration applications. Coordination with maintenance jurisdictions as described in Chapter 301 is critical to evaluating the potential maintenance outcomes for retrofit options being considered. The retrofit options discussed within the following subsections are more likely to be applied in urban context settings. Note that cities over 25,000 population will have the responsibility of maintaining any retrofit delineation, and it will be critical to ensure they have the resources to maintain striped retrofit features.

The following subsections describe several common applications of retrofit options.

1238.04(1) Relocate Curbs

Changes to the geometric cross section may involve relocating the existing curb. While installing a new curb may be preferred, there are a number of additional considerations (like stormwater conveyance) that make relocating curb lines cost-prohibitive. However, there are multiple retrofit solutions that can provide effective accommodation including, but not limited to:

- Striping combined with MUTCD-approved channelization devices.
- Curb extensions offset from the original curb. Depending on the use of the new curbed section, retrofit designs may include slotted grates tying the existing curb and new curb together while maintaining the original stormwater conveyance system.
- Colorized pavement to delineate a change of use.

Use retrofit features as a low-cost solution to create wider sidewalk areas, curb extensions, bicycle parking areas, parklet areas, and/or green street low-impact development solutions.

Note that retrofits like this must comply with the accessibility criteria for pedestrian facilities in Chapter 1510.

"Moving the Curb" Photo courtesy of NACTO.org

1238.04(2) Parklets and Plazas

Parklets and plazas reuse existing right of way in urban and rural town centers, providing public space to support the economic vitality and social livability performance of a particular context. As geometric cross sections are reconfigured, spaces may become available at intersections or for repurposing a parking area into either plazas or parklets. The primary intent of presenting these treatments is for low-speed roadways or main streets with volumes at or below 20,000 ADT. However, there are many potential constraints external to the engineering design that may need resolution before application. Consult with Real Estate Services to discuss the specific property management-related concerns and any potential lease and/or economic payment considerations proportionally appropriate for utilization of the highway space in this manner, as further detailed in RCW 47.24.020(15).

A parklet specifically uses the area usually used for parking to create a space for pedestrians. A common application provides seating accommodations to support local restaurants and shops.

Parklet designs will vary depending on local jurisdiction regulations, but they typically include railing and/or planter boxes to provide a separation of uses between people and traffic. Parklet design should not cover catch basins or other features that may require frequent maintenance. Parklets interact with motorized vehicle traffic best when placed on tangent alignments.

Plazas can reuse right of way to define a relatively large common public space. Plazas are typically associated with a central gathering location for special events, and will likely have limited application on Washington state highways.

1238.05 References

1238.05(1) Design Guidance

Highway Runoff Manual, M 31-16, WSDOT

Local Agency Guidelines (LAG), M 36-63, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction, M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction, M 41-10, WSDOT

1238.05(2) Supporting Information

Understanding Flexibility in Transportation Design – Washington, WA-RD 638.1, Washington State Department of Transportation, 2005
www.wsdot.wa.gov/research/reports/fullreports/638.1.pdf

Urban Street Design Guide, National Association of City Transportation Officials, New York, NY, 2013
www.nacto.org

Urban Street Stormwater Guide, National Association of City Transportation Officials, New York, NY, 2017
www.nacto.org

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition
www.transportation.org/Pages/Default.aspx

Chapter 1239 Geometric Cross Section – Shoulders, Side Slopes, Curbs, and Medians

1239.01 Introduction

This chapter provides information on geometric cross section components that are common to many facility types. Cross section elements include: shoulders, medians and outer separations, side slopes, and curbing.

Refer to the *Design Manual* Glossary for many of the terms used in this chapter. Refer to Chapter 300 for design documentation requirements.

1239.02 Shoulders

Shoulders are typically used on high or intermediate speed limited and non-limited access facilities, some rural contexts, as well as intermediate-speed locations that do not have streetsides (curb-sections) (see Chapter 1238). Intermediate-speed locations in suburban and urban contexts that utilize streetsides do not need to include a shoulder unless determined to be necessary by safety performance analysis, hydraulic analysis or engineering judgment.

Shoulders provide space to escape potential collisions or reduce their severity. They also provide a sense of openness, contributing to driver ease at higher speeds. Shoulders also reduce seepage adjacent to the traveled way by discharging stormwater farther away.

1239.02(1) Shoulder Width

Shoulder width ranges for highways are shown in Exhibit 1239-1. Use the mode/function/performance approach (Chapter 1106) to choose a dimension from the range given.

Exhibit 1239-1 Shoulder Widths for Highways

Highway Speed	Highway Type	Shoulder Width [1] [2]	
		Inside	Outside
High speed	Freeway (including Interstate)	See Chapter 1232	
	Other highway	4' – 10'	4' – 10'
Intermediate speed	All	4' – 8'	4' – 8'
Low speed	All	0' – 8' [2]	2' – 8'

Notes:

[1] Bus use only shoulder width range is 12-ft to 14-ft.

[2] If curb or barrier present, see Exhibit 1239-9.

1239.02(1)(a) Shoulder Width Considerations

Exhibit 1239-2 lists considerations for choosing an appropriate shoulder width from the range given. The considerations listed help one to understand the modal needs and function associated with different shoulder widths.

Contact the Area Maintenance Superintendent to determine the shoulder width appropriate for maintenance operations. In some cases, a continuous width is not necessary; instead, the focus is placing the shoulder width near assets with high-frequency maintenance needs. Compare the added cost of the wider shoulders to the added benefits to maintenance operations as well as other benefits that may be derived (see Chapter 301).

The usable shoulder is the width necessary to provide the desired function (see Exhibit 1239-2). Usable shoulder width is less than the constructed shoulder width when vertical features (such as traffic barrier or walls) are at the edge of the shoulder. This is because drivers tend to shy away from the vertical feature. For widening for traffic barrier, see Chapter 1610. For requirements for lateral clearance to barrier or curb, see 1239.06.

Shoulder widths greater than 10 feet may encourage use as a travel lane. Therefore, use shoulders wider than 10 feet only to meet one of the listed functions (see Exhibit 1239-2).

When walls are placed adjacent to shoulders, see Chapters 730 and 740 for barrier guidance.

Exhibit 1239-2 Shoulder Function & Modal Accommodation Width Considerations

Shoulder Function	Shoulder Width Guidance [7]
Stopping out of the traffic lanes	8 ft – 12 ft [1]
Minimum lateral clearance to curb or barrier	See 1239.06
Hard shoulder running	11 ft to 14 ft [2]
Bicycle use	4 ft [3]
Pedestrian use	4 ft [3]
Large-vehicle off-tracking on curves	Use turn simulation software to determine shoulder needs
U-turn turnouts	Varies – See Chapter 1310
Maintenance operations	Varies [4] [5]
Law enforcement, emergency services & incident response	8 ft [5]
Transit stops	See Chapter 1430
Slow-vehicle turnouts and shoulder driving	See Chapter 1270
Ramp meter storage	8 – 12 ft [1]
HOV bypass	10 – 14 ft [6]
Ferry holding	8 ft – 12 ft [1]
For use as a lane during reconstruction of the through lanes	8 ft – 12 ft [1]
Structural support of pavement	2 ft
Improve sight distance in cut sections	See Chapter 1260

Notes:

[1] 10 foot minimum recommended for freight or transit vehicles.

[2] For bus use only shoulder, the range is 12 ft to 14 ft and the selected width should be determined with transit provider. For lateral clearance requirements see 1239.06.

[3] Minimum shoulder function width for bicycles. Additional width is recommended when combined with shoulder rumble strips, curb, or barrier (see Chapter 1600 and the *Standard Plans*). For guidance, see Chapter 1520 for accommodating bicycles and Chapter 1510 for accommodating pedestrians.

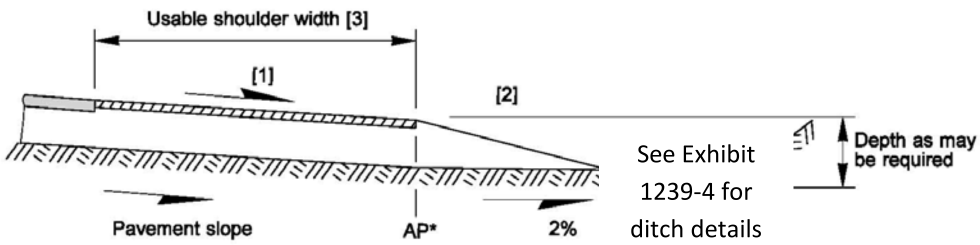
[4] 10 foot usable width to park a maintenance truck out of the through lane; 14 foot width for equipment with outriggers to work out of traffic.

[5] For additional information, see Chapters 1370, 1410 and 1720.

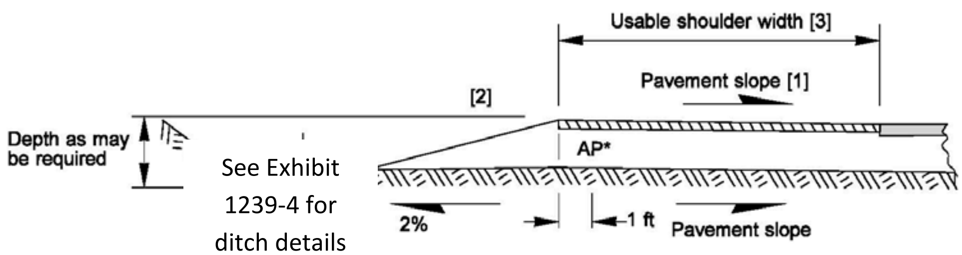
[6] Determine width with transit provider, and see 1239.06 for lateral clearance requirements.

[7] Presence of barrier or curb may require additional width. Use auto turn studies for non-tangent alignments.

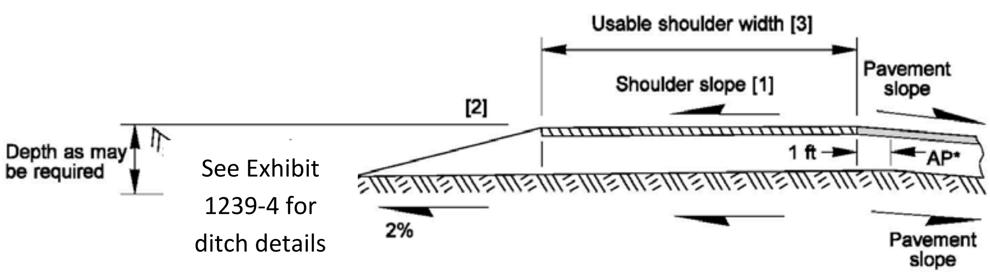
Exhibit 1239-3 Shoulder Details



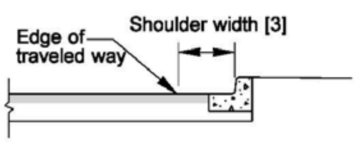
Shoulder Design on the Low Side of the Roadway for Cross Slopes Greater Than 2%



Shoulder Design on the High Side of the Roadway on Curves and Divided Roadways Shoulder Slopes With Roadway



Shoulder Design on the High Side of the Roadway on Curves and Divided Roadways Shoulder Slopes Away From Roadway



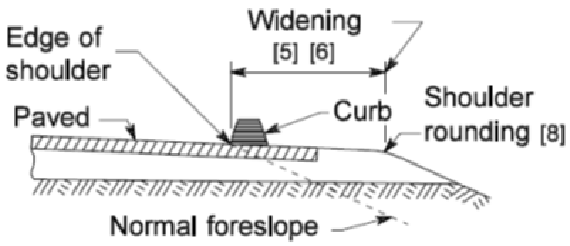
Shoulder Design with Curb [4] [5]

*AP = Angle point in the subgrade

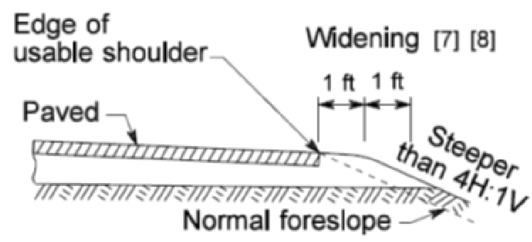
Notes:

- The top three drawings illustrate angle points in subgrade to drain stormwater away from the roadbed.
- For applicable numbered notes, see next page.

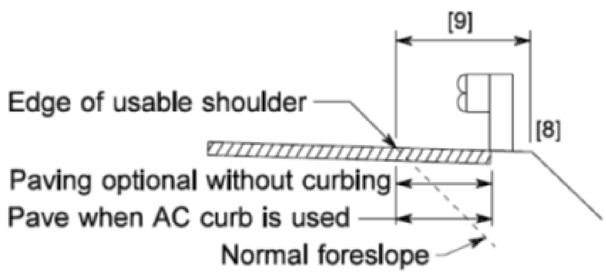
Exhibit 1239-3 Shoulder Details (continued)



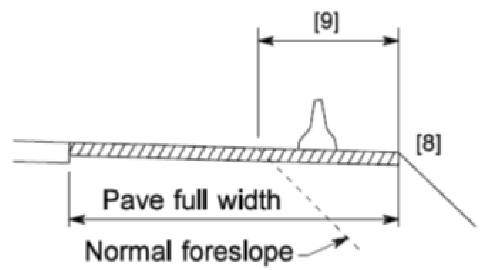
Asphalt Concrete Curb Placement



Shoulder Rounding [2]



Shoulder Widening for Guardrail



Shoulder Widening for Barrier

Notes:

[1] Shoulder cross slopes are normally the same as the cross slopes for adjacent lanes. (For examples and additional information for locations where it may be desirable to have a shoulder cross slope different than the adjacent lane, see Chapter 1250).

[2] Provide widening and slope rounding outside the usable shoulder when foreslope is steeper than 4H:1V.

[3] For shoulder width guidance, see Exhibit 1239-1.

[4] For additional requirements for sidewalks, see Chapter 1510.

[5] See 1239.05 for curb design guidance.

[6] Provide paved shoulders wherever extruded curb is placed. (See the *Standard Plans* for additional details and dimensions.)

[7] When rounding is provided, consider uniform application on all ramps and crossroads, as well as the main roadway. End rounding on the crossroad just beyond the ramp terminals and at a similar location where only a grade separation is involved.

[8] When widening beyond the edge of usable shoulder for curb or barrier, additional widening for slope rounding may be omitted.

[9] For widening guidelines for guardrail and concrete barrier, see Chapter 1610.

General:

On divided multilane highways, see Exhibits 1239-12a through 1239-12c for additional details for median shoulders.

1239.03 Side Slopes and Ditches

The design for side slopes can affect shoulder design, clear zone requirements, and whether or not traffic barrier is necessary. Side slopes are more commonly encountered in high-speed and/or rural contexts. After the foreslope has been determined, use the guidance in Chapter 1600 to determine the need for a traffic barrier.

When designing side slopes, attempt to fit the slope selected for any cut or fill into the existing terrain to give a smooth transitional blend from the construction to the existing landscape when practicable. Flatter slopes are desirable, especially with higher posted speeds and when the associated cost does not significantly exceed other design options. Side slopes not steeper than 4H:1V, with smooth transitions where the slope changes, will provide a reasonable opportunity to recover control of an errant vehicle. Side slopes designed to 4H:1V or flatter are preferred. Provide widening and slope rounding outside the usable shoulder when foreslope is steeper than 4H:1V. Do not disturb existing stable cut slopes just to meet the 4H:1V side slope preference. When an existing slope is to be revised, document the reason for the change in the BOD.

3H:1V side slopes are traversable, but not necessarily recoverable. If providing 3H:1V slopes, consider placement of a flat area extending from the toe of the slope for errant vehicle recovery (see Chapter 1600). Where mowing is contemplated, provide slopes not steeper than 3H:1V to allow for mowing. If there will be continuous traffic barrier on a fill slope, and mowing is not contemplated, the slope may be steeper than 3H:1V. When providing side slopes steeper than 3H:1V, document the reason for the decision.

Where unusual geological features or soil conditions exist, treatment of the slopes depends upon results of a review of the location by the Region Materials Engineer (RME).

Do not install traffic barrier unless an object or condition is present that calls for mitigation in accordance with Chapter 1600 criteria. Unmitigated critical slopes will require a Design Analysis. The steepest slope allowed is determined by the soil conditions. Where favorable soil conditions exist, higher fill slopes may be as steep as 1½H:1V. (See Chapter 1600 for clear zone and barrier criteria.)

If borrow is necessary, consider obtaining it by flattening cut slopes uniformly on one or both sides of the highway. Where considering wasting excess material on an existing side slope, consult the RME to verify that the foundation soil will support the additional material.

Provide for drainage from the roadway surface and drainage in ditches (see Chapter 800). For drainage ditches, see 1239.03(1). At locations where vegetated filter areas or detention facilities will be established to improve highway runoff water quality, provide appropriate slope, space, and soil conditions for that purpose. (See the *Highway Runoff Manual* for design criteria and additional guidance.)

Except under guardrail installations, it is desirable to plant and establish low-growing vegetation on non-paved roadsides. This type of treatment relies on the placement of a lift of compost or topsoil over base course material in the roadway cross section. Consult with the area Maintenance Superintendent and the region or HQ Landscape Architect to determine the appropriate configuration of the roadway cross section and soil and plant specifications.

Flatten crossroad and road approach foreslopes to 6H:1V where feasible, and consider at least to 4H:1V. Provide smooth transitions between the main line foreslopes and the crossroad or road approach foreslopes. Where possible, move the crossroad or road approach drainage away from the main line. This can locate the pipe outside the Design Clear Zone and reduce the length of pipe.

Provide slope treatment as shown in the *Standard Plans* at the top of roadway cut slopes except for cuts in solid rock. Unless Class B slope treatment is called for, Class A slope treatment is used. Call for Class B slope treatment where space is limited, such as where right of way is restricted.

1239.03(1) Drainage Ditches

Exhibit 1239-4 provides general information regarding drainage ditch design. The preferred cross section of a ditch is trapezoidal as shown. A 'V' ditch can be used where constraints, such as limited right of way or sensitive areas, preclude a trapezoidal ditch. Ensure hydraulic design requirements are met.

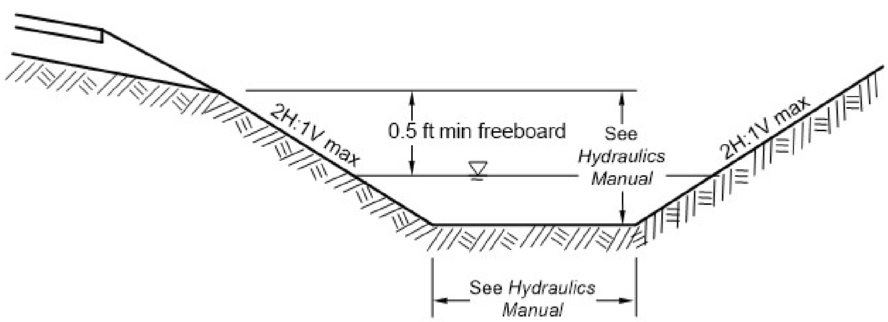
Where a drainage ditch is located adjacent to the toe of a side slope, consider the stability of the foreslope and backslope. A drainage ditch placed immediately adjacent to the toe of side slopes has the effect of increasing the height of the side slope by the depth of the ditch. In cases where the foundation soil is weak, the extra height could result in a side slope failure. As a general rule, the weaker the foundation and the higher the side slopes, the farther the ditch should be from the toe of slope. Consult the Region Materials Engineer for the proper ditch location.

When topographic restrictions exist, consider an enclosed drainage system with appropriate inlets and outlets.

Maintenance operations are also facilitated by adequate width between the toe of the slope and an adjacent drainage ditch. Where this type of facility is anticipated, provide sufficient right of way for access to the facility and place the drainage ditch near the right of way line.

Exhibit 1239-4 Drainage Ditch Details

Corrected here per Technical Errata 10-04-17



Notes:

- Freeboard is the vertical distance from the bottom of base course to the 10-year storm water surface (see the *Hydraulics Manual* for more information.)
- Coordinate ditch design with region Hydraulics
- See other sections of this chapter for shoulder and side slope details.

1239.03(2) Bridge End Slopes

Bridge end slopes are determined by several factors, including context, fill height, depth of cut, soil stability, and horizontal and vertical alignment. Coordinate bridge end slope treatment with the HQ Bridge and Structures Office (see Chapter 720). Whenever possible, design to avoid creating environments that might be desirable to the homeless, both for their safety and the safety of maintenance staff.

Early in the bridge plan development, determine preliminary bridge geometrics, end slope rates, and toe of slope treatments. Exhibit 1239-5a provides guidelines for use of slope rates and toe of slope treatments for overcrossings. Exhibit 1239-5b shows toe of slope treatments to be used on the various toe conditions.

Exhibit 1239-5a Bridge End Slopes

Bridge End Condition	Toe of Slope End Slope Rate		Lower Roadway Treatment [1]		Slope Rate
End Piers on Fill	Height	Rate	Posted speed of lower roadway	Treatment	
	≤ 35 ft > 35 ft	1¾H:1V 2H:1V [2]	> 50 mph ≤ 50 mph	Rounding No rounding	
End Piers in Cut	Match lower roadway slope [3]		No rounding, toe at centerline of the lower roadway ditch.		[4]
Lower Roadway in Cut	Match lower roadway slope [3]		No rounding, toe at centerline of the lower roadway ditch.		[4]
Ends in Partial Cut and Fill	When the cut depth is > 5 ft and length is > 100 ft, match cut slope of the lower roadway		When the cut depth is > 5 ft and length is > 100 ft, no rounding, toe at centerline of the lower roadway ditch		[4]
	When the cut depth is ≤ 5 ft or the length is ≤ 100 ft, it is designer's choice		When the cut depth is ≤ 5 ft or the length is ≤ 100 ft, it is designer's choice		[4]

Notes:

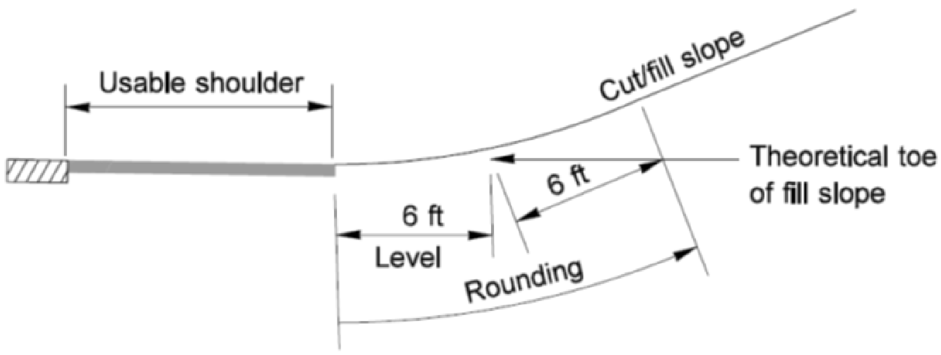
[1] See Exhibit 1239-5b.

[2] Slope may be 1¾H:1V in special cases.

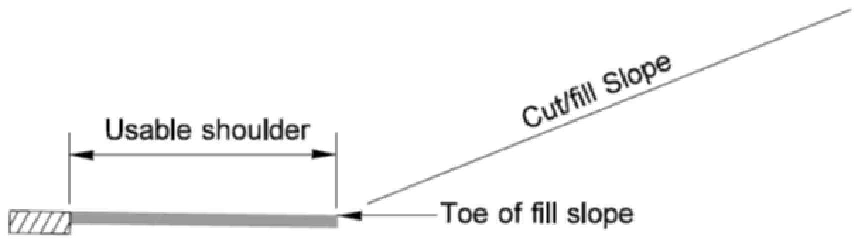
[3] In interchange areas, continuity may require variations.

[4] See 1239.03.

Exhibit 1239-5b Bridge End Slope Details



Rounding



No Rounding

Toe at ℄ of Roadway Ditch

1239.04 Roadway Sections in Rock Cuts

There are two basic design treatments applicable to rock excavation. Typical sections for rock cuts, illustrated in Exhibits 1239-6 and 1239-7, are guides for the design and construction of roadways through rock cuts. Design A applies to most rock cuts. Design B is a talus slope treatment. Changes in slope or fallout area are recommended when justified. Base the selection of the appropriate sections on an engineering study and the recommendations of the region Materials Engineer and region Landscape Architect. Obtain concurrence from the Headquarters (HQ) Materials Lab.

1239.04(1) Design A

This design is shown in stage development to aid the designer in selecting an appropriate section for site conditions in regard to backslope, probable rockfall, hardness of rock, and so on.

The following guidelines apply to the various stages shown in Exhibit 1239-6:

- **Stage 1** is used where the anticipated quantity of rockfall is small, adequate fallout width can be provided, and the rock slope is ½H:1V or steeper. Controlled blasting is recommended in conjunction with Stage 1 construction.
- **Stage 2** is used when a "rocks in the road" problem exists or is anticipated. Consider it on flat slopes where rocks are apt to roll rather than fall.
- **Stage 3** represents the full implementation of all protection and safety measures applicable to rock control. Use it when extreme rockfall conditions exist.

Show Stage 3 as the ultimate stage for future construction in the Plans, Specifications, and Estimates (PS&E) if there is any possibility that it will be needed.

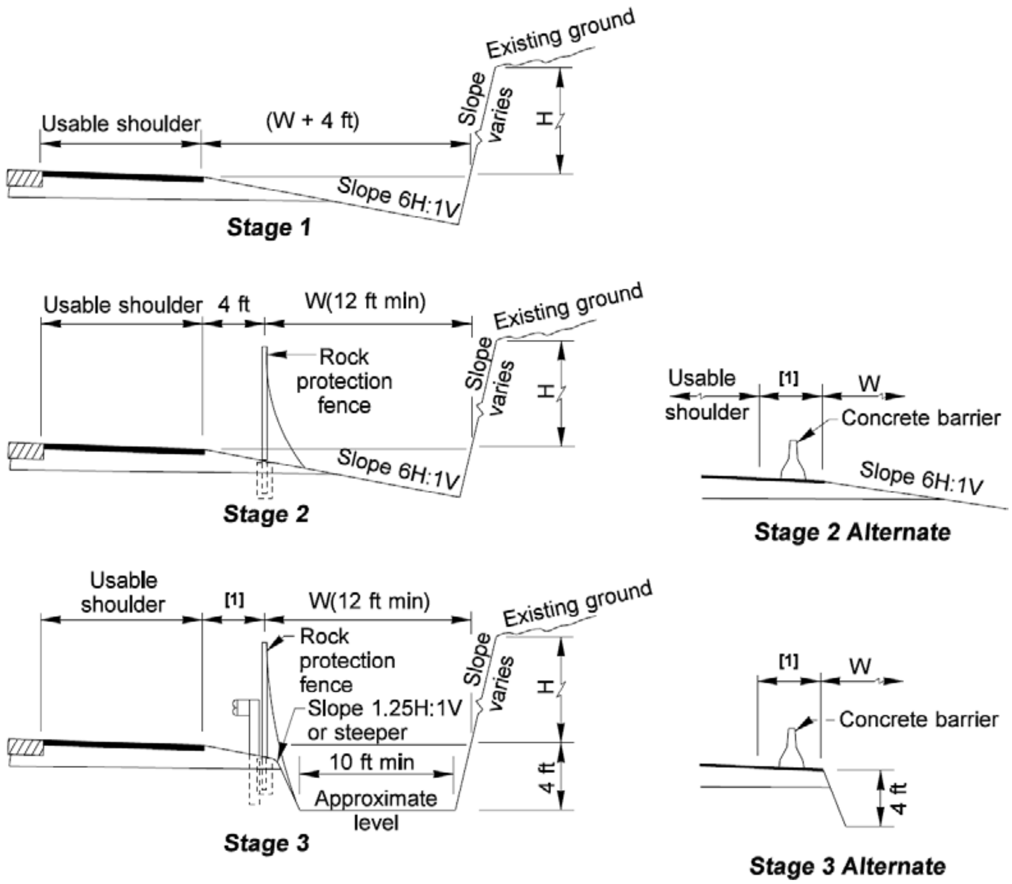
The use of Stage 2 or Stage 3 alternatives (concrete barrier) is based on the designer's analysis of the particular site. Considerations include maintenance; size and amount of rockfall; probable velocities; availability of materials; ditch capacity; adjacent traffic volumes; distance from traveled lane; and impact severity. Incorporate removable sections in the barrier at approximately 200-foot intervals. Provide appropriate terminal treatment (see Chapter 1610).

Occasionally, the existing ground above the top of the cut is on a slope approximating the design cut slope. The height (H) is to include the existing slope or that portion that can logically be considered part of the cut. Select cut slopes for a project that provide stability for the existing material.

Benches may be used to increase slope stability; however, the use of benches may alter the design given in Exhibit 1239-6.

The necessity for benches, as well as their width and vertical spacing, is established after an evaluation of slope stability. Make benches at least 20 feet wide. Provide access for maintenance equipment to the lowest bench and to the higher benches if feasible. Greater traffic benefits in the form of added safety, increased horizontal sight distance on curves, and other desirable attributes may be realized from widening a cut rather than benching.

Exhibit 1239-6 Roadway Sections in Rock Cuts: Design A



Rock Slope	H (ft)	W (ft)
Near Vertical	20 – 30	12
	30 – 60	15
	> 60	20
0.25H:1V through 0.50H:1V	20 – 30	12
	30 – 60	15
	60 – 100	20
	>100	25

Notes:

[1] For widening for guardrail and concrete barrier, see Chapter 1610.

General:

- Treat cut heights less than 20 feet as a normal roadway unless otherwise determined by the Region Materials Engineer.
- Stage 2 and Stage 3 Alternates may be used when site conditions dictate.
- Fence may be used in conjunction with the Stage 3 Alternate. (See Chapter 1600 for clear zone guidelines.)

1239.04(2) Design B

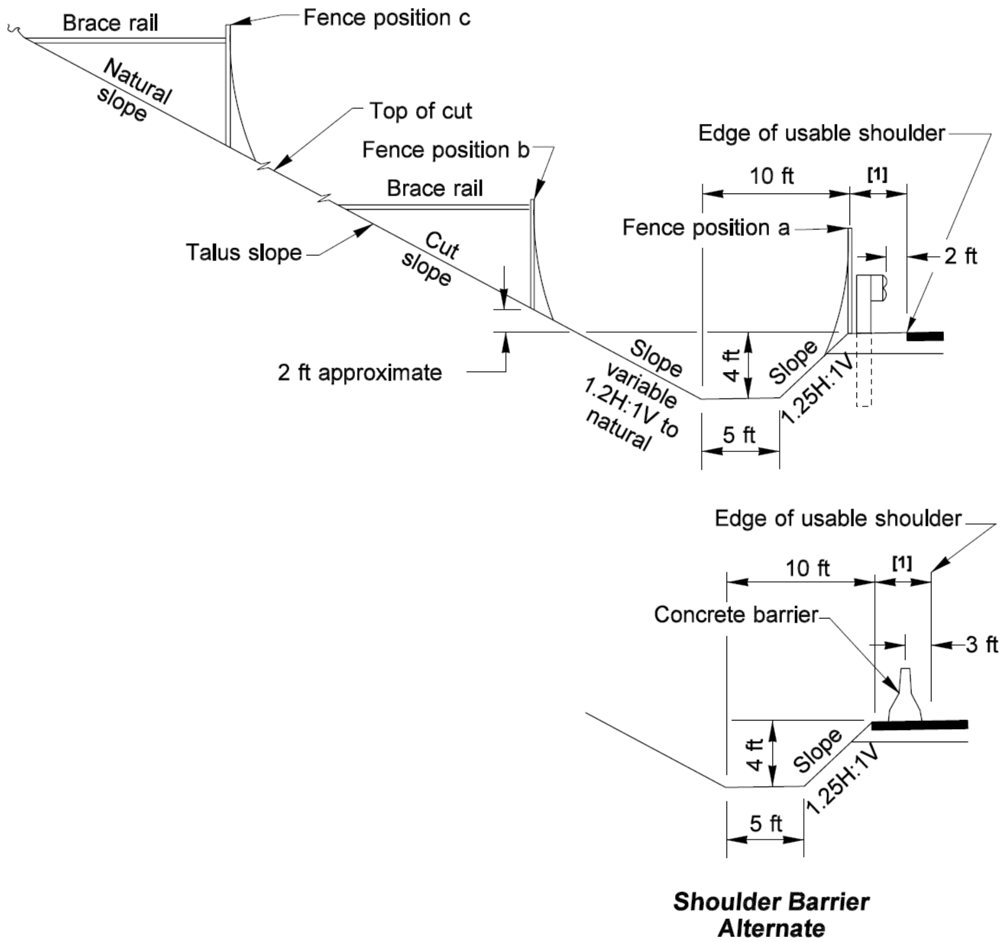
A talus slope treatment is shown in 1239-7. The rock protection fence is placed at any one of the three positions shown, but not in more than one position at a particular location. Consult with the RME for the placement of the rock protection fence in talus slope areas.

- **Fence position a** is used when the cliff generates boulders less than 0.25 yd^3 in size and the length of the slope is greater than 350 feet.
- **Fence position b** is the preferred location for most applications.
- **Fence position c** is used when the cliff generates boulders greater than 0.25 yd^3 in size regardless of the length of the slope. On short slopes, this may require placing the fence less than 100 feet from the base of the cliff.
- Use of gabions may be considered instead of the rock protection shown in fence position a. Because gabion treatment is considered similar to a wall, provide appropriate face and end protection (see Chapters 730 and 1610).

Use of the alternate shoulder barrier is based on the designer's analysis of the particular site. Considerations similar to those given for Design A alternatives apply.

Evaluate the need for rock protection treatments other than those described above for cut slopes that have relatively uniform spalling surfaces (consult with the RME).

Exhibit 1239-7 Roadway Sections in Rock Cuts: Design B



Notes:

[1] For widening for guardrail and concrete barrier, see Chapter 1610.

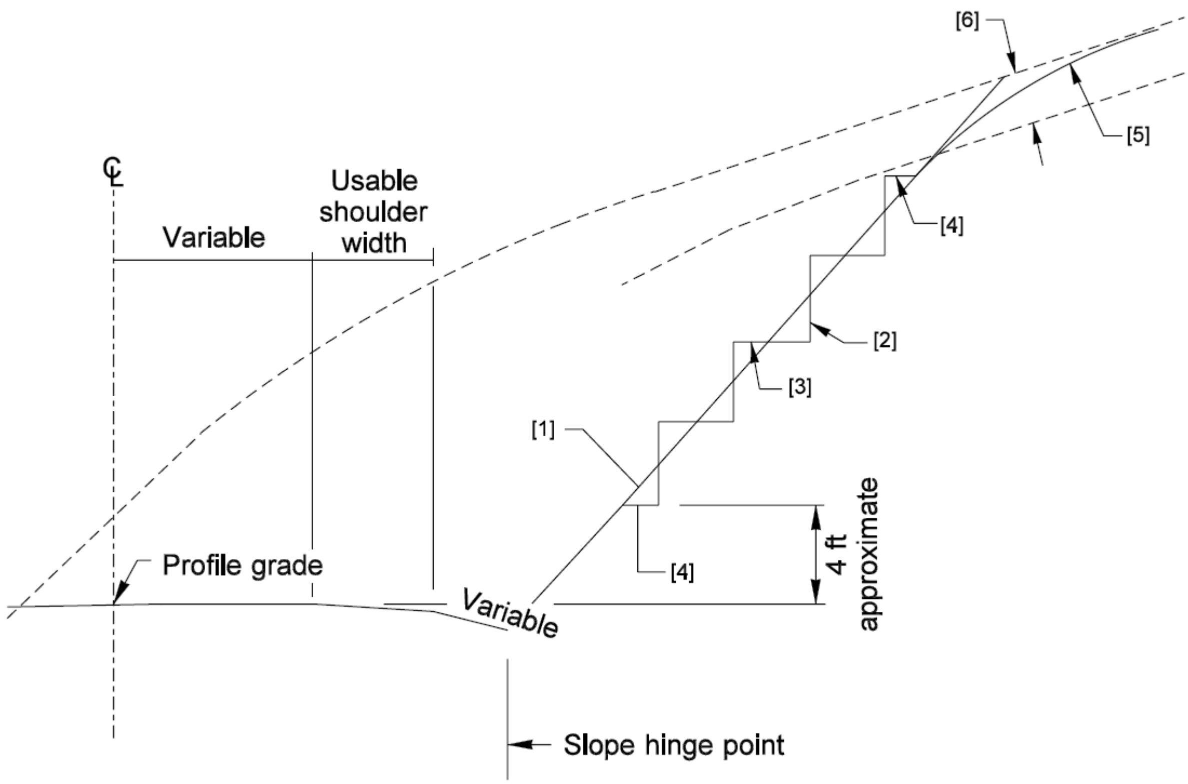
General:

- Ordinarily, place fence within a zone of 100 feet to 200 feet maximum from base of cliff, measured along the slope.
- Rock protection fence may be used in conjunction with the Shoulder Barrier Alternate when site conditions dictate.

1239.04(3) Stepped Slopes

Stepped slopes are a construction method intended to promote early establishment of vegetative cover on the slopes. They consist of a series of small horizontal steps or terraces on the face of the cut slope. Soil conditions dictate the feasibility and necessity of stepped slopes. They are to be considered on the recommendation of the RME (see Chapter 610). Consult the region landscape personnel for appropriate design and vegetative materials to be used. Use Exhibit 1239-8 for stepped slope design.

Exhibit 1239-8 Stepped Slope Design



Notes:

[1] Staked slope line: Maximum slope 1H:1V.

[2] Step rise: Height variable 1 foot to 2 feet.

[3] Step tread: Width = staked slope ratio x step rise.

[4] Step termini: Width ½-step tread width.

[5] Slope rounding.

[6] Overburden area: Variable slope ratio.

1239.05 Curbs

Curbs are designated as either vertical or sloped. Vertical curbs have a face slope not flatter than 1H:3V. Sloped curbs have a sloping face that is more readily traversed.

Curbs can also be classified as mountable. Mountable curbs are sloped curb with a height of 6 inches or less; 4 inches or less is recommended to reduce underside vehicle damage if driven over. When the face slope is steeper than 1H:1V, the height of a mountable curb is limited to 4 inches or less.

(a) Use vertical curbs with a height of 6 inches or more:

- To inhibit vehicles from leaving the roadway on low-speed roadways.
- To discourage vehicles from leaving low - and intermediate-speed roadways.
- For walkway and pedestrian refuge separations.
- For raised islands on which a traffic signal or traffic signal hardware is located.
- For expediting transfer times for transit partners on low- speed roadways in urban and suburban contexts (verify curb height needed with transit provider).

(b) Consider vertical curbs with a height of 6 inches or more:

- To inhibit midblock left turns.
- For divisional and channelizing islands.
- For landscaped islands.
- For stormwater conveyance

(c) Provide sloped curbs where a curb is needed but vertical curb is not suitable.

(d) Provide mountable curbs where a curb is needed and accommodation for specific design users makes it necessary.

(e) See Chapter 1320 for use of curbs in roundabouts.

In general, curbs are not recommended on high-speed facilities. Avoid using curbs if the same objective can be attained with pavement markings. However, 4-inch-high sloped curbs may be used on high-speed facilities to control drainage or for access control. Locate sloped curb no closer to the traveled way than the outer edge of the shoulder. Provide sloping end treatments where the curb is introduced and terminated. 6-inch-high sloped curbs may be considered on high-speed urban and suburban contexts where streetside zones are provided or where traffic movements are to be restricted. Provide justification for the use of vertical curb when applied to high-speed facilities.

Intermediate speed facilities may use vertical or sloped curbs; however, consider sloped curbs for intermediate target speeds. Consider use of 12-inch to 18-inch vertical curb when analysis demonstrates a need to reduce lane departure concerns on intermediate-speed facilities. All curb types are appropriate for low-speed facilities.

Where curbing is to be provided, provide a design that collects the surface water at the curb and drains it without ponding or flowing across the roadway as much as practicable to meet the safety and mobility performance needs for a project.

In some areas, curb may be needed to control runoff water until ground cover is attained to control erosion. Plan to remove the curb when the ground cover becomes adequate. Arrange for curb removal with region maintenance staff as part of the future maintenance plans (see Maintenance Owner's Manual guidance in Chapter 301). When curb is used in conjunction with guardrail, see Chapter 1610 for guidance. For existing curb, particularly on high-speed facilities, evaluate the continued need for the curb. Remove curbing that is no longer needed.

When an overlay will reduce the height of a curb, evaluate grinding (or replacing the curb) to maintain curb height if recommended by the pavement design and drainage needs. (See 1230.06(1) for shoulder cross slope considerations.) To maintain or restore curb height, consider lowering the existing pavement level and improving cross slope by grinding before an asphalt overlay or as determined by the pavement design. The cross slope of the shoulder may be steepened to maximize curb height and minimize other related impacts. Note that grinding can cause issues with meeting ADA criteria at curb ramps for counter slope and crosswalk running slope. See Chapter 1510 for more information.

Curbs can hamper snow-removal operations. In areas of heavy snowfall, get the Area Maintenance Superintendent's review for the use of curbing.

For curbs at traffic islands, see Chapter 1310. For curbs at roundabouts, see Chapter 1320 and the *Standard Plans*.

1239.06 Lateral Clearance to Curb and Barrier

Lateral clearance to curb or barrier is the perpendicular distance from edge of traveled way to the face of a curb or a traffic barrier (guardrail, concrete barrier, etc.). Lateral clearance includes the shoulder width. The minimum lateral clearance to the face of a curb or barrier is shown in Exhibit 1239-9. See also Chapter 1310 for intersections including clearance to curb at traffic islands.

Exhibit 1239-9 Minimum Lateral Clearance to Barrier and Curb

	Curb Left or Right [1] [2]	Barrier
High Speed	4 ft; curb not recommended	4 ft
Intermediate Speed		
Low Speed	2 ft min. [3] [4]	
Ramps [5]	4 ft	

Notes:

[1] For HOV lanes on arterials streets, see Section 1410.06(4)(d)

[2] Measured from the edge of traveled way to the face of curb.

[3] When mountable curb is used on low speed routes (35 mph or less), maintaining shoulder width is desirable; however, with justification, curb may be placed at the edge of traveled way.

[4] On low speed urban roadways (35 mph or less), maintaining shoulder width is desirable; however, with justification, curb (mountable or non-mountable) may be placed at the edge of traveled way.

[5] Raised median for two-way ramps (see 1360.03(5).)

1239.07 Medians and Outer Separations

Medians are either restrictive or nonrestrictive. Restrictive medians physically limit motor vehicle encroachment, using raised curb, median barrier, fixed delineators, vegetative strips, or vegetative depressions. Nonrestrictive medians limit motor vehicle encroachment legally, and use pavement markings to define locations where turns are permissible. The main functions of an outer separation are to separate the main roadway from a frontage road or service lane, or to provide modal segregation. Consider medians or outer separations to optimize the desired performance objective, such as safety, throughput operations, pedestrian mobility needs, etc.

Provide a median or outer separation to:

- Separate traffic (such as with HOT lanes) and/or modal users (such as bike buffers).
- Separate differing alignments on divided highways.
- Reduce head-on collisions.
- Manage speed.
- Provide a refuge area for emergency parking.
- Allow for future widening of a planned phase.
- Separate collector-distributor lanes, weigh sites, or rest areas.
- Accommodate drainage facilities.
- Accommodate bridge piers at undercrossings.
- Provide vehicle storage space for crossing and left-turn movements at intersections.
- Accommodate headlight glare screens, including planted or natural foliage.
- Provide recovery areas for errant or disabled vehicles.
- Accommodate pedestrian refuge area at crossing locations.
- Provide storage space for snow and water from traffic lanes.
- Provide increased safety, comfort, and ease of operations for different modes.
- Control access.
- Provide enforcement areas.

The width of a median is measured from edge of traveled way to edge of traveled way and includes shoulders. Median widths can vary greatly based on the functional use of the median, target speed, and context. Guidance for median widths depending on their function and context is given in Exhibits 1239-10 and 1239-11.

1239.07(1) Median Design: High and Intermediate Speed

Exhibit 1239-10 lists width considerations for median functions common on high-speed facilities. Depending on the context and performance needs, this guidance may also apply to intermediate speed facilities as well.

When the horizontal and vertical alignments of the two roadways of a divided highway are independent of one another, determine median side slopes in conformance with 1239.03 and Chapters 1600 and 1610. Independent horizontal and vertical alignment, rather than parallel alignment, can allow for reduced grading or cut sections.

Considerable latitude in grading treatment is intended on wide, variable-width medians, provided the minimum performance needs are met or exceeded. Unnecessary clearing, grubbing, and grading are undesirable within wide medians. Use selective thinning and limited reshaping of the natural ground when feasible. For median clear zone criteria see Chapter 1600, and for slopes between the face of traffic barriers and the traveled way see Chapter 1610.

In areas where land is expensive, make an economic comparison of wide medians to narrow medians with barrier. Consider right of way, construction, maintenance, and safety performance. The widths of medians need not be uniform. Make the transition between median widths as long as practical. (See Chapter 1210 for minimum taper lengths.)

When using concrete barriers in depressed medians or on curves, provide for surface drainage on both sides of the barrier. The transverse notches in the base of precast concrete barrier are not intended to be used as a drainage feature, but rather as pick-up points when placing the sections.

At locations where the median will be used to allow vehicles to make a U-turn, consider increasing the width to meet the needs of the selected design vehicles making the U-turn. (For information on U-turn locations, see Chapter 1310.) Document the selected design vehicle and provide alternate route information for vehicles not serviced by the U-turn.

Where feasible, widen medians at intersections on rural divided multilane highways. Provide sufficient width to store vehicles crossing the expressway or entering the expressway with a left turn.

When the median is to be landscaped, or where rigid objects are to be placed in the median, see Chapter 1600 for traffic barrier and clear zone guidance. When the median will transition for use as a left-turn lane, see Chapter 1310 for left-turn lane design considerations.

Exhibit 1239-10 Median Functions and Guidance: High and Intermediate Speeds

Median Functional Use	Width Guidance
Separating opposing traffic	Varies[1] and see Chapters 1600 and 1610
Separating alignments	Varies See 1239.03 and Chapters 1600 and 1610 [2]
Recovery/Refuge areas for errant vehicles	See 1239.03 and Chapter 1600
Median signing and illumination – Undivided highways and ramps	6 ft [1] or as recommended for signing and illumination design
Storage space for snow	Consult Region Maintenance
Enforcement areas	See Chapters 1370 and 1410, and consult with Washington State Patrol
Vehicle storage space for crossing at intersections	See Chapter 1310, and consult with region traffic engineer
Median U-turn or Median crossover	See Chapters 1310 and 1370
Outer separation for frontage or collector-distributer	6 ft – or more [1] and see Chapters 1360, 1600 and 1610
Transit use	Varies; see Chapter 1420 and discuss with Transit Agency [3]

Notes:

[1] Conduct safety performance analysis and include potential countermeasures identified to obtain the desired safety performance. Consult with maintenance; additional width may be appropriate for unconstrained right of way locations, maintenance functions, or for divided highways on independent alignments.

[2] An economic comparison of wide medians to narrow medians with barrier is recommended.

[3] For planning and scoping purposes, 32 ft can be the assumed minimum for two-way transit operations or 22 ft for one-way transit operations.

1239.07(2) Median Design: Low and Intermediate Speeds

Exhibit 1239-11 provides design guidance for medians within low-speed transportation contexts. Depending on the context and performance needs, this guidance may also apply to intermediate speed facilities as well. In low-speed urban and suburban contexts, see Chapter 1600 for Design Clear Zone requirements.

A common form of restrictive median on urban managed access highways is the raised median. For more information on traffic volume thresholds for restrictive medians on managed access highways, see Chapter 540.

Exhibit 1239-11 Median Functions and Guidance: Low and Intermediate Speeds

Median Functional Use	Width Guidance
Access Control – Restrictive	Width of raised median feature [1] [2]
Access Control – Non-restrictive	1 ft minimum [3] (see Chapter 540)
Pedestrian refuge for crossing locations	6 ft minimum, excluding curb width (see Chapter 1510)
Speed management and/or aesthetic design – Vegetated	Varies [2] [4] (see Chapter 1103)
Drainage or treatment facilities	Varies [5]
Bike buffer treatment	2 ft – 3 ft (see Chapter 1520)
Transit connection	Varies [6] (see Chapters 1238 and 1430)
Outer separation used for a pedestrian zone	9 ft – 16 ft [4] [7] [8]

Notes:

[1] The width of a raised median can be minimized by using a dual-faced cement concrete traffic curb, a precast traffic curb, or an extruded curb.

[2] Consider width necessary for lateral clearance.

[3] 2 ft minimum if adjacent lane widths are less than 11 ft.

[4] Consult Region Landscape Architect; width will depend on type of plantings. Over-excavation may be necessary to prepare soil for the selected plantings to ensure mature heights are obtained.

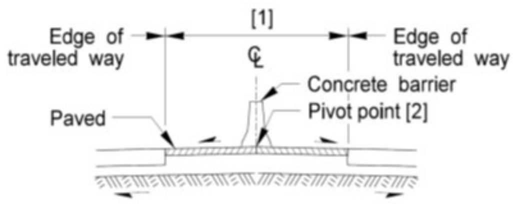
[5] Consult Hydraulic Report for width necessary for drainage or treatment facilities.

[6] Consult with the transit provider. If a transit shelter is planned, a minimum 5 ft clear area measured from the edge of shelter roofing to face of curb width, is necessary for pedestrians to move to and around the shelter and for lift extension (see Chapter 1430).

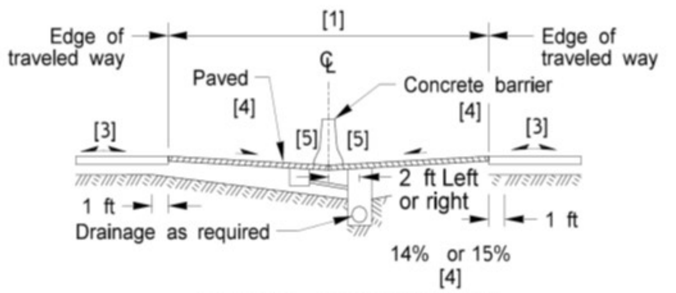
[7] Consider width needed for plantings or street furniture to create the appropriate pedestrian zone segregation and environment.

[8] See also Chapter 1510

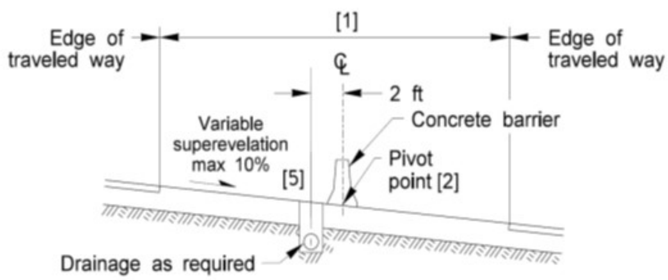
Exhibit 1239-12a Divided Highway Median Sections



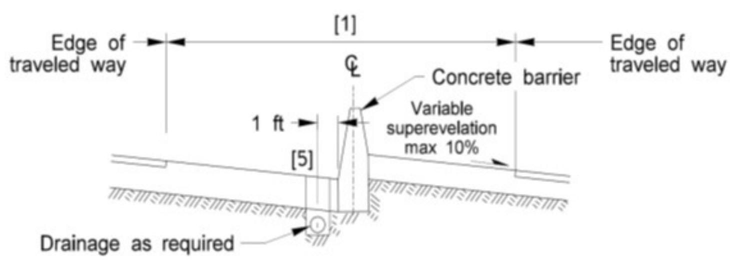
Design A: Crowned Median



Design: B Depressed Median



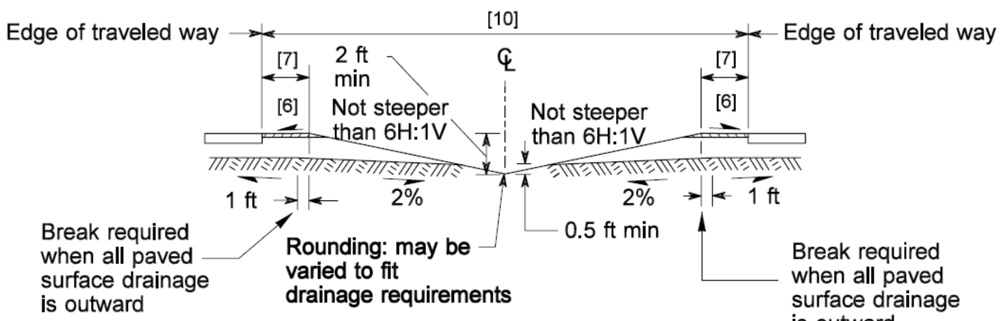
Alternate Design 1: Treatment on Curves



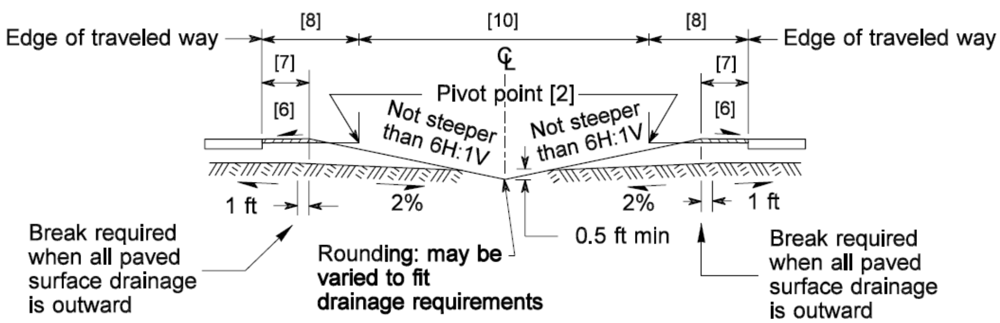
Alternate Design 2: No Fixed Pivot Point [2]

Note:
For applicable notes, see Exhibit 1239-12c.

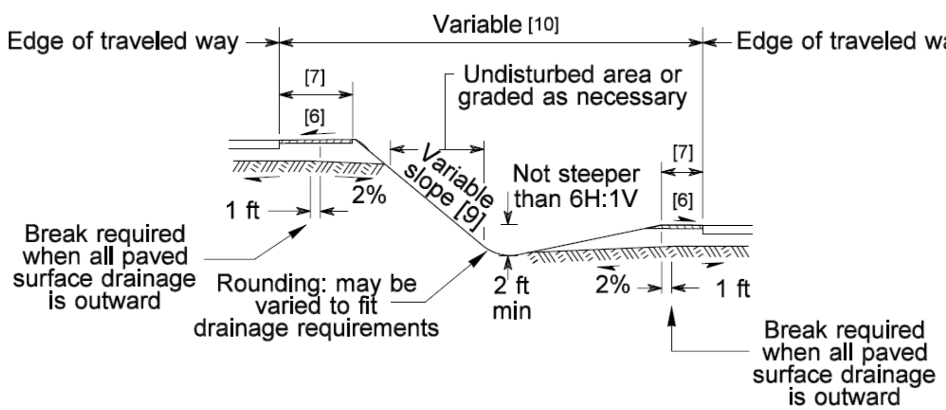
Exhibit 1239-12b Divided Highway Median Sections



Design C: Minimum Nonpaved Median For 4 or More Lanes [2]



Design D: Minimum for 4 or More Lanes With Future Lanes in Median

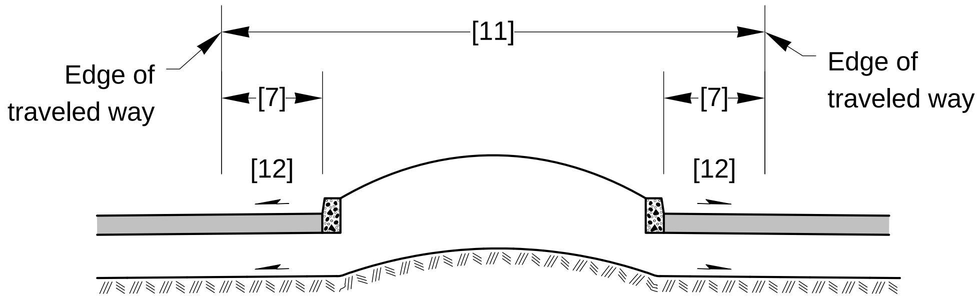


Design E: Minimum for 4 or More Lanes With Independent Alignment

Note:

For applicable notes, see Exhibit 1239-12c.

Exhibit 1239-12c Divided Highway Median Sections



Design F: Raised Median[13]

Notes:

[1] For guidance on median widths, see Exhibits 1239-10 and -11

[2] Consider vertical clearances, drainage, and aesthetics when locating the pivot point.

[3] Generally, slope pavement away from the median. When barrier is present and the roadway is in a superelevation, size the shoulder so that standing water is not in the travel lane. Where appropriate, a crowned roadway section may be used in conjunction with the depressed median.

[4] Design B may be used uniformly on both tangents and horizontal curves. Use Alternate Design 1 or Alternate Design 2 when the "rollover" between the shoulder and the inside lane on the high side of a superelevated curve exceeds 8%. Provide suitable transitions at each end of the curve for the various conditions encountered in applying the alternate to the basic median design.

[5] Method of drainage pickup to be determined by the designer.

[6] Median shoulders normally slope in the same direction and rate as the adjacent through lane. See 1250.02(2) for examples and additional information for locations where it may be desirable to have a shoulder cross slope different than the adjacent lane.

[7] For guidance on shoulder widths, see 1239.02.

[8] Future lane width of a planned phase.

[9] Widen and round foreslopes steeper than 4H:1V as shown in Exhibit 1239-3. See Chapter 1600 for barrier recommendations.

[10] Designs C, D, and E are rural high-speed median designs. See Exhibit 1239-10 for recommended median widths.

[11] Raised medians may be paved or landscaped. For clear zone and barrier guidelines when fixed objects or trees are in the median, see Chapter 1600.

[12] Lane and shoulders normally slope away from raised medians. When they slope toward the median, provide for drainage.

[13] See 1239.05 and 1239.06 for curb design guidance.

Chapter 1250 Cross Slope and Superelevation

1250.01 General

Use this chapter to design roadway cross slopes and superelevation. Cross slopes function to drain water away from the roadway and 2% is a commonly used slope rate. To maintain the design speed, highway and ramp curves are usually superelevated to overcome part of the centrifugal force that acts on a vehicle.

1250.02 Roadway Cross Slope

1250.02(1) Lanes

The cross slope on tangents and curves is a main element in roadway design. The cross slope or crown on tangent sections and large radius curves is complicated by the following two contradicting controls:

- Reasonably steep cross slopes aid in water runoff and minimize ponding as a result of pavement imperfections and unequal settlement.
- Steeper cross slopes are noticeable in steering, increase the tendency for vehicles to drift to the low side of the roadway, and increase the susceptibility of vehicles to slide to the side on icy or wet pavements.

A 2% cross slope is normally used for tangents and large-radius curves on high and intermediate pavement types, although cross slopes may vary from the target 2%.

The algebraic difference in cross slopes is an operational factor that can affect vehicles making a lane change across a grade-break during a passing maneuver on a two-lane two-way roadway. Its influence increases when increased traffic volumes decrease the number and size of available passing opportunities.

On ramps with metering, consider how cross slopes can impact driver comfort within the queue. Additionally, larger cross slopes may present concerns about maintaining vehicle lateral position within the queue lane, depending on weather and resulting pavement conditions.

A somewhat steeper cross slope may be needed to facilitate recommended drainage design, even though this might be less desirable from an operational point of view. In such areas, consider not exceeding design cross slopes of 2.5% with an algebraic difference of 5%.

For a two-lane two-way roadway, provide an algebraic difference to meet the appropriate conditions stated above except when drainage design recommends otherwise.

1250.02(2) Shoulders

Shoulder cross slopes are normally the same as the cross slopes for adjacent lanes. With justification, shoulder slopes may be increased to 6%. On the high side of a roadway with a plane section, such as a turning roadway in superelevation, the shoulder may slope in the opposite direction from the adjacent lane. The maximum difference in slopes between the lane and the shoulder is 8%. Locations where it may be desirable to have a shoulder slope different than the adjacent lane are:

- Where curbing is used.
- Where shoulder surface is bituminous, gravel, or crushed rock.
- Where overlays are planned and it is desirable to maintain the grade at the edge of the shoulder.
- On divided highways with depressed medians where it is desirable to drain the runoff into the median.
- On the high side of the superelevation on curves where it is desirable to drain stormwater or meltwater away from the roadway.
- At intersections where pedestrian signal accommodations are provided within the shoulder

Where extruded curb is used, see the *Standard Plans* for placement (see Chapter 1239 for information on curbs). Widening is also normally provided where traffic barrier is installed (see Chapter 1610 and the *Standard Plans*).

On ramps with metering, where the shoulder is or could be utilized for queuing, consider how the shoulder cross slope can impact driver comfort within the queue. Additionally, larger shoulder cross slopes may present concerns of maintaining vehicle lateral position within the queue lane, depending on weather and resulting pavement conditions.

The remainder of this chapter provides information to design superelevation.

1250.03 Superelevation Rate Selection

The maximum superelevation rate allowed is 10%.

Depending on design speed, construct large-radius curves with a normal crown section. The minimum radii for normal crown sections are shown in Exhibit 1250-1. Superelevate curves with smaller radii as follows:

- Exhibit 1250-4a (emax=10%) is desirable for all open highways, ramps, and long-term detours, especially when associated with a main line detour.
- Exhibit 1250-4b (emax =8%) may be used for freeways in urban design areas and areas where the emax =6% rate is allowed but emax =8% is preferred.
- Exhibit 1250-4c (emax =6%) may be used—with justification—for non-freeway highways in urban design areas, in mountainous areas, and for short-term detours, which are generally implemented and removed in one construction season.
- Exhibit 1250-5 may be used for turning roadways at intersections, urban managed access highways with a design speed of 40 mph or less, and—with justification—ramps in urban areas with a design speed of 40 mph or less.

When selecting superelevation for a curve, consider the existing curves on the corridor. To maintain route continuity and driver expectance on open highways, select the chart (see Exhibits 1250-4a, 4b, or 4c) that best matches the superelevation on the existing curves.

In locations that experience regular accumulations of snow and ice, limit superelevation from the selected chart to 6% or less. In these areas, provide justification for superelevation rates greater than 6%. Vehicles moving at slow speeds or stopped on curves with supers greater than 6% tend to slide inward on the radius (downslope).

Round the selected superelevation rate to the nearest full percent.

Exhibit 1250-1 Minimum Radius for Normal Crown Section

Design Speed (mph)	Minimum Radius for Normal Crown Section (ft)
15	945
20	1,680
25	2,430
30	3,325
35	4,360
40	5,545
45	6,860
50	8,315
55	9,920
60	11,675
65	13,130
70	14,675
75	16,325
80	18,065

1250.04 Existing Curves

Evaluate the superelevation on an existing curve to determine its adequacy. Use the equation in Exhibit 1250-2 to determine the minimum radius for a given superelevation and design speed.

Exhibit 1250-2 Minimum Radius for Existing Curves

$$R = \frac{6.68V^2}{e + f}$$

Where:
R = The minimum allowable radius of the curve (ft)
V = Design speed (mph)
e = Superelevation rate (%)
f = Side friction factor from Exhibit 1250-3

Address superelevation when the existing radius is less than the minimum radius calculated using the equation or when the maximum speed determined by a ball banking analysis is less than the design speed. When modifying the superelevation of an existing curve, provide superelevation as given in 1250.02.

Exhibit 1250-3 Side Friction Factor

Design Speed (mph)	Side Friction Factor (f)
15	32
20	27
25	23
30	20
35	18
40	16
45	15
50	14
55	13
60	12
65	11
70	10
75	9
80	8

1250.05 Turning Movements at Intersections

Curves associated with the turning movements at intersections are superelevated using the rates for low-speed urban roadway curves. Use superelevation rates as high as practicable, consistent with curve length and climatic conditions. Exhibit 1250-5 shows the minimum superelevation for the given design speed and radius. When using high superelevation rates on short curves, provide smooth transitions with merging ramps or roadways.

1250.06 Runoff for Highway Curves

Provide transitions for all superelevated highway curves as specified in Exhibits 1250-6a through 6e. Which transition to use depends on the location of the pivot point, the direction of the curve, and the roadway cross slope. The length of the runoff is based on a maximum allowable difference between the grade at the pivot point and the grade at the outer edge of traveled way for one 12-foot lane.

Pay close attention to the profile of the edge of traveled way created by the superelevation runoff; do not let it appear distorted. The combination of superelevation transition and grade may result in a hump and/or dip in the profile of the edge of traveled way. When this happens, the transition may be lengthened to eliminate the hump and/or dip. If the hump and/or dip cannot be eliminated this way, pay special attention to drainage in the low areas to prevent ponding. Locate the pivot point at the centerline of the roadway to help minimize humps and dips at the edge of the traveled lane and reduce the superelevation runoff length.

When reverse curves are necessary, provide sufficient tangent length for complete superelevation runoff for both curves—that is, from full superelevation of the first curve, to level to full superelevation of the second curve. If tangent length is longer than this, but not sufficient to provide full super transitions—that is, from full superelevation of the first curve, to normal crown to full superelevation of the second curve—increase the superelevation runoff lengths until they abut. This provides one continuous transition, without a normal crown section, similar to Designs C2 and D2 in Exhibits 1250-6c and 6d, except that full super will be attained rather than the normal pavement slope as shown.

Superelevation runoff on structures is permissible but not desirable. Whenever practicable, strive for full super or normal crown slopes on structures.

1250.07 Runoff for Ramp Curves

Superelevation runoff for ramps use the same maximum relative slopes as the specific design speeds used for highway curves. Multilane ramps have a width similar to the width for highway lanes; therefore, Exhibits 1250-6a through 6e are used to determine the superelevation runoff for ramps. Superelevation transition lengths (L_T) for single-lane ramps are given in Exhibits 1250-7a and 7b. Additional runoff length for turning roadway widening is not required.

1250.08 Documentation

Refer to Chapter 300 for design documentation requirements.

1250.09 References

1250.09(1) Design Guidance

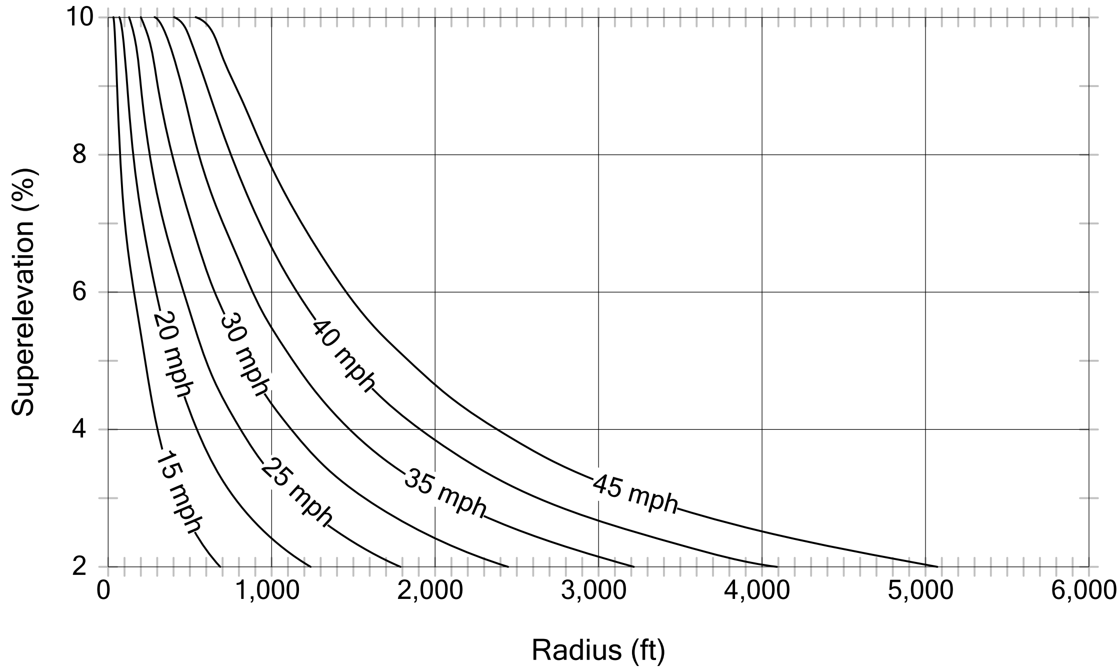
Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

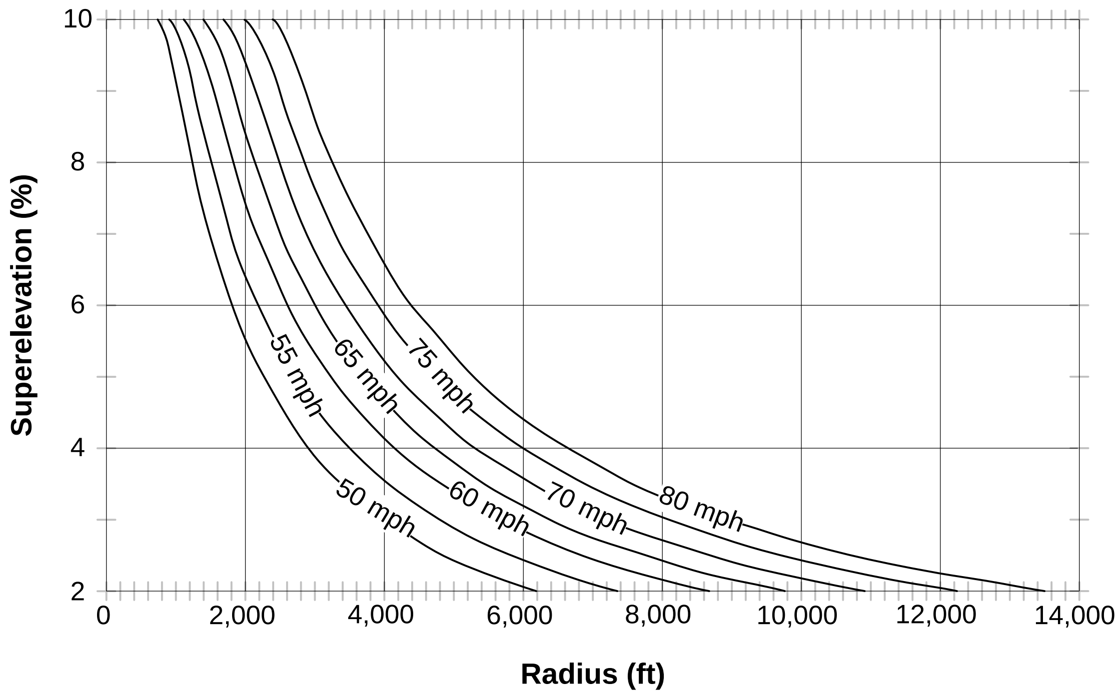
Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

1250.09(2) Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition

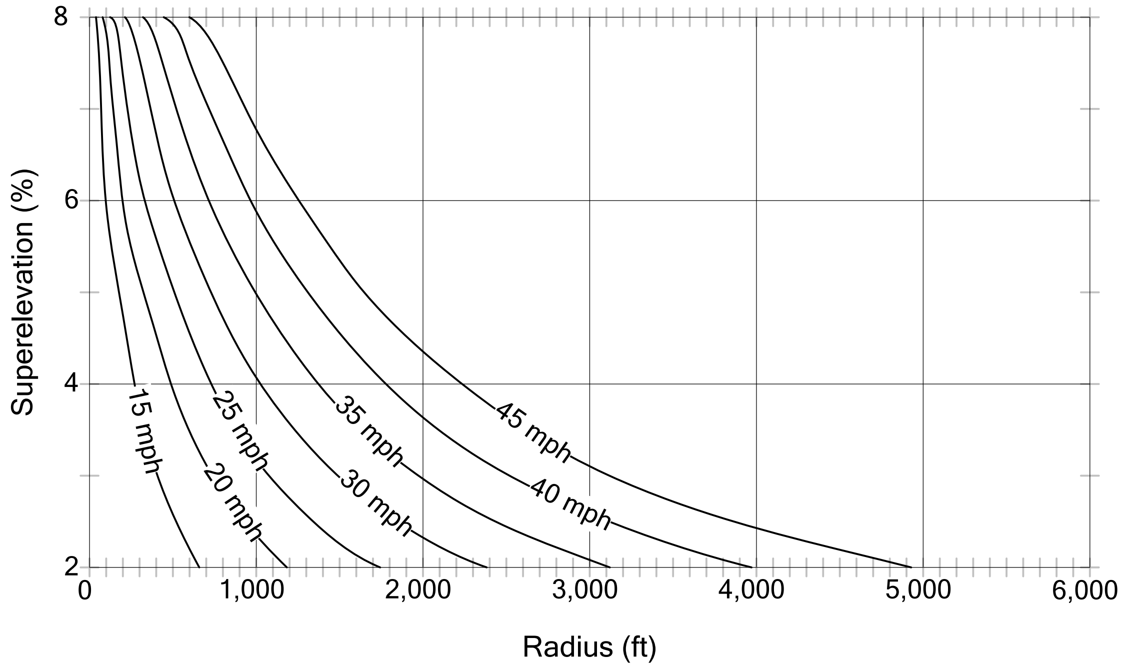
Exhibit 1250-4a Superelevation Rates (10% Max)

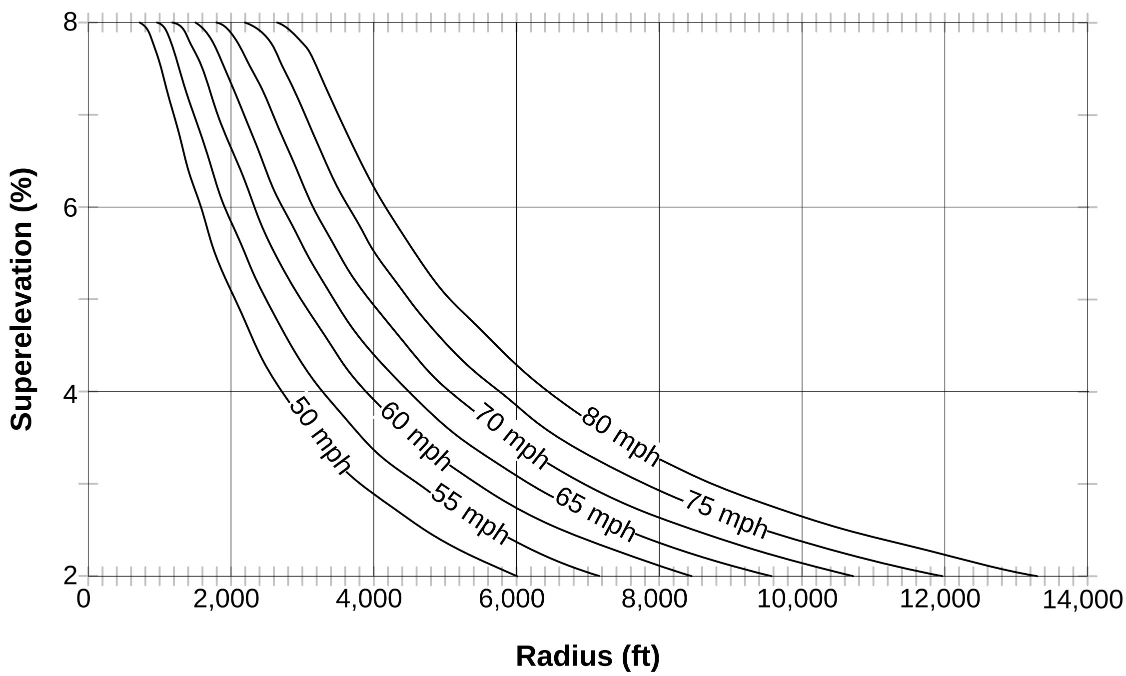




Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	40	75	130	205	295	415	545	700	880	1,095	1,345	1,640	1,980	2,380

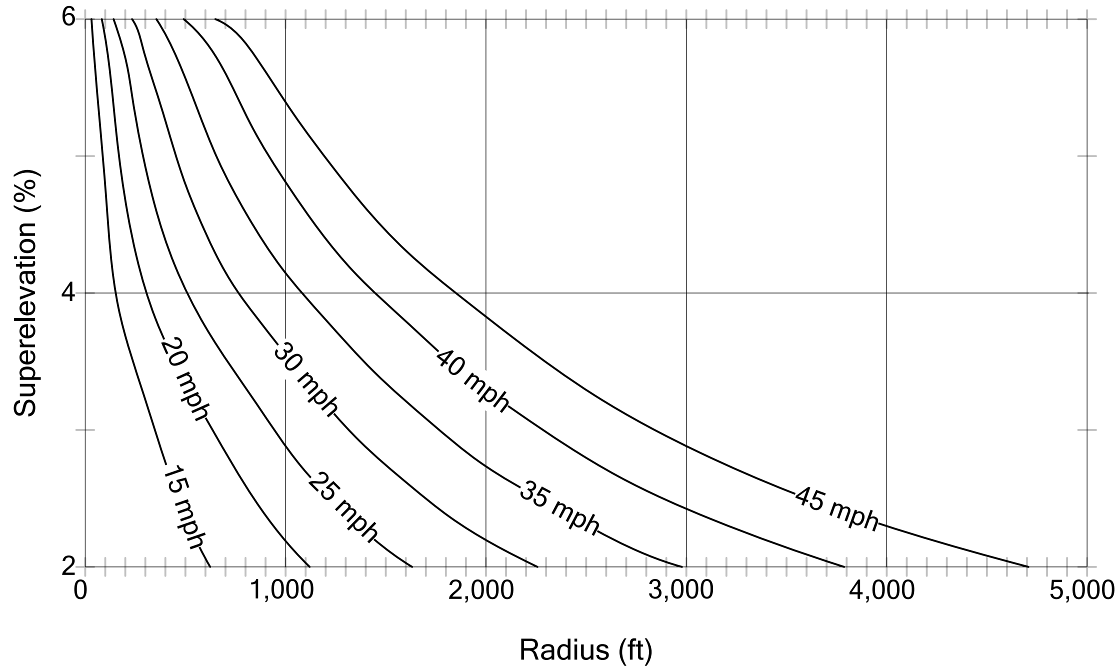
Exhibit 1250-4b Superelevation Rates (8% Max)

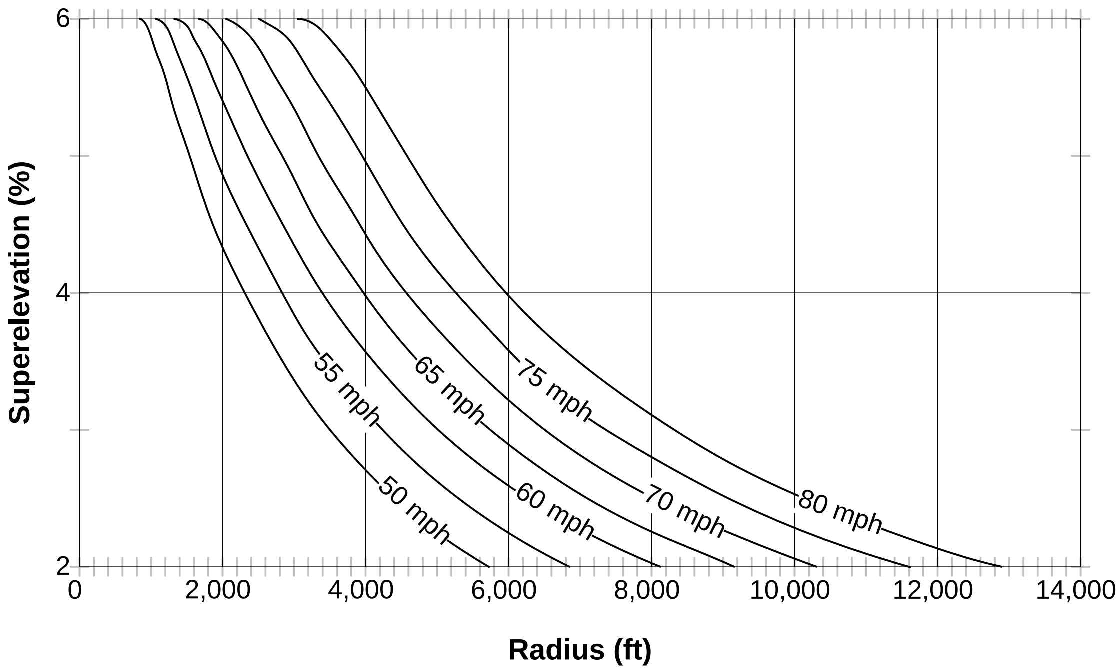




Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	40	80	135	215	315	450	590	760	965	1,205	1,490	1,820	2,215	2,675

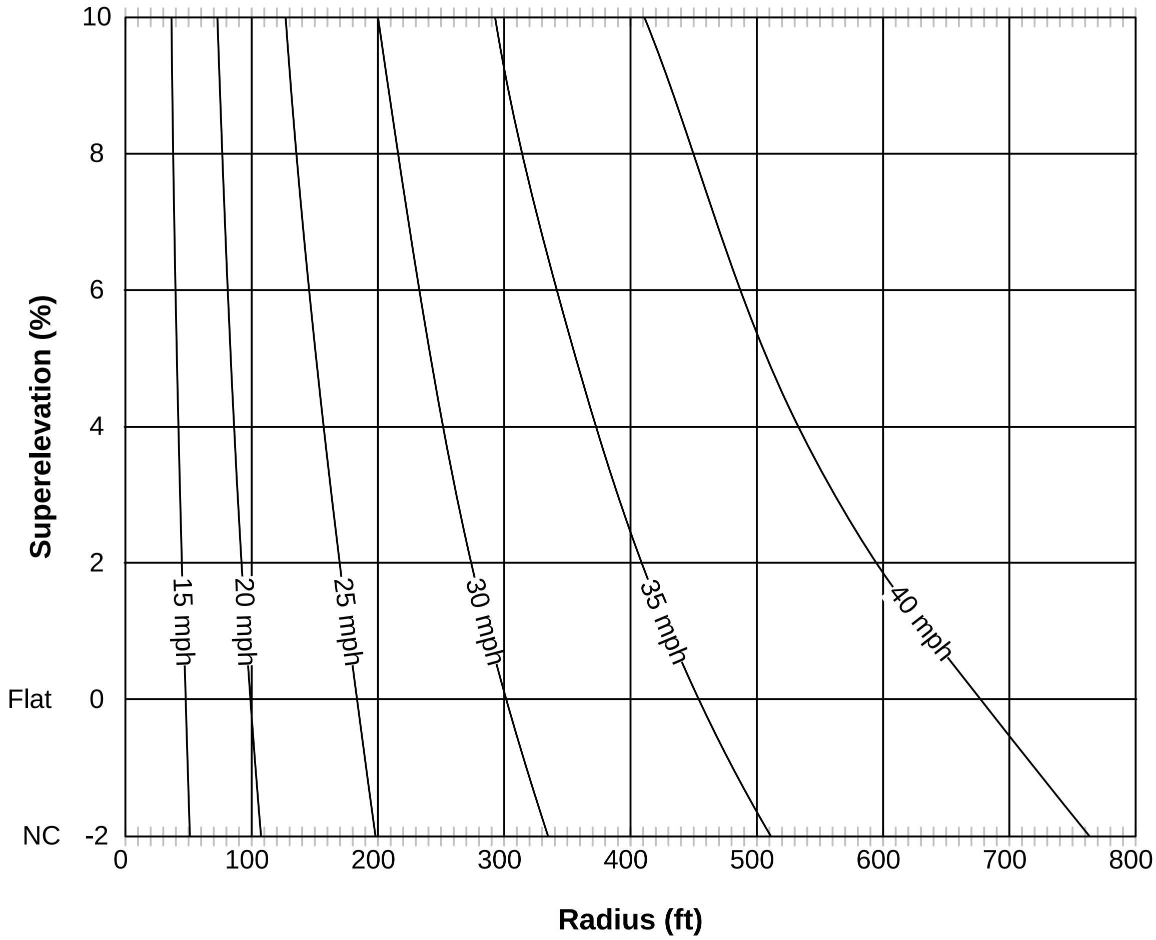
Exhibit 1250-4c Superelevation Rates (6% Max)





Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	40	85	145	235	345	490	645	840	1,065	1,340	1,665	2,050	2,510	3,055

Exhibit 1250-5 Superelevation Rates for Intersections and Low-Speed Urban Roadways



NC = Normal crown

Exhibit 1250-6a Superelevation Transitions for Highway Curves

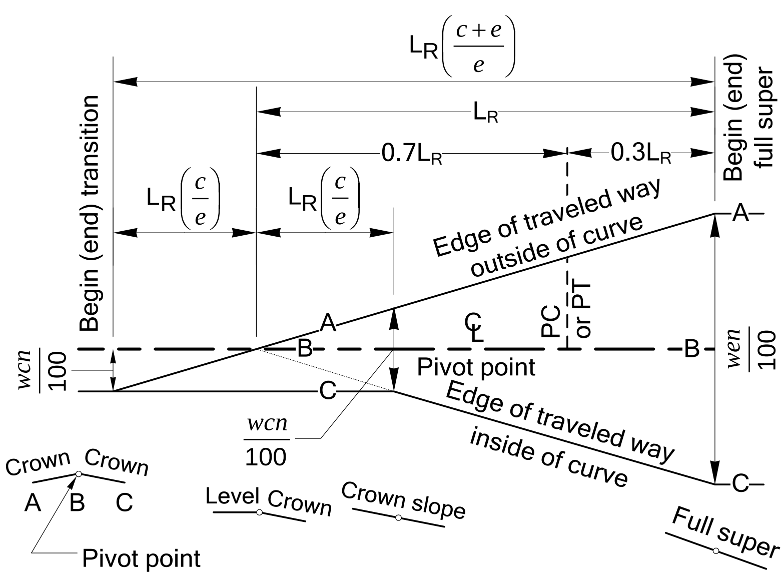
e (%)	L_B=Basic Runoff in Feet for Design Speed*													
	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph	70 mph	75 mph	80 mph
2	30	30	35	35	40	40	45	50	50	55	55	60	65	70
3	45	50	50	55	60	60	65	70	75	80	85	90	95	105
4	60	65	70	75	75	85	90	95	100	105	110	120	125	135
5	75	80	85	90	95	105	110	120	130	135	140	150	160	170
6	90	95	105	110	115	125	135	145	155	160	170	180	190	205
7	110	115	120	130	135	145	155	170	180	185	195	210	220	240
8	125	130	135	145	155	165	180	190	205	215	225	240	250	275
9	140	145	155	165	175	185	200	215	230	240	250	270	285	310
10	155	160	170	180	195	205	220	240	255	265	280	300	315	345

*Based on one 12-ft lane between the pivot point and the edge of traveled way. When the distance exceeds 12 ft, use the following equation to obtain L_R:

$$L_R = L_B(1+0.04167X)$$

Where:

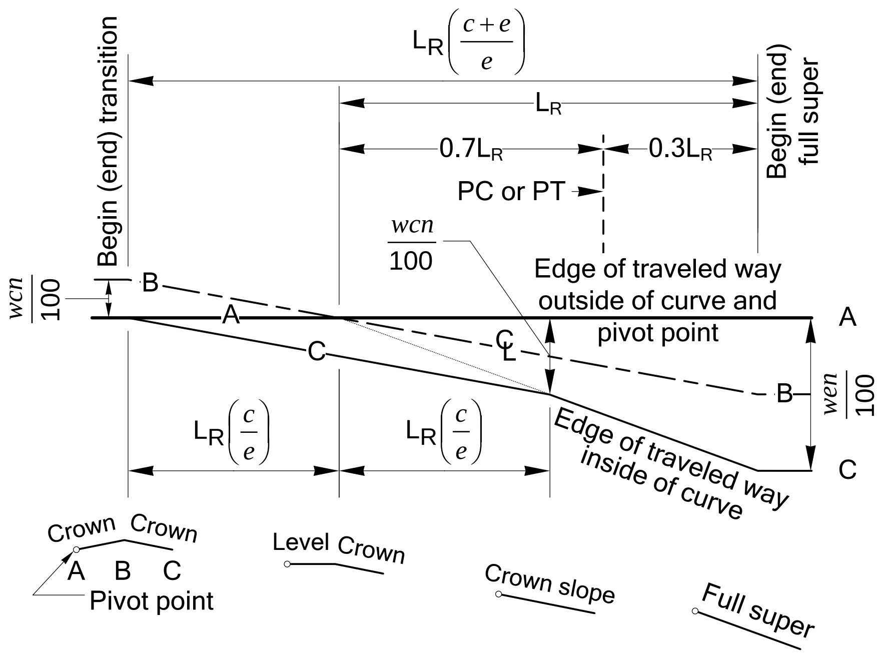
X = The distance in excess of 12 ft between the pivot point and the farthest edge of traveled way, in ft.



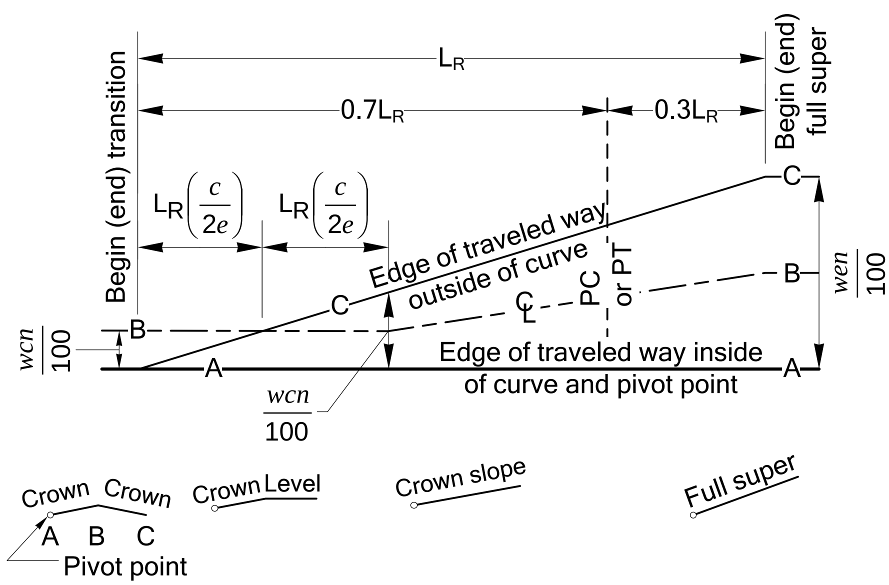
Design A – Pivot Point on Centerline Crown Section

c = Normal crown (%)
e = Superelevation rate (%)
n = Number of lanes between points
w = Width of lane

Exhibit 1250-6b Superelevation Transitions for Highway Curves



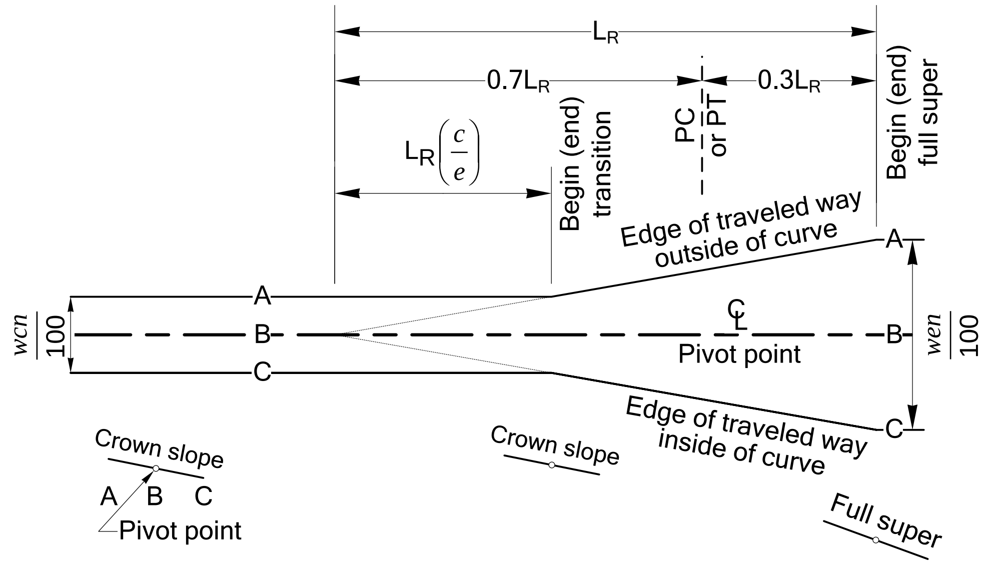
Design B[1] – Pivot Point on Edge of Traveled Way: Outside of Curve Crowned Section



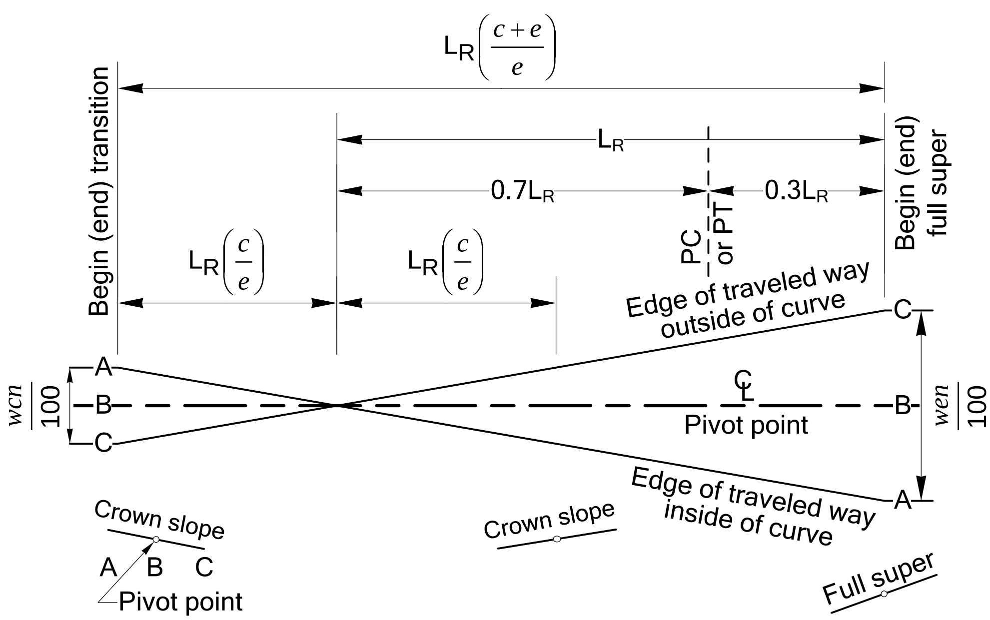
Design B[2] – Pivot Point on Edge of Traveled Way: Inside of Curve Crowned Section

c = Normal crown (%)
e = Superelevation rate (%)
n = Number of lanes between points
w = Width of lane

Exhibit 1250-6c Superelevation Transitions for Highway Curves



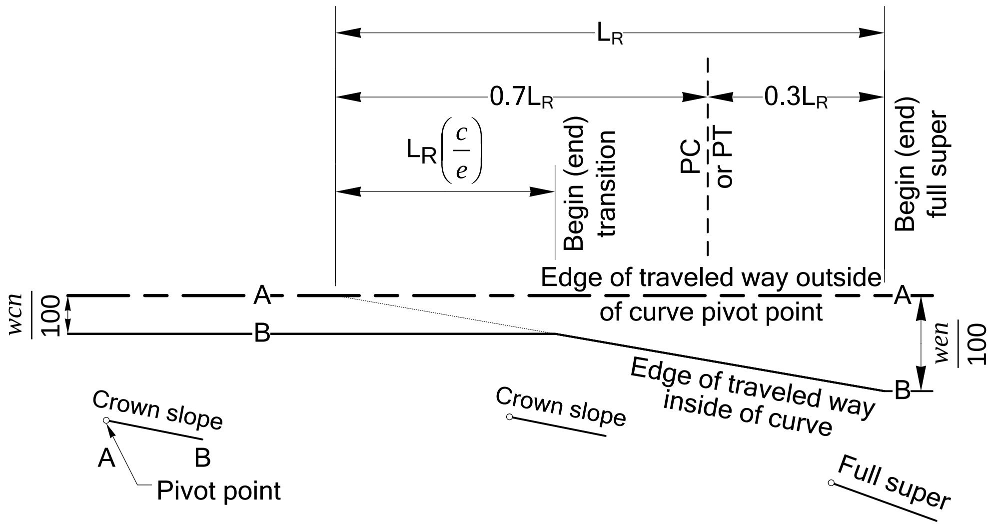
Design C[1] – Pivot Point on Centerline Curve in Direction of Normal Pavement Slope: Plane Section



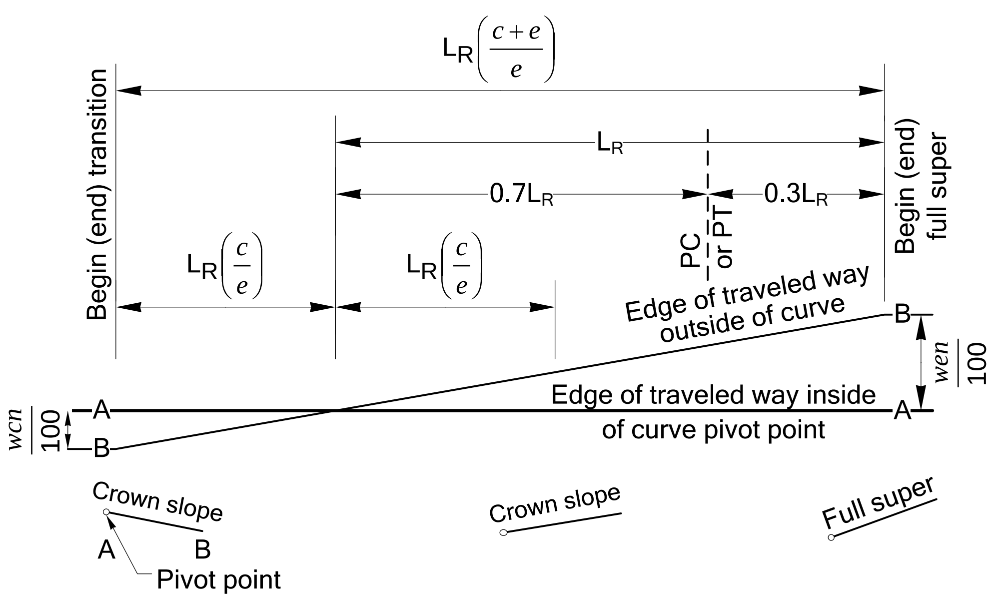
Design C[2] – Pivot Point on Centerline Curve Opposite to Normal Pavement Slope: Plane Section

c = Normal crown (%)
e = Superelevation rate (%)
n = Number of lanes between points
w = Width of lane

Exhibit 1250-6d Superelevation Transitions for Highway Curves



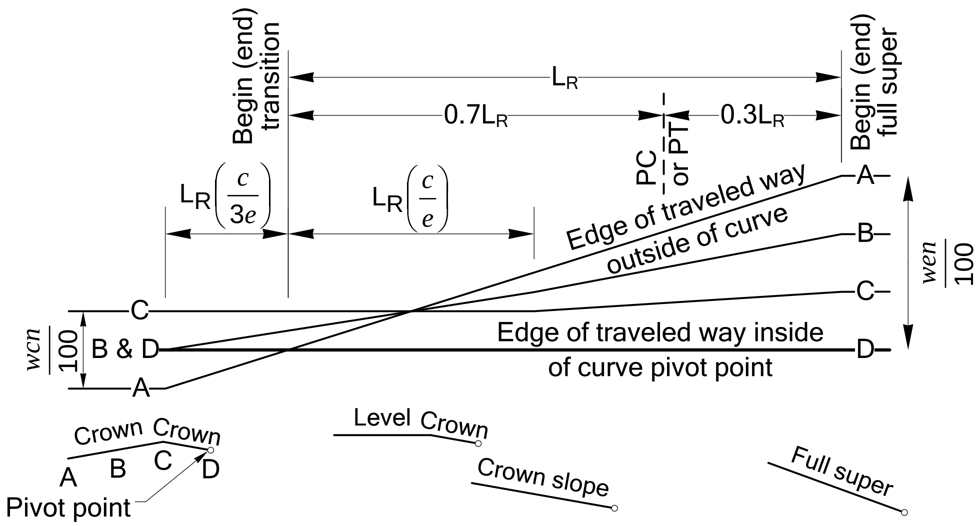
Design D[1] – Pivot Point on Edge of Traveled Way Curve in Direction of Normal Pavement Slope: Plane Section



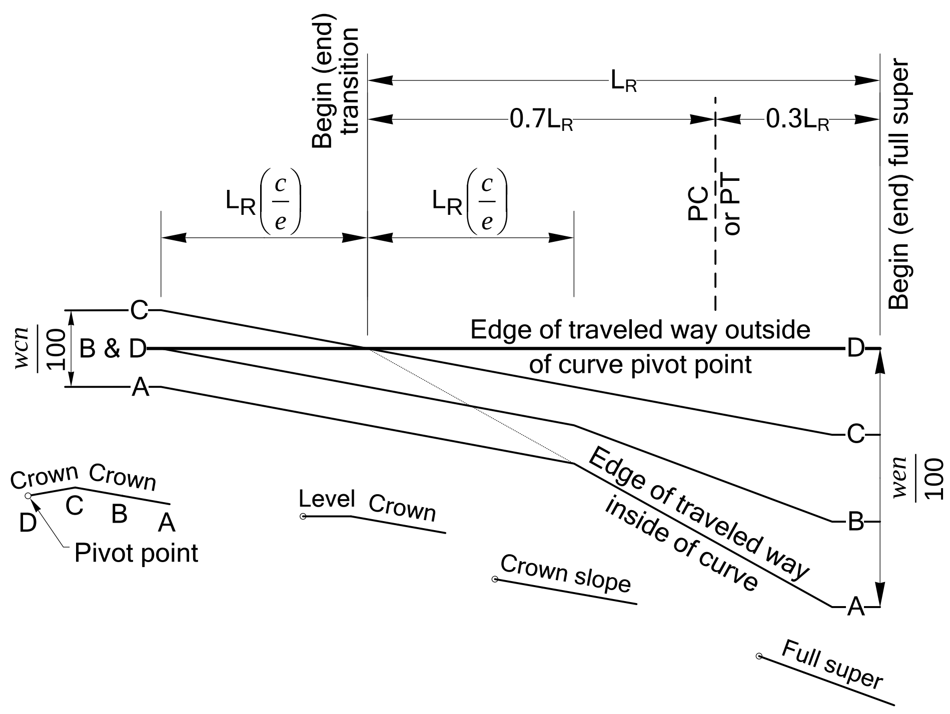
Design D[2] – Pivot Point on Edge of Traveled Way Curve Opposite to Normal Pavement Slope: Plane Section

c = Normal crown (%)
e = Superelevation rate (%)
n = Number of lanes between points
w = Width of lane

Exhibit 1250-6e Superelevation Transitions for Highway Curves



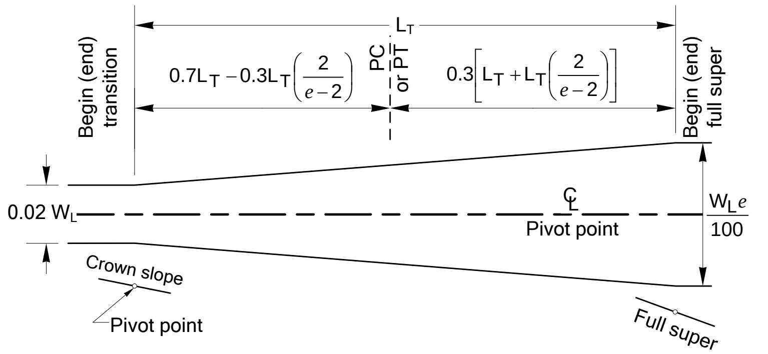
Design E[1] – Six-Lane With Median, Pivot Point on Edge of Traveled Way: Inside of Curve Crown Section



Design E[2] – Six-Lane With Median, Pivot Point on Edge of Traveled Way: Outside of Curve Crown Section

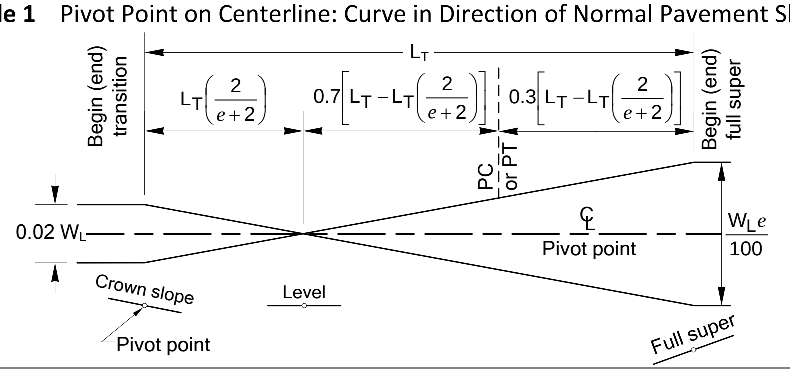
c = Normal crown (%)
e = Superelevation rate (%)
n = Number of lanes between points
w = Width of lane

Exhibit 1250-7a Superelevation Transitions for Ramp Curves



e (%)	Length of Transition in Feet for Design Speed							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
3	10	15	15	15	15	15	15	15
4	20	25	25	25	25	30	30	35
5	30	35	35	35	40	45	45	50
6	40	45	45	50	55	55	60	65
7	50	55	55	60	65	70	75	80
8	60	65	70	75	80	85	90	95
9	70	75	80	85	95	100	105	110
10	80	85	90	100	105	115	120	130

Table 1 Pivot Point on Centerline: Curve in Direction of Normal Pavement Slope

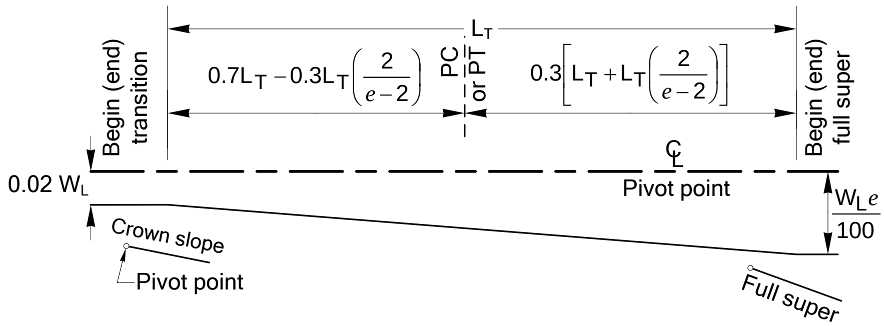


e (%)	Length of Transition in Feet for Design Speed							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
2	40	40	45	50	55	55	60	65
3	50	55	55	60	65	70	75	80
4	60	65	70	75	80	85	90	95
5	70	75	80	85	90	100	105	110
6	80	85	90	95	105	115	120	130
7	90	95	100	110	120	125	135	145
8	100	105	115	120	130	140	150	160
9	110	120	125	135	145	155	165	175
10	120	130	135	145	160	170	180	190

Table 2 Pivot Point on Centerline: Curve in Direction Opposite to Normal Pavement Slope

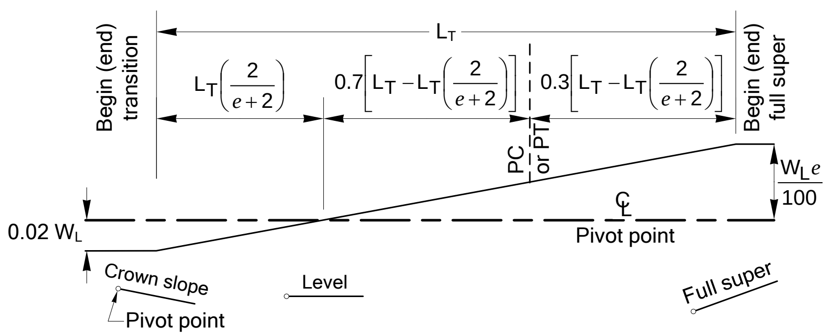
W_L = Width of ramp lane

Exhibit 1250-7b Superelevation Transitions for Ramp Curves



e (%)	Length of Transition in Feet for Design Speed							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
3	20	25	25	25	25	30	30	35
4	40	45	45	50	55	55	60	65
5	60	65	70	75	80	85	90	95
6	80	85	90	100	105	115	120	130
7	100	105	115	120	130	140	150	160
8	120	130	135	145	160	170	180	190
9	140	150	160	170	185	195	210	225
10	160	170	180	195	210	225	240	255

Table 3 Pivot Point on Edge of Traveled Way: Curve in Direction of Normal Pavement Slope



e (%)	Length of Transition in Feet for Design Speed							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
2	80	85	90	100	105	115	120	130
3	100	105	115	120	130	140	150	160
4	120	130	135	145	160	170	180	190
5	140	150	160	170	185	195	210	225
6	160	170	180	195	210	225	240	255
7	180	190	205	220	235	255	270	290
8	200	210	225	245	265	280	300	320
9	220	235	250	265	290	310	330	350
10	240	255	270	290	315	340	360	385

Table 4 Pivot Point on Edge of Traveled Way: Curve in Direction Opposite to Normal Pavement Slope

W_L = Width of ramp lane

Chapter 1270 Auxiliary Lanes

1270.01 General

Auxiliary lanes are used to comply with capacity demand; maintain lane balance; accommodate speed change, weaving, and maneuvering for entering and exiting traffic; and encourage carpools, vanpools, and the use of transit.

For signing and delineation of auxiliary lanes, see the *Standard Plans*, the *Traffic Manual*, and the MUTCD. Contact the region Traffic Engineer for guidance.

Although slow-vehicle turnouts, shoulder driving for slow vehicles, and chain-up areas are not auxiliary lanes, they are covered in this chapter because they perform a similar function.

For additional information, see the following chapters:

Chapter	Subject
1103	Design controls, including speed
1230	Geometric cross section components
1310	Turn lanes
1310	Speed change lanes at intersections
1360	Collector-distributor roads
1360	Weaving lanes
1410	High-occupancy vehicle lanes

1270.02 Climbing Lanes

1270.02(1) General

Climbing lanes (see Exhibit 1270-1) are normally associated with truck traffic, but they may also be considered in recreational or other areas that are subject to slow-moving traffic. Climbing lanes are designed independently for each direction of travel.

1270.02(2) Climbing Lane Warrants

Generally, climbing lanes are provided when two warrants—speed reduction and level of service—are met. Either warrant may be waived if, for example, slow-moving traffic is causing an identified collision trend or congestion that could be corrected by the addition of a climbing lane. However, under most conditions, climbing lanes are built when both warrants are met.

1270.02(2)(a) Warrant No. 1: Speed Reduction

Exhibit 1270-2a shows how the percent and length of grade affect vehicle speeds. The data is based on a typical commercial truck.

The maximum entrance speed, shown in the graphs, is 60 mph. This is the maximum value regardless of the posted speed of the highway. When the posted speed is above 60 mph, use 60 mph in place of the posted speed. Examine the profile at least ¼ mile preceding the grade to obtain a reasonable approach speed.

If a vertical curve makes up part of the length of grade, approximate the equivalent uniform grade length.

Whenever the gradient causes a 10 mph speed reduction below the posted speed limit for a typical truck for either two-lane or multilane highways, the speed reduction warrant is met (see Exhibit 1270-2b).

1270.02(2)(b) Warrant No. 2: Level of Service (LOS)

The level of service warrant for two-lane highways is met when the upgrade traffic volume exceeds 200 vehicles per hour and the upgrade truck volume exceeds 20 vehicles per hour. On multilane highways, a climbing lane is warranted when a capacity analysis shows the need for more lanes on an upgrade than on a downgrade carrying the same traffic volume.

Exhibit 1270-1 Climbing Lane Example

1270.02(3) Climbing Lane Design

When a climbing lane is justified, design it in accordance with Exhibit 1270-3. Provide signing and delineation to identify the presence of the auxiliary lane. Begin climbing lanes at the point where the speed reduction warrant is met and end them where the warrant ends for multilane highways and 300 feet beyond for two-lane highways. Consider extending the auxiliary lane over the crest to improve vehicle acceleration and sight distance.

Design climbing lane width equal to that of the adjoining through lane and at the same cross slope as the adjoining lanes. Whenever possible, maintain a shoulder width equal to the adjacent roadway segments (preserve shoulder width continuity). On two-way two-lane highways, the shoulder may be reduced to 4 feet. If the shoulder width is reduced to 4 feet document the reasoning for the decision in the design parameter sheets. If the shoulder width is reduced to less than 4 feet, a design analysis is required.

Exhibit 1270-2a Speed Reduction Warrant: Performance for Trucks

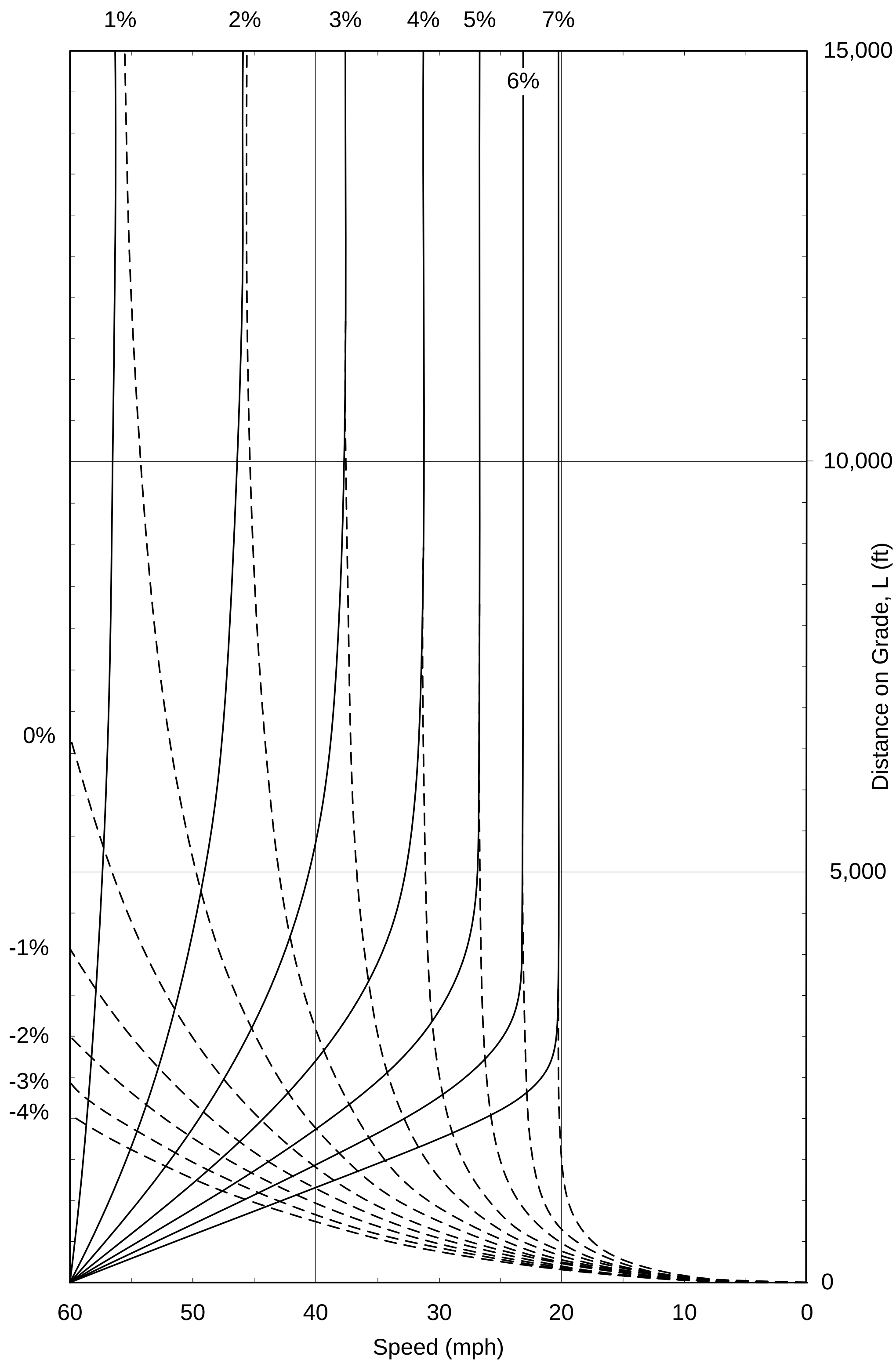
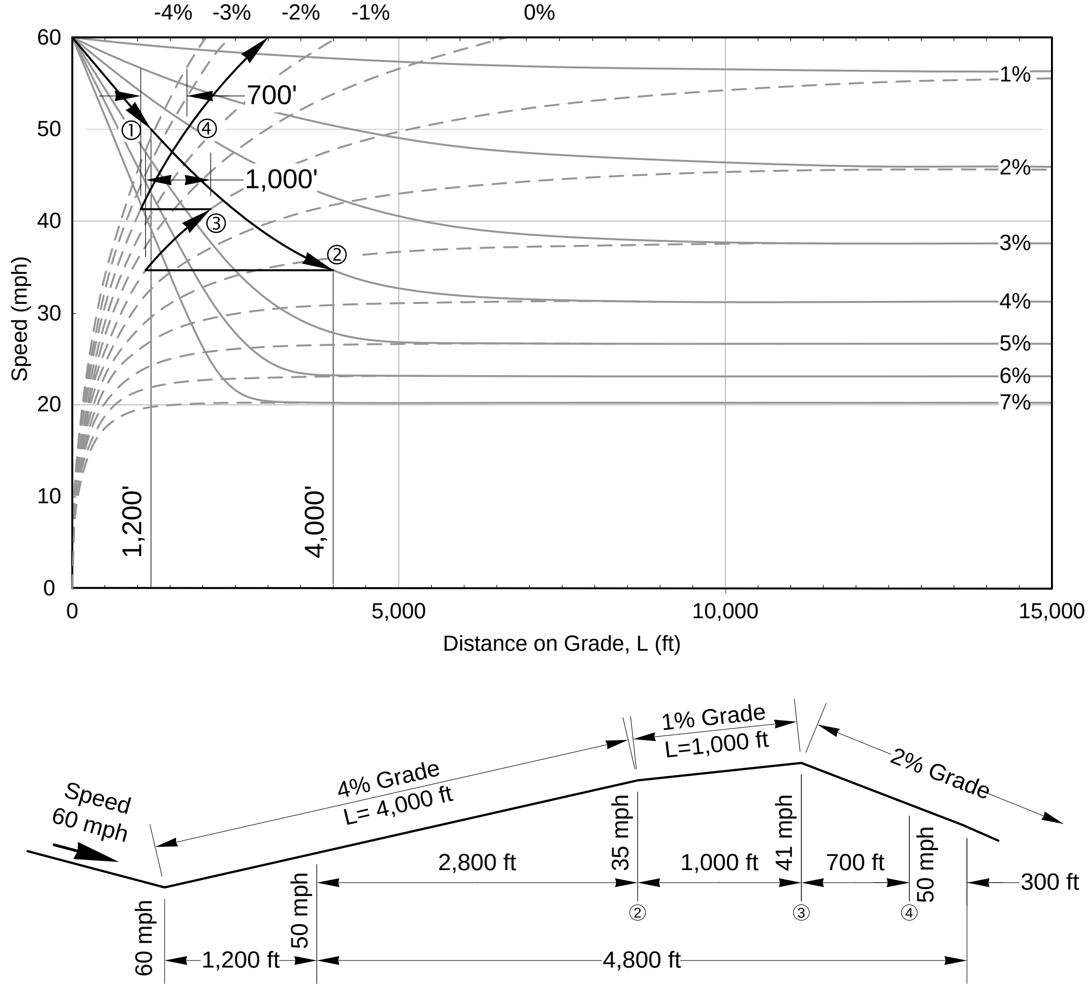


Exhibit 1270-2b Speed Reduction Warrant Example



Given:

A two-lane highway meeting the level of service warrant, with the above profile, and a 60 mph posted speed.

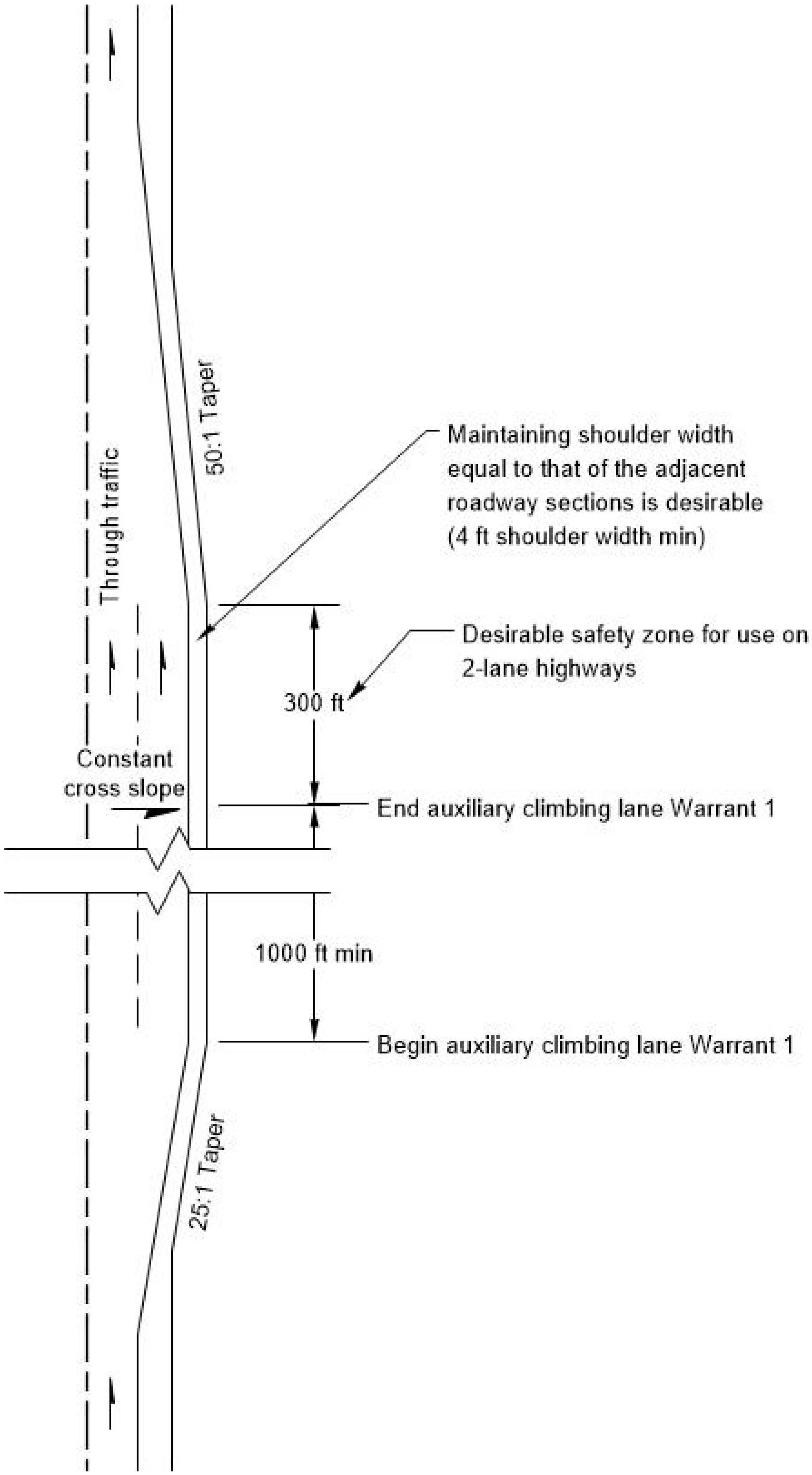
Determine:

Is the climbing lane warranted? If so, what is its length?

Solution:

1. Follow the 4% grade deceleration curve from a speed of 60 mph to a speed of 50 mph at 1,200 ft. The speed reduction warrant is met and a climbing lane is needed.
2. Continue on the 4% grade deceleration curve to 4,000 ft. Note that the speed at the end of the 4% grade is 35 mph.
3. Follow the 1% grade acceleration curve from a speed of 35 mph for 1,000 ft. Note that the speed at the end of the 1% grade is 41 mph.
4. Follow the -2% grade acceleration curve from a speed of 41 mph to a speed of 50 mph, ending the speed reduction warrant. Note that the distance is 700 ft.
5. The total auxiliary lane length is (4,000-1,200)+1,000+700+300=4,800 feet. 300 ft is added to the speed reduction warrant for a two-lane highway (see 1270.02(3) and Exhibit 1270-3).

Exhibit 1270-3 Auxiliary Climbing Lane



1270.03 Passing Lanes

1270.03(1) Passing Lane Benefits

A passing lane (see Exhibit 1270-4) is an auxiliary lane provided in one or both directions of travel on a two-lane highway to improve passing opportunities. They may be intermittent or continuous passing lanes in level or rolling terrain and short four-lane sections. The objectives of passing lanes are to:

- Improve overall traffic operations on two-lane highways by breaking up traffic platoons and reducing delays caused by inadequate passing opportunities over substantial lengths of highway.
- Increase average travel speed within the passing lane itself; the speed benefits of passing lanes continue downstream of the lane. Passing lanes typically reduce the percent time spent following within the passing lane itself. These “percent time spent following” benefits can continue for some distance downstream of the passing lane.
- Improve safety by providing assured passing opportunities without the need for the passing driver to use the opposing traffic lane. Safety evaluations have shown that passing lanes and short four-lane sections reduce collision rates and severity.

1270.03(2) Passing Lane Length

Design passing lanes long enough to provide a reduction in traffic platooning. To maximize the traffic operational efficiency of a passing lane in level or rolling terrain, its length can vary from 0.5 mile to 2.0 miles depending on the directional flow rate, as shown in Exhibit 1270-5. Passing lanes longer than 2 miles can cause the driver to lose the sense that the highway is a two-lane facility. However, these lengths may vary for other reasons such as addressing safety-related issues. Passing lanes longer than 2.0 miles or shorter than 0.5 miles in length may be used depending on the identified need or other operational considerations within the design. Lengths shown do not include passing lane tapers at the beginning or end of the passing lane.

Exhibit 1270-4 Passing Lane Example

Exhibit 1270-5 Length of Passing Lanes

Directional Flow Rate (pc/h)	Passing Lane Length (mi)
100	≤0.50
200	>0.50-0.75
400	>0.75-1.00
≥700	>1.00-2.00
Source: Transportation Research Board, Highway Capacity Manual, 2000	

For assistance in developing a passing lane length, see the following website for an example of a self-modeling spreadsheet. This spreadsheet develops passing lane lengths based primarily on vehicle speed differentials and is to be used in conjunction with traffic modeling efforts. Contact the Headquarters Design Office for assistance (www.wsdot.wa.gov/design/policy/default.htm).

1270.03(3) Passing Lane Location

A number of factors are considered when selecting an appropriate location for a passing lane, including the following:

- Locate passing lanes where decision sight distance (see Chapter 1260) at the lane decrease tapers can be provided.
- Provide stopping sight distance continuously along the roadway
- Avoid locating passing lanes near high-volume intersections, existing structures, railroad crossings, areas of dense development, and two-way left-turn lanes.
- Locate passing lanes where they appear logical to the driver.
- Carefully consider highway sections with low-speed curves (curves with superelevation less than required for the design speed) before installing a passing lane, since they may not be suitable for passing. For information on superelevation, see Chapter 1250.
- Avoid other physical constraints, such as bridges and culverts, if they restrict the provision of a continuous shoulder.
- Consider the number, type, and location of intersections and road approaches.
- Consider grades when choosing the side on which to install the passing lane. Uphill grades are preferred but not mandatory.
- Preference for passing is normally given to the traffic departing a developed area such as a small town.

1270.03(3)(a) Traffic Operational Considerations

When passing lanes are provided at an isolated location, their typical objective is to reduce delays at a specific bottleneck; for example, climbing lanes (see 1270.02). The location of the passing lane is dictated by the needs of the specific traffic operational problem encountered.

When passing lanes are provided to improve traffic operations over a length of road, there is flexibility in the choice of passing lane locations to maximize their operational effectiveness and minimize construction costs.

If delay problems on an upgrade are severe, the upgrade will usually be the preferred location for a passing lane.

Passing lanes at upgrades begin before speeds are reduced to unacceptable levels and, where possible, continue over the crest of the grade so that slower vehicles can regain some speed before merging.

1270.03(3)(b) Construction Cost Considerations

The cost of constructing a passing lane can vary substantially, depending on terrain, highway structures, shoulders, and adjacent development. Thus, the choice of a suitable location for a passing lane may be critical to its cost-effectiveness.

Generally, passing lanes in level and rolling terrain can be placed where they are least expensive to construct, avoiding locations with high cuts and fills and existing structures that would be expensive to widen.

1270.03(3)(c) Intersection-Related Considerations

Consider a corridor evaluation of potential passing lane locations for each direction, avoiding placement of passing lanes near intersections. Avoid or minimize turning movements on a road section where passing is encouraged.

Low-volume intersections and driveways are allowed within passing lanes, but not within the taper transition areas.

Where the presence of higher-volume intersections and driveways cannot be avoided, consider including provisions for turning vehicles, such as left-turn lanes.

Provide right- and left-turn lanes in passing lane sections where they would be provided on a conventional two-lane highway.

Left turns within the first 1,000 feet of a passing lane are undesirable. Strategies to address the turning movement could include left-turn lanes, right-in/right-out access, beginning the passing lane after the entrance, and so on.

1270.03(4) Passing Lane Design

Where a passing lane is planned, evaluate several possible configurations (see 1270.03(4)(a)) that are consistent with the corridor and fit within the constraints of the specific location.

The recommended minimum transition distance between passing lanes in opposing directions is 500 feet for “tail-to-tail” and 1,500 feet for “head-to-head” (see Exhibit 1270-7).

Some separation between lanes in opposite directions of travel is desirable; however, passing lanes can operate effectively with no separation. In either situation, address pavement markings and centerline rumble strips as appropriate.

It is desirable to channelize the beginning of a passing lane to move traffic to the right lane in order to promote prompt usage of the right lane by platoon leaders and maximize passing lane efficiency.

Widening symmetrically to maintain the roadway crown at the centerline is preferred, including in continuous passing lane configurations. However, the roadway crown may be placed in other locations as deemed appropriate. Considerations for crown locations might include: costs, constructability, right of way, environmentally sensitive roadsides, or other factors.

1270.03(4)(a) Alternative Configurations

Where a passing lane will be provided, evaluate the configurations shown in Exhibit 1270-6. In the exhibit, general passing lane configurations and their typical applications are described in the following:

a. Isolated Passing Lane – Exhibit 1270-6 (a)

- Two-lane highway with passing lane provided at a spot location to dissipate queues.
- For isolated grades, consider climbing lanes (see 1270.02).

b. Intermittent Passing Lanes, Separated – Exhibit 1270-6 (b)

- Often pairs are used at regular intervals along a two-lane highway.
- Frequency of passing lanes depends on desired level of service.
- The spacing between passing lanes and between pairs may be adjusted to fit the conditions along the route (see 1270.03(3)).

c. Continuous Passing Lanes – Exhibit 1270-6 (c)

- Use only when constraints do not allow for the use of other configurations. The use of this configuration requires concurrence from the region Traffic Engineer. (See Exhibit 1270-7 for additional information regarding buffer areas.)
- Appropriate for two-lane roadways carrying relatively high traffic volumes where nearly continuous passing lanes are needed to achieve the desired level of service.
- Particularly appropriate over an extended section of roadway where a wide pavement is already available.
- May be used as an interim stage for an ultimate four-lane highway.

d. Short Four-Lane Section – Exhibit 1270-6 (d)

- Sufficient length for adjoining passing lanes is not available.
- Particularly appropriate where the ultimate design for the highway is four lanes.

e. Intermittent Three-Lane Passing Lanes – Exhibit 1270-6 (e)

- Does not require the slow vehicle to change lanes to allow passing.
- Requires the widening to transition from one side of the existing roadway to the other.
- Eliminates the head-to-head tapers.

1270.03(4)(b) Geometric Aspects

Carefully design transitions between passing lanes in opposing directions. Intersections, bridges, other structures, two-way left-turn lanes, painted medians, or similar elements can be used to provide a buffer area between opposing passing lanes. The length of the buffer area between adjoining passing lanes depends on the configuration (see Exhibit 1270-7).

Exhibit 1270-6 illustrates five passing lane design configurations. Part (c) illustrates a continuous three-lane section with alternating passing lanes. Consider a four-lane cross section when volume demand exceeds the capacity of a continuous three-lane roadway.

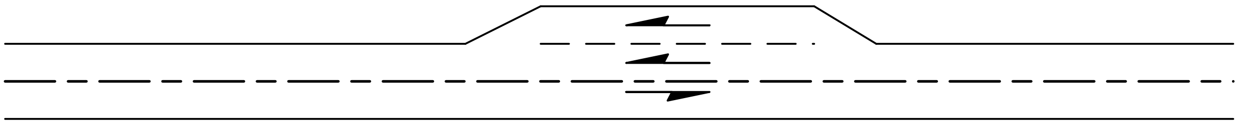
Exhibit 1270-8 illustrates taper rates, cross slopes, and section lengths for three and four-lane passing sections. Where practicable provide shoulder width in a passing lane section equal to the shoulder width on the adjacent segments of a two-lane highway. However, the shoulder may be reduced to 4 feet. If the shoulder width is reduced to 4 feet, document the reason for the decision on the design parameter sheets. If the shoulder width is reduced to less than 4 feet, a design analysis is required. See Chapter 1600 for shoulder rumble strip criteria and considerations.

Where practicable, design the passing lane width the same as the lane width on the adjacent segments of the two-lane highway.

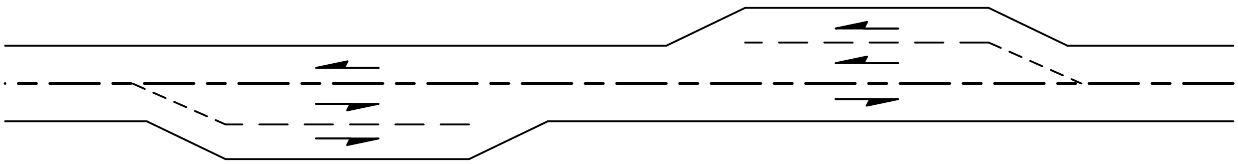
Provide a 25:1 or flatter taper rate to increase the width for a passing lane. When all traffic is directed to the right lane at the beginning of the passing lane, provide a taper rate of the posted speed:1. Provide a posted speed:1 taper rate for the merging taper at the end of a passing lane. (Refer to the Lane Transitions section in Chapter 1210 for additional information on taper rates.) Consider a wide shoulder at the lane drop taper to provide a recovery area for drivers who encounter a merging conflict.

Provide signing and delineation to identify the presence of an auxiliary passing lane. Refer to the *Standard Plans*, the *Traffic Manual*, and the MUTCD for passing lane signing and marking guidance.

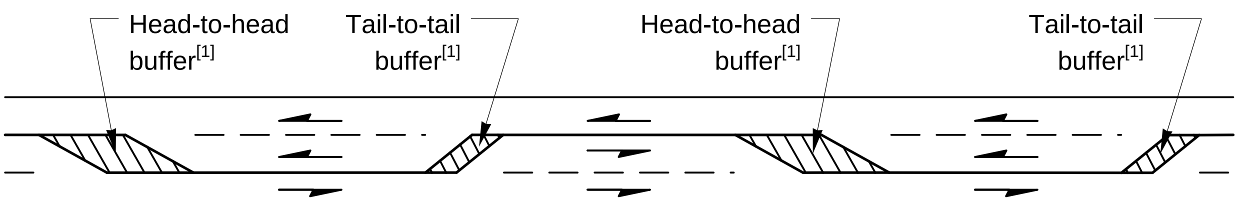
Exhibit 1270-6 Passing Lane Configurations



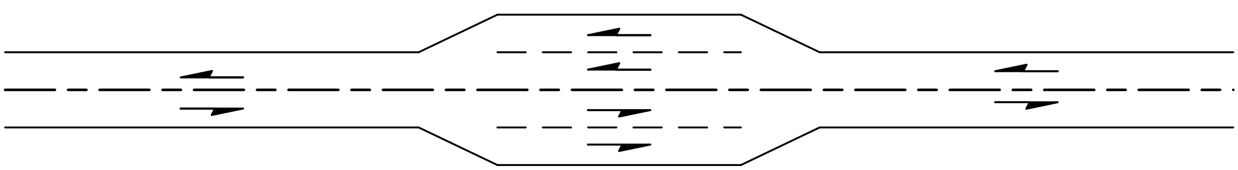
(a) Isolated Passing Lane



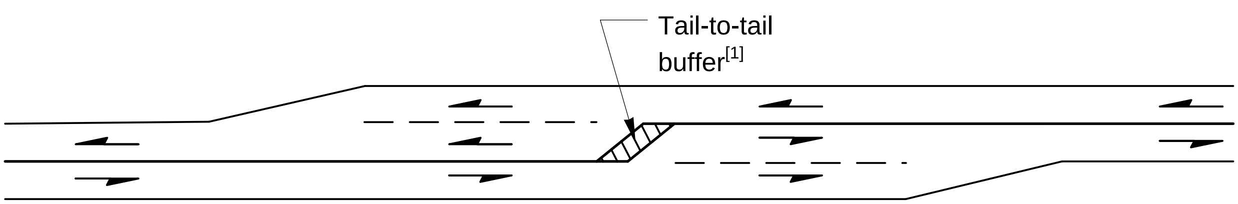
(b) Intermittent Passing Lane



(c) Continuous Three-Lane Section



(d) Short Four-Lane Section



(e) Intermittent Three-Lane Passing Lanes

Note:

[1] See Exhibit 1270-7 for buffer design.

Exhibit 1270-7 Buffer Between Opposing Passing Lanes

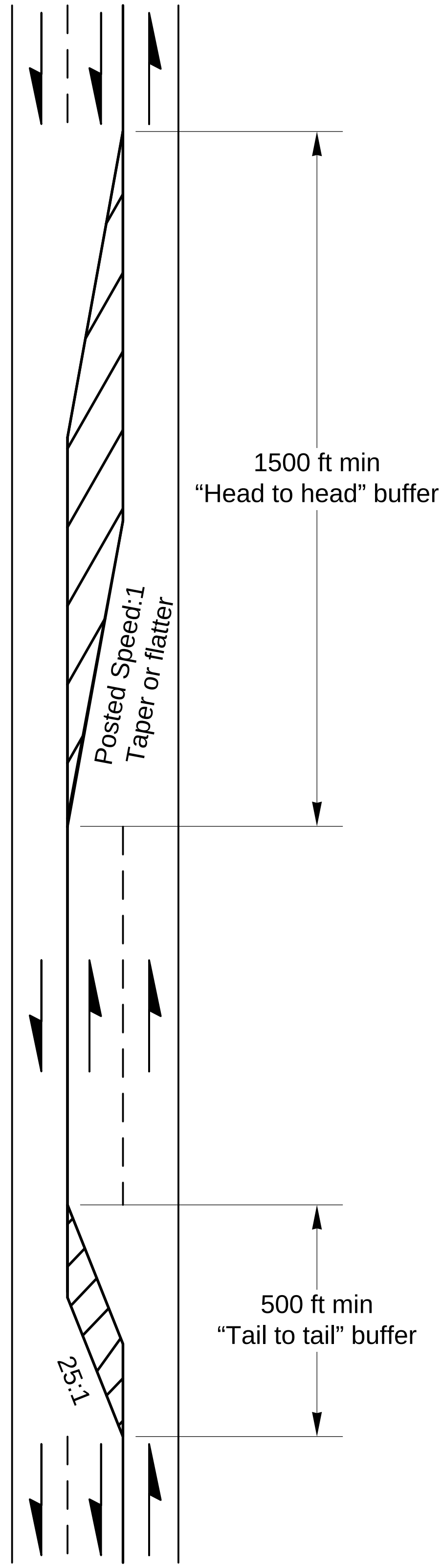
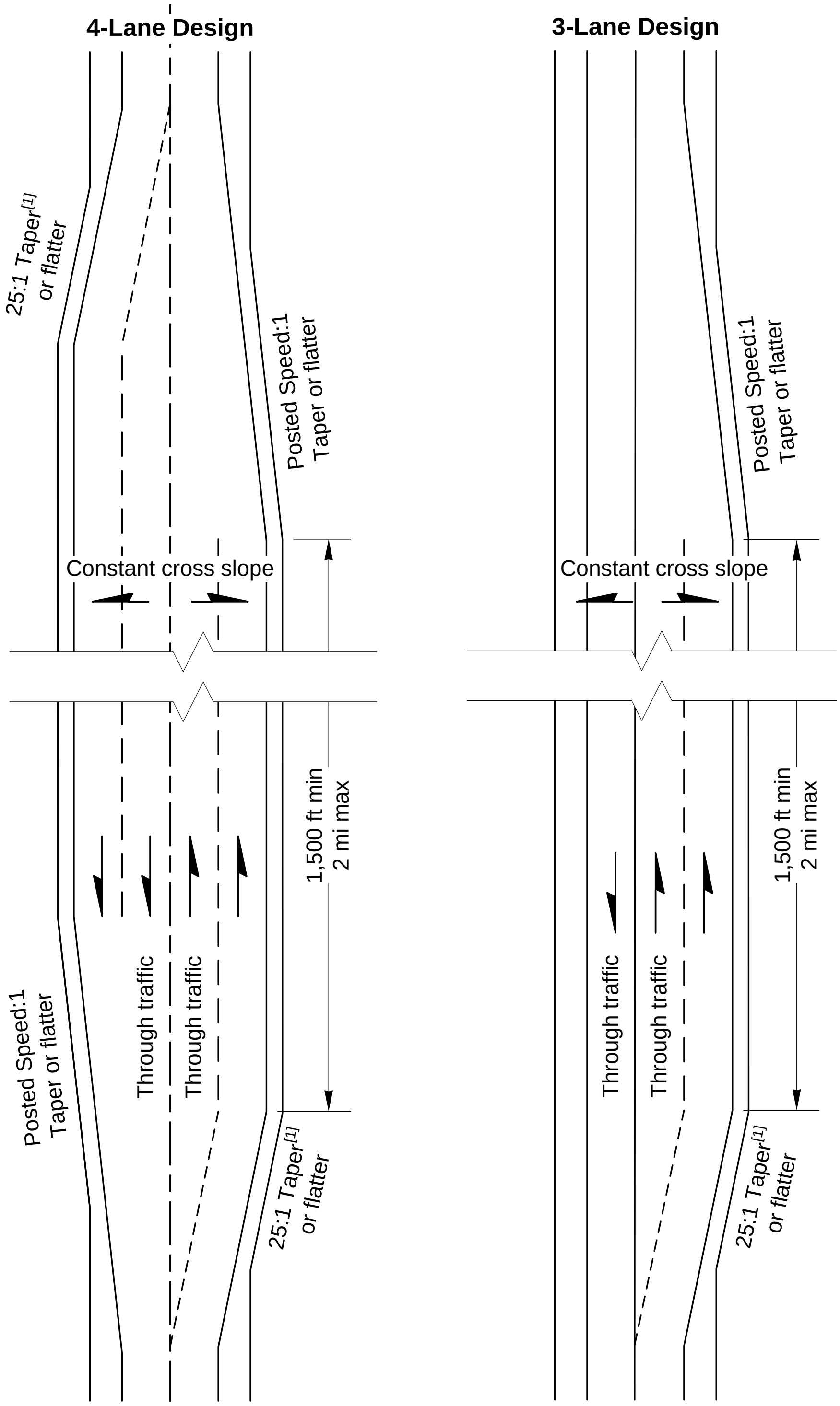


Exhibit 1270-8 Auxiliary Passing Lane



Notes:

[1] Provide a posted speed:1 taper when all traffic is directed to the right lane at the beginning of the passing lane.

[2] Where practicable provide the same lane and shoulder widths in the passing section as on adjacent segments. See 1270.03(4)(b).

1270.04 Slow-Moving Vehicle Turnouts

1270.04(1) General

RCW 46.61.427 states:

> *On a two-lane highway where passing is unsafe … a slow-moving vehicle, behind which five or more vehicles are formed in a line, shall turn off the roadway wherever sufficient area for a safe turn-out exists, in order to permit the vehicles following to proceed…*

A slow-moving vehicle turnout is not an auxiliary lane. Its purpose is to provide sufficient room for a slow-moving vehicle to pull out of through traffic and stop if necessary, allow vehicles to pass, and then return to the through lane. Generally, a slow-moving vehicle turnout is provided on existing roadways where passing opportunities are limited, where slow-moving vehicles such as trucks and recreational vehicles are predominant, and where the cost to provide a full auxiliary lane would be prohibitive.

1270.04(2) Design

Base the design of a slow-moving vehicle turnout primarily on sound engineering judgment. Designs may vary from one location to another. Provide a length between 100 and 1,320 feet, excluding tapers. Select a width adequate for the vehicle type expected to use the turn-out, between 8 to 12 feet in width. Surface the turnouts with a stable, unyielding material (such as BST or HMA) with adequate structural strength to support the heavier traffic.

To improve the ability of a vehicle to safely reenter through traffic, locate slow-moving vehicle turnouts where adequate sight distance is available. The minimum design range for slow-vehicle turnouts may be where at least design stopping sight distance is available. See Chapter 1260.

Sign slow-moving vehicle turnouts to identify their presence. For guidance, see the Standard Plans, the Traffic Manual, and the MUTCD.

1270.05 Shoulder Driving for Slow Vehicles

1270.05(1) General

Use of a shoulder driving section is an alternative means to meet the performance objectives provided by climbing or passing lanes.

Review the following when considering a shoulder driving section:

- Horizontal and vertical alignment
- Character of traffic
- Presence of bicycles
- Road approaches and intersections
- Clear zone (see Chapter 1600)

1270.05(2) Design

When designing a shoulder for shoulder driving, locate where full design stopping sight distance (speed/path/direction decision sight distance is desirable) and a minimum length of 600 feet are available. Where practicable, avoid sharp horizontal curves. When barriers or other roadside objects are present, the minimum width is 12 feet. The shoulder width depends on the vehicles that will be using the shoulder. Where trucks will be the primary vehicle using the shoulder, use a 12-foot width; when passenger cars are the primary vehicle, a 10-foot width may be used.

Shoulder driving and bicycles are not compatible. When the route has been identified as a local, state, or regional significant bike route, shoulder driving for slow vehicles is undesirable. Reconstruct the shoulders to provide adequate structural strength for the anticipated traffic. Select locations where the side slope meets the criteria of Chapter 1239. When providing a transition at the end of a shoulder driving section, use a 50:1 taper.

Signing for shoulder driving is required (see the Standard Plans, the Traffic Manual, and the MUTCD). Install guideposts when shoulder driving is to be permitted at night.

1270.06 Emergency Escape Ramps

1270.06(1) General

Consider an emergency escape ramp (see Exhibit 1270-9) whenever a long, steep downgrade is encountered. In this situation, the possibility exists of a truck losing its brakes and going out of control at a high speed. Consult local maintenance personnel and check crash data to determine whether or not an escape ramp is justified.

Exhibit 1270-9 Emergency Escape Ramp Example

1270.06(2) Design

1270.06(2)(a) Types

Escape ramps include the following types:

- Gravity escape ramps are ascending grade ramps paralleling the traveled way. They are commonly built on old roadways. Their long length and steep grade can present the driver with control problems, not only in stopping, but with rollback after stopping. Gravity escape ramps are the least desirable design.
- Sand pile escape ramps are piles of loose, dry sand dumped at the ramp site, usually not more than 400 feet in length. The deceleration is usually high and the sand can be affected by weather conditions; therefore, they are less desirable than arrester beds. However, where space is limited, they may be suitable.
- Arrester beds are parallel ramps filled with smooth, free-draining gravel. They stop the out-of-control vehicle by increasing the rolling resistance and are the most desirable design. Arrester beds are commonly built on an upgrade to add the benefit of gravity to the rolling resistance. However, successful arrester beds have been built on a level or descending grade.
- The Dragnet Vehicle Arresting Barrier consists of chain link or fiber net that is attached to energy-absorbing units. (See Chapter 1610 for additional information.)

1270.06(2)(b) Locations

The location of an escape ramp depends on terrain, length of grade, sight distance, and roadway geometrics. Desirable locations include before a critical curve, near the bottom of a grade, or before a stop. It is desirable that the ramp leave the roadway on a tangent at least 3 miles from the beginning of the downgrade.

1270.06(2)(c) Lengths

The length of an escape ramp depends on speed, grade, and type of design used. The minimum length is 200 feet. Calculate the stopping length using the equation in Exhibit 1270-10.

Exhibit 1270-10 Emergency Escape Ramp Length

$$L = \frac{V^2}{0.3(R \pm G)}$$

Where:
L = Stopping distance (ft)
V = Entering speed (mph)
R = Rolling resistance (see Exhibit 1270-11)
G = Grade of the escape ramp (%)

Speeds of out-of-control trucks rarely exceed 90 mph; therefore, the desirable entering speed is 90 mph. Other entry speeds may be used when justification and the method used to determine the speed are documented.

Exhibit 1270-11 Rolling Resistance (R)

Material	*R*
Roadway	1
Loose crushed aggregate	5
Loose non-crushed gravel	10
Sand	15
Pea gravel	25

1270.06(2)(d) Widths

The width of each escape ramp depends on the needs of the individual situation. It is desirable for the ramp to be wide enough to accommodate more than one vehicle. The desirable width of an escape ramp to accommodate two out-of-control vehicles is 40 feet and the minimum width is 26 feet.

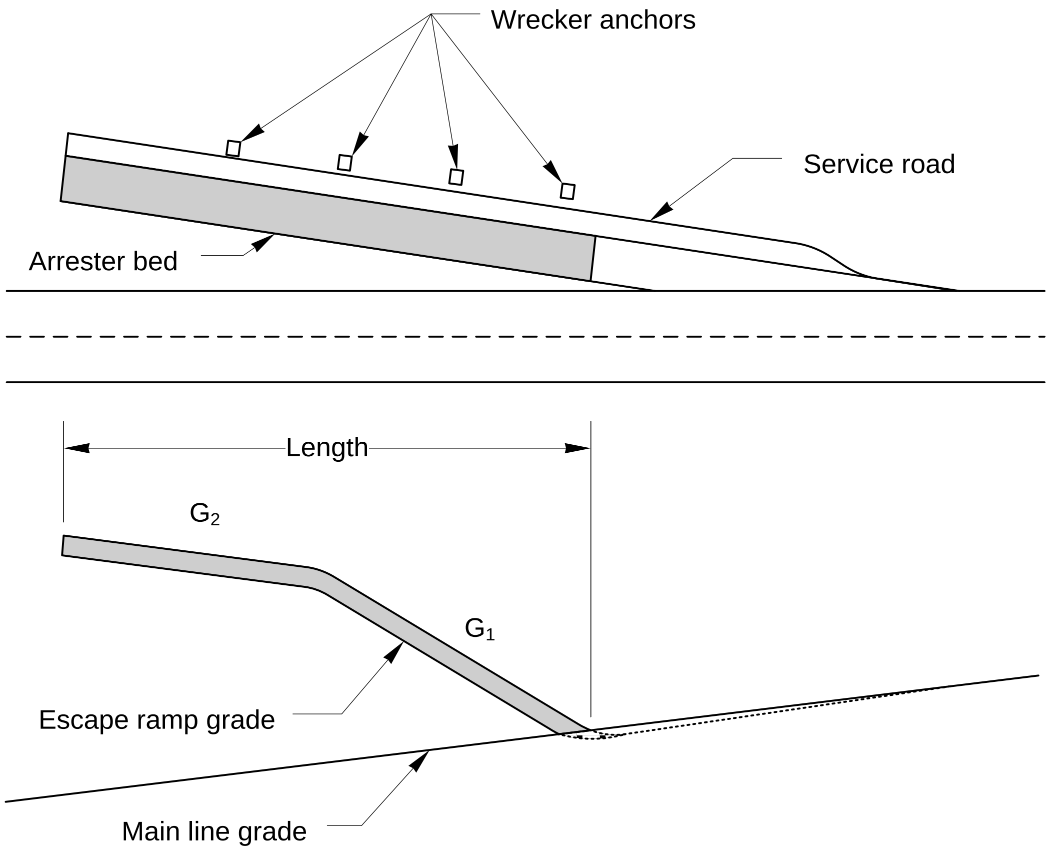
The following items are additional considerations in the design of emergency escape ramps:

- If possible, at or near the summit, provide a pull-off brake check area. Also, include in this area informative signing about the upcoming escape ramp.
- Free-draining, smooth, non-crushed gravel is desirable for an arrester bed. To assist in smooth deceleration of the vehicle, taper the depth of the bed from 3 inches at the entry to a full depth of 18 to 30 inches in not less than 100 feet.
- Mark and sign in advance of the ramp. Discourage normal traffic from using or parking in the ramp. Sign escape ramps in accordance with the guidance contained in the MUTCD for runaway truck ramps.
- Provide drainage adequate to prevent the bed from freezing or compacting.
- Consider including an impact attenuator at the end of the ramp if space is limited.
- A surfaced service road adjacent to the arrester bed is needed for wreckers and maintenance vehicles to remove vehicles and make repairs to the arrester bed. Anchors are desirable at 300-foot intervals to secure the wrecker when removing vehicles from the bed.

Typical examples of arrester beds are shown in Exhibits 1270-9 and 1270-12.

Include justification, all calculations, and any other design considerations in the emergency escape ramp documentation.

Exhibit 1270-12 Typical Emergency Escape Ramp



1270.07 Chain-Up and Chain-Off Areas

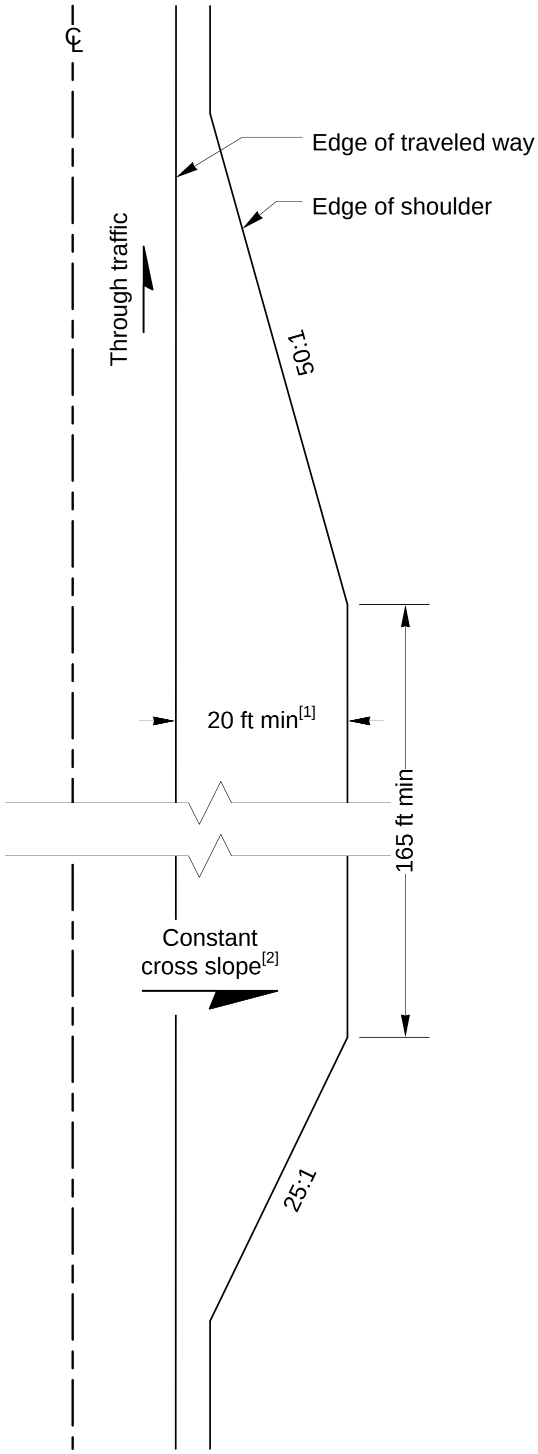
Provide chain-up areas to allow chains to be put on vehicles out of the through lanes at locations where traffic enters chain enforcement areas. Provide chain-off areas to remove chains out of the through lanes for traffic leaving chain enforcement areas.

Chain-up or chain-off areas are widened shoulders, designed as shown in Exhibit 1270-13. Locate chain-up and chain-off areas where the grade is 6% or less and desirably on a tangent section.

Consider illumination for chain-up and chain-off areas on multilane highways. When deciding whether or not to install illumination, consider traffic volumes during the hours of darkness and the availability of power.

The wide shoulders at chain-up and chain-off areas may encourage parking. When parking is undesirable, consider parking restrictions.

Exhibit 1270-13 Chain-Up/Chain-Off Area



Notes:

[1] Where traffic volumes are low and trucks are not a concern, the width may be reduced to 10 ft min, with 15 ft desirable.

[2] 2% desirable. (See Chapter 1250 for traveled way cross slope.)

1270.08 Documentation

Refer to Chapter 300 for design documentation requirements.

1270.09 References

1270.09(1) Federal/State Laws and Codes

Revised Code of Washington (RCW) 46.61, Rules of the road

1270.09(2) Design Guidance

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

Standard Plans for Road, Bridge, and Municipal Construction (*Standard Plans*), M 21-01, WSDOT

Traffic Manual, M 51 02, WSDOT

1270.09(3) Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition

Emergency Escape Ramps for Runaway Heavy Vehicles, FHWA-T5-79-201, March 1978

Highway Capacity Manual, latest edition, Transportation Research Board, National Research Council

Truck Escape Ramps, NCHRP Synthesis 178, Transportation Research Board

Chapter 1300 Intersection Control Type

1300.01 General

It is WSDOT practice to analyze potential intersection solutions at all intersection improvement locations in accordance with *E 1082 – Business Practices for Moving Washington* and E 1090 – *Moving Washington Forward: Practical Solutions*. The objective is to provide the optimum solution within available resources, with an emphasis on low-cost investments. The analysis can be done for individual intersections, or on a corridor or network basis. This chapter provides guidance on preliminary intersection analysis and selection of control type. Intersection design is completed using Chapter 1310 for the geometrics of intersections, Chapter 1320 for roundabouts, and Chapter 1330 for traffic signals. Use the aforementioned chapters in conjunction with chapters 1106, 1230 series, 1430, 1510, and 1520 to assist with dimensioning design elements.

Consider design users and the balance between modes, safety and mobility performance considerations, context-sensitive/sustainable design, and economics when selecting and evaluating alternatives to meet the needs of the project.

Identification of intersection projects can come from a variety of programs and sources, including those funded by local agencies and developers. The intent of this chapter is that the ICA procedures apply to all types of intersection modifications on the state highway system. Potential safety project locations are identified through the safety priority programming process. Other programs may identify intersection needs through the priority array programming process, but the influence of the type of intersection control with respect to specific performance category needs may not be fully understood until contributing factors analysis is completed (see Chapter 1101).

Complete an Intersection Control Analysis (ICA) as early in the project development process as practicable, taking into account the level of community engagement that may need to occur prior to approval. The ICA (see 1300.05 for procedures) should be initiated no later than the scoping phase. ***Scale the ICA according to the size and complexity of the project***; for example, evaluation of adding a turn lane to an existing intersection control may take less effort than evaluating new intersection control. Consult the region or HQ Traffic offices for assistance with the level of effort required.

It is WSDOT policy to focus on lower cost solutions with the intent to optimize return on investment. Only when all at-grade intersection alternatives are ruled out, including turn restrictions and complete intersection removal, should other more-costly measures be considered, such as grade-separation. Ramp terminal intersections are subject to the analysis requirements of this chapter. See Chapters 1360 and 550 for additional information.

For additional information, see the following chapters:

Chapter	Subject
320	Traffic analysis
321	Sustainable Safety Analysis
530	Limited access control
540	Managed access control
550	Interchange Justification Report
1100	Practical Design
1101	Need Identification
1103	Design Controls
1106	Design Element Dimensioning
1230	Geometric Cross Section Basics; and other 1230 series chapters
1310	Intersections
1320	Roundabouts
1330	Traffic signals
1340	Road Approaches
1360	Interchanges
1510	Pedestrian facilities
1515	Shared-use paths
1520	Bicycle facilities

1300.02 Intersection Control Objectives

Intersections are an important part of highway design. Intersection control choice requires consideration of all potential users of the facility, including drivers of motorcycles, passenger cars, heavy vehicles of different classifications, public transit, and bicyclists and pedestrians.

Design users have varying skills and abilities. Younger and older drivers in particular are subject to a variety of behavioral or human factors that can influence elements of their driving ability. See NCHRP Report 600 – Human Factors Guidelines for Road Systems: Second Edition for additional information (http://www.trb.org/Main/Blurbs/167909.aspx). Bicyclists, from recreational to commuters, also have a variety of skill sets that can influence the effectiveness of bike facilities and intersection operational design (see Chapter 1520 for additional information). Meeting the needs of one user group can directly influence the service that other groups experience. The selection process evaluates these competing needs and results in an optimal balance of tradeoffs for all design users, recognizing the context and priorities of the location.

The intent of an ICA is not to design an intersection, but to evaluate the compatibility of different intersection control types with respect to context, modal priority, intersection design vehicle and the identified balance of performance needs. Four basic intersection design considerations are shown in Exhibit 1300-1 and can affect the intersection control types depending on the situation.

The objectives of the ICA are to:

- Provide a consistent framework to determine the most compatible intersection control type for the location, context, economics, and balance of performance needs.

- Evaluate the operational and safety performance for various appropriate and feasible intersection control types under consideration.
- Evaluate the modal performance considerations between different intersection control types with respect to the identified modal priority and intersection design vehicle (see Chapter 1103). Identify the potential modal treatments that augment the control types.
- Consider the intersection operations and the relationship with adjacent intersections and other access points.
- Evaluate the intersection control types for potential sustainability, cost-effectiveness, and expected maintenance and operations life cycle needs.
- Establish that a roundabout is the preferred intersection control type. When a roundabout is not selected, provide justification to support alternative decisions.
- Consider emerging alternative intersection designs such as displaced left-turn (DLT) and restricted crossing u-turn intersections (RCUT) where appropriate.
- Select the most cost-effective intersection control type for the project based on overall need and context.

Exhibit 1300-1: Intersection Design Considerations

Human Factors	
• Driving habits • Driver workload • Driver expectancy • Driver error • Driver distractions • Perception-reaction time	• Conformance to natural paths of movement • Pedestrian use and habits • Bicycle traffic use and habits • Visual recognition of roadway cues • Compatibility with context characteristics • Demand for alternative mode choices
Traffic Considerations	
• Design users, modal priority, and intersection design vehicle • Design and actual capacities • Design-hour turning movements • Variety of movements (diverging/merging/weaving/crossing)	• Vehicle size and operating characteristics • Vehicle speeds • Transit involvement • Crash Experience • Bicycle movements • Pedestrian movements
Physical Elements	
• Character and use of abutting property • Vertical alignments at the intersection • Sight distance • Angle of the intersection • Conflict areas • Speed-change lanes • Managed lanes (HOV, HOT, shoulder) • Accessible facilities • Parking zones • Geometric design features	• Traffic control devices • Illumination • Roadside design features • Environmental factors • Crosswalks • Transit facilities • Driveways • Streetside design features • Adjacent at-grade rail crossing • Access management treatments including turn restrictions
Economic Factors	
• Cost of improvements, annual maintenance, operations and life cycle costs, and salvage value • Effects of controlling access and right of way on abutting properties where channelization restricts or prohibits vehicular movements • Energy consumption and emissions	

1300.03 Common Types of Intersection Control

1300.03(1) Uncontrolled Intersections

- Uncontrolled intersections do not have signing, and the normal right of way rule (RCW 46.61.180) applies.
- This intersection type is typically found on local roads and streets where the volumes of the intersecting roadways are low and roughly equal, speeds are low, and there is little to no crash history.
- Uncontrolled intersections are not recommended for state routes.

1300.03(2) Yield Control

- Intersections with yield control assign right of way without requiring a stop.
- Mostly used at rural low-volume ramps and wye (Y) intersections.
- Yield control is generally not recommended in urban locations or where pedestrians are expected.

1300.03(3) Two-Way Stop Control

- Intersections with two-way stop control are a common, lower cost control, which require the traffic on the minor roadway to stop and yield to mainline traffic before entering the major roadway.
- Along certain corridors, especially where u-turn opportunities exist, consider limiting access at two-way stops to "right-in, right-out only."

1300.03(4) Multi-Way Stop Control

- Multi-way stop control normally requires all traffic to stop before entering the intersection.
- Fewer fatal and injury crashes than two-way stop control.
- Multi-way stop control is suited for lower speed facilities with approximately equal volumes on all legs and total entering volumes not exceeding 1,400 vehicles during the peak hour.
- Increased traffic delays, fuel consumption, and air pollution.
- Multi-way stop control is not recommended on multilane state routes or at intersections with unbalanced directional traffic flows because of the delays and queues introduced on the major-volume legs of the intersection.

1300.03(5) Roundabouts

Roundabouts are often circular (or near-circular) at-grade intersections, where traffic on the approaches yield to traffic within the circulating roadway. Roundabouts are an effective intersection type that may offer the following:

- Reduced fatal and injury crashes compared with other at-grade intersection types.
- Fewer conflict points.
- Lower potential for wrong-way driving.
- Reduced traffic delays.
- Traffic-calming and lower speeds.
- More capacity than a two-way or multi-way stop.
- Quickly serves pedestrians needing to cross the intersection and shortens crossing distance for pedestrians by allowing for crossing in stages where needed. Reduces vehicular approach speeds that in turn reduces injury risk to pedestrians.
- Ability to serve high turning volumes with minimal number of approach lanes.
- Improved operations where space for queuing is limited.
- At ramp terminals where left-turn volumes are high, improved capacity without affecting the structure.
- Facilitation of u-turn movements and can be appropriate when combined with access management along a corridor.
- Aesthetic treatments and gateways to communities.
- Roundabouts are scalable and site-specific solutions, with flexibility to fit funding and a variety of site constraints. See Chapter 1320 for more information on roundabout types and design.

1300.03(6) Traffic Control Signals

- Signalized intersections may offer the following:
- Increased capacity of the intersection.
- Allow for improved progression within a coordinated system along a corridor or a grid.
- Can be used to interrupt heavy traffic at intervals to permit other traffic, vehicular or pedestrian, to complete their movement or enter the intersection.
- Can be preempted to provide priority service to railroad, emergency responders, transit and approaches where advance queue loops are used.

However, signalized intersections:

- Require continual maintenance and engineering for optimal operations.

- Cannot adequately balance large traffic flows with pedestrian demands.
- Can be susceptible to power outages and detection failures.

Indiscriminate use of traffic signals can adversely affect the safety performance and operational efficiency of vehicle, bicycle, and pedestrian traffic. Therefore, and as required by the MUTCD, a traffic signal should be considered for installation only after if it is determined to meet specific "warrants" and an engineering study shows that the installation would improve safety and/or operations. Satisfying a signal warrant does not mandate the installation of a traffic signal nor by itself meet the requirements of 1300.05; but failing to satisfy at least one warrant shall remove the signal from consideration.

Not all crashes are correctable with the installation of a traffic signal. Traffic signals may decrease the potential for crashes of one type and increase the potential for another type. For instance, rear-end crashes more frequently occur with signals because of stopping and starting of vehicles. At operating speeds above 40 mph, the severity of these rear-end crashes tend to be higher. This requires careful consideration of the location characteristics, traffic flow, and crash history.

State statutes (RCW 46.61.085) require WSDOT approval for the design and location of all conventional traffic signals and for some types of beacons located on city streets forming parts of state highways. The Traffic Signal Permit (DOT Form 242-014 EF) is the formal record of the department's approval of the installation and type of signal. For traffic signal permit guidance, see Chapter 1330.

1300.03(7) Alternative Intersections

Alternative intersections work mainly by rerouting U and left turns, and/or separating movements. Alternative intersections may have different terminology in different areas, but the most common types include:

- Median u-turn (MUT)
- Jug handle
- Bowtie
- Restricted crossing u-turn (RCUT)
- Displaced left-turn intersection (DLT)
- Continuous green tee
- Split intersection
- Quadrant roadway intersection
- Single quadrant interchange
- Echelon
- Center turn overpass

As alternative intersections may be relatively new to Washington State and its users, more education and community engagement will be necessary to ensure project success. However, extensive experience shows that many of these intersection types can provide better operational and safety performance, often at much less cost than traditional strategies.

Three types of alternative intersections are highlighted in the subsections below: median u-turn (MUT), restricted crossing u-turn (RCUT), and displaced left-turn (DLT) intersections. For more information about these and other intersection design solutions, see the Federal Highway Administration (FHWA) Alternative Intersection Design web page:
http://safety.fhwa.dot.gov/intersection/alter_design/

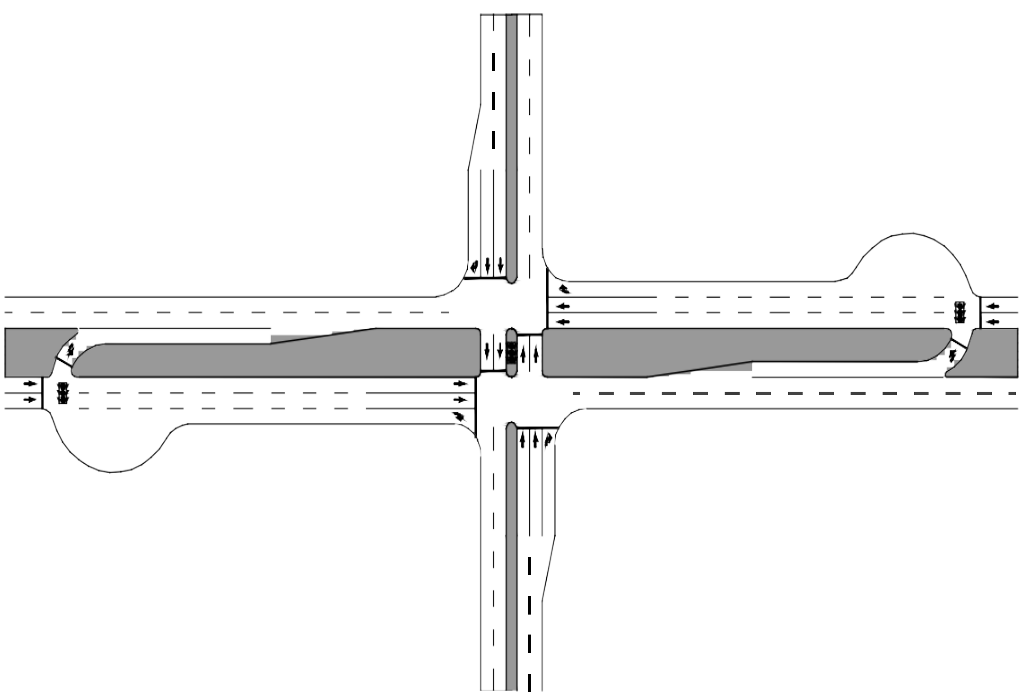
1300.03(7)(a) Median U-Turn

The median u-turn (MUT) intersection treatment relocates left turn movements downstream from the intersection resulting in lower delays, higher throughput, and reduction in the number and severity of crashes. Left-turning drivers proceed straight through the at-grade intersection, and then execute a u-turn at some distance downstream at a new or existing median opening. The main intersection is typically signalized and can be highly efficient needing only two signal phases. By removing the left turns at the main intersection, the MUT design results in a significant reduction in rear-end, angle, and sideswipe crashes; while reducing the number of conflict points from 32 to 16 when compared to a conventional signalized intersection. The MUT can also have advantages for pedestrians with fewer conflict points and a lower delay. However, the intersection design may reduce bicyclist mobility as they are expected to use the pedestrian crossings in order to perform left turns at the intersection. The MUT intersection design is more likely to be suitable for consideration in situations where:

- The intersection is over capacity.
- There are heavy through volumes and low to moderate left turn volumes.
- The intersection is within a higher-speed, median-divided corridor.
- There are safety concerns at an existing signalized intersection or corridor.

Refer to FHWA's *Median U-Turn Intersection Informational Guide* for geometric design considerations and recommendations. (See Chapter 1310 for geometrics when designing the u-turn movement for the MUT intersection.)

Exhibit 1300-2 Median U-Turn Intersection Example



MUT Intersection from FHWA's Median U-Turn Intersection Informational Guide

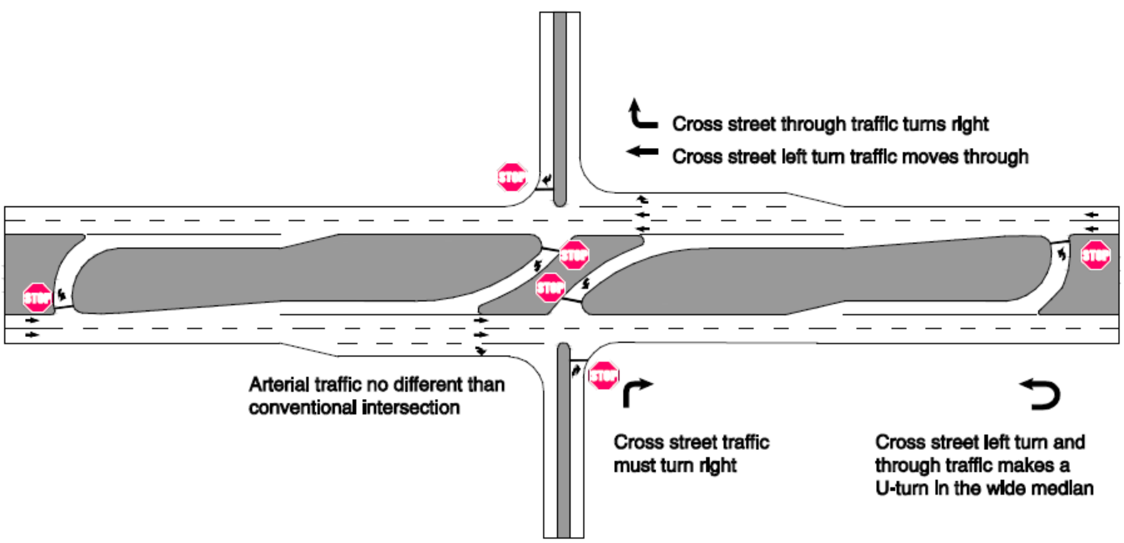
1300.03(7)(b) Restricted Crossing U-Turn Intersection

Restricted crossing u-turn (RCUT) intersections, also known as superstreets or J-turns, have similarities with the MUT in that the minor road through and left-turning movements are redirected (see Exhibit 1300-2). This intersection type results in lower delays, improved progression, and a potential reduction in the total number of crashes and fatal and injury crashes.

Drivers on the minor road approaches must turn right onto the major road and then perform a u-turn maneuver at a median opening downstream. However, the major road left turn movements are still allowed at the main intersection. RCUT intersections may or may not warrant signalization due to traffic volumes, and those with signalization require fewer signal phases and shorter cycle lengths than a traditional signalized intersection. The RCUT intersection is more likely suitable for consideration in situations where:

- The intersection is over capacity.
- There is a need to improve travel time and progression for the major road.
- There are crashes at the intersection related to turning movements that can reduced by a RCUT.
- The intersection is within a higher-speed, multilane corridor.
- There are low through and left turn volumes on the minor road.
- Pedestrian volumes are low.
- The major roadway contains sufficient median width, or total right of way width, to support the u-turn movements.

Exhibit 1300-3 Restricted Crossing U-Turn Intersection Example with Stop-control



Example of RCUT Intersection with stop-control from FHWA's Restricted Crossing U-Turn Intersection Informational Guide

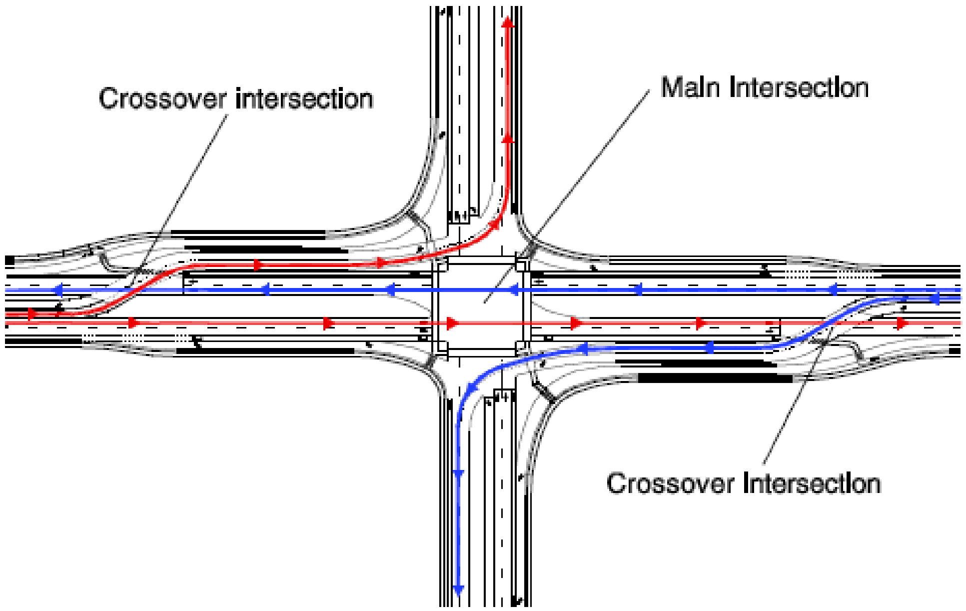
The RCUT intersection may be a potential alternative compared to a grade-separated interchange, at locations meeting grade-separated considerations identified in 530.04(3). Refer to FHWA's *Restricted Crossing U-Turn Intersection Informational Guide* for geometric design considerations and recommendations. (See Chapter 1310 for geometrics when designing the u-turn movement for the RCUT.)

1300.03(7)(c) Displaced Left-Turn Intersection

The displaced left-turn (DLT) intersection, also known as a continuous flow intersection, works mainly by relocating one or more left turn movements to the other side of the opposing traffic via an interconnected signalized crossover. This essentially causes the traffic signal system to be more efficient by eliminating the left turn phase at the main intersection allowing for more green time to be allocated to other movements. The DLT can reduce delays by up to 40%, but often can be delivered for just slightly more cost than a typical signalized intersection. Compared with a conventional intersection, the DLT can be more challenging for pedestrians due to longer crossing distances and counter-intuitive left turn vehicular movements. However, the DLT typically has shorter cycle lengths and potentially shorter delays. The DLT intersection design is best applied in situations where:

- There are high left-turn and through volumes.
- Intersection is over capacity.
- There are excessive delays and queuing, especially when left turn queues extend past the available storage bays.
- Pedestrian volumes are low.
- Sufficient right-of-way exists on the leg(s) that need to be widened to accommodate the new lanes.
- Context is urban/suburban.

Exhibit 1300-4 Displaced Left Turn Intersection Example



Example of DLT Intersection from FHWA's Displaced Left Turn Intersection Informational Guide

1300.04 Modal Considerations

When designing a multimodal intersection, consideration needs to be given to all design users at the intersection, the intersection design vehicle and selected modal priority (see Chapter 1103).

It is not appropriate to design for specific modal treatments on the outset of evaluating intersection control types. However, modally oriented intersection treatments may be necessary to enhance specific modal baseline or contextual performance needs (see Chapter 1101), and may influence the control type selection. Include a discussion of the potential modally oriented treatments relevant to the control types being analyzed and modal performance needs. Evaluate the potential effect of modal specific treatments on all design users relevant for the control types evaluated in the ICA.

1300.04(1) Pedestrian Considerations

Consider the intersection type and how it accommodates pedestrians. With each intersection type, there may be specific elements and/or treatments applicable for pedestrians (see, for example chapters 1231 and 1510) to meet modal performance needs identified (see Chapter 1101).

For example, a signalized intersection with a long cycle length, high speeds, or frequent permitted turning movements is generally not appropriate for areas with moderate to high pedestrian demand. However, a responsive signal in an urban downtown core with low speeds is typically well respected with high compliance and short delays.

Often, single-lane roundabouts can be accommodating to pedestrians with high compliance rates, short delays, and minimal disruption to vehicular traffic flow due to short crossing distances and two-stage crossings.

Additional information on emerging practices to address pedestrian performance needs for different intersection control types can be found at the Pedestrian and Bicycle Information Center (http://www.pedbikeinfo.org/)

For signalized intersections, sidewalk and ramp designs have additional requirements to accommodate the pedestrian features of the traffic signal system (see Chapter 1330).

1300.04(2) Bicycle Considerations

For consideration of bicycle needs at intersections and treatments that may have an operational effect on other design users, see chapters 1515 and 1520. Additional emerging practice information to address bicycle performance needs for different intersection control types can be found at the Pedestrian and Bicycle Information Center (http://www.pedbikeinfo.org/) and the NACTO Urban Bikeway Design Guide (https://nacto.org/publication/urban-bikeway-design-guide/).

1300.04(3) Transit Considerations

When transit vehicles are identified as a modal priority, consider treatments to meet the performance needs of the specific transit vehicle types and their effect on the performance of other design users (see Chapter 1103). Transit oriented treatments can vary significantly depending on the proximity of stop locations with respect to the intersection location and origin of the transit movement (see Chapter 1430 for bus stop placement guidelines), and the type of transit vehicle (such as a fixed guideway vehicle). Discuss treatment options and any operating restrictions the transit provider may have regarding different intersection control types.

1300.04(4) Operational Considerations

Traditional delay analysis focuses on determining the peak-hour letter-graded Level of Service (LOS) of an individual intersection. However, as this approach often does not account for multimodal users and as roughly 80% of the daily traffic volumes occur outside of the peak hours, a more encompassing review of the intersection is needed to provide sufficient multimodal capacity and safety performance at all hours of the day.

Intersection control can have an influence on road user behavior and modal operations, not just at the intersection itself, but also along the corridor or surrounding network, even when the intersection has an acceptable LOS. Delay affects route and mode choice and sometimes whether a user will decide to complete the trip. A user's willingness to accept delay depends on many factors including the user's knowledge of the transportation network, anticipated traffic conditions, and alternative options. The increasing presence of in-vehicle guidance systems and real-time traffic apps further aids the user in selecting the route with shortest travel times. Also, some alternatives that may improve mobility for one mode, such as the addition of turn lanes, may result in a performance degradation or even discourage trips for pedestrians or other modes. Thus, it is important to consider the effects of intersection control on the surrounding network and for all potential users. The following are some factors when selecting and evaluating alternatives:

- Access management strategies can be effective in promoting efficient travel patterns and rerouting traffic to other existing intersections. Check with the WSDOT region Planning Office for future land use plans or comprehensive plans to provide for future growth accommodation.
- Consider the volume to capacity (V/C) ratio, the delay, and the queue length of each approach. Some scenarios may require additional sensitivity analysis to determine the impacts of small changes in volumes.
- Examine the effects of existing conditions. Consider progression through nearby intersections (corridor and network analysis) and known risky or illegal driving maneuvers.
- Consider the possibility that traffic from other intersections with lower LOS will divert to the new/revised intersection.

1300.05 Procedures

For new intersections, determine and document intersection control according to the applicable procedures in this chapter.

For intersection improvement projects involving pavement construction and/or reconstruction, or preservation projects such as signal replacement/rehabilitation, evaluate intersection control in accordance with this chapter unless there is documentation that this analysis has already been completed and is referenced in the Project Summary.

Control for existing intersections that are unaffected by the project (per the contributing factors analysis) or are receiving minor revisions such as signal timing changes or rechannelization of existing pavement are not subject to further evaluation.

1300.05(1) Intersection Control Analysis (ICA)

The Intersection Control Analysis is a 5-step process meant to screen and evaluate alternatives to determine the best possible intersection type and design. Due to the safety and operational performance record, ***a roundabout is the preferred intersection control type and is required to be evaluated in Step 1. If a roundabout is selected and no other feasible alternatives remain after Step 2, contact the Region Traffic Engineer to determine if further analysis is required.***

For each alternative, provide a brief description of the assumed layout. Include the number of lanes on major and minor approaches and any measures necessary to accommodate multi-modal users. For a roundabout, document the assumed inscribed circle diameter. For a signal, document the assumed cycle length and phasing strategy used for the analysis.

Step 1: Background and Project Needs – Describe the existing conditions. Include physical characteristics of the site, posted speed, AADT, channelization and control features, multimodal facilities, context, and modal priority.

Document the project needs and which performance measures will be used for analysis and comparison of project alternatives in Step 3. Identify all project alternatives under consideration. For each alternative, determine if it is expected to meet the basic needs of the project. If an alternative does not pass this initial screening, remove it from consideration. All remaining alternatives are to proceed to Step 2.

Step 2: Feasibility – Develop the alternatives at a sketch level to determine the footprint required to achieve performance measures. Consider right-of-way, environmental, cost, context-sensitive/sustainable design, and geometrics/physical constraints for each remaining alternative. If an alternative is not practicable from any of these perspectives, remove it from consideration. All remaining alternatives are to proceed to Step 3. **If a roundabout is the only remaining viable alternative at this stage, contact the Region Traffic Engineer to determine if further analysis in Steps 3 and 4 is required.**

- Determine the **right of way** requirements and feasibility. Discuss the right of way requirements and the feasibility of acquiring that right of way in the analysis. Include sketches or plan sheets with sufficient detail to identify topography, existing utilities, environmental constraints, drainage, buildings, and other fixed objects. An economic evaluation will be useful if additional right of way is needed. Include the right of way costs in the benefit/cost analysis (Step 4).
- Identify known **environmental** concerns that could influence control type selection. At this stage, are there any red flags or obvious concerns between potential control types? Are there any known environmental risks that may substantially increase the cost of the project or available information that could help in alternatives comparison? Consult with region Environmental staff for support.
- Consider **Context Sensitive/Sustainable Design**. Context sensitive design is a model for transportation project development. A proposed transportation project is to be planned not only for its physical aspects as a facility serving specific transportation objectives, but also for its effects on the aesthetic, social, economic, and environmental values, needs, constraints, and opportunities in a larger community setting. Projects designed using this model:
    - Optimize safety of the facility for both the user and the community.
    - Promote multimodal solutions.

- Are in harmony with the community, and preserve the environmental, scenic, aesthetic, historic, and natural resource values of the area.
- Are designed and built with minimal disruption to the community.
- Involve efficient and effective use of the resources (time, budget, community) of all involved parties.

Step 3: Analysis – Perform and report the results of applicable analyses for all remaining alternatives and the no-build condition for performance measures identified in Step 1. The analysis is scalable, but typically should include the measures below. The level of effort should be based on project complexity, cost of proposed alternatives, context, and impact to the network and other modes. Contact the region Traffic Office early in the process to determine the network area of influence and scope of analysis. Include the following:

- Traffic Analysis – Use the opening year and selected design year for analysis (see Chapter 1103). In some cases, it may also be appropriate to analyze the horizon year as well. Identify and justify any growth rates used and provide turning movements for all scenarios. There are several deterministic and microsimulation tools for analyzing delay and intersection performance. Traffic volumes and the proximity to other access points will dictate the modeling effort required. Contact the region Traffic Office to determine the appropriate approved tool. For more information and guidance on traffic analysis, refer to Chapter 320 and the Traffic Analysis webpage (🖰 http://www.wsdot.wa.gov/Design/Traffic/Analysis/).
  - Peak hour(s) – Report the delay for each alternative.
  - Off-Peak – Report the delay for an additional time period representative of off-peak travel. Depending on location, up to 80% of total delay can occur in off-peak hours.
  - If a traffic signal is under consideration, perform and report the findings of the signal warrant analysis.
- Report the expected average crash frequency (total and fatal/all injury) of each alternative. When a safety need has been identified in Step 1, perform a crash analysis and summarize the findings. See Chapter 321 for more information.
- Multimodal safety and operations – Briefly discuss how the design for each alternative is expected to affect multimodal users, when applicable. Potential items to consider include pedestrian delay, number of lanes to cross, protected vs permitted turning movements, motorist approach speed, etc. When applicable, evaluate multimodal treatments that may be necessary for each alternative to meet the performance needs.

Step 4: Benefit/Cost Analysis – When applicable, report the Benefit/Cost (B/C) for mobility (due to change in travel time) and/or the B/C for safety (due to change in crash frequency/severity). Include the following in the analysis:

- Project costs related to design, right of way, and construction.
- Annual maintenance and operations cost. For signals, this should include the cost of signal engineers and technicians to review and implement signal timings and respond to malfunctions and emerging issues. This value can be obtained from the region Traffic Office.

- Travel time savings based on the reduction in delay over the life cycle during identified peak hours and/or off-peak hours.
- Societal cost savings (considered as the Benefit in the analysis) of reduced crash frequency and/or severity using a predictive method as described in Chapter 321. Use the following for WSDOT Societal Costs for crashes:
    - Fatal crash: $2,900,000
    - Serious injury crash: $2,900,000
    - Evident injury crash: $155,000
    - Possible injury crash: $60,000
    - Property damage only crash: $10,000
- Salvage value of right of way, grading and drainage, and structures.

Step 5: Selection – Based on performance tradeoffs and documented project needs, select the recommended alternative.

1300.05(1)(a) Additional Information

Discuss the following in the ICA as needed to further support the selection (is it an item that will have a significant effect on the decision?):

- Review the corridor sketch plans and database with the regional planning office.
- Information from a corridor or planning study.
- Current and future land use and whether or not the intersection control will reasonably accommodate future land use traffic changes.
- Community engagement and local agency coordination and comments.
- Effect on future local agency projects.
- Other elements considered in the selection of the intersection control.

1300.05(2) Community Engagement

Community engagement is a necessary element of project development. Technical, public, and political aspects must be considered. There is often concern from communities regarding control types that may be under consideration, especially the types of intersections that may seem unfamiliar or that break from the traditional approach. Education and outreach efforts, if necessary, are collaborative and are most useful during the analysis and early scoping stages. It is critical that community engagement efforts occur with preparation and well-organized content regarding the performance data associated with different control types to inform communities of the distinct differences between control types with respect to the context, modes, safety and operations desired. Use contextual performance needs (see Chapter 1101) identified by the community to help support the options being considered at a given location.

Follow the guidelines of WSDOT's Community Engagement Plan (www.wsdot.wa.gov/planning/), and document the effort as indicated in Chapter 1100.

1300.05(3) Approval

The ICA shall be prepared by or under the direct supervision of a licensed Professional Engineer. Approval of the ICA (see Chapter 300 for more information) requires the following:

- Region Traffic Engineer Approval
- HQ Traffic Approval

1300.05(4) Local Agency or Developer-Initiated Intersections

Chapter 320 provides guidance for preparation of a Traffic Impact Analysis (TIA). Early in the design process, local agencies and developers should coordinate with the region office to identify specific intersections for further analysis. The project initiator provides an Intersection Control Analysis (ICA) for approaches and intersections with state routes per 1300.05, or references this information in the TIA. The project initiator documents the design considerations and submits the ICA and all documentation to the region for approval (per 1300.05). After the ICA is approved, finalize the intersection design and obtain approval per Chapters 300 (for documentation), 1310 (for intersections), 1320 (for roundabouts), and 1330 (for traffic signals).

1300.06 Documentation

Refer to Chapter 300 for additional design documentation requirements.

1300.07 References

1300.07(1) Federal/State Laws, Codes, and Policies

Revised Code of Washington (RCW) 46.61, Rules of the road

Washington Administrative Code (WAC) 468-52, Highway access management – access control classification system and standards

Secretary's Executive Order: E 1082, *Business Practices for Moving Washington*, August 2012, WSDOT

1300.07(2) Design Guidance

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO Current Edition

Highway Capacity Manual (HCM), latest edition, Transportation Research Board, National Research Council

Local Agency Guidelines (LAG), M 36-63, WSDOT

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

1300.07(3) Supporting Information

Highway Safety Manual (HSM), AASHTO

Roundabouts: An Informational Guide, FHWA-RD-00-067, USDOT, FHWA

Roundabouts: An Informational Guide, Second Edition, NCHRP Report 672, Transportation Research Board, 2010

A Review of the Signalized Intersections: Informational Guide. FHWA-HRT-04-092, USDOT, FHWA, APRIL 2004. 🖰 www.fhwa.dot.gov/publications/research/safety/04092/

Choosing Intersection Control, IMSA Journal, Buckholz, Nov/Dec 2002.
🖰 www.imsasafety.org/journal/nd02/buckholz.pdf

A Comparison of a Roundabout to Two-way Stop Controlled Intersections with Low and High Traffic Volumes, Luttrell, Greg, Eugene R. Russell, and Margaret Rys, Kansas State University

Guidance for Implementation of the AASHTO Strategic Highway Safety Plan, Volume 5: A Guide for Addressing Unsignalized Intersection Collisions, NCHRP Report 500, Transportation Research Board, 2003

Guidance for Implementation of the AASHTO Strategic Highway Safety Plan Volume 12: A Guide for Reducing Collisions at Signalized Intersections, NCHRP Report 500, Transportation Research Board, 2004

U-turn Based Intersections, FHWA
🖰 https://safety.fhwa.dot.gov/intersection/innovative/uturn/

Crossover-Based Intersections, FHWA
🖰 https://safety.fhwa.dot.gov/intersection/innovative/crossover/

Synthesis of the Median U-Turn Intersection Treatment, Safety, and Operational Benefits, FHWA-HRT-07-033, USDOT, FHWA

Alternative Intersections/Interchanges: Informational Report (AIIR), FHWA-HRT-09-060, Hughes et al., USDOT, FHWA, 2010

Field Evaluation of a Restricted Crossing U-Turn Intersection, FHWA-HRT-12-037, USDOT, FHWA

Roundabouts and Sustainable Design, Ariniello et al., Green Streets and Highways – ASCE, 2011

Pedestrian and Bicycle Information Center 🖰 www.pedbikeinfo.org/

Community Engagement Plan, WSDOT 🖰 http://www.wsdot.wa.gov/planning/default.htm

Chapter 1310 Intersections

1310.01 General

Intersections are a critical part of Washington State Department of Transportation (WSDOT) highway design because of increased conflict potential. Traffic and driver characteristics, bicycle and pedestrian needs, physical features, and economics are considered during the scoping and design stages to develop channelization and traffic control to provide multimodal traffic flow through intersections.

See chapters in the 1100 series for instruction on multimodal practical design, including identifying project needs, context, design controls, modal performance, alternatives analysis, and design element dimensioning.

This chapter provides guidance for designing intersections, including ramp terminals. Refer to the following chapters for additional information:

Chapter	Subject
1103	Design controls
1106	Design element dimensions
1230	Geometric cross section
1300	Intersection control type
1320	Roundabouts
1330	Traffic signals
1340	Driveways
1360	Interchanges
1510	Pedestrian facilities
1520	Roadway bicycle facilities

For assistance with intersection design, contact the Headquarters (HQ) Design Office.

1310.02 Design Considerations

Consider all potential users of the facility in the design of an intersection. This involves addressing the needs of a diverse mix of user groups, including passenger cars, heavy vehicles of varying classifications, bicycles, and pedestrians. Often, meeting the needs of one user group results in a compromise in service to others. Intersection design balances these competing needs, resulting in appropriate levels of operation for all users.

In addition to reducing the number of conflicts, minimize the conflict area as much as possible while still providing for the design vehicle (see Chapter 1103). This is done to control the speed of turning vehicles and reduce the area of exposure for vehicles, bicycles, and pedestrians. For additional information on pedestrian needs, see Chapter 1510. For intersections with shared-use paths, see Chapter 1515. For bicycle considerations at intersections, see Chapter 1520.

1310.02(1) Non-Geometric Considerations

Geometric design considerations, such as sight distance and intersection angle, are important. Equally important are perception, contrast, and a driver's age. Perception is a factor in the majority of crashes. Regardless of the type of intersection, the function depends on the driver's ability to perceive what is happening with respect to the surroundings and other vehicles. When choosing an acceptable gap, the driver first identifies the approaching vehicle and then determines its speed. The driver uses visual clues provided by the immediate surroundings in making these decisions. Thus, given equal sight distance, it may be easier for the driver to judge a vehicle's oncoming speed when there are more objects to pass by in the driver's line of sight. Contrast allows drivers to discern one object from another.

1310.02(2) Intersection Angle and Roadway Alignment

An important intersection design characteristic is the intersection angle. The desirable intersection angle is 90°, with 60° to 120° allowed. Do not put angle points on the roadway alignments within intersection areas or on the through roadway alignment within 100 feet of the edge of traveled way of a crossroad. However, angle points within the intersection are allowed at intersections with a minor through movement, such as at a ramp terminal (see Exhibit 1310-2).

When feasible, locate intersections such that curves do not begin or end within the intersection area. It is desirable to locate the PC and PT 250 feet or more from the intersection so that a driver can settle into the curve before the gap in the striping for the intersection area. Do not locate short curves where both the PC and PT are within the intersection area.

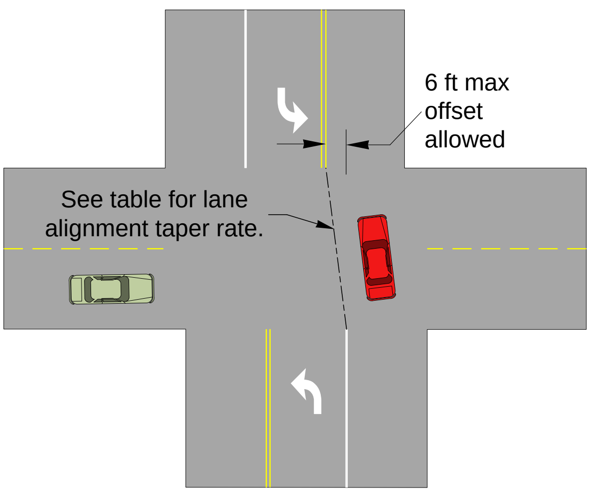
1310.02(3) Lane Alignment

It is desirable that entering through traffic is aligned with the exit lanes. However, the entering and exit lanes may be offset up to 6 feet when the following conditions are met:

- Illumination is provided.
- The intersection is not within a horizontal curve, nor is it within a crest vertical curve.
- The taper rates provided in Exhibit 1310-1 are used.
- There is a posted speed of 55 mph or less.

Consider dotted extension lines that continue through the intersection.

Exhibit 1310-1 Lane Alignment Taper Rate



Posted Speed	Taper Rate
55 mph	55:1
50 mph	50:1
45 mph	45:1
40 mph	27:1
35 mph	21:1
30 mph	15:1
25 mph	11:1

1310.02(4) Intersection Spacing

Provide intersection spacing for efficient operation of the highway. The minimum design intersection spacing for highways with limited access control is covered in Chapter 530. For other highways, the minimum design intersection spacing is dependent on the managed access highway class. (See Chapter 540 for minimum intersection spacing on managed access highways.)

As a minimum, provide enough space between intersections for left-turn lanes and storage length. Space signalized intersections and intersections expected to be signalized to maintain efficient signal operation. Space intersections so that queues will not block an adjacent intersection.

Evaluate existing intersections that are spaced less than shown in Chapters 530 and 540. Also, evaluate closing or restricting movements at intersections with operational issues. Document the spacing of existing intersections that will remain in place and the effects of the spacing on operation, capacity, and circulation.

1310.02(5) Accommodating vs. Designing for Vehicles

Accommodating for a vehicle allows encroachment of other lanes, shoulders, or other elements to complete the required maneuver. Designing for a vehicle does not require encroachment on those elements.

There are competing design objectives when considering the crossing needs of pedestrians and the turning needs of larger vehicles. To design for large design vehicles, larger turn radii are used. This results in increased pavement areas, longer pedestrian crossing distances, and longer traffic signal arms. (See Chapter 1103 for design vehicle selection criteria.)

When appropriate, to reduce the intersection area, consider accommodating for large vehicles instead of designing for them. This reduces the potential for vehicle/pedestrian conflicts, decreases pedestrian crossing distance, and controls the speeds of turning vehicles. Use turn simulation software (such as AutoTURN®) to verify the design.

1310.02(6) Sight Distance

For stopping and decision sight distance criteria, see Chapter 1260. Intersection sight distance criteria are discussed in section 1310.05.

1310.02(7) Crossroads

When the crossroad is a city street or county road, design the crossroad beyond the intersection area in cooperation with the local agency.

When the crossroad is a state facility, design the crossroad according to the *Design Manual*. Continue the cross slope of the through roadway shoulder as the grade for the crossroad. Use a vertical curve that is at least 60 feet long to connect to the grade of the crossroad.

Evaluate the profile of the crossroad in the intersection area. The crown slope of the main line might need to be adjusted in the intersection area to improve the profile for the cross traffic.

Design the grade at the crosswalk to meet the requirements for accessibility. (See Chapter 1510 for additional crosswalk information.)

In areas that experience accumulations of snow and ice for all legs that require traffic to stop, design a maximum grade of ±4% for a length equal to the anticipated queue length for stopped vehicles.

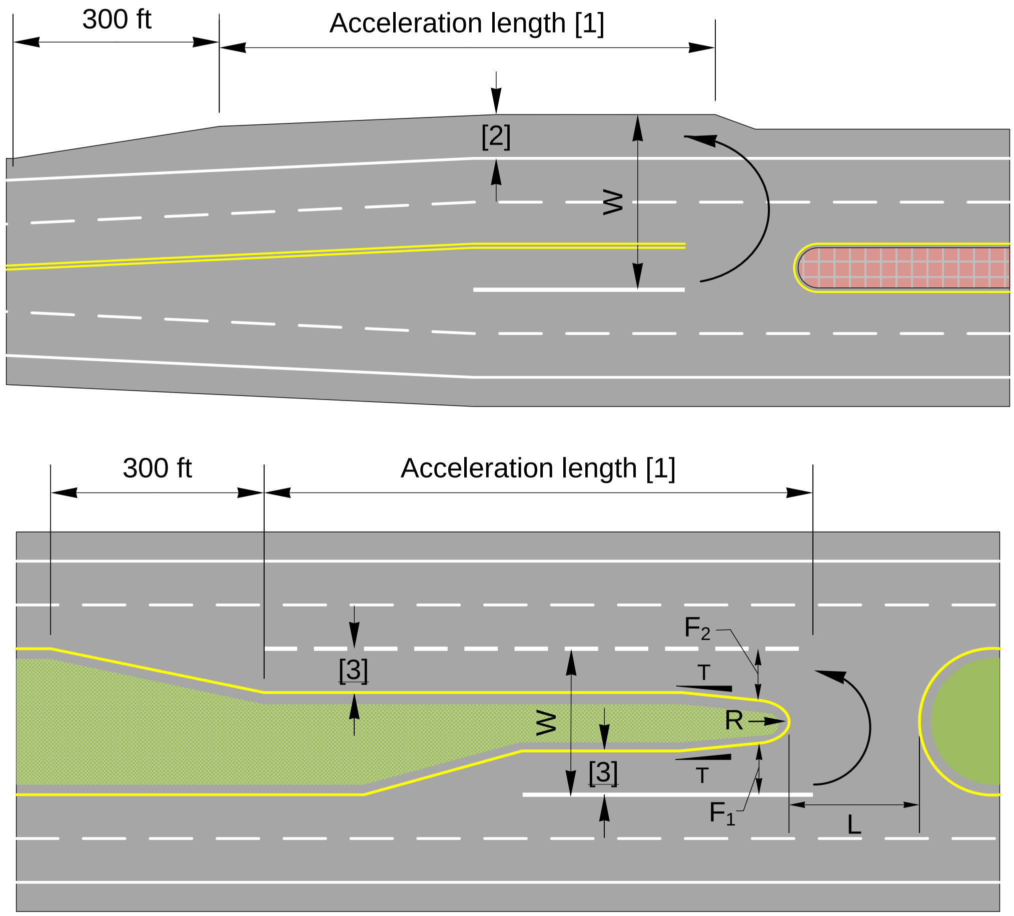
1310.02(8) Rural Expressway At-Grade Intersections

Evaluate grade separations at all intersections on rural expressways.

Design high-speed at-grade intersections on rural expressways as indirect left turns, split intersections, or roundabouts.

The State Traffic Engineer's approval is required for any new intersection or signal on a rural expressway.

Exhibit 1310-18 U-Turn Median Openings



Vehicle	W	R	L	F_1	F_2	T
P	52	14	14	12	12	—
SU-30	87	30	20	13	15	10:1
CITY-BUS	87	28	23	14	18	10:1
WB-40	84	25	27	15	20	6:1
WB-67	94	22	49	15	35	6:1

U-Turn Design Dimensions

Notes:

[1] The minimum length of the acceleration lane is shown in Exhibit 1310-14. Acceleration lane may be eliminated at signal-controlled intersections.

[2] When U-turn uses the shoulder, provide shoulder width sufficient for the intersection design vehicle to make the turn and shoulder pavement designed to the same depth as the through lanes for the acceleration length and taper.

[3] Lane width as determined by Chapters 1106 and 1230.

General:
All dimensions are in feet.

1310.05 Intersection Sight Distance

Providing drivers the ability to see stop signs, traffic signals, and oncoming traffic in time to react accordingly will reduce the probability of conflicts occurring at an intersection. Actually avoiding conflicts is dependent on the judgment, abilities, and actions of all drivers using the intersection.

The driver of a vehicle that is stopped and waiting to cross or enter a through roadway needs obstruction-free sight triangles in order to see enough of the through roadway to complete all legal maneuvers before an approaching vehicle on the through roadway can reach the intersection. Use Exhibit 1310-19a to determine minimum intersection sight distance along the through roadway.

The sight triangle is determined as shown in Exhibit 1310-19b. Within the sight triangle, lay back the cut slopes and remove, lower, or move hedges, trees, signs, utility poles, signal poles, and anything else large enough to be a sight obstruction. Eliminate parking to remove obstructions to sight distance. In order to maintain the sight distance, the sight triangle must be within the right of way or a state maintenance easement (see Chapter 510).

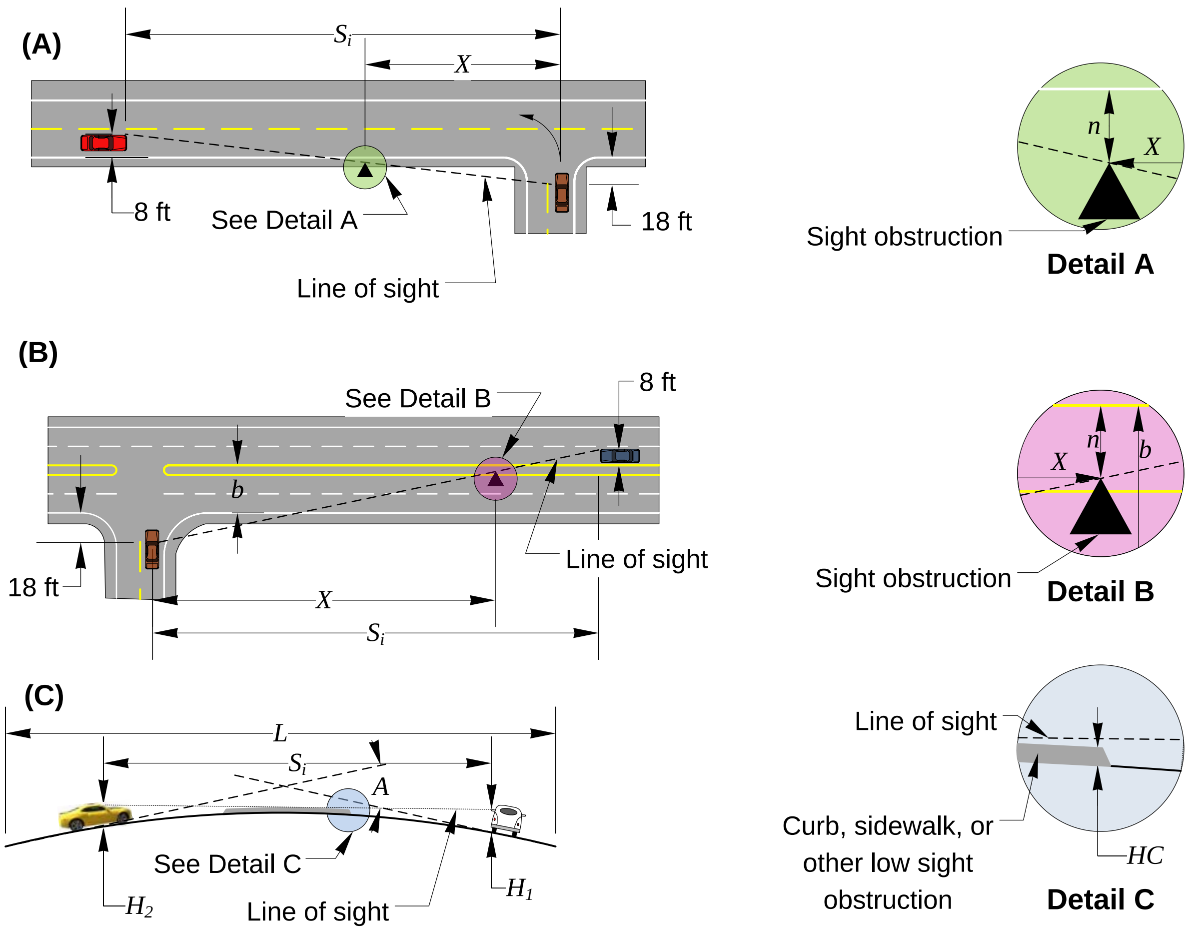
The setback distance for the sight triangle is 18 feet from the edge of traveled way. This is for a vehicle stopped 10 feet from the edge of traveled way. The driver is almost always 8 feet or less from the front of the vehicle; therefore, 8 feet are added to the setback. When the stop bar is placed more than 10 feet from the edge of traveled way, providing the sight triangle to a point 8 feet back of the stop bar is desirable.

Provide a clear sight triangle for a P vehicle at all intersections. In addition, provide a clear sight triangle for the SU-30 vehicle for rural highway conditions. If there is significant combination truck traffic, use the WB-67 rather than the SU-30. In areas where SU-30 or WB vehicles are minimal and right of way restrictions limit sight triangle clearing, only the P vehicle sight distance needs to be provided.

At existing intersections, when sight obstructions within the sight triangle cannot be removed due to limited right of way, the intersection sight distance may be modified. Drivers who do not have the desired sight distance creep out until the sight distance is available; therefore, the setback may be reduced to 10 feet. Document the right of way width and provide a brief analysis of the intersection sight distance clarifying the reasons for reduction. Verify and document that there is no identified crash trend at the intersection. Document the intersection location and the available sight distance as a Design Analysis.

If the intersection sight distance cannot be provided using the reductions in the preceding paragraph, where stopping sight distance is provided for the major roadway, the intersection sight distance, at the 10-foot setback point, may be reduced to the stopping sight distance for the major roadway, with a Design Analysis and HQ Design Office review and concurrence. (See Chapter 1260 for required stopping sight distance.) Document the right of way width and provide a brief analysis of the intersection sight distance clarifying the reasons for reduction. Verify and document that there is no identified crash trend at the intersection. Document the intersection location and the available sight distance as a Design Analysis.

Exhibit 1310-19b Sight Distance at Intersections



For sight obstruction driver cannot see over:

$$S_i = \frac{(26+b)(X)}{(18+b-n)}$$

Where:

S_i = Available intersection sight distance (ft)
n = Offset from sight obstruction to edge of lane (ft)
b = Distance from near edge of traveled way to near edge of lane approaching from right (ft) (b=0 for sight distance to the left)
X = Distance from centerline of lane to sight obstruction (ft)

For crest vertical curve over a low sight obstruction when S<L:

$$S_i = \sqrt{\frac{100L\left[\sqrt{2(H_1 - HC)} + \sqrt{2(H_2 - HC)}\right]^2}{A}}$$

$$L = \frac{AS_i^2}{100\left[\sqrt{2(H_1 - HC)} + \sqrt{2(H_2 - HC)}\right]^2}$$

Where:

Si = Available sight distance (ft)
H_1 = Eye height (3.5 ft for passenger cars; 6 ft for all trucks)
H_2 = Approaching vehicle height (3.5 ft)
HC = Sight obstruction height (ft)
L = Vertical curve length (ft)
A = Algebraic difference in grades (%)

1310.06 Signing and Delineation

Use the MUTCD and the *Standard Plans* for signing and delineation criteria. Provide a route confirmation sign on all state routes shortly after major intersections. (See Chapter 1020 for additional information on signing.)

Painted or plastic pavement markings are normally used to delineate travel paths. For pavement marking details, see the MUTCD, Chapter 1030, and the *Standard Plans*.

Contact the region or HQ Traffic Office for additional information when designing signing and pavement markings.

1310.07 Procedures

Document design decisions and conclusions in accordance with Chapter 300. For highways with limited access control, see Chapter 530.

1310.07(1) Approval

An intersection is approved in accordance with Chapter 300. Complete the following items, as needed, before intersection approval:

- Intersection Control Type Approval (see Chapter 1300)
- Design Analyses approved in accordance with Chapter 300
- Approved Traffic Signal Permit (DOT Form 242-014 EF) (see Chapter 1330)

1310.07(2) Intersection Plans

Provide intersection plans for any increases in capacity (turn lanes) at an intersection, modification of channelization, or change of intersection geometrics. Support the need for intersection or channelization modifications with history; school bus and mail route studies; hazardous materials route studies; pedestrian use; public meeting comments; etc.

For information to be included on the intersection plan for approval, see the Intersection/ Channelization Plan for Approval Checklist on the following website:

www.wsdot.wa.gov/design/projectdev/

1310.07(3) Local Agency or Developer-Initiated Intersections

Intersections in local agency and developer projects on state routes must receive the applicable approvals in section 1310.07(1) as part of the intersection design process.

The project initiator submits an intersection plan and the documentation of design decisions that led to the plan to the region for approval. For those plans requiring a Design Analysis, the Design Analysis must be approved in accordance with Chapter 300 prior to approval of the plan. After the plan approval, the region prepares a construction agreement with the project initiator (see the *Utilities Manual*).

1310.08 Documentation

Refer to Chapter 300 for design documentation requirements.

Chapter 1320 Roundabouts

1320.01 General

Modern roundabouts are near-circular intersections at grade. They are an effective intersection type with fewer conflict points and lower speeds, and they provide for easier decision making than other intersection types. They also require less maintenance than traffic signals. Well-designed roundabouts have been found to reduce crashes (especially fatal and severe injury collisions), traffic delays, fuel consumption, and air pollution. They also have a traffic-calming effect by reducing vehicle speeds using geometric design rather than relying solely on traffic control devices.

Roundabout design is an iterative process.

A well-designed roundabout achieves a balance of safety and efficiency.

Good design is a process of creating the smooth curvature, channelization, and deflection required to achieve consistent speeds, well-marked lane paths, and appropriate sight distance.

Roundabout

The decision to install a roundabout is the result of an Intersection Control Analysis (see Chapter 1300) approved by the region Traffic Engineer or other designated authority.

1320.02 Roundabout Types

There are five basic roundabout types: mini, compact, single-lane, multilane, and teardrop described in the following sections.

1320.02(1) Mini-Roundabouts

Mini-roundabouts are small single-lane roundabouts generally used in 25 mph or less urban/suburban environments. Because of this, mini-roundabouts are typically not suitable for use on higher-volume (greater than 6,000 AADT) state routes. In retrofit applications, mini-roundabouts are relatively inexpensive because they normally require minimal additional pavement at the intersecting roads. A 2-inch mountable curb for the splitter islands and the central island is desirable because larger vehicles might be required to cross over it.

A common application is to replace a stop-controlled or uncontrolled intersection with a mini-roundabout to reduce delay and increase capacity. With mini roundabouts, the existing curb and sidewalk at the intersection can sometimes be left in place.

1320.02(2) Compact Roundabouts

Compact roundabouts are a hybrid of attributes found in mini- and single-lane roundabouts. Similar to a mini-roundabout, a compact roundabout may require minimal additional pavement, has a completely mountable center island, and in many cases existing curb or sidewalk can be left in place. As a result, compact roundabouts rarely require the purchase of right of way. Compact roundabouts are similar to single-lane roundabouts regarding design vehicle assumptions, ability to process traffic volumes, and signing.

Compact roundabouts

1320.02(2) Single-Lane Roundabouts

Single-lane roundabouts have single-lane entries at all legs and one circulating lane. They typically have mountable raised splitter islands, a mountable truck apron, and a landscaped central island.

Single-lane roundabout

1320.02(3) Multilane Roundabouts

Multilane roundabouts have at least one entry or exit with two or more lanes and more than one circulating lane. The operational practice for trucks negotiating roundabouts is to straddle adjacent lanes.

Multilane roundabout

1320.02(4) Teardrop Roundabout

Teardrops are usually associated with ramp terminals at interchanges: typically, at diamond interchanges. Teardrop roundabouts allow the "wide node, narrow link" concept. Unlike circular roundabouts, teardrops do not allow for continuous 360° travel resulting in less vehicle conflicts as traffic traveling on the crossroad (link) between ramp terminal intersections (nodes) does not encounter a yield as it enters the teardrop intersections. At higher ADT locations this lack of conflicting vehicles can result in a higher throughput, but can also result in limited gaps for the off ramp approach. Consult HQ or region Traffic Office for guidance.

Teardrop roundabouts

1320.03 Capacity Analysis

Use the capacity analysis completed as part of the Intersection Control Analysis (see Chapter 1300) to verify the number of lanes required for every individual movement in the design year.

1320.04 Geometric Design

1320.04(1) Selecting Shape and Placement

Roundabout shape is an important decision, because the shape can affect design elements that affect safety performance and operation of the roundabout.

1320.04(1)(a) Circular

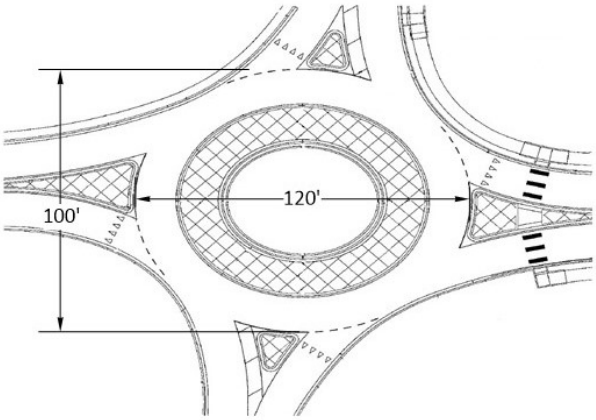
The circular shape is the most desirable roundabout shape when constraints allow. If a circular shape is not feasible, contact the region Traffic Office to investigate other shapes described below. Sometimes a circular shape
can be used by slightly offsetting the placement of the roundabout.

Circular shape

1320.04(1)(b) Non-Circular

A non-circular roundabout is a good choice when constraints such as right of way, existing roadway alignments, buildings, and/or environmentally sensitive areas influence the shape.

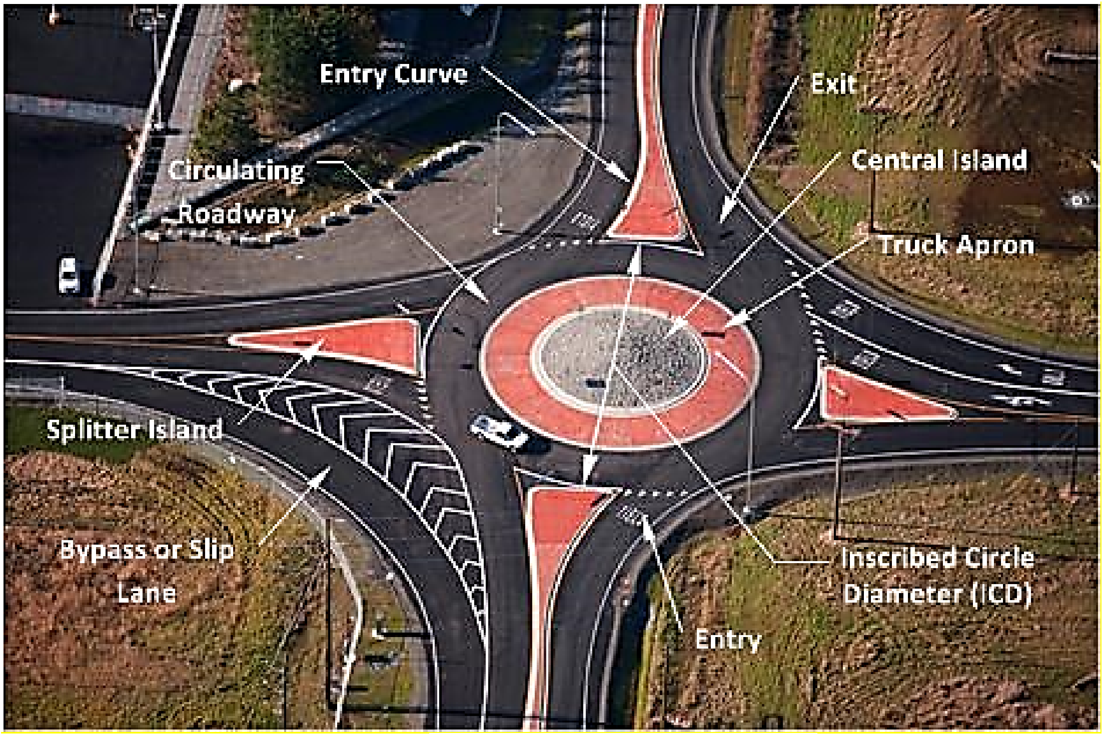
Experiment with different roundabout sizes and radii, and use design vehicle turning software (such as AutoTURN®) to refine the shape to find the best operation while retaining desired speeds.



Non-circular roundabout with example dimensions

1320.04(2) Roundabout Design Elements

This section provides guidance for roundabout design elements. The photo below labels many of them.



Roundabout design elements

1320.04(2)(a) Curbing

All curbing within a roundabout should be rolled. The type of rolled curbing appropriate for a roundabout is shown in the Standard Plan Roundabout Cement Concrete Curbs: F-10.18.

Exception: existing curb untouched as part of a mini or compact roundabout installation may remain.

1320.04(2)(b) Truck Apron

A truck apron is the mountable portion of the central island used to accommodate the turning path of a design vehicle larger than a passenger vehicle or BUS, and helps to minimize the overall footprint of the roundabout. Generally, the truck tractor can traverse the roundabout in the circulating lane while the trailer is allowed to off track onto the apron. The apron is raised above the circulating path to provide guidance for drivers in the circulating lane.

A truck apron's width is based on the needs of the design vehicle. If buses are a consistent vehicle using the intersection try to minimize apron use for all movements, however this is not a requirement. Use turn simulation software (such as AutoTURN®) to fine tune the width of apron needed, so as not to design an apron that won't be used.

The apron color should be easily distinguishable in contrast with the adjacent circulating roadway and pedestrian facilities. Work with the region Landscape Architect (HQ Roadside and Site Development Section for regions without a Landscape Architect) for concrete color and texture.

Roundabout showing colored truck apron at central island and at buffer area between travel lanes and sidewalk

1320.04(2)(c) Central Island

The central island is the portion of the roundabout that is inside of the circulating roadway and typically includes an inside truck apron and a landscaped area (except for mini-roundabouts and compact roundabouts, which have no landscaped area and are entirely mountable).

Central island shape is a function of the site-specific needs of a roundabout intersection. It doesn't have to be an identical shape of the inscribed circle diameter (ICD) dimensions, but should support the design principles of deflection and low speeds, and the accommodation of the design vehicle.

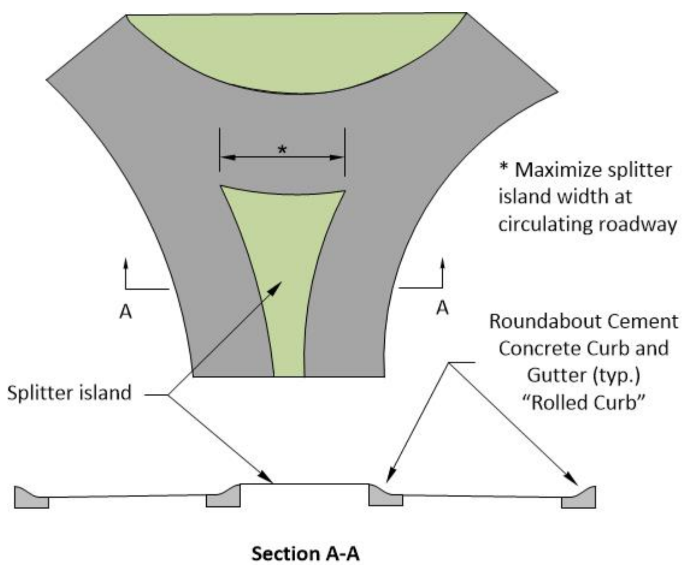
Roundabouts present opportunities to create community focal points, landscaping, and other gateway features within an intersection. The central island may include enhancements (such as landscaping, sculptures, or fountains), which serve both an aesthetic purpose and provide visual indication of the intersection for approaching motorists (this is particularly important for high speed approaches). Ideal central island treatments fit the context and result in minimal consequence to any vehicle that may encroach on the non-mountable portion of the central island. These treatments should not attract pedestrians to the central island, as pedestrians should never cross the circulating roadway. Work with the region Landscape Architect (HQ Roadside and Site Development Section for regions without a Landscape Architect) for central island features. See Chapter 950 Public Art for policy and guidance.

1320.04(2)(d) Splitter Island

A splitter island is the raised island at each two-way leg between entering and exiting vehicles, designed primarily to control the entry and exit speeds by providing deflection. They also discourage wrong-way movements, and provide pedestrian refuge. Splitter islands can have different shapes based on entry angle requirements and exit design speeds.

Raised channelization, or the appearance of raised curbing, is important, as research shows that drivers will slow down when they perceive that the driving width is narrowing.

The length of the splitter island will vary (typical lengths: 30 ft to 350 ft) based on the terrain, access considerations, site-specific mainline and crossroad operational speeds and the stepdown speeds to the final desired entry speed, which is usually 15–25 mph. (See 1320.04(3)(a) for using chicanes on higher-speed roadways.)



Splitter Island

Try to maximize the splitter island width adjacent to the circulating roadway. The larger achieved width, the better a driver approaching the roundabout can perceive whether a driver in the circulating lane will exit or continue inside the roundabout. This results in better gap acceptance. This may also support a better pedestrian refuge design.

1320.04(2)(e) Inscribed Circle Diameter (ICD)

The Inscribed Circle Diameter (ICD), that is, the overall outside diameter of a roundabout, is determined by the variables design vehicle, design speed, and the number of circulatory lanes.

The ranges of ICD in Exhibit 1320-1 are only suggestions to start a roundabout design. The ICD for noncircular shapes should be defined with dimensions along the X and Y axis.

Exhibit 1320-1 Suggested Initial Design Ranges

Design Element	Mini [1]	Compact	Single-Lane	Multilane
Number of Lanes	1	1+	1	2+
Inscribed Circle Diameter [2]	45' – 80'	65' – 120'	80' – 150'	120' – 165'
Circulating Roadway Width	N/A	N/A	14' – 19'	29'
Entry Widths	N/A	N/A	16' – 18'	25'

Notes:
The "+" symbol used here means that a portion of the circulating roadway may have more than one lane.
[1] Reserved for urban/suburban intersections with a 25 mph or less posted speed.
[2] The given diameters assume a circular roundabout; adjust accordingly for other shapes. Some conditions may require ICDs outside ranges shown here.

1320.04(2)(f) Entry

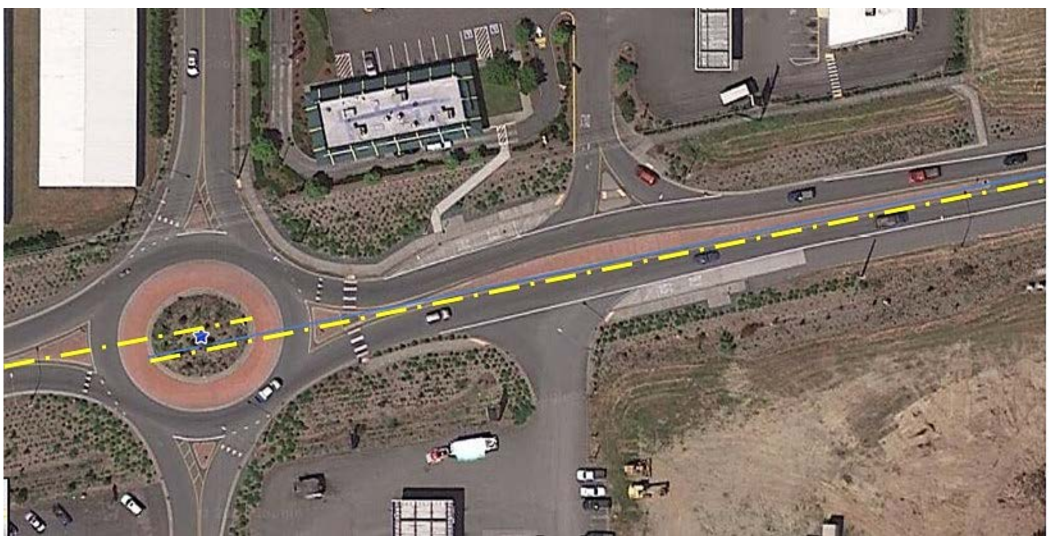
1. Deflection

Ideal alignment offers an entry design that provides deflection, speed control, and reasonable view angles to drivers while balancing property impacts and costs. While most intersections are at 90º angles and most through movements are straight, deflection contributes to the safety performance of a roundabout. Deflection is primarily achieved with the central island and supporting it with splitter islands on all entries to the roundabout.

2. Alignment Offset

There are three alignment choices for attaching entry legs to the circulatory roadway:

- The offset left alignment is preferred. It constrains the entry, slowing a vehicle's approach speed, and opens up the exit for efficient egress.
- The symmetrical alignment (if needed) is acceptable for lower speed contexts such as 30 mph.
- The offset right alignment tends to allow faster entry speeds and constrains the exit; it is undesirable.



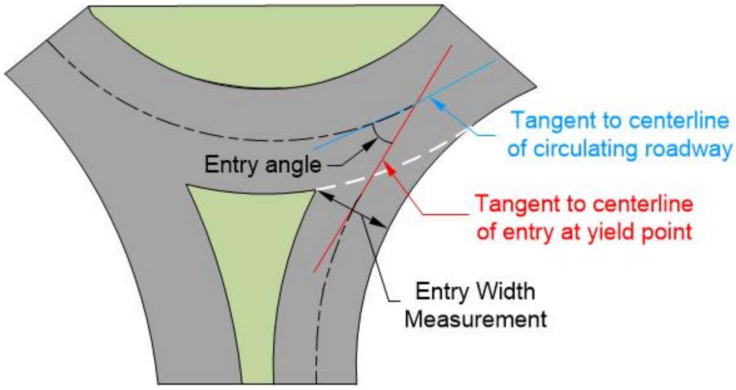
Offset left alignment (preferred)

3. Entry Angle

To achieve the proper amount of deflection for each approach to a roundabout, there is a range of angle values that are desirable. This range is usually between 20 and 40 degrees. The purpose of entry angle is so vehicles don't hit broadside.

4. Entry Width

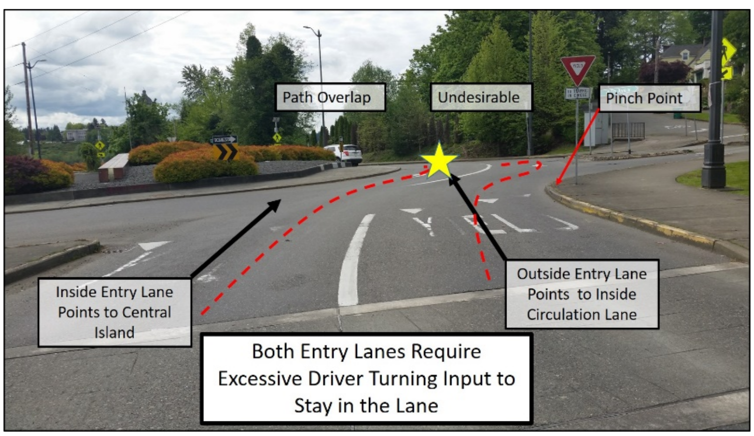
Entry width is determined by the turning template of the design vehicle turning through the entry curve at the desired entry speed. The ranges of entry widths in Exhibit 1320-1 are only suggestions to start a roundabout design.



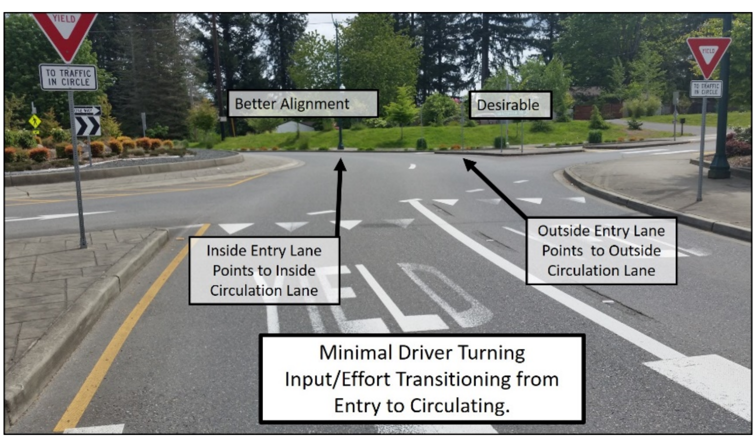
Entry angle and width

5. Path Overlap

In a multilane roundabout, if the vehicles in the entry are aligned toward the central island or the truck apron, the vehicle on the right is pointed toward the inside lane and tends to go in that direction, while the vehicle on the left tends to be squeezed to the right toward the vehicle on the right. Avoid path overlap. Avoid a design that aligns an entering vehicle at the incorrect lane in the circulatory roadway. As a vehicle enters the circulating roadway it should be headed directly toward its respective lane within the circulating roadway. For multilane roundabouts, if inside lane is pointing at truck apron this is also considered to be path overlap. If right entry lane is pointing to left circulatory lane, then there is path overlap.



Path overlap conflict

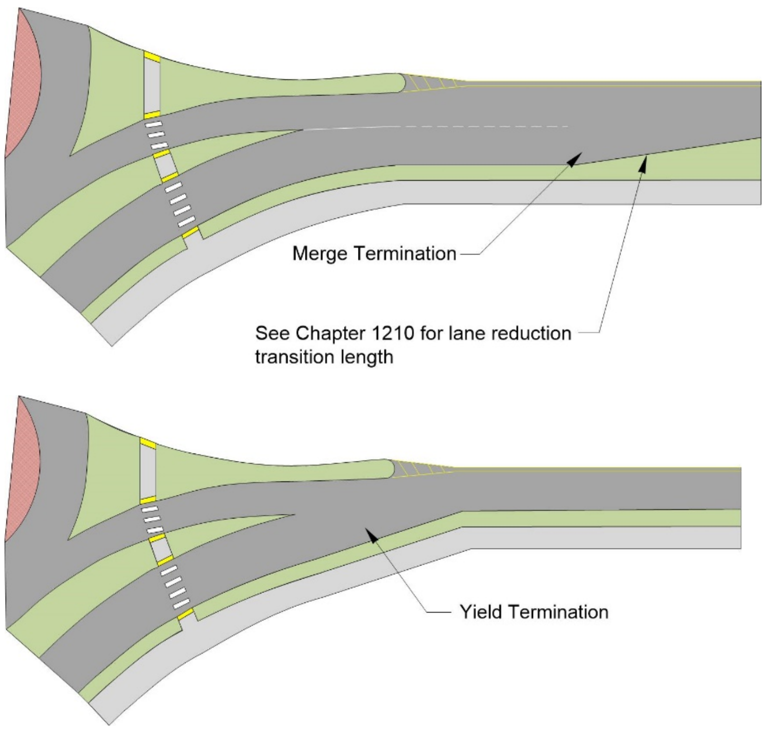


Good path alignment

1320.04(2)(g) Right-Turn Slip Lanes

Right-turn slip lanes are a proven way to increase the "life" of an intersection by removing traffic that would otherwise enter the roundabout and reduce the available capacity to other movements. If a right-turn movement has 250 vehicles/hour or more, or if over 40% of the total approach volume is taking right turns, a slip lane should be considered.

The conflicting volume of vehicles on the merge will influence the length of merge lane prior to termination. Speeds can be very low and vehicles can take turns at these low speeds. Multimodal considerations will influence the length based on crosswalk location and bicycle use.



Right-turn slip lanes showing merge and yield termination

1320.04(3) Speed Control

Roundabout operation performance is dependent on low, consistent vehicle speeds. Low and consistent operating speeds facilitate appropriate gap acceptance by an entering driver. Design for travel path operating speeds between 15 mph and 25 mph (see 1320.04(3)(b)). Design to have low-speed differentials (12 mph or under) between entering and circulating traffic. Multilane roundabouts might have higher speeds along their respective travel paths, but generally 30 mph or less.

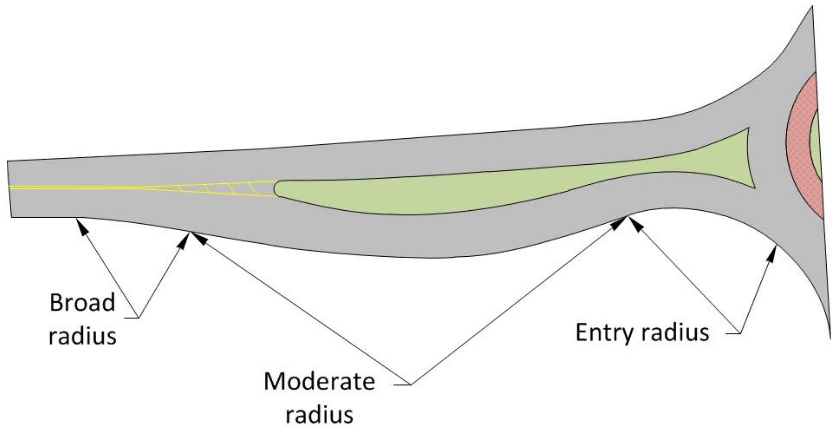
The ideal design speed mechanism has the entry and circulating speeds being similar. This varies due to size, shape and context of the roundabout.

The vehicle then moves into and through the circulation lane, being controlled all along by the design speed of the circulating lane. The circulating design speed controls the exit speed; therefore, the exit design speed, as calculated in the Travel Path section below, is not as critical.

Designing geometric entry speed control encourages lower speeds and lower speed differentials at conflict points, which reduces the potential for collisions.

1320.04(3)(a) Chicanes

Chicanes are a type of horizontal deflection used in traffic calming to reduce the speed of vehicles. Research has shown that chicanes have value in slowing down higher approach speeds.



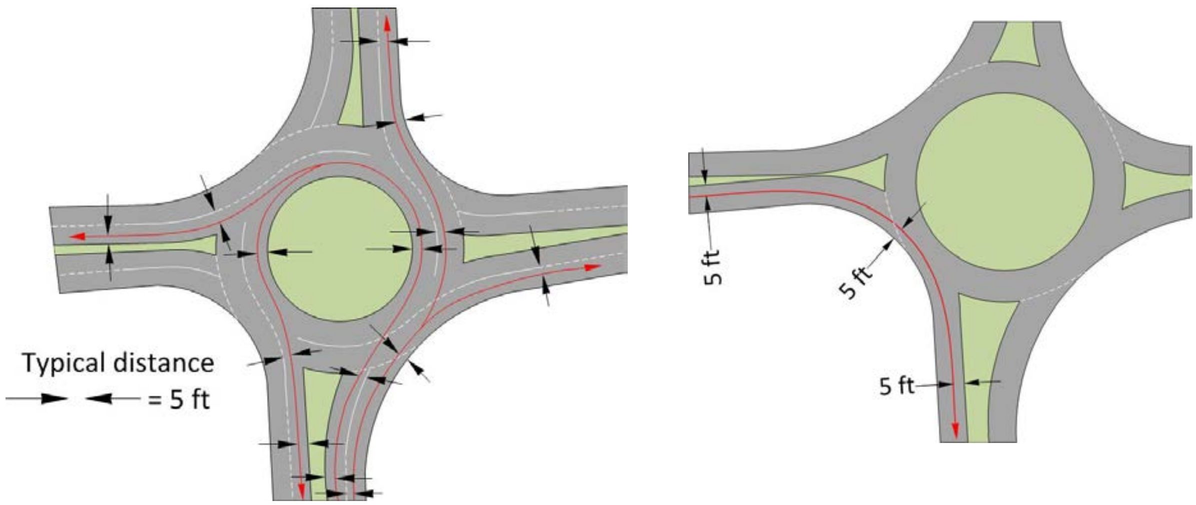
Chicane

Consider chicanes where posted speeds near the roundabout are 45 mph or higher. Design chicane curves with successively smaller radii in order to successively reduce vehicle speeds approaching the roundabout entry. Use Exhibit 1320-2 to determine the radii-speed relationship (the radii are measured using the offsets recommended in the Travel Paths section). The normal cross slope (superelevation in 1320-2) is 2% however, site conditions may require more based on how you tilt the plane of the roundabout for site specific conditions. A minus (-) 2% drains toward the central island.

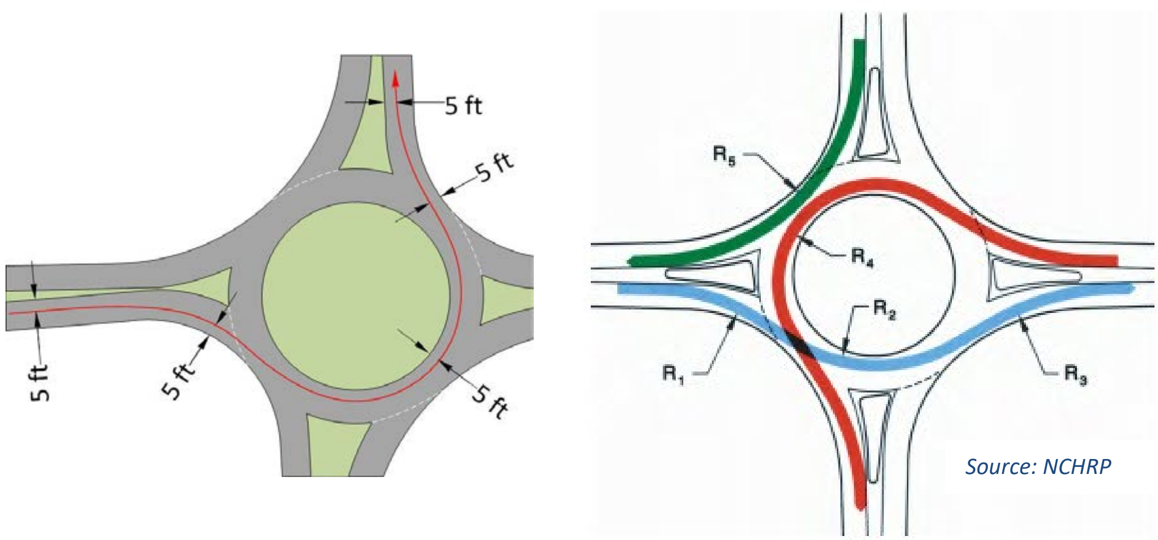
Also, consider the grade of the roadways that enter the roundabout, because a vehicle can more easily slow down on an upgrade than on a downgrade. Adjust the length of the deceleration based on the "Adjustment Factors for Grades Greater Than 3%" in *Design Manual* Exhibit 1360-10.

1320.04(3)(b) Travel Paths

Travel path calculations can be used on all roundabout designs to get an understanding of speeds for different paths throughout the roundabout. A travel path is the shortest path through the roundabout, no closer than 5 feet from any curb face or lane line as shown. Use Exhibit 1320-2 and R_1 through R_5 to determine Travel Path speeds.

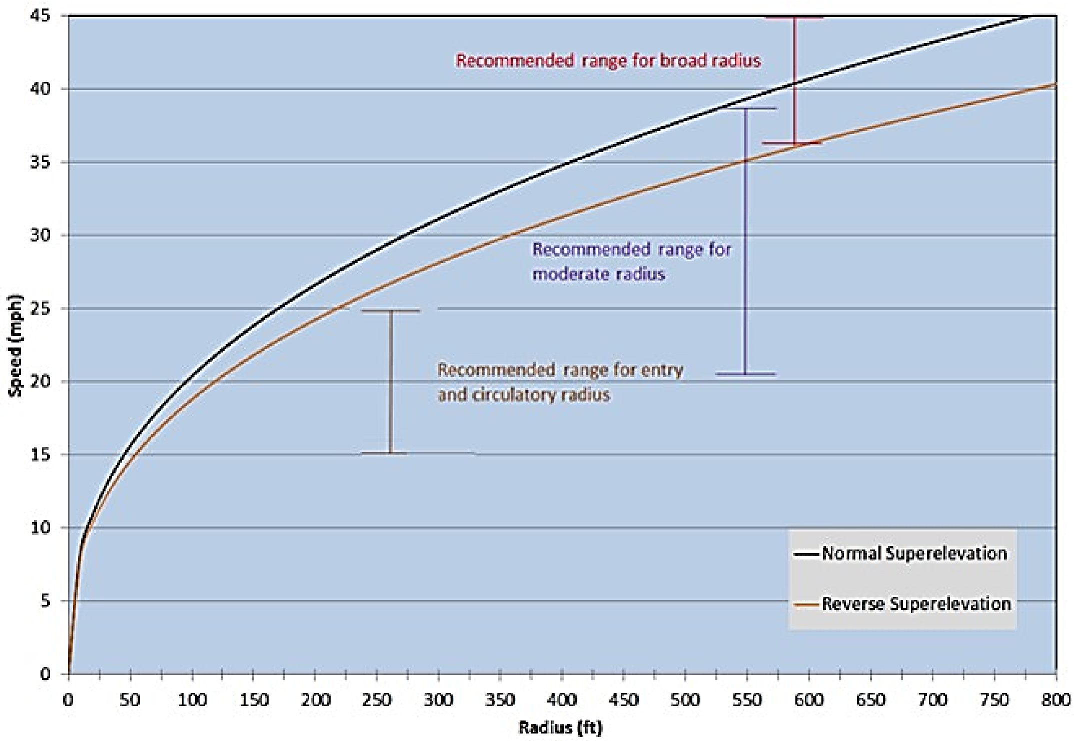


Travel paths



Source: NCHRP

Exhibit 1320-2 Radii-Speed Relationship on Approach Legs and R Value Relationships



1320.04(4) Grades

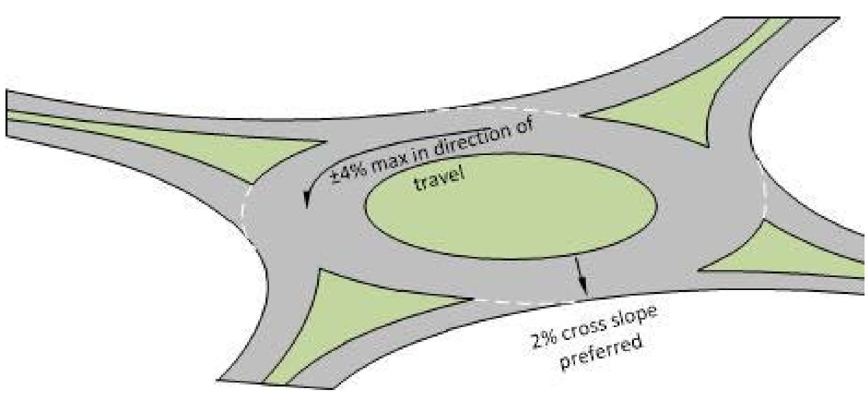
Do not use grades as a constraint during scoping to rule out a roundabout. Be aware of how the profiles mesh with sight distances and ADA pedestrian requirements.

1320.04(4)(a) Circulatory Roadway

The circulatory roadway grade value should not exceed 4%. Terrain may require benching the roundabout to fit conditions.

1320.04(4)(b) Grade Transitions for Roadway Entry and Exit to the Circulatory Roadway

Consider the grade transitions and make them as long as feasible. When designing for pedestrians see Chapter 1510 and work with region ADA subject matter expert to ensure that grades for ADA compliance at all pedestrian crossing are met.

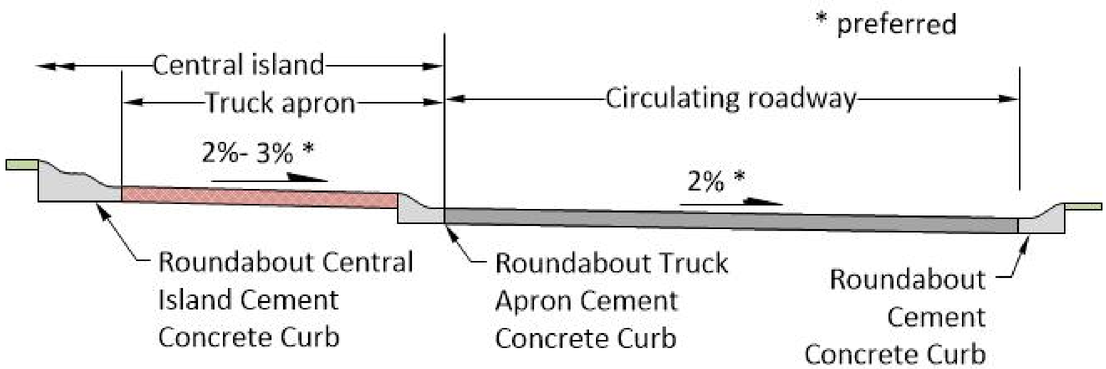


Grades and preferred cross slope

1320.04(5) Circulatory Roadway Cross Slope

The circulatory roadway cross slope may range from 1.5% to 4.0% (2.0% preferred), away from the central island to promote lower circulating speeds, improve central island visibility, minimize breaks in cross slope of entry and exit lanes, and facilitate drainage of water to the outside of the roundabout.

Sometimes roundabouts have to be built on a titled plane or benched and cross slope conditions will vary by leg or quadrant on the circulating roadway and may fall outside the 1.5% - 4.0% range. However, it is desirable to match existing ground elevation as much as possible.



Drawing shows preferred slopes. Site conditions and drainage may require slopes outside these ranges.

Cross slopes

1320.04(6) Design Tools

During the scoping or preliminary geometric design process, do not to use truck turning paths alone as a constraint to eliminate a roundabout at an intersection. There are several design tools available to aid in the design of a roundabout. It is important to understand how the software works, its default settings, and its application to the design process.

1320.04(6)(a) Design Vehicle Assumptions

While all highway-to-highway movements require accommodating a WB-67, there are certain assumptions that must be made with software programs that replicate truck swept paths. Determine which truck percentage defaults are to be used (recognizing that truck percentages can range from 2% to 20%) so that different segments can be modeled accurately. Recognize that within a set percentage, WB-67s may only represent a small sample of the entire truck volume on any given day. Therefore, consider whether a WB-67 should be designed for, or accommodated (also see Chapter 1103).

1. Designing for a WB 67

A roundabout that is being designed for a WB-67 may result in wider lane widths and a larger Inscribed Circle Diameter. For this situation, rolled curb design is critical to the truck's traversing the roundabout (see *Standard Plan* F-10.18 for curb details). Outside aprons may not be needed in many situations based on AutoTurn® modeling and knowledge of driver turning behavior when encountering geometric features.

2. Accommodating a WB 67

A roundabout that is designed to accommodate a WB-67 assumes that a WB-67 could utilize truck aprons to maneuver through the roundabout, if necessary, which should reduce the overall footprint of the roundabout. For this situation, rolled curb is critical to the truck's traversing the roundabout confidently. Although outside truck aprons are needed infrequently, there may be situations where the design may need to incorporate them. Contact HQ Traffic for guidance.

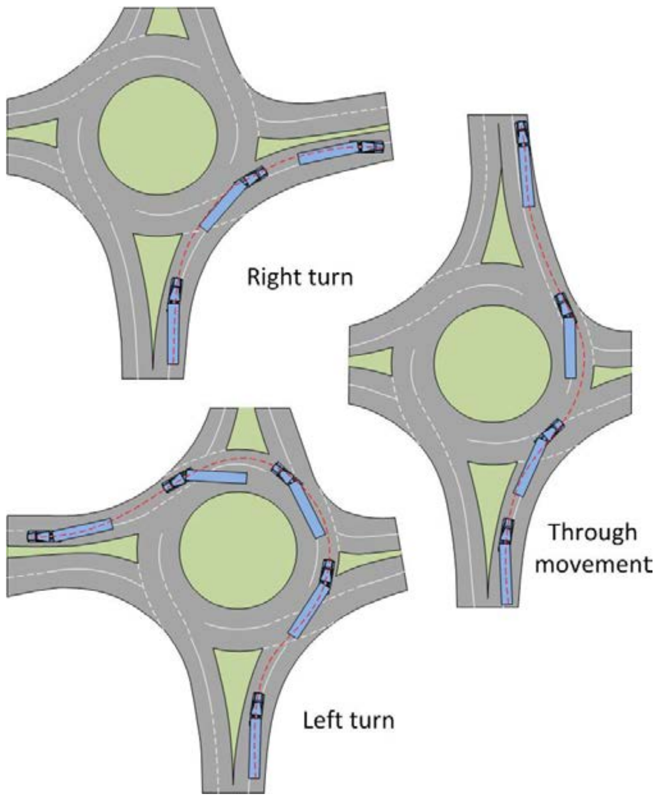
1320.04(6)(b) Truck Swept Path

In some cases, roundabouts of the perfect circular variety with symmetrical roadway attachments require less specific knowledge of truck-turning software and its applications. However, when looking at a non-circular shaped roundabout where the combination of the truck's speed, its turning angle settings, its rear axle locations, and its alignment are the critical design elements to address, a mastery of the software is required. Designers that are unfamiliar with how to apply the software inputs accurately to model a truck's swept path need to contact HQ Traffic Office for guidance. Poor alignment of a truck swept path can result in unnecessarily large roundabout footprints, higher than desired Travel Path speeds, or uncomfortable driving maneuvers by the freight community.

Assume that a truck will travel much slower through a roundabout than the Travel Path speed calculated for passenger vehicles (see 1320.04(3)(b)). Adjust the software input to allow a slower truck speed in order to make a good engineering judgment about how fast a truck may use a roundabout (for example, for AutoTURN® use 5 mph). Design tool default settings don't necessarily allow the maximization of the tool and can prohibit the designer from getting a good, balanced design between passenger car speeds and truck accommodation.

Single lane roundabout - Truck using the truck apron

When using a truck-turning software tool like AutoTURN® on multilane roundabouts, assume a truck's travel path will occupy (straddle) parts of two adjacent lanes.



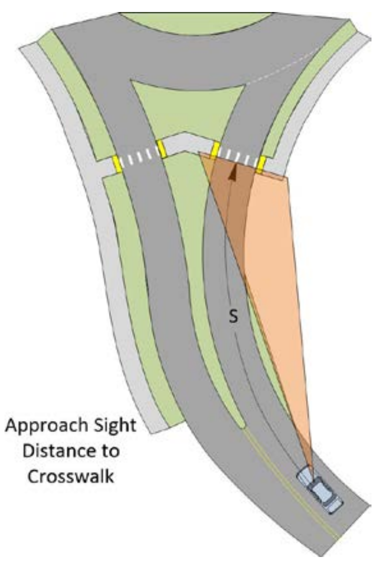
Multilane roundabout - truck straddles lanes

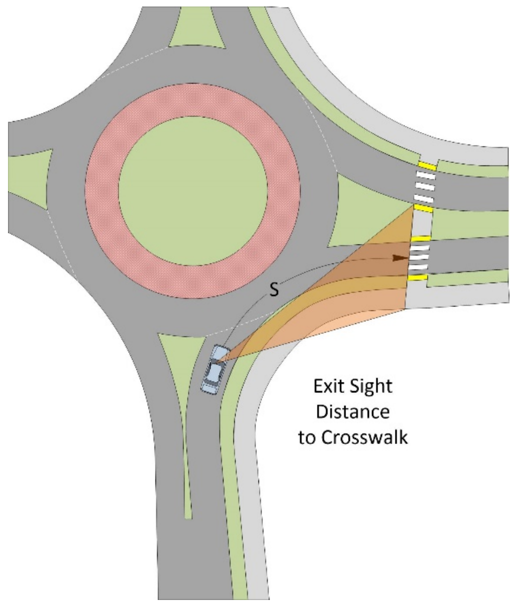
1320.04(7) Sight Distance

Sight distance is an important design consideration at roundabouts. Restricting sight distance across the central island with strategic landscaping may enhance the intersection by making the intersection a focal point and encouraging lower speeds. Work with the region Traffic Engineer and Landscape Architect (HQ if there is no region contact) to determine this balance. Provide sight triangle plan sheets for consideration of landscape design.

1320.04(7)(a) Stopping

Use the design stopping sight distance in Chapter 1260. Anticipated speeds throughout the roundabout can be calculated using Exhibit 1320-2, based on the Travel Path radius and direction of the particular curve. The design stopping sight distance is measured along the vehicle's path as it follows the curvature of the roadway; it is not measured as a straight line.





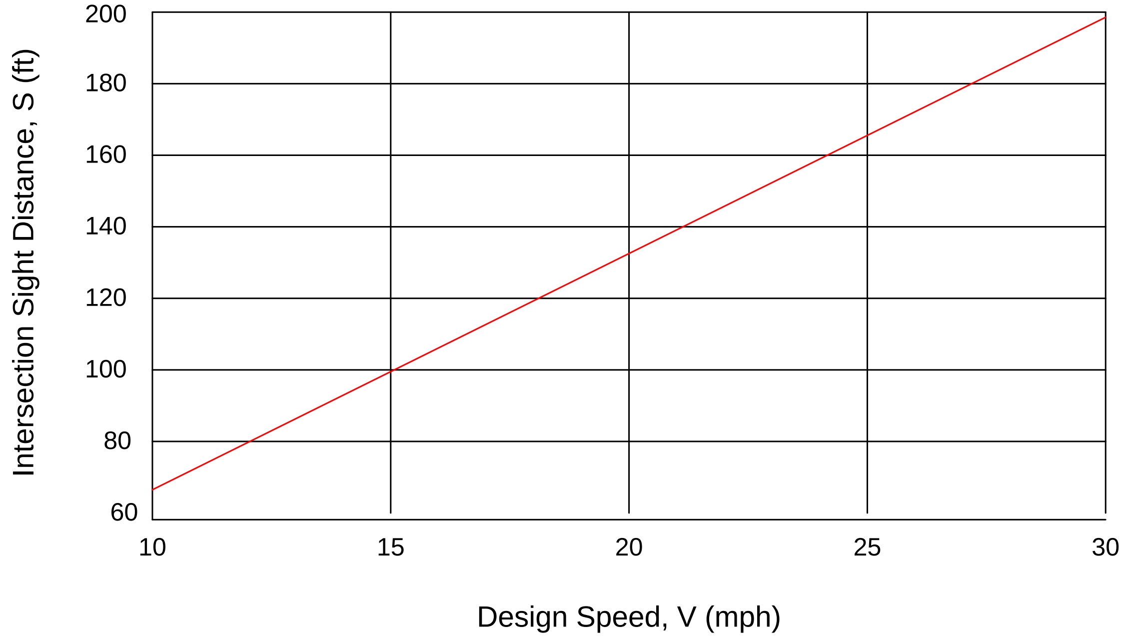
Sight distance – Approach and Exit

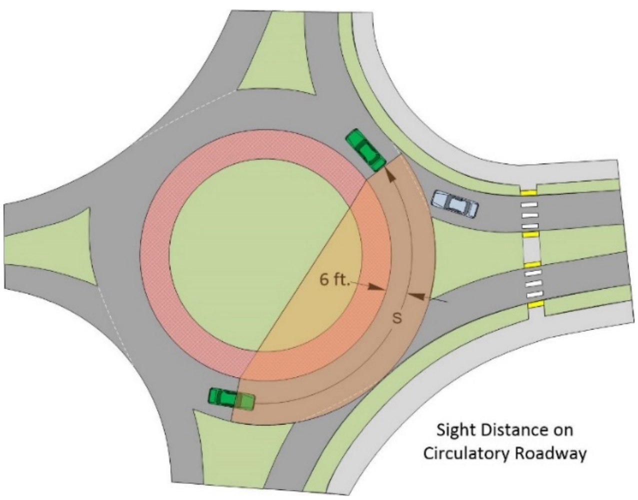
1320.04(7)(b) Intersection

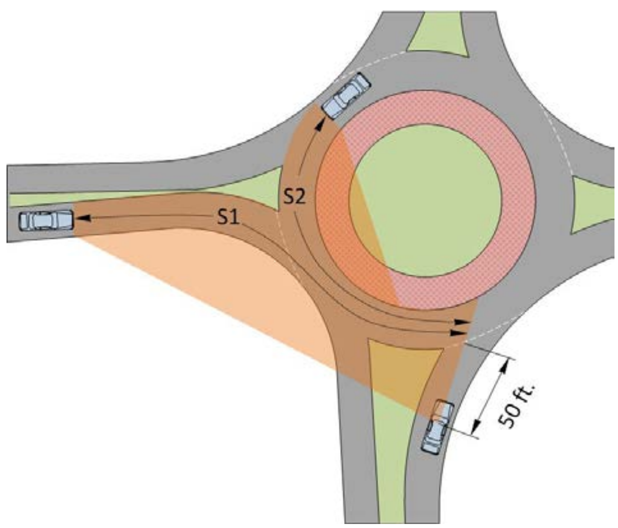
Provide minimum intersection sight distance. Longer sight distances can lead to higher vehicle speeds that reduce gap opportunities for entering vehicles. For intersection sight distance at roundabouts, provide entering vehicles a clear view of traffic on the circulating roadway and on the immediate upstream approach in order to aid in judging an acceptable gap.

The intersection sight distance at roundabouts is given in Exhibit 1320-3. The S_1 intersection sight distance is based on the average of the entering and circulating speeds, and the S_2 intersection sight distance is based on the left-turning speed. The sight distance may also be calculated using the intersection sight distance equation given in Chapter 1310 using a time gap (tg) of 4.5 seconds.

Exhibit 1320-3 Intersection Sight Distance







1320.04(8) Railroad Crossings

Although it is undesirable to locate any intersection near an at-grade railroad crossing, this situation exists at many locations on the highway system. Experience shows that a roundabout placed near a crossing has some operational advantages. If there is a railroad crossing near the roundabout contact HQ Traffic Office for further guidance.

1320.05 Pedestrians

As part of the approved Intersection Control Analysis (ICA), it has already been determined whether pedestrians will use the roundabout and, if so, which legs (see Chapter 1300).

With the knowledge of where pedestrian facilities are needed, design the roundabout while keeping in mind the ADA requirements for crosswalks, sidewalks, paths, and other pedestrian facilities.

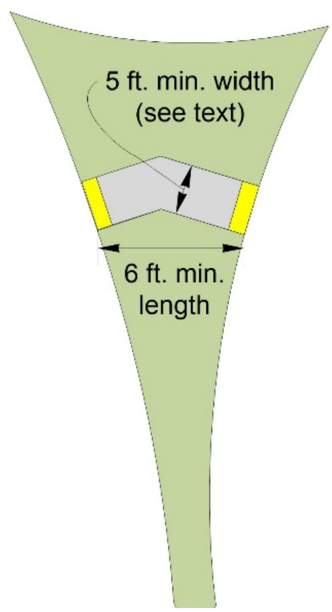
1320.05(1) Crossing Location

The pedestrian crossing located on the entry side of a roundabout leg should be at least 20 feet from the yield line so that a pedestrian can walk behind a vehicle that is waiting at the yield line. If there is an extremely large truck percentage, consider moving the crossing to accommodate the most common truck.

The crossing located in the exit side of the roundabout leg can be closer to the roundabout, because as the vehicles leave the roundabout, they accelerate and make it harder to find a break in traffic. As speed increases, drivers are less likely and less able to stop. Verify that no significant, large sight obstructions are located within the sight lines.

1320.05(2) Splitter Island Pass Through

Design the splitter island pass through a minimum of 5 feet wide, or the width of the sidewalk, whichever is greater. The length of the pass through (measured back of curb to back of curb of the splitter island) is to be a minimum of 6 feet long measured along the shortest section of the pedestrian path. Consider a “V” shape pass through as shown.



Splitter island pass through

1320.05(3) Buffers

Wherever feasible, separate sidewalks from the curb with a buffer. Landscaping or colored concrete are acceptable for the buffer. See WSDOT *Standard Plan F10-18* for dimension details. Do not compromise required vehicle sight triangle needs.

The buffer discourages pedestrians from crossing to the central island or cutting across the circulatory roadway of the roundabout. It also helps guide pedestrians with vision impairments to the designated crosswalks, and can accommodate the occasional inexperienced truck driver who encroaches up onto a curb while traversing through the roundabout.

1320.05(4) Curb Ramps

Roundabouts with buffers typically have combination-type curb ramps; otherwise, parallel curb ramps are normally used. (See Chapter 1510 and the *Standard Plans* for curb ramp information.)

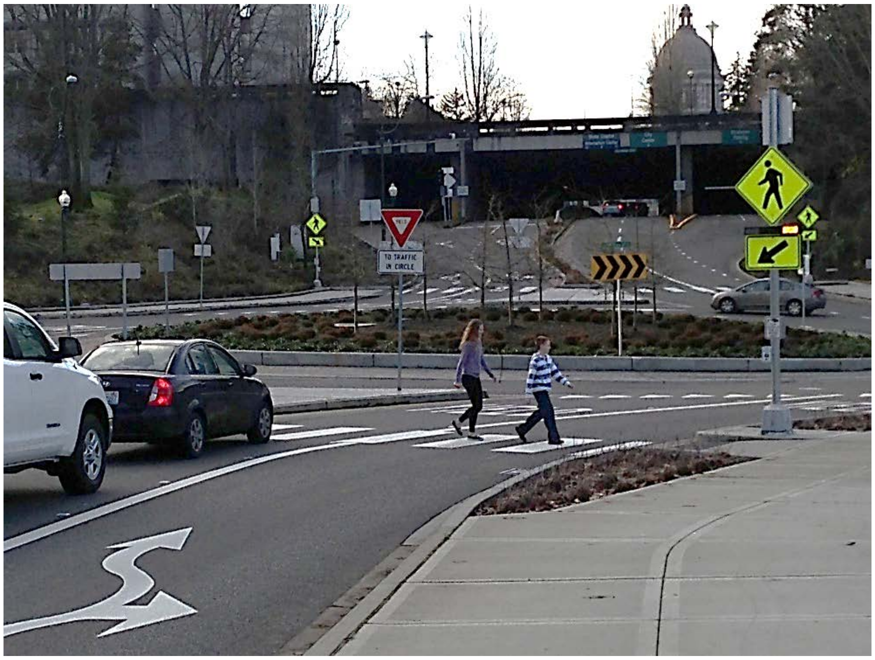
1320.05(5) Sight Triangles

A vehicle sight triangle specific to pedestrians (see 1320.04(7)) must include the whole curb ramp, including the landing, where pedestrians are likely to wait to cross.

It is also important that pedestrians are also able to see approaching vehicles.

1320.05(6) Pedestrian Beacons

On multilane roundabouts, consider installing pedestrian beacons to warn drivers when a pedestrian wants to cross the roadway. Work with the region Traffic Engineer on types and locations of pedestrian beacons.



Pedestrian beacons

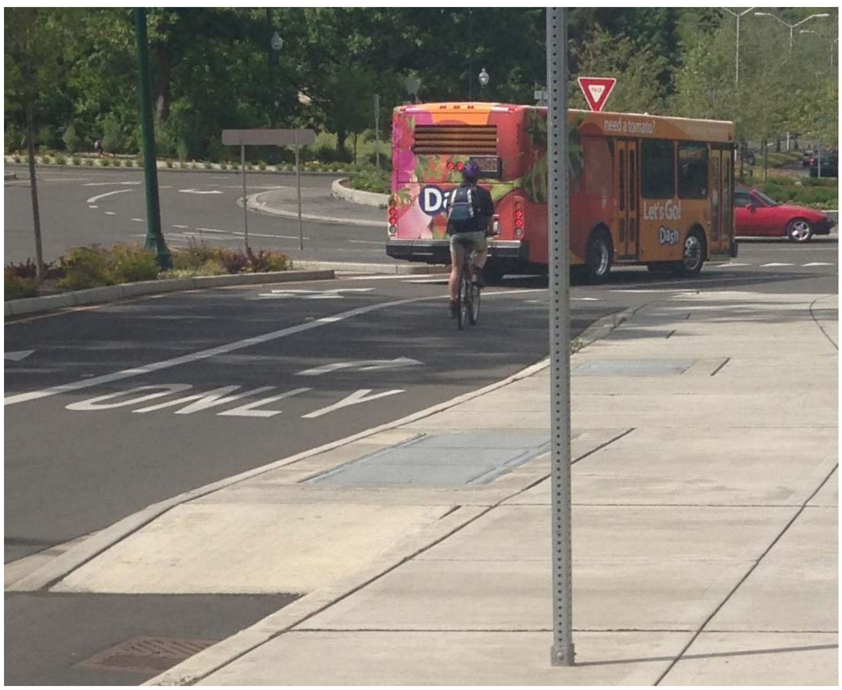
1320.06 Bicycles

Provide bicyclists with similar options to negotiate roundabouts as they have at other intersections. Consider how they navigate either as motor vehicles or pedestrians depending on the size of the intersection, traffic volumes, their experience level, and other factors.

Bicyclists are often comfortable riding through single-lane roundabouts in low-volume environments in the travel lane with motor vehicles, as speeds are comparable and potential conflicts are low.

At larger or busier roundabouts, cyclists may be more comfortable using ramps connecting to a sidewalk around the perimeter of the roundabout as a pedestrian. Where bicycle lanes or shoulders are used on approach roadways, they should end before the geometry changes the approach to the roundabout.

Contact the HQ Design Office for bicycle ramp design options.



Bicycle rider using lane

1320.07 Signing

The graphic shown is an example of potential signing for a single-lane roundabout. For additional information, refer to the MUTCD, Plan Sheet Library, and the *Standard Plans* for details on signing.

A preliminary sign plan is developed to identify existing and proposed signing on state highways. Sign plans on state routes are to be reviewed and approved by the region Traffic Engineer and then furnished to the HQ Traffic Office for review.

The plan provides an easily understood graphic representation of the signing, and it provides statewide uniformity and consistency for regulatory, warning, and guide signs at roundabouts on the state highway system. For roundabouts located near a port, industrial area, or route that accommodates oversize loads, consider using perforated square steel posts.

Signing example

1320.08 Pavement Marking

See *Standard Plan* M-12.10 for roundabout pavement marking details. Consult region Traffic on traffic pavement markings and materials.

1320.09 Illumination

Provide illumination for each of the conflict points between circulating and entering traffic in the roundabout and at the beginning of the raised splitter islands. Illuminate raised channelization or curbing. Position the luminaires on the upstream side of each crosswalk to improve the visibility of pedestrians. Light the roundabout from the outside in toward the center. This improves the visibility of the central island and circulating vehicles to motorists approaching the roundabout. Ground-level lighting within the central island that shines upward toward objects in the central island can also improve their visibility. Consult with the region Traffic office for illumination design. (See Chapter 1040 for additional information on illumination.) On higher-speed approaches, consider internally illuminated bollards (IIB) in lieu of other illumination.

1320.10 Road Approach, Parking, and Transit Facilities

Road approach (road or driveway) connections to the circulating roadway are not allowed at roundabouts unless they are designed as a leg to the roundabout. It is desirable that road approaches not be located on the approach or departure legs within the length of the splitter island. The minimum distance from the circulating roadway to a road approach is controlled by corner clearance using the outside edge of the circulating roadway as the crossroad. When minimum corner clearance cannot be met, document the decision in accordance with Chapters 530 and 540.

If a parcel adjoins two legs of the roundabout, it is acceptable to provide a right-in/right-out driveway within the length of the splitter islands on both legs. This provides for all movements; design both driveways to accommodate their design vehicles.

Roadways between roundabouts may have restrictive medians with left-turn access provided with U-turns at the roundabouts.

Parking is not allowed in the circulating roadway or on the entry or exit roadway within the length of the splitter island.

Transit stops are not allowed in the circulating roadway, in the approach lanes, or in the exit lanes prior to the crosswalk. Locate transit stops on the roadway before or after the roundabout, in a pullout, or where the pavement is wide enough that a stopped bus does not block the through movement of traffic or impede sight distance.

Right in / right out driveways

1320.11 Geometric Design Peer Review

Conduct a peer review of the roundabout design with the following participants.

- Region Traffic Office
- Assistant Sate Traffic Engineer
- Region Project Development Engineer or Engineering Manager
- Assistant State Design Engineer

The intent of this meeting is to review, discuss, evaluate, and provide feedback on the 2-D roundabout layout design in order to finalize the channelization plan.

1320.12 Documentation and Approvals

Refer to Chapter 300 for design documentation and approval requirements.

1320.13 References

1320.13(1) Federal/State Laws and Codes

See Chapter 1510 for Americans with Disabilities Act Policy and references

Revised Code of Washington (RCW) 47.05.021, Functional classification of highways

Washington Administrative Code (WAC) 468-58-080, Guides for control of access on crossroads and interchange ramps

1320.13(2) Design Guidance

Roundabout Cement Concrete Curbs: *Standard Plan F-10.18-00*

Roundabout Pavement Markings: *Standard Plan M-12.10*

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA, as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

Standard Plans for Road, Bridge, and Municipal Construction (*Standard Plans*), M 21 01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (*Standard Specifications*), M 41-10, WSDOT

1320.13(3) Supporting Information

Roundabouts: An Informational Guide Second Edition, NCHRP Report 672, Transportation Research Board, 2010 http://nacto.org/docs/usdg/nchrprpt672.pdf

Roundabouts: An Informational Guide, FHWA-RD-00-067, USDOT, FHWA http://www.fhwa.dot.gov/publications/research/safety/00067/index.cfm

Highway Capacity Manual 2010 (HCM 2010), Transportation Research Board, National Research Council, Washington D.C., 2000

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO

"Crash Reductions Following Installation of Roundabouts in the United States," Insurance Institute for Highway Safety, March 2000
🖰 https://www.dot.ny.gov/main/roundabouts/files/insurance_report.pdf

"Long-Term Trends in Public Opinion Following Construction of Roundabouts," Insurance Institute for Highway Safety, 2007
🖰 http://trrjournalonline.trb.org/doi/abs/10.3141/2019-26

Truck and Bus Safety; Roundabouts, Journal of the Transportation Research Board No. 2585, 2016.
🖰 http://trrjournalonline.trb.org/toc/trr/2585/

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005
🖰 www.wsdot.wa.gov/research/reports/600/638.1.htm

Chapter 1330 Traffic Control Signals

1330.01 General

Traffic control signals are automated traffic control devices that warn or direct motorists to take a specific action. Traffic control signals are used to control the assignment of right of way at locations where conflicts with motorists, bicyclists, and pedestrians exist or where passive devices such as signs and markings do not provide the necessary flexibility of control to move motorists, bicyclists, and pedestrians in an efficient manner.

The decision to install a traffic signal is the result of an Intersection Control Analysis (ICA) (see Chapter 1300) that is approved by the region Traffic Engineer or other designated authority.

1330.02 Procedures

1330.02(1) Traffic Signal Permit

State statutes (RCWs) require Washington State Department of Transportation (WSDOT) approval for the design and location of all conventional traffic signals and some types of beacons located on city streets forming parts of state highways. Approval by WSDOT for the design, location, installation, and operation of all other traffic control signals installed on state highways is required by department policy.

The Traffic Signal Permit (DOT Form 242-014 EF) is the formal record of the signal warrant analysis required by the MUTCD and the department's approval of the installation and type of signal. Permits are required for the following types of signal installations:

- Conventional traffic signals
- Emergency vehicle signals
- Intersection control beacons
- Lane control signals
- Movable bridge signals
- Ramp meter signals
- Pedestrian signals
- Pedestrian Hybrid Beacon signals ("HAWK" signals)
- Temporary traffic signals (only when not being used in place of a permanent, permitted signal)
- Queue-cutter traffic signals

The Permit and its supporting data must be included in the Design Documentation Package (DDP.) The permit is completed by the requesting agency and submitted, complete with supporting data, through the region Traffic Office to the approving authority for approval. See 1330.02(1)(a) for Signal Warrant information required as part of the supporting documentation.

The approving authority is the Regional Administrator or authorized delegate. The approving authority approves or denies the application and sends it back to the region Traffic Office. The region Traffic Office retains a record of the approved permit and supporting data and forwards a copy of the Permit and the supporting data to the State Traffic Engineer at WSDOT Headquarters (HQ). Preserve the approved permit as required by 1330.07 Documentation.

Emergency vehicle signals require annual permit renewal. The region Traffic Office reviews the installation for compliance with requirements. If satisfactory, the permit is renewed by the Regional Administrator with a letter to the operating agency. A copy of this letter is also sent to the State Traffic Engineer.

Permits are not required for portable traffic signals, speed limit sign beacons, stop sign beacons, or lane assignment signals at toll facilities.

A new permit application is required when the level of control is increased, such as changing from an intersection control beacon to a conventional traffic signal or adding an approach to an existing signal system.

For a reduction in the level of control, such as converting a conventional signal to a flashing intersection beacon or removal of the signal, submit the “Report of Change” portion of the traffic signal permit, complete with supporting data, to the approving authority, with a copy to the region Traffic Office and State Traffic Engineer.

If experimental systems are proposed, region Traffic Engineer review and approval is required. The region Traffic Office will send the approved proposal to the State Traffic Engineer for review and approval. The State Traffic Engineer will forward the approved proposal to FHWA for their approval. A copy of the approval from FHWA will be returned and must be preserved as required by 1330.07 Documentation.

Any signal system requiring a permit, with the exception of Ramp Meter signals, also requires Preliminary Signal Plan approval from the WSDOT HQ Traffic Office (see 1330.05).

1330.02(1)(a) Signal Warrants

A signal warrant is a minimum condition that is to be met before a signal may be considered for installation. Satisfying a warrant does not mandate the installation of a traffic signal. The warranting condition(s) supports the inclusion of a traffic signal for consideration as part of the Intersection Control Analysis performed during the scoping of the project (see Chapter 1300). For a list of the traffic signal warrants and information on how to use them, see the *Manual on Uniform Traffic Control Devices* (MUTCD). Contact the region Traffic Engineer for region specific practices Address all warrants listed in the currently adopted MUTCD as part of the Signal Warrant Analysis. Mark warrants which do not apply as “Not Applicable” and include a basic supporting statement or similar justification. Include the Signal Warrant Analysis in the Signal Permit supporting data.

1330.02(2) Responsibility for Funding, Construction, Maintenance, and Operation

Responsibility for the funding, construction, maintenance, and operation of traffic signals on state highways has been defined by legislative action and Transportation Commission resolutions (see Exhibit 1330-1). Responsibilities vary depending on location, jurisdiction, and whether or not limited access control has been established. Limited access as used in this chapter refers to full, partial, or modified limited access control that has been established as identified in the Access Control Tracking System:
www.wsdot.wa.gov/design/accessandhearings/tracking.htm

Exhibit 1330-1 Responsibility for Facilities

Responsibility for Various Types of Facilities on State Highways				
Area	**Responsibility**	**Emergency Vehicle Signals**	**Traffic Signals, Pedestrian Signals, & Intersection Control Beacons**	**Reversible Lane Signals & Movable Bridge Signals**
Cities with a population of 25,000 or greater	Finance Construct Maintain Operate	ESD [1] ESD [1] ESD [1] ESD [1]	City [2] City [2] City [2] City [2]	City [2] City [2] City [2] City [2]
All other locations	Finance Construct Maintain Operate	ESD [1] ESD [1] ESD [1] ESD [1]	State/County [3] /Other [4] State/County [3] /Other [4] State State	State State State State

Notes:
[1] ESD refers to the applicable Emergency Service Department.
[2] Does not apply to state highways with established limited access control (see 1330.02(2)(c)).
[3] Beyond corporate limits due to county activity (see 1330.02(2)(d)).
[4] Other refers to signals proposed by or required due to third party activity (see 1330.02(2)(g)).

(a) **Inside the corporate limits of cities with a population of 25,000 or greater where there is no established limited access control:** The city is responsible for the funding, construction, maintenance, and operation of traffic signals. Population figures can be found at:
www.ofm.wa.gov/pop/

(b) **Inside the corporate limits of cities with a population of less than 25,000:** WSDOT is responsible for funding, construction, maintenance, and operation of traffic signals. Population figures can be found at: www.ofm.wa.gov/pop/

(c) **Inside the corporate limits of cities with a population of 25,000 or greater where there is established limited access control:** WSDOT is responsible for funding, construction, maintenance, and operation of traffic signals. Population figures can be found at:
www.ofm.wa.gov/pop/

(d) **Outside the corporate limits of cities and outside established limited access control areas:** WSDOT is responsible for funding, construction, maintenance, and operation of a traffic signal when a new state highway crosses an existing county road. When a new county road intersects an existing state highway, WSDOT is responsible for only the maintenance and operation of a traffic signal. The county is responsible for the construction costs of the traffic signal and associated illumination. When it is necessary to construct a traffic signal at an existing county road and state highway intersection, the construction cost distribution is based on the volume of traffic entering the intersection from each jurisdiction's roadway. The county's share of the cost, however, is limited to a maximum of 50%. The state is responsible for maintenance and operation (WAC 468-18-040).

(e) Outside the corporate limits of cities and inside established limited access control areas: WSDOT is responsible for funding, construction, maintenance, and operation of traffic signals.

(f) Emergency vehicle signals: The emergency service agency is responsible for all costs associated with emergency vehicle signals.

(g) Third party agreement signals: At those locations where WSDOT is responsible for traffic signals and third party activity justifies the installation of a traffic signal, as determined by an ICA, the following rules apply:

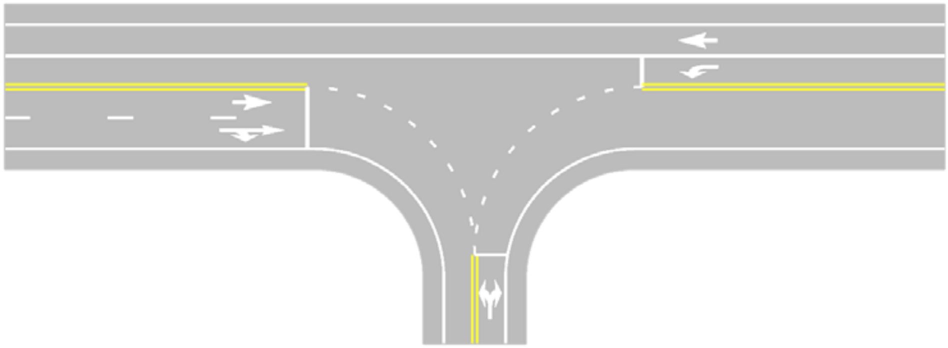
- The third party is responsible for funding the design and construction of the traffic signal system, unless another arrangement is agreed upon with WSDOT.
- The third party obtains a traffic signal permit.
- The third party agrees to design and construct the traffic signal in conformance with WSDOT's guidelines and requirements.
- The third party agrees to submit the design and construction documents to WSDOT for review and approval by the region Traffic Engineer.
- Preserve all third party provided documents and any third party agreement(s) as required by 1330.07 Documentation.

1330.03 Intersection Design Considerations

Signalized intersections require different design considerations than non-signalized intersections. These elements should be considered as early as the ICA process (see Chapters 1300 and 1310 for further guidance.) This Section discusses basic intersections with relatively simple geometry. For more complex or innovative intersection layouts such as Diverging Diamond Interchanges (DDIs), Displaced Left Turns (DLTs), or Single Point Urban Interchanges (SPUIs), contact the WSDOT HQ Traffic Office for support.

Consider providing an unrestricted through lane on the major street of a T intersection (sometimes referred to as a Continuous Green "T" (CGT) intersection). This design allows for one traffic movement to flow without restriction. When this is used on through roadways with a posted speed of 45 MPH or greater, the through lane must be separated by a physical barrier or the through movement must also be signalized. If there is a crosswalk across the through lane, the through lane must be signalized. Exhibit 1330-2 shows an example of a CGT intersection.

Exhibit 1330-2 Example Continuous Green "T" (CGT) Intersection Layout



1330.03(1) Left Turns

It is recommended that a left turn storage lane be provided for all main line roadways where left turns are allowed. This helps to avoid having stopped traffic in a through lane with a green through signal display. This also helps to support potential future changes in left turn operations. See Section 1330.06(1) for additional discussion.

Left-turning traffic can operate more efficiently when the opposing left-turn lanes are directly opposite each other. When a left-turn lane is offset into the path of an opposing through lane, the left-turning driver may assume the opposing vehicles are also in a left-turn lane and fail to yield. To prevent this occurrence, less efficient split phasing may be necessary. (See Chapter 1310 for guidance on lane offsets and opposing left-turn clearance.) Where there are opposing through lanes but no opposing left turn lane, install a striped or raised median area opposite the left turn lane if possible.

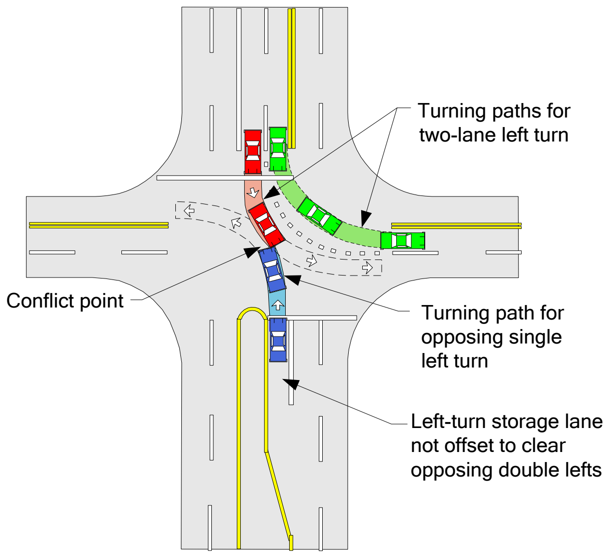
Place stop lines so that they are out of the path of conflicting left turns. Check the geometric layout by using turning templates or a computerized vehicle turning path program (such as AutoTURN®) to determine whether the proposed layout and phasing can accommodate the design vehicles. Also, check the turning paths of opposing left-turn movements. In many cases, the phase analysis might recommend allowing opposing left turns to run concurrently, but the intersection geometrics are such that this operation cannot occur. The intersection should be large enough to accommodate opposing left turning vehicle paths with a 4-foot minimum (12-foot desirable) separation between them. Where this separation cannot be achieved, less efficient signal phasing may be required to accommodate opposing left turns.

Some intersections may have multi-lane left turns. At locations with closely spaced intersections, a multi-lane left-turn storage area might be the only solution to reduce the potential for the left-turn volume to back up into an adjacent intersection. As with single left turn lanes, the intersection should be large enough to accommodate opposing left turning vehicle paths with a 4-foot minimum (12-foot desirable) separation between them. Where this separation cannot be achieved, less efficient signal phasing may be required to accommodate opposing left turns.

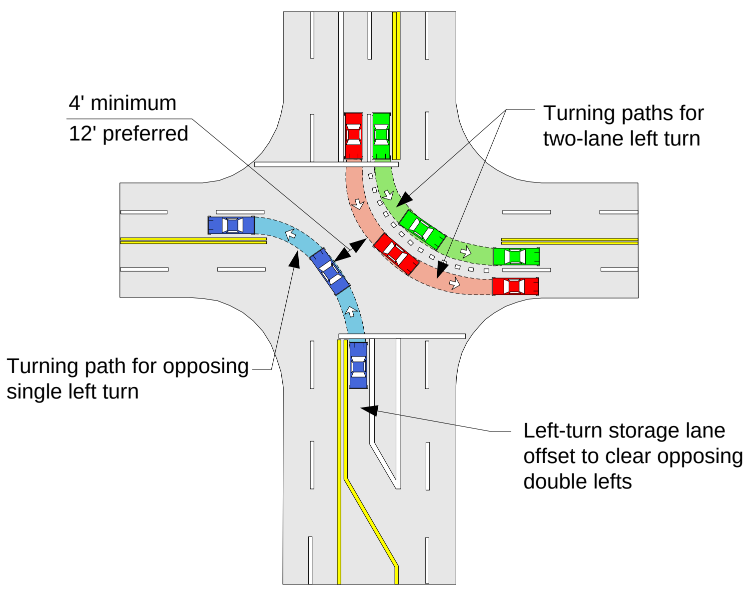
At smaller intersections, the opposing single-lane left-turn movement might not be able to turn during the two-lane left-turn phase and it might be necessary to reposition this lane. If the opposing left turns cannot time together, the reduction in delay from the two-lane left-turn phase is likely to be nullified by the requirement for a separate opposing left-turn phase. Exhibit 1330-3 shows two examples of two-lane left turns with opposing single-left arrangements.

Two receiving lanes are required for two-lane left-turn movements. In addition, these receiving lanes are to extend well beyond the intersection before reducing to one lane. A lane reduction immediately beyond the intersection can cause delays and backups into the intersection because the left-turning vehicles usually move in dense platoons, which may make merging and lane changes difficult. (See Chapter 1310 for guidance on lane reductions on intersection exits.)

Exhibit 1330-3 Left-Turn Lane Configuration Examples



Single left turn lane not offset – overlapping left turn paths



Offset single left turn lane – opposing lefts no longer in conflict

1330.03(2) Right Turns

Large right-turn curb radii at intersections sometimes have impacts on traffic signal operation. Larger radii allow faster turning speeds and might move the pedestrian entrance point farther away from the intersection area. Pedestrian crossing times are increased because of the longer crossing, thereby reducing the amount of time available for vehicular traffic. (See Chapter 1310 for guidance on determining these radii.)

At intersections with large right-turn radii, consider installing raised traffic islands. These islands are primarily designed as pedestrian refuge areas. (See Chapter 1510 for pedestrian refuge islands and traffic island designs.) Traffic islands may decrease the required pedestrian clearance intervals; however, large radii and raised traffic islands may make it difficult for pedestrians to navigate the intersection. Where pedestrians are expected to cross a right turn lane to a traffic island, it is recommended to use a compound right turn-lane design as shown in Chapter 1310.

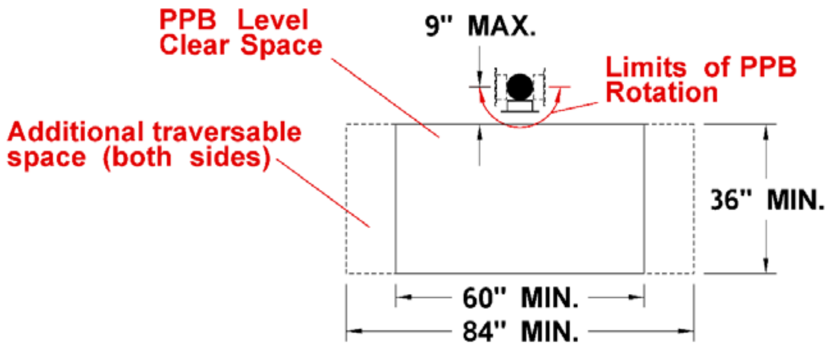
1330.03(3) Pedestrian Features

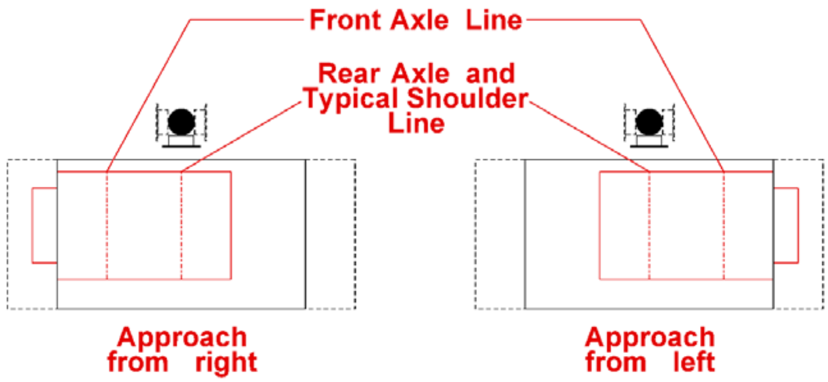
Additional sidewalk criteria must be met to accommodate pedestrians at signalized intersections. Mobility assistance devices such as wheelchairs and scooters add complexity to the system design. Coordination is required between sidewalk design, curb ramp design and pedestrian pushbutton (PPB) placement. In most cases, an initial sidewalk and curb ramp design should be developed, and then adjustments made as necessary to accommodate the PPBs and ensure that the pedestrian access route is maintained (See Chapter 1510 for more information on accessible pedestrian routes.) The following describe the required level clear space for PPBs (see Exhibit 1330-4):

- The level clear space must be a minimum of 36 inches by 60 inches in size, unobstructed, with the PPB centered along one of the 60 inch sides. Possible obstructions include the pole baseplate and the pushbutton itself.
- 12 inches of additional traversable surface (such as sidewalk) is required at each end of the 60 inch level clear space for a total unobstructed area of 36 inches by 84 inches. Curb ramp slopes are considered traversable for these purposes.
- To be considered level, the level clear space may have a maximum of 2% cross slope and 2% running slope.

  Note: It is recommended that cross slopes and running slopes be designed to be less than the allowed maximum to allow for some tolerance in construction. For example, design the level clear space for a maximum 1.5% cross slope and running slope (rather than 2% maximum).
- The level clear space should be centered relative to the pole with the PPB either facing the level clear space, or with the face of the PPB rotated up to 90 degrees as needed to align the tactile arrow of an APS PPB with the direction of crossing.
- The level clear space should be as close to the PPB as possible, but may be up to 9 inches away from the center of the physical pushbutton (i.e., not the housing or assembly), as measured perpendicular from one of the 60 inch sides. Measuring from the center of the pole upon which the PPB is mounted will normally result in the PPB meeting the 9 inch reach requirement.

Exhibit 1330-4 Basic Level Clear Space for Pedestrian Pushbuttons





Manual Wheelchair Example

PPBs at newly constructed/reconstructed intersection quadrants must meet the above criteria.

The level clear space for the PPB is not required to be concurrent with sidewalk ramp landings, but using one level clear space for both is desirable and does occur frequently. Exhibits 1330-5a and 1330-5b show examples of how the level clear space for the PPB overlays with typical perpendicular and parallel ramp designs. The 48 inch by 48 inch dimensions shown are the typical required level landings for curb ramps.

PPBs at existing intersection quadrants that are not being reconstructed should meet as many of these criteria as possible. If it is not possible to get the level clear space close enough to the pole, an extension may be used to get the PPB itself within 9 inches of the level clear space. Extensions may only be used when no other alternative is physically possible, and are limited to 12 inches in length. See 1330.04(4) for additional requirements.

Exhibit 1330-5a Example Basic Perpendicular Ramp PPB Level Clear Space

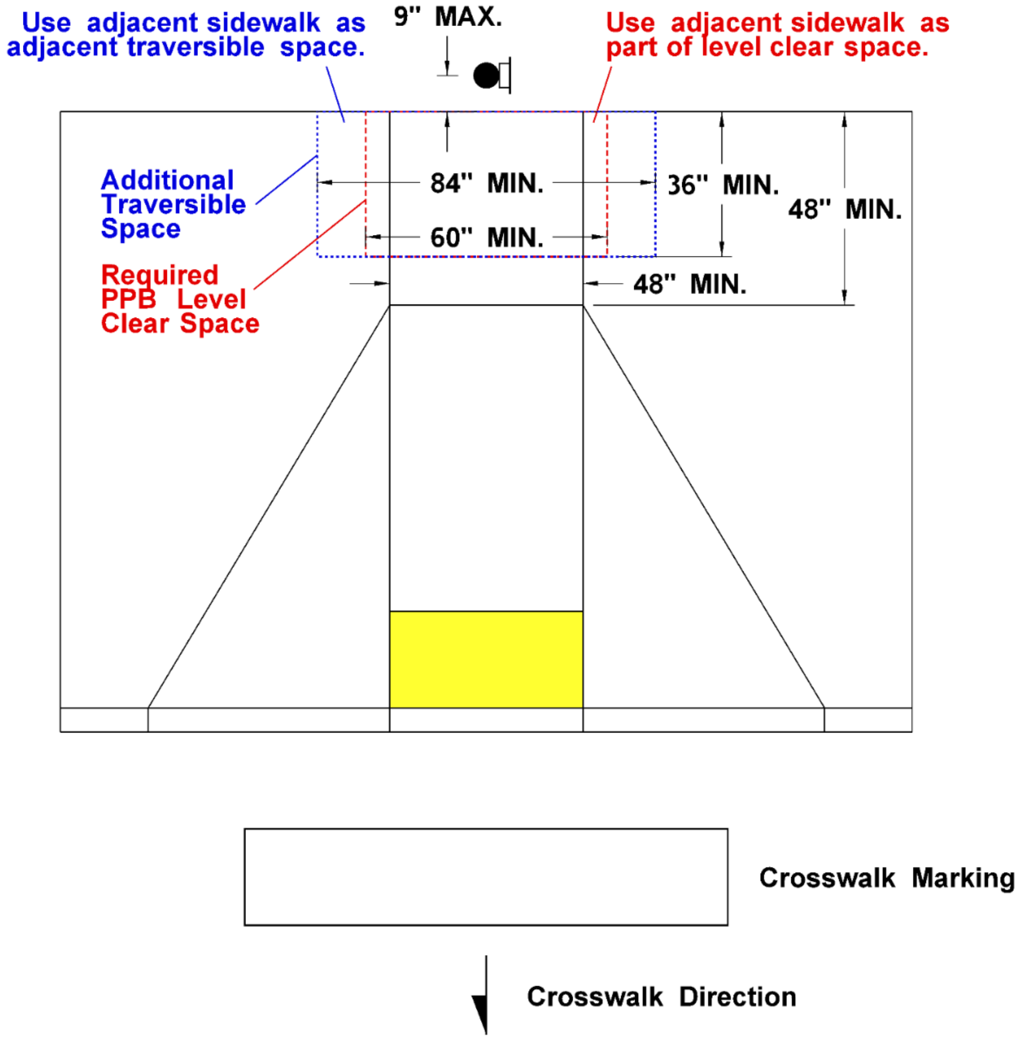
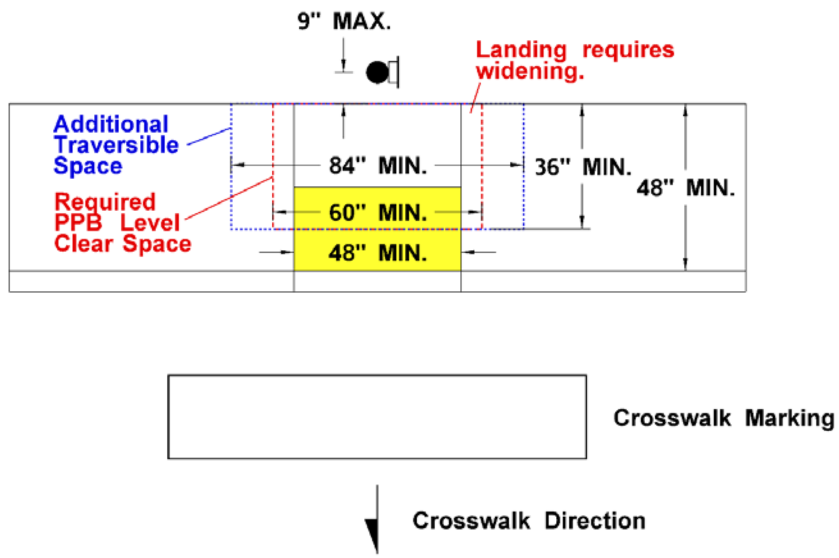
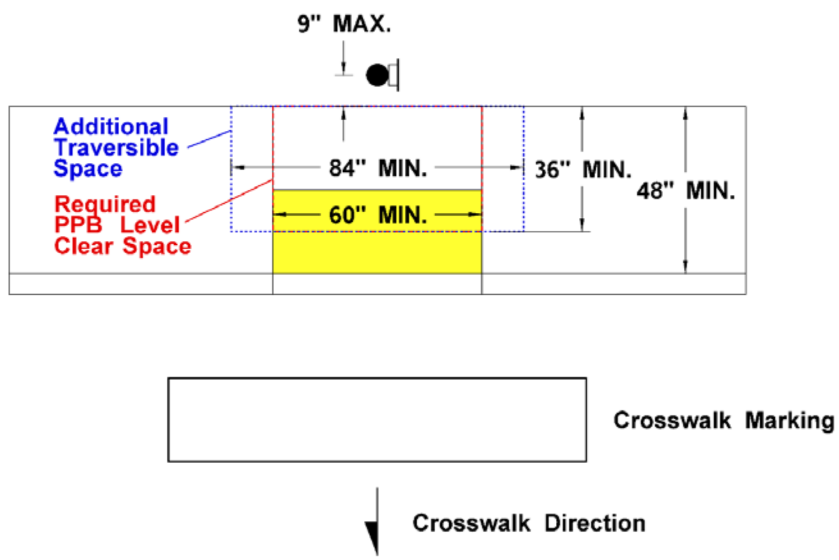


Exhibit 1330-5b Example Basic Parallel Ramp PPB Level Clear Space



Minimum 48" Wide Landing



Landing Widened to 60"

1330.03(4) Road Approaches and Driveways

If roadway approaches and driveways are located too close to an intersection, the traffic from these facilities can affect signal operations. Consider eliminating the accesses or restricting them to “right in/right out”. If a driveway or road approach is directly opposite a leg of the intersection, that approach may be signalized. If the approach is signalized, it must be signalized as if it were a standard intersection leg, and the pedestrian crossing across the approach must also be signalized as if it were a standard crosswalk.

Management of driveways and road approaches should be determined early (preferably no later than scoping) so that they can be considered and addressed in the design. (See Chapters 530 and 540 for further guidance.) Consider shifting the location of advance detection upstream to clear an access point so that vehicles entering from the access point will not affect detection and operation of the signal.

1330.03(5) Skewed Intersections

Skewed intersections, because of their geometry, are challenging to signalize and delineate. Where feasible, modify the skew angle to provide more normal approaches and exits. In many cases, the large paved areas for curb return radii at skewed intersections can be reduced when the skew angle is reduced. (See Chapter 1310 for requirements and design options.) Visibility of pedestrians is of particular concern, and must also be taken into consideration.

1330.03(6) Transit Stops

Transit stop and pullout locations should be located on the far side of the intersection to minimize their impacts on signal operation. (See Chapter 1430 for transit stop and pullout designs.)

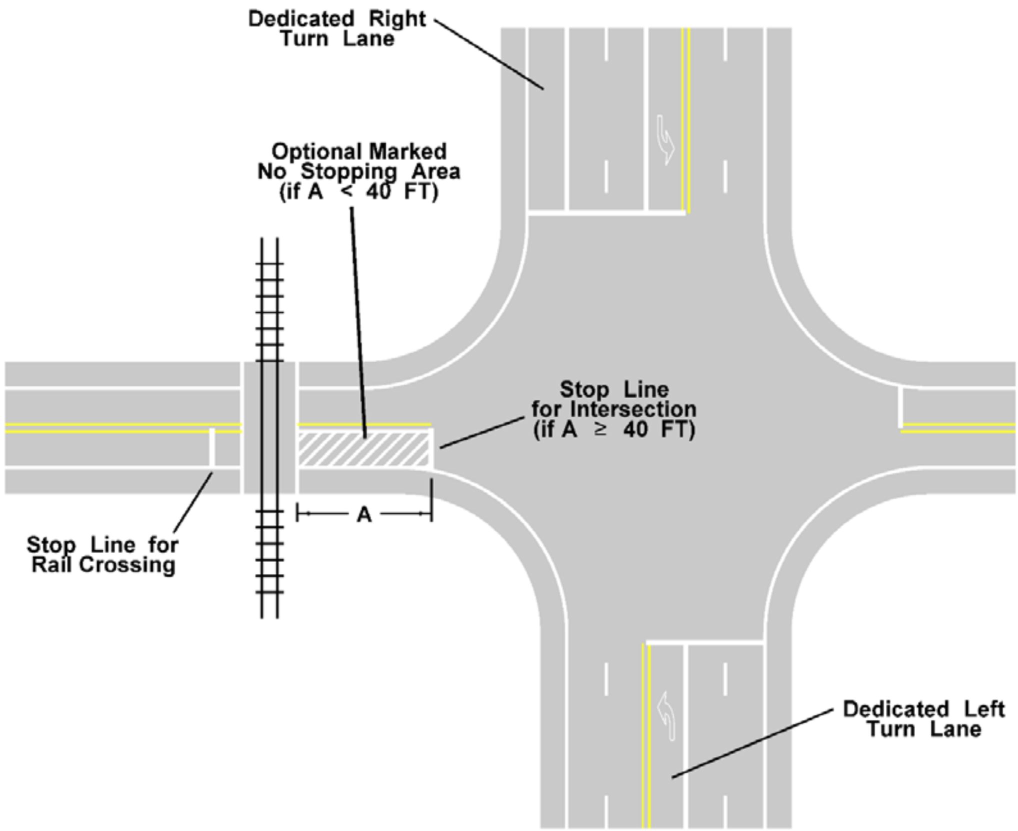
1330.03(7) Railroad Crossings

Where railroad preemption is used at a signalized intersection, install left and right turn lanes for the movements leading to the leg of the intersection with the railroad crossing if possible. This greatly improves the efficiency of the signal during railroad preemption when turns are restricted. Also consider providing a left-turn lane for the minor leg opposing the railroad crossing. This will allow for more effective signal operations during long periods of railroad preemption.

Where there is less than 40 feet between the nearest rail and the normal location of the stop line, do not install a stop line between the tracks and the intersection. Use the same stop line for the traffic signal and the rail crossing instead. Exhibit 1330-6 shows recommended intersection features for intersections near rail crossings.

Contact the WSDOT HQ Traffic Office for assistance with standalone queue-cutter signals.

Exhibit 1330-6 Recommended Features for Intersections Near Rail Crossings



1330.04 Conventional Traffic Signal Design

1330.04(1) General

The goal of any traffic signal design is to assign right of way in the most efficient manner possible and still be consistent with traffic volumes, intersection geometrics, and safety.

An advanced signalized intersection warning sign and beacon assembly to warn motorists of a signalized intersection should be installed when either of the two following conditions exists:

(a) The visibility requirements in the MUTCD are not achievable.

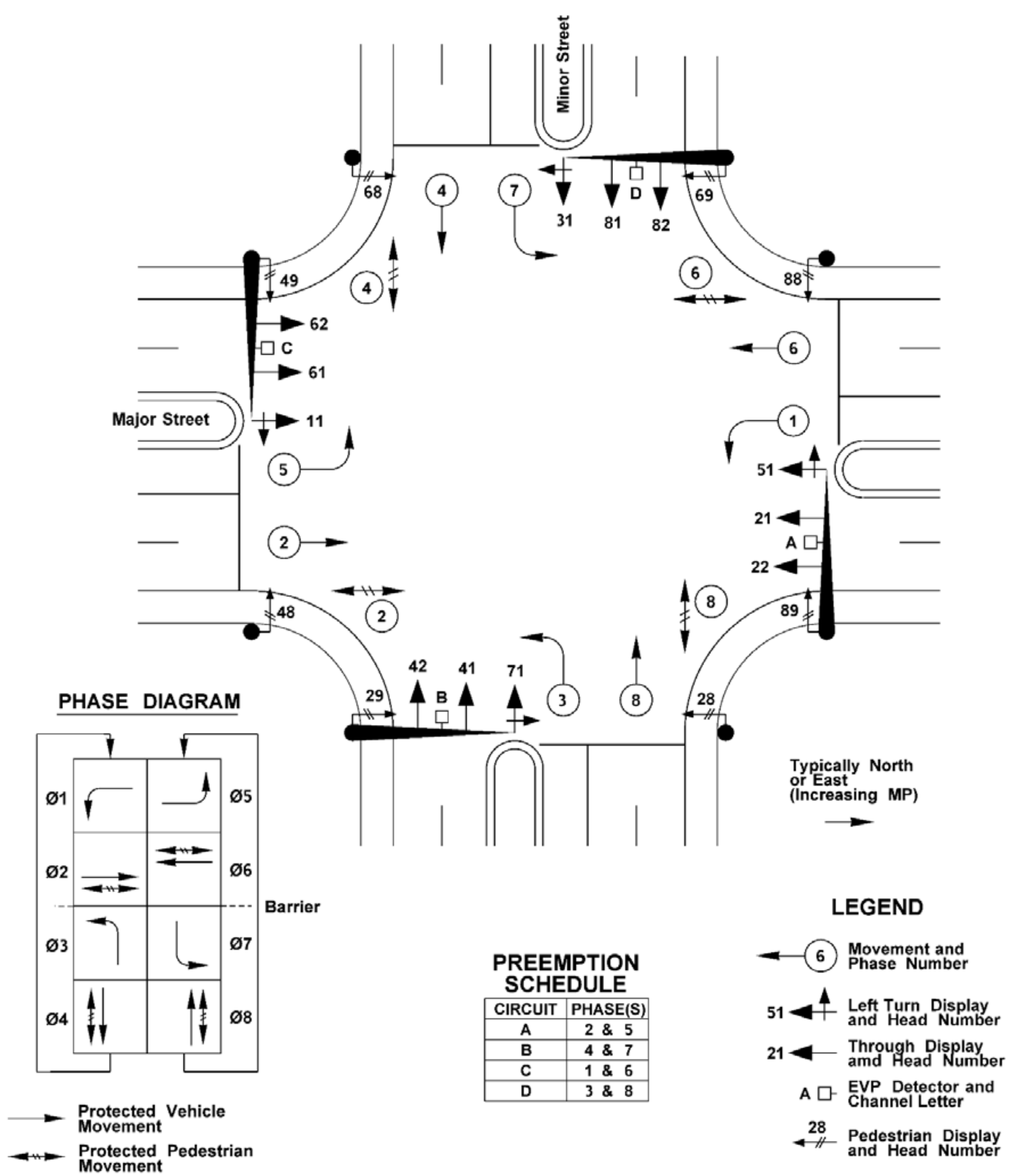
(b) The posted speed is 55 mph or higher and the next nearest signalized intersection is more than 2 miles away; this does not apply to freeway off-ramps.

This warning sign and beacon assembly consists of a W3-3 sign with Type IV reflective sheeting and one or two continuously flashing beacons. Where two beacons are used, the beacons should flash alternately instead of simultaneously. Locate the sign in advance of the intersection in accordance with Table 2C-4 (Condition A) of the MUTCD. The warning sign and beacon assembly may be omitted with approval from the region Traffic Engineer.

1330.04(2) Signal Phasing

With some exceptions, the fewer the traffic signal phases, the more efficient the operation of the traffic signal. The number of phases required for efficient operation is related to intersection geometrics, traffic volumes, composition of traffic flow, turning movement demands, and desired level of driver comfort. The traffic movements at an intersection have been standardized to provide consistency in both traffic signal design and driver expectations. (See Exhibit 1330-7 for standard intersection movements, signal head (display) numbering, and standard phase operation.)

Exhibit 1330-7 Standard Intersection Movements, Head Numbers, and Phase Operation



PREEMPTION SCHEDULE

CIRCUIT	PHASE(S)
A	2 & 5
B	4 & 7
C	1 & 6
D	3 & 8

For WSDOT operated signals, the region Signal Operations Engineer will develop the signal phasing plan or review proposed phasing for systems designed by others. For signals operated by other jurisdictions, the operating jurisdiction should be involved in signal phasing development. Phasing development is addressed in 1330.06 Operational Considerations for Design. Phasing development should begin as soon as the decision is made to install a traffic signal and may begin as early as the intersection control analysis. Provide the proposed channelization plans and traffic count data to the region Signal Operations Engineer or phasing designer as early as possible, as phasing information is required to complete the signal system design.

For WSDOT owned and operated signals, vehicle and pedestrian movement phase numbering is standardized to provide uniformity in signal phase numbering, signal display numbering, preemption channel identification, detection numbering, and circuit identification. For signals owned and operated by other jurisdictions, refer to that jurisdiction's guidelines for phase and equipment numbering. The following are general guidelines for the WSDOT numbering system:

1. Phases 2 and 6 are normally assigned to the major street through movements, with phase 2 assigned to the northbound or eastbound direction of the major street. This results in phase 2 being aligned with the direction of increasing mileposts.
2. Phases 1 and 5 are normally assigned to the major street protected left-turn movements.
3. Phases 4 and 8 are normally assigned to the minor street through movements, with phase 4 normally assigned to the approach to the left of the phase 2 approach (as viewed from the phase 2 stop line).
4. Phases 3 and 7 are normally assigned to the minor street protected left-turn movements.
5. Phasing on new signals installed within an already signalized corridor should be assigned to match the existing corridor phasing – even if it doesn't follow the standard phasing conventions listed above.
6. At T intersections, the movement on the stem of the T is normally assigned to either phase 4 or phase 8. Which phase is used will normally depend on the major street phase assignments.
7. At intersections where split phasing is used (opposing directions time separately) assign phases normally but show the split phase phasing diagram, unless otherwise directed by maintenance and operations staff.
8. Signal displays are numbered as follows:

    a. The first number indicates the signal phase and the second number is the number of the signal head, counting from centerline (or left edge line) to the right edge line of the approach. For example, signal displays for phase 2 are numbered, as viewed from left to right, 21, 22, 23, and so on. If the display is an overlap, the designation is the letter assigned to that overlap. For example, signal displays for overlap A are number A1, A2, A3, and so on.

    b. If the display is protected/permissive, the display is numbered with the phase number of the through display followed by the phase number of the left-turn phase. For example, a protected/permissive signal display for phase 1 (the left-turn movement) and phase 6 (the compatible through movement) is numbered 61/11. For overlap right turns, the protected portion may either be an overlap phase, or it may be the same phase as the complementing left turn phase.

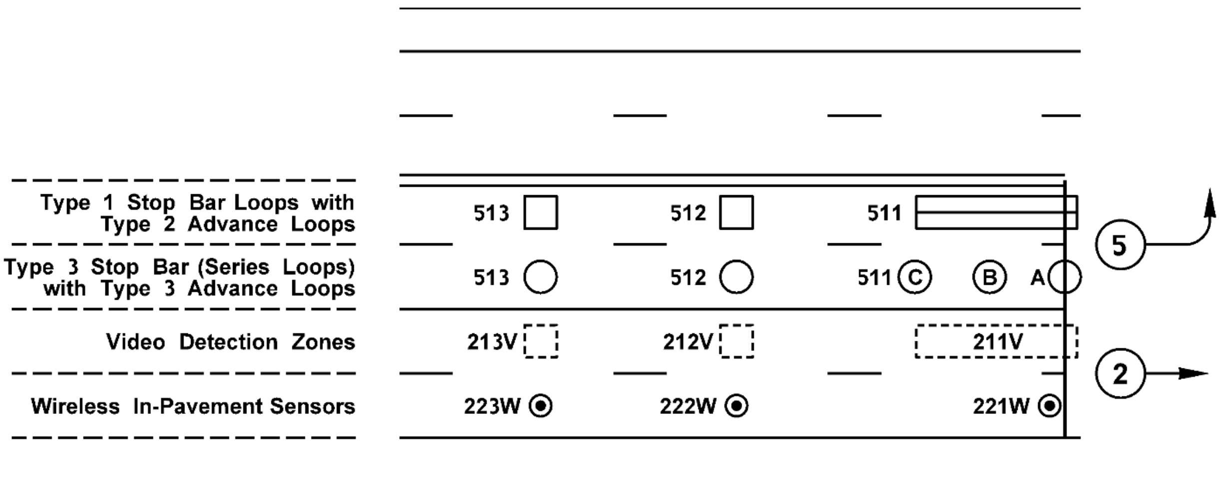
With a conventional protected/permissive left-turn display, the circular red, yellow, and green displays are connected to the through phase (phase 6, in this example) controller output and the steady yellow and green arrow displays are connected to the left turn phase (phase 1, in this example) controller output.

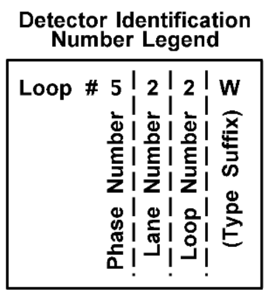
When a flashing yellow arrow display is used, coordinate with the Signal Operations Engineer and signal maintenance group to determine appropriate wiring. For new cabinets, always specify an auxiliary output rack when protected/permissive phasing will be used.

9. Pedestrian displays and detectors are numbered with the first number indicating the signal phase and the second number as either an 8 or 9. For example, pedestrian displays and detectors 28 and 29 are assigned to phase 2. If there are more than two displays or detectors for a single pedestrian phase, use letter suffixes for additional displays and detectors (28A / 29A, 28B / 29B, etc.).
10. Vehicle detector numbering depends on the type of detection:
    a. Induction loop detectors use three digit numbers for designation. The first number represents the phase. The second number represents the lane number, starting from the left lane and moving towards the right edge line. The third number represents the loop number counting from the stop line back. For example, detection loops for phase 2 detectors are numbered 211, 212, 213 for lane 1; 221, 222, 223 for lane 2; and so on. For loops tied together in series for a single detection channel, such as a three loop series stop line detector, the individual loops in the series use a letter suffix. For a stop line detector in lane 1 for phase 2, using three loops in series, the loops would be designated 211A, 211B, and 211C.
    b. Video detectors are designated V#, where "#" is the through phase number for that approach, even if it will cover additional phases (such as left turn or overlap) for that approach. If the video detector is for advance detection, the suffix "A" is added. For example, the advance video detector for phase 6 would be V6A.

       Video detection zones may be drawn on the contract plans if desired, but these will normally be field established and adjusted and may not end up as shown in the plans. If used, video detection zones are labeled the same as loop detectors, but with a "V" suffix. For example, the stop line video detection zone for phase 5 would be 511V.
    c. Radar detectors are designated similar to video detectors, but use an "R" prefix in place of the "V". For example, the advance radar detector for phase 4 would be R4A.
    d. Wireless in pavement sensors use the same numbering scheme as induction loops, but add a "W" suffix. For example, the phase 7 stop line sensor would be 711W.
    e. Exhibit 1330-8 shows examples of standard detector numbering.
11. Emergency vehicle detectors use letter designations: Channel A detectors cover phase 2 and phase 5; Channel B detectors cover phase 4 and phase 7; Channel C detectors cover phase 1 and phase 6; and Channel D detectors cover phase 3 and phase 8. When there are multiple detectors for the same channel, the first detector uses the letter, and all other detectors use a number suffix (C, C1, C2, etc.).

Exhibit 1330-8 Detector Numbering Examples





1330.04(3) Vehicle Signal Displays

Signal displays are the devices used to convey right of way assignments and warnings from the signal controller to the motorists and pedestrians. When selecting display configurations and locations, the most important objective is the need to present these assignments and warnings to the motorists and pedestrians in a clear, concise, and uniform manner.

The use of ball, steady arrow, or flashing yellow arrow displays is dependent upon the signal phasing. Use the approved signal phasing diagram to determine which display types can be used for which movements. Typical vehicle signal displays are shown in Exhibits 1330-9a through 9h. In addition to the display requirements contained in the MUTCD, the following also apply:

1. A minimum of two indications for the through movement, if one exists at an intersection, must be provided - even if it is not the primary (predominant) movement. Provide a minimum of two indications for the major signalized turn movement of an intersection if no through movement exists, such as on the stem of a T intersection. These signal faces are to be spaced a minimum of 8 feet apart. At a T intersection, select the higher-volume movement as the primary movement and provide displays accordingly.

   A green left-turn arrow on a primary display and a green ball on the other primary display do not comply with this rule. At an intersection where left turns are prohibited, the leftmost through display may use a green up arrow in place of the green ball display. At an intersection where right turns are prohibited, the rightmost through display may use a green up arrow in place of the green ball display.

2. All displays for an approach, regardless of phase served, are to be a minimum of 8 feet apart.
3. Locate displays directly overhead and centered over the associated lane of the applicable vehicular traffic as it moves through the intersection. (See Exhibits 1330-9a through 9h for signal head locations.) For intersections with a skew for through traffic, locate signal displays for through traffic in one of the following ways:

   a. Over the center of the outbound (far side) lane

   b. Over a line drawn between the center of the approaching lane and the center of the associated outbound lane, ending at the stop lines

   Left turn displays may either be located relative to the through displays or in line with approaching traffic, dependent on ability to mount the display(s). (See Exhibit 1330-10 for skew placement examples.)
4. Locate displays a minimum of 50 feet and a maximum of 180 feet from the stop line. The preferred location of the signal heads is between 60 and 120 feet from the stop line. When the nearest signal face is located between 150 and 180 feet beyond the stop line, engineering judgment of conditions, including worst-case visibility conditions, is to be used to determine whether the provision of a supplemental or nearside signal face would be beneficial. When it is not physically possible to locate displays at least 50 feet from the stop line, the distance to the displays may be reduced as follows:

   a. 3-section vertical and 5-section cluster (doghouse) displays may be located between 40 and 50 feet from the stop line.

   b. 4-section vertical displays may be located between 41 and 50 feet from the stop line.

   c. 5-section vertical displays may be located between 45 and 50 feet from the stop line.

   The distances listed above are the minimums required to maintain 16.5 feet of clearance over the roadway with a backplate installed.

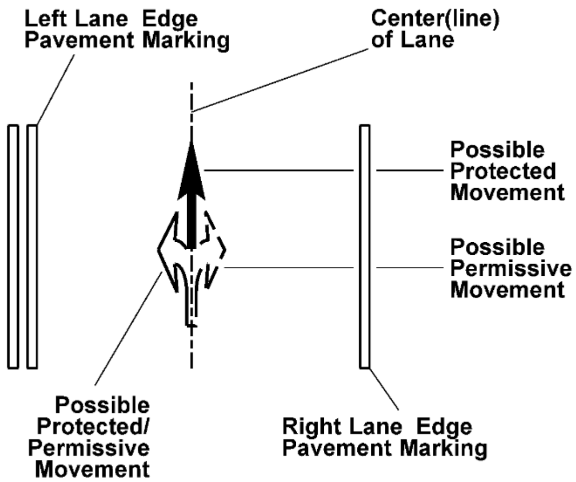
   Overhead displays should always be located on the far side of the crossing roadway for the best visibility. Locating overhead displays on the near side of the roadway results in issues with visibility and driver compliance with stop lines. When an overhead display is located on the near side of the crossing roadway, the stop line typically has to be pushed back so that the minimum visibility distance is met. However, this also pushes the stop line back too far for drivers to see cross traffic, resulting in drivers creeping past the stop line towards the intersection – especially for turning traffic. This results in both the driver being stopped past the stop line and being unable to see the signal displays.

   For ramp meter signals, place Type RM signal standards and displays at the stop line.
5. Use vertical vehicle-signal display configurations. Horizontal displays are not allowed unless clearance requirements cannot be achieved with vertical displays or unless they are being installed at an intersection to match other displays in the intersection. Approval by the State Traffic Engineer is required for the installation of horizontal displays.

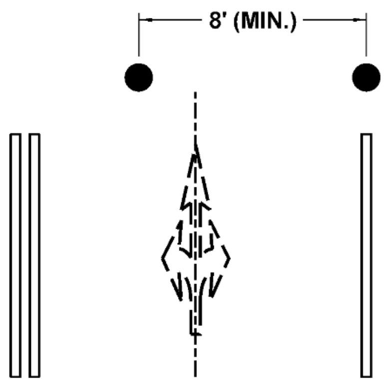
6. Use 12-inch signal sections for all vehicle displays except the lower display for a post mounted ramp meter signal.
7. Provide displays for turning movements with dedicated lanes as follows:
   a. For protected movements, use all arrow displays.
   b. For protected / permissive movements, use four section arrow displays. Alternatively, a shared five section cluster (doghouse) display may be used for both the turn lane and the adjacent through lane. Note: A three section arrow display, with bi-modal flashing yellow arrow / steady green arrow may be used in cases where windload or vertical roadway clearance will not allow for the use of a four-section display. If vertical clearance can be accommodated through adjustments to the signal display mount, such as mounting the Type M mount between different display sections, a four section arrow display should be used.
8. Use steady green arrow indications only when the associated movement is completely protected from conflict with other vehicular and pedestrian movements. This includes conflict with a permissive left-turn movement. At T intersections, steady green arrow displays may not be used for a movement that has a conflicting pedestrian movement.
9. Use either Type M or Type N mountings for vehicle display mountings on mast arms, as directed by the region maintenance staff or owning agency. Provide only one type of mounting for each signal system. Mixing mounting types at an intersection is not acceptable except for supplemental displays mounted on the signal standard shaft.
10. Use backplates for all overhead-mounted displays for new, updated, or rebuilt signal faces. Add backplates to all existing signal displays that do not already have them.
11. Use Type E mountings for pedestrian displays mounted on signal standard shafts unless otherwise approved by region maintenance staff or the owning agency.
12. Include supplemental signal displays when the approach is in a horizontal or vertical curve and the intersection visibility requirements of this section and the MUTCD cannot be met, unless approved otherwise by the region Traffic Engineer.

    Supplemental far side displays are recommended at intersections with higher truck volumes, as the trucks will frequently block visibility of overhead displays for following drivers. Supplemental far side protected left turn displays are recommended for long left turns.

Exhibit 1330-9a Signal Display Placements – Key to Diagrams



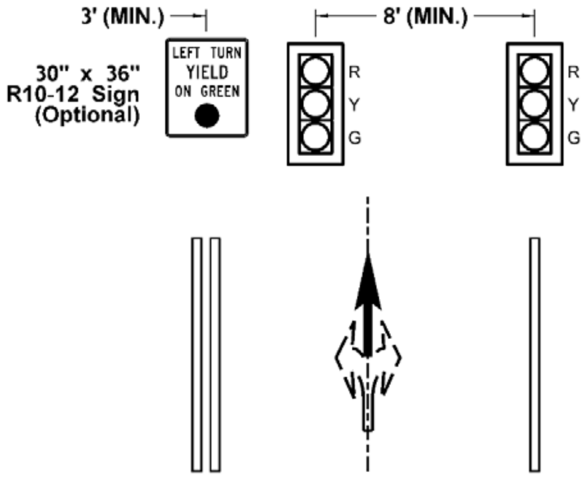
Pavement markings are used to represent possible lane lines and vehicular movements. The lane lines shown are typical, but not necessarily required.



All signal mounts must be a minimum of 8 feet apart, measured center to center.

This example shows typical mount locations for a single approach lane.

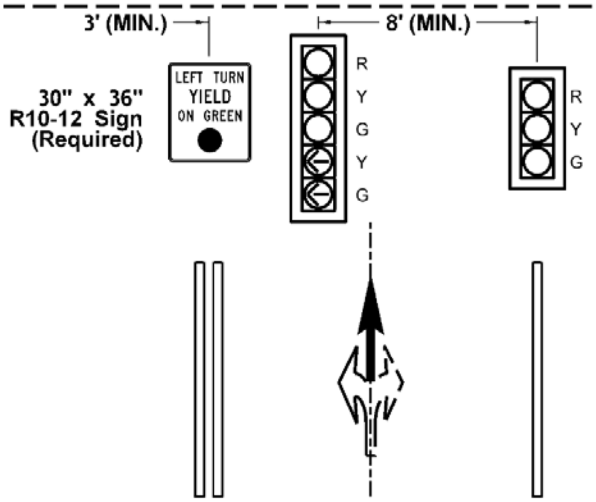
Exhibit 1330-9b Signal Displays for Single Lane Approach



Single lane approach with permissive (or no left turns).

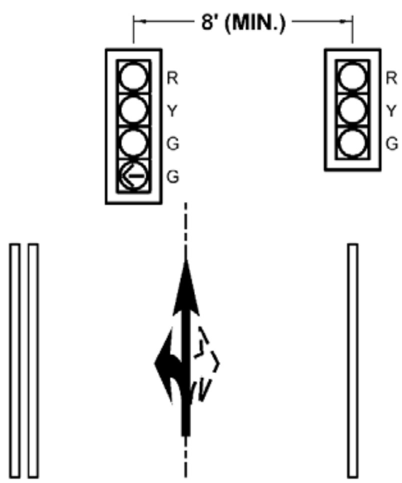
R10-12 sign optional.

Where left turns are prohibited, install a 30” x 30” R3-2 No Left Turn (Symbol) Sign in place of the R10-12 sign shown here.



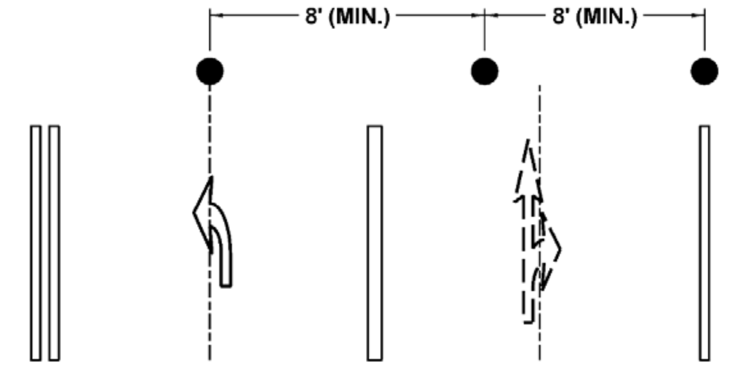
Single lane approach with protected / permissive left turns.

R10-12 sign required.



Single lane approach with protected left turns.

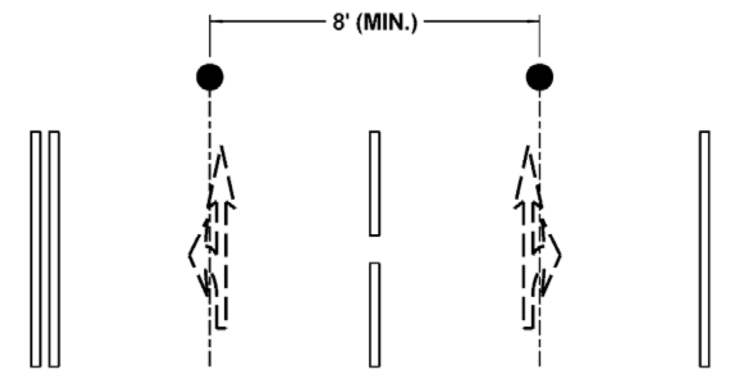
Exhibit 1330-9c Signal Display Mounting Locations for Multi-Lane Approaches



Single through lane with left turn lane(s).

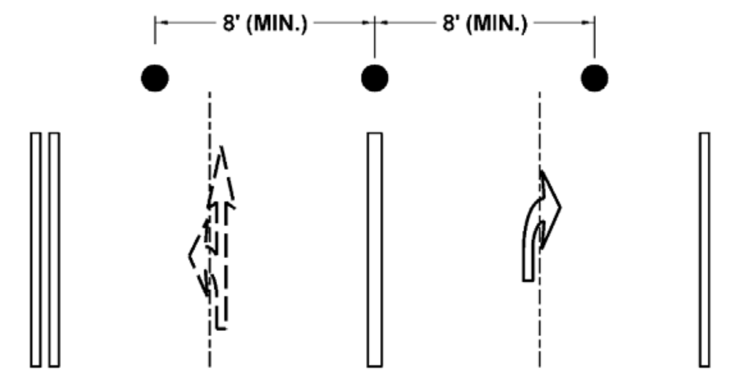
Through lane displays arranged the same as for a single lane approach.

Left turn display(s) centered over lane(s).



Multiple through lanes.

Center displays over each lane.

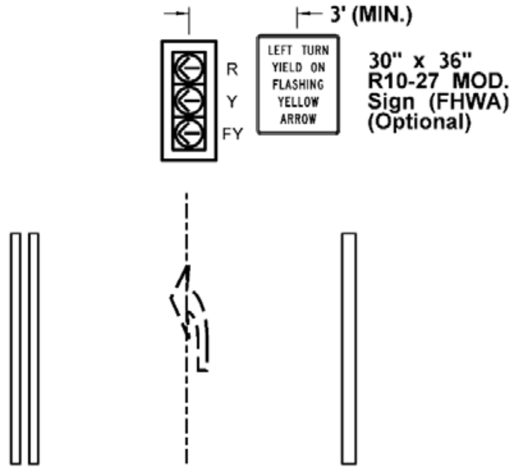


Single through lane with right turn lane(s).

Through lane displays arranged the same as for a single lane approach.

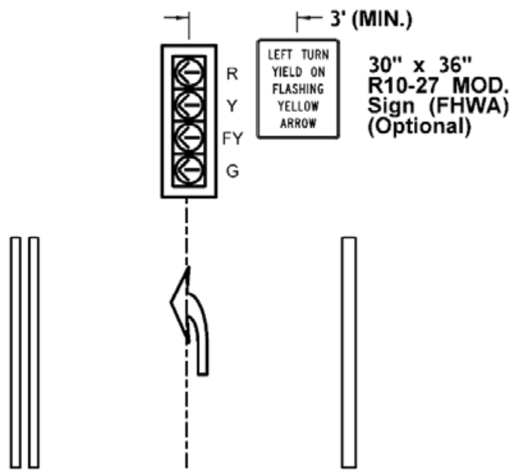
Ensure that the 8-foot spacing requirement is met if a right turn display is installed overhead.

Exhibit 1330-9d Signal Displays for Dedicated Left Turn Lanes



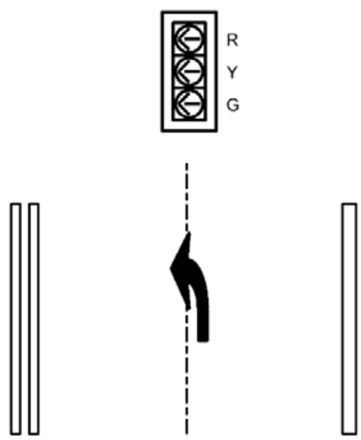
Dedicated left turn lane with permissive left turns.

R10-27 (Modified) sign optional.



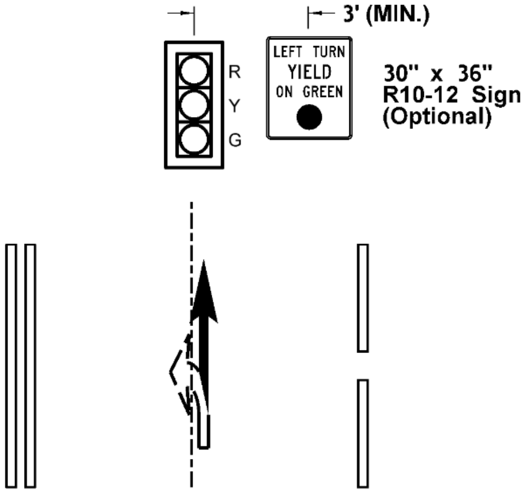
Dedicated left turn lane with protected / permissive left turns.

R10-27 (Modified) sign optional.



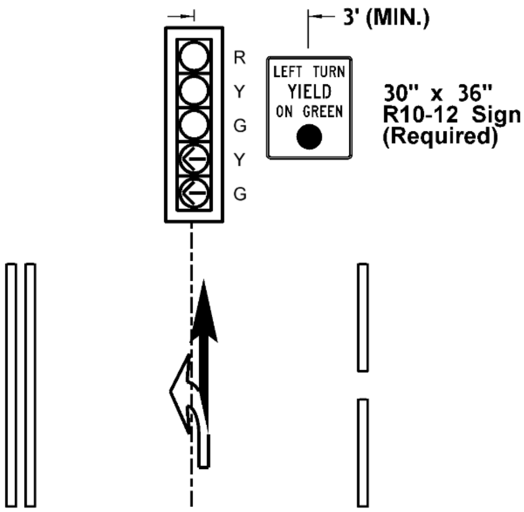
Dedicated left turn lane with protected left turns.

Exhibit 1330-9e Signal Displays for Shared Through-Left Lanes – Multiple Through Lanes



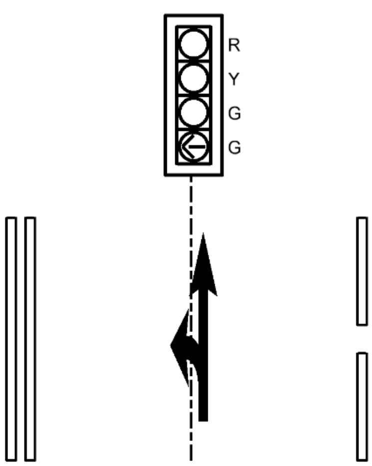
Shared through-left lane with permissive left turns.

R10-12 sign optional.



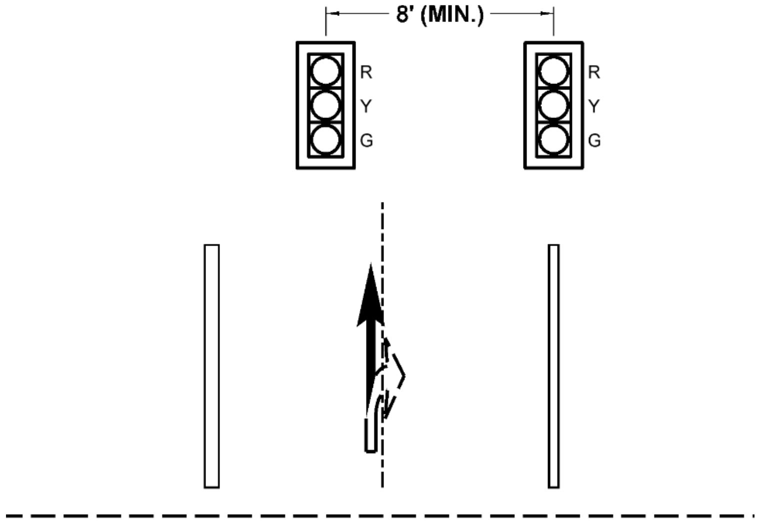
Shared through-left lane with protected / permissive left turns.

R10-12 sign required.

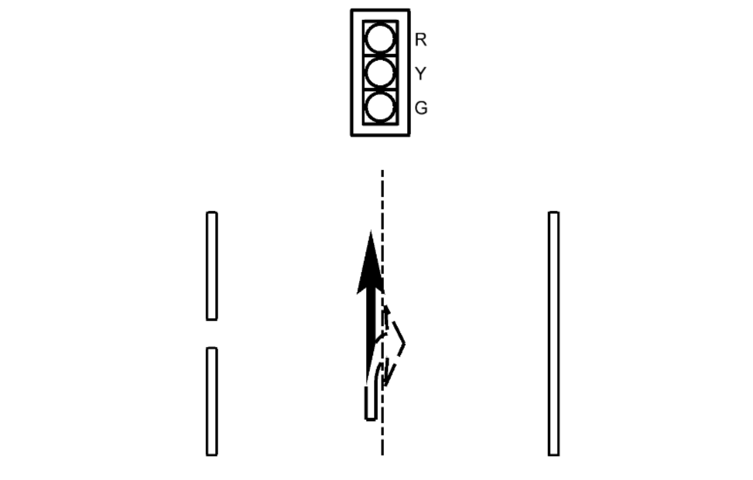


Shared through-left lane with protected left turns.

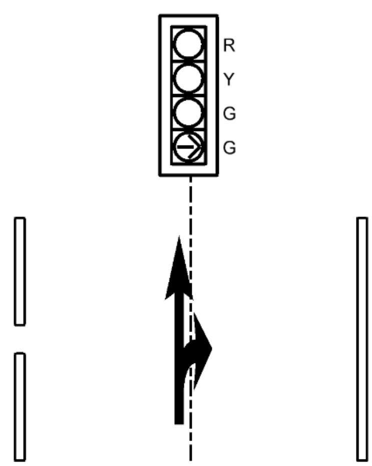
Exhibit 1330-9f Signal Displays for Shared Through-Right Lanes



Single shared through-right lane with permissive right turns.



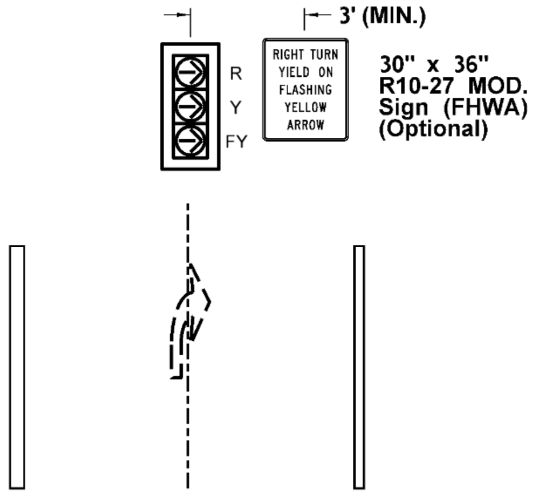
Shared through-right lane, multiple through lanes, with permissive right turns.



Shared through-right lane, multiple through lanes, with protected right turns.

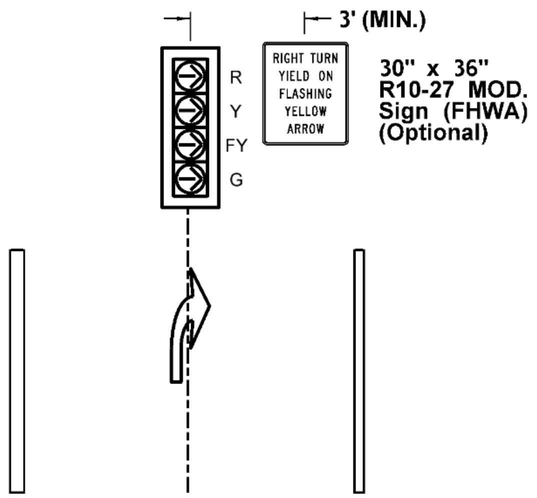
For protected / permissive right turns, mirror protected / permissive left turn display from Exhibit 1330-9e.

Exhibit 1330-9g Signal Displays for Dedicated Right Turn Lanes



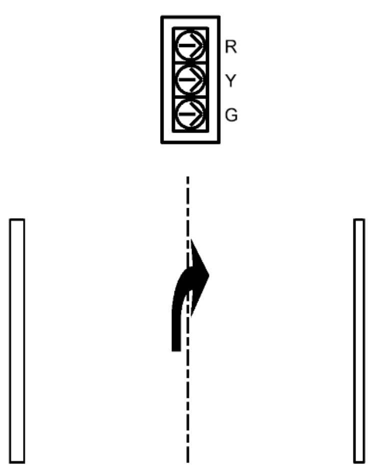
Dedicated right turn lane with permissive right turns.

R10-27 (Modified) sign optional.



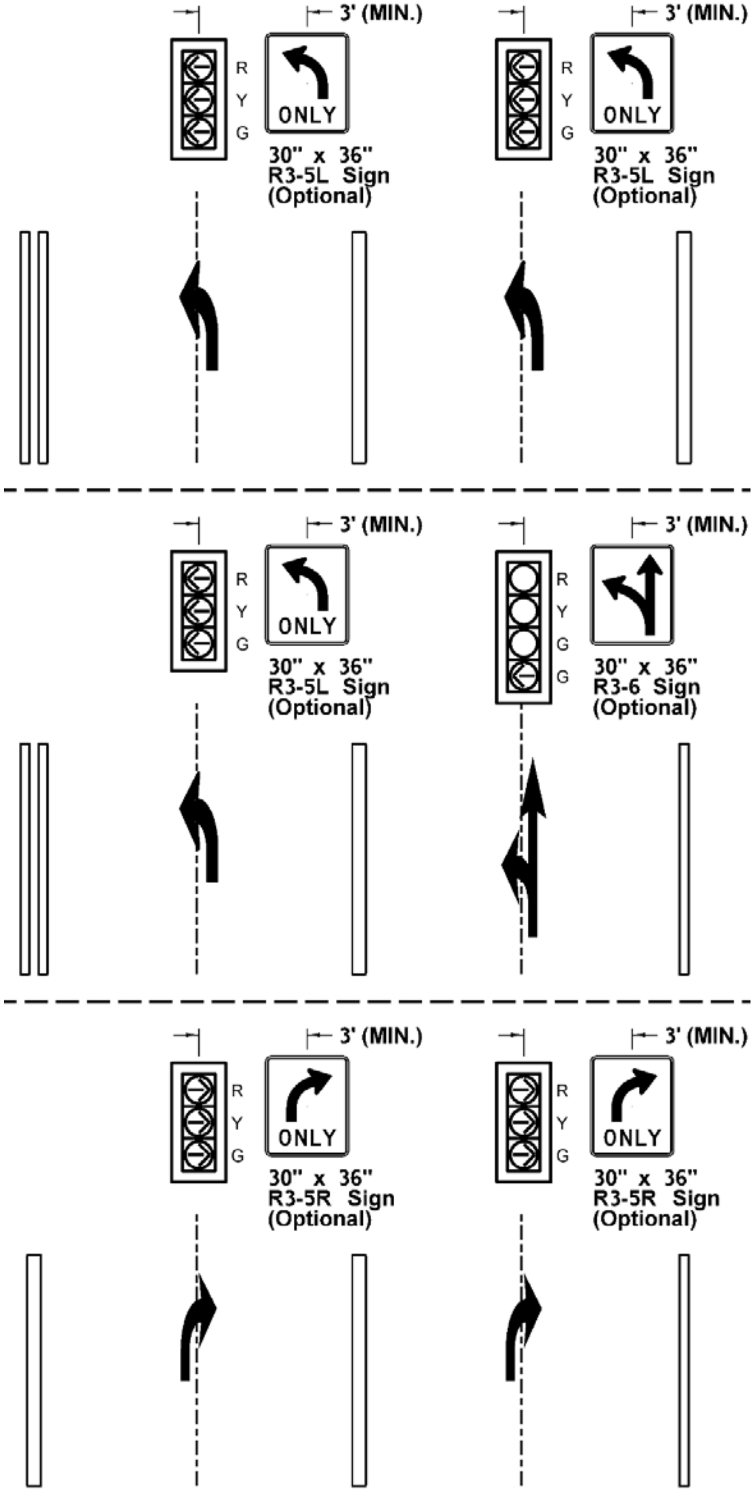
Dedicated right turn lane with protected / permissive right turns.

R10-27 (Modified) sign optional.



Dedicated right turn lane with protected right turns.

Exhibit 1330-9h Signal Displays for Multiple Turn Lanes



Multiple left turn lanes.

R3-5L signs optional.

Multiple left turn lanes, with a shared through-left lane.

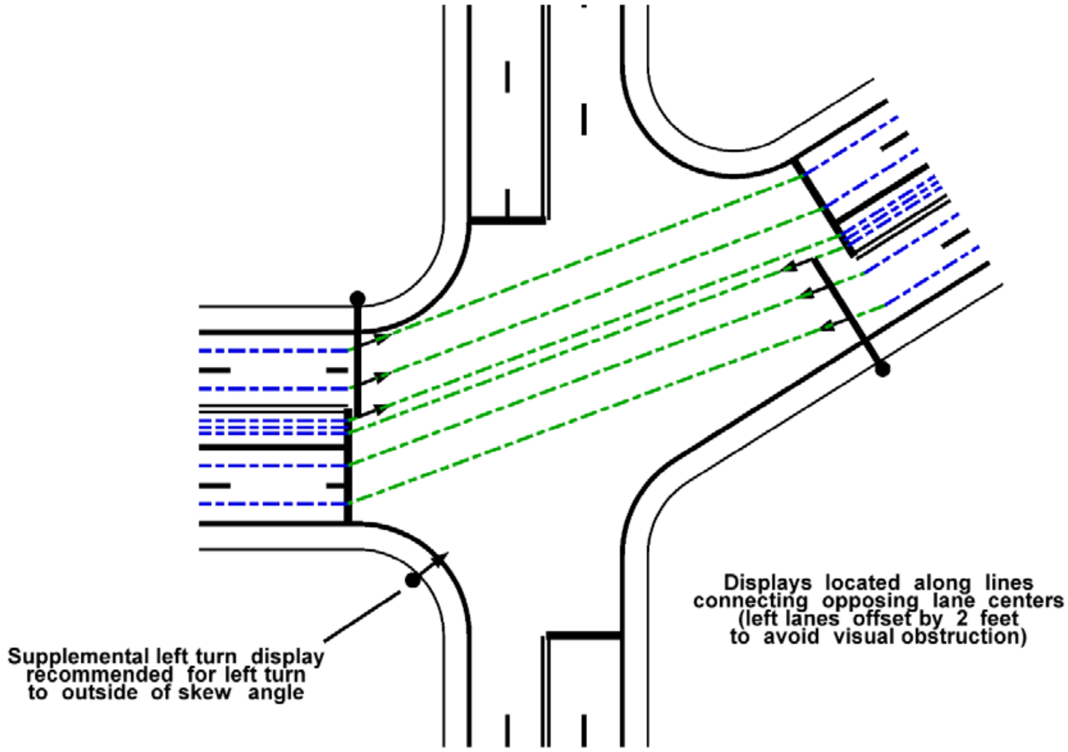
R3-5L and R3-6 signs optional.

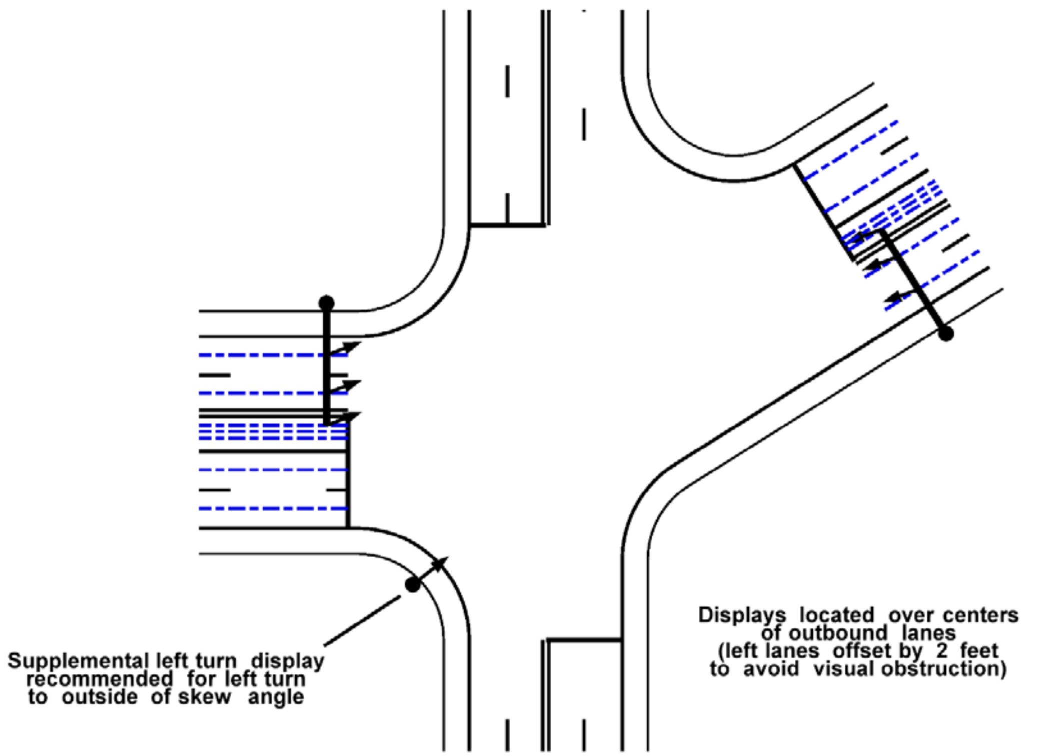
Mirror for right turns.

Multiple right turn lanes.

R3-5R signs optional.

Exhibit 1330-10 Example Signal Display Placement for Skew Intersection





The minimum mounting height for overhead signal displays is 16.5 feet from the roadway surface to the bottom of the signal housing, including the backplate. There is also a maximum height for signal displays allowed by the MUTCD, since the roof of a vehicle can obstruct a motorist's view of a signal display. The maximum heights from the roadway surface to the bottom of the signal display housing with 12-inch displays are shown in Exhibit 1330-11.

Exhibit 1330-11 Signal Display Maximum Heights

Distance to Stop Line (ft)	Signal Display Arrangement	Maximum Height (to bottom of display housing [3])
40 [1]	Vertical 3-section	17.5 ft
42 [1]	Vertical 4-section	17.0 ft
45 [1]	Vertical 5-section [2]	17.0 ft
53 to 180	Vertical 3-section	22.0 ft
	Vertical 4-section	20.8 ft
	Vertical 5-section [2]	19.6 ft

Notes:

[1] Minimum distance required to achieve 16.5 feet of clearance with backplate installed.

[2] For 5-section cluster displays, use the Vertical 3-section heights.

[3] Subtract 0.5 ft for height to bottom of backplate.

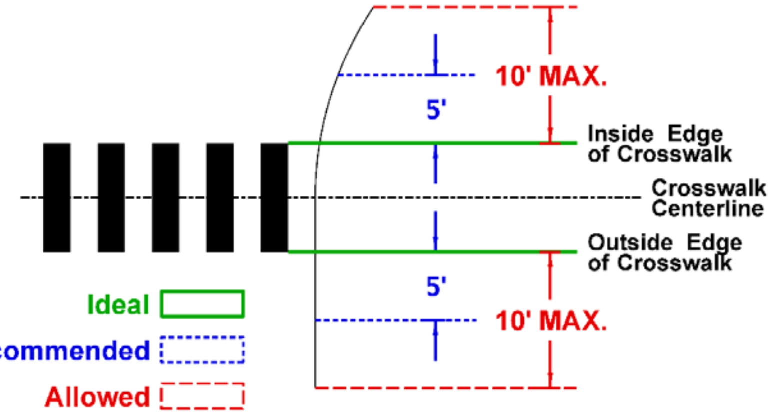
At signalized intersections with railroad preemption, install blankout signs for turning movements that do not have a dedicated signal display (3-section arrow display). Blankout signs are 36" x 36" and will display either a No Right Turn symbol (R3-1) or No Left Turn symbol (R3-2) when activated, as appropriate. Blankout signs should be placed the same as equivalent static signs.

1330.04(4) Pedestrian Equipment

Pedestrian equipment consists of pedestrian signal displays and pedestrian detectors (pushbuttons). New signal systems are required to use countdown displays and Accessible Pedestrian Signal (APS) pushbuttons. See 1330.04(4)(a) for pedestrian display and detection requirements for existing signal systems. No intersection may have a mix of APS and non-APS pushbuttons, nor may any intersection have a mix of countdown and non-countdown pedestrian displays.

Pedestrian displays are required to be installed with the bottom of the display housing no less than 7 feet or more than 10 feet above the sidewalk surface. Pedestrian displays are required to be installed to provide maximum visibility at the beginning of the controlled crosswalks. To accomplish this, pedestrian displays should be located no more than 5 feet from the outside edge of the crosswalk, as measured on a line perpendicular to the crosswalk centerline (See Exhibit 1330-12). The offset distance may be offset up to a maximum of 10 feet from the outside edge of the crosswalk if physical constraints prevent the display from being placed no more than 5 feet from the outside edge of the crosswalk.

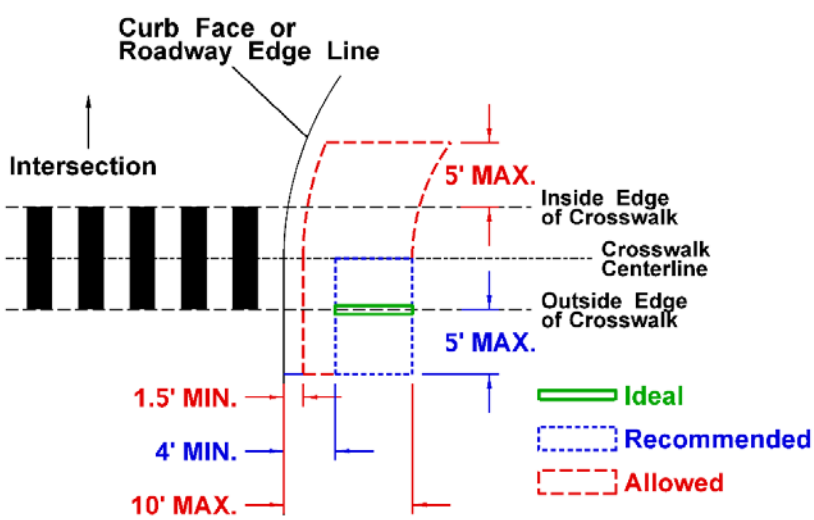
Exhibit 1330-12 Pedestrian Display Placement Requirements



Pedestrian pushbuttons (PPBs) are required to be located within a certain distance of the crosswalk being served. Pedestrian pushbutton location requirements are as follows:

- The PPB should be between 4 and 10 feet from the face of curb, where sidewalk is present, or the edge line of the roadway where there is no sidewalk. The PPB may be between 1.5 and 4 feet from the curb face or edge line, but this is not recommended due to proximity to the roadway. The PPB may not be closer than 1.5 feet from the curb face or edge line. Contact the HQ Traffic Office if the PPB cannot be placed within 10 feet of the curb face or edge line.
- The PPB should be located as close to the outside edge of the crosswalk line as possible, so that for APS PPBs, the button and sign face towards the core of the intersection, rather than back down the adjacent approaching roadway. The PPB may be located no more than 5 feet outside either edge of the crosswalk line.
- If possible, PPBs should be located on separate poles and be separated by a minimum of 10 feet.
- See Exhibit 1330-13 for recommended and allowed PPB placement locations.

Exhibit 1330-13 PPB Placement Requirements



PPBs are required to be located so that the actual button, not just the assembly, is within 9 inches of a level all-weather surface (generally sidewalk or paved road shoulder) as described in 1330.03(3). To accomplish this, certain criteria must be met depending on the type of pole upon which the pushbutton is installed:

a. For vertical shaft poles (Type PPB, PS, I, FB, or RM), the center of the pole shall be no more than 9 inches from the edge of the level clear space. The pushbutton shall not be oriented more than 90 degrees from facing the level clear space. (See Exhibit 1330-14a.)

b. For larger signal standards (Type II, III, IV, IV, or SD), the button must face the level clear space, with the edge of the pole baseplate no more than 6 inches from the edge of the level clear space. It is recommended that the pole either be in the sidewalk, or the edge of the pole base plate be installed as close to the back of sidewalk as possible. (See Exhibit 1330-14b.) Some minor rotation of the button on the pole is possible, but even smaller angles may quickly exceed the allowed reach limit – particularly on larger poles.

Exhibit 1330-14a PPB Placement on Vertical Shaft Poles

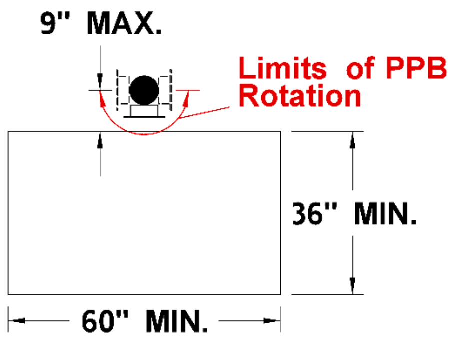
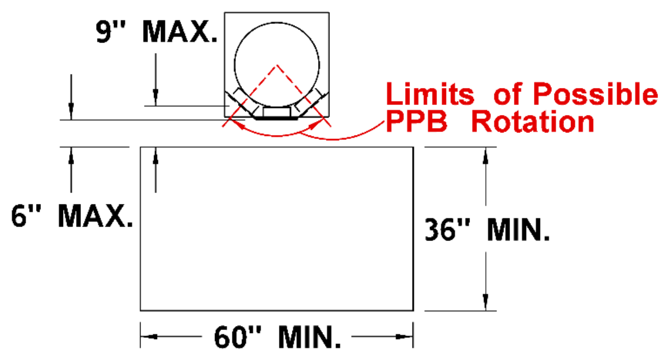


Exhibit 1330-14b PPB Placement on Large Signal Standards



In all cases, it is recommended that the pole be installed in the sidewalk for maximum accessibility. However, the pole and the pushbutton itself are obstructions and must not encroach upon the required minimum pedestrian access route widths (see Chapter 1510).

PPBs are required to be installed at 42 inches above the level clear space, as measured to the center of the actual button. Existing pushbuttons do not require a height adjustment if the center of the actual button is within a range of 36 to 48 inches above the level clear space.

For WSDOT owned systems, pedestrian signal equipment may not be installed on light standards. Do not install pedestrian signal equipment on light standards for systems owned by other jurisdictions unless directed by that jurisdiction.

1330.04(4)(a) Accessible Pedestrian Signals (APS) and Countdown Pedestrian Displays

Accessible Pedestrian Signals (APS) consist of a pedestrian pushbutton with integrated vibro-tactile and audible versions of the visual indications presented by pedestrian signal displays. APS are required at any location with a pedestrian display – *even if there was no pedestrian detection previously*. This is due to the requirement to provide non-visual indication of the pedestrian phase.

Countdown pedestrian displays are displays which use a combination of an overlapping person (walk) and hand (don't walk) indication and an adjacent two digit countdown timer display. The timer counts down the seconds remaining in the pedestrian clearance phase (flashing don't walk).

For existing signalized intersections where pedestrian equipment was not previously installed, the installation of accessible pedestrian signals (APS) and countdown pedestrian displays is required for the entire intersection. This may require new or relocated poles, as well as additional ramp and sidewalk work beyond that necessary for basic sidewalk and ramp ADA compliance.

At signalized intersections with existing pedestrian equipment:

- For any project that qualifies as an "alteration" under ADA guidelines, as part of the ADA work, sidewalk and ramp work shall be coordinated with signal system work to ensure that all poles with pedestrian equipment meet accessibility requirements for APS pushbuttons for the entire traffic signal system at that intersection. This may require new or relocated poles, as well as additional ramp and sidewalk work beyond that necessary for basic sidewalk and ramp ADA compliance.
    - For WSDOT owned signal systems, APS pushbuttons and countdown displays must be installed.
    - For signal systems owned by other agencies, install APS pushbuttons and countdown displays if funded by the owning agency.
- For other projects, where pushbuttons are being relocated on a single corner, including to a new pole, and no other work (including sidewalk or ramp work) is taking place at any other corner, pushbuttons may be relocated or replaced with the same type of pushbutton as currently exists at that intersection. Countdown pedestrian displays are not required to be installed at that intersection. New pole location(s) must meet accessibility requirements for both the existing and APS pushbuttons.
- Where APS pushbuttons are being installed at a signal system in response to a public request, all pushbuttons are required to be replaced with APS pushbuttons and all pedestrian displays are required to be replaced with countdown pedestrian displays at

that intersection. Additional poles may be required and ramp and sidewalk work may be necessary to support access to new APS locations / orientations.

- Where pushbuttons are only being adjusted in height at a signal system, no other revisions are required.
- For all other cases, APS pushbuttons and countdown pedestrian displays shall be installed over the entire intersection. This may require additional ramp and sidewalk work to provide required accessibility to and for APS locations / orientations beyond that already required for other ADA compliance efforts.

1330.04(5) Signal Standards (Supports)

Signal standards consist of five main types of supports: Vertical Steel Shaft, Cantilevered Steel Mast Arm, Steel Strain Pole, Wood Strain Pole, and Signal Bridge. The type of support selected will depend on required placement of vehicle signal displays and the ability of the support to reach that location. The MUTCD states that the preferred location for signal displays is overhead on the far side of the intersection.

Signal displays may also be mounted to bridges where clearance will not allow an alternate signal standard type. Installation on bridges requires approval of both the region Traffic Engineer and the HQ Bridge and Structures Office.

Signal Standards shall be considered in the following order of preference:

1. **Cantilevered Steel Mast Arm**. These are the standard support type for permanent systems, and should be used whenever possible. Mast arm installations are preferred because they generally provide better placement of the signal displays, greater stability for signal displays in high-wind areas, and reduced maintenance costs. Mast arm lengths are limited to 65 feet from center of pole to farthest display mount – if additional length is needed, an alternate support type must be used.
2. **Span Wire System (Steel or Wood Strain Poles).** These systems may be used when displays are needed at a greater distance than a mast arm system can support, or if a system is expected to be in place for less than 5 years. Steel poles are required to be used for permanent signal systems. Temporary signal systems (systems to be removed under the same contract as installation) may use wood poles. The use of wood poles beyond the end of a contract or for longer than 5 years requires the approval of the region Traffic Engineer. Individual spans have a limit of 150 feet – longer spans require design by the HQ Bridge and Structures Office.
3. **Signal Bridge.** Signal bridges shall only be used when no other alternative can physically be installed and support displays in the required locations. Diagonal signal bridges are not recommended as they are extremely difficult to maintain and result in displays being too close to at least one of the two cross streets, resulting in poor display visibility. Diagonal spans in general are not recommended as a failure will result in the loss of the entire signal system, rather than just one or two directions.
4. **Vertical Steel Shaft.** Vertical steel shaft supports should only be used for supplemental vehicle displays or pedestrian equipment. In special cases (such as in a small historic town), vertical steel shaft supports may be used without overhead signal displays if approved by the region Traffic Engineer, as allowed by the MUTCD. This practice is not recommended, as displays are too easily obstructed from view.

When placing signal standards, the primary consideration is the visibility of signal faces. Place the signal supports as far as feasible from the edge of the traveled way without adversely affecting signal visibility. (The MUTCD provides additional guidance on locating signal supports.) Initially, lay out the location for supports for vehicle display systems, pedestrian detection systems, and pedestrian display systems independently to determine the optimal location for each type of support. Consider the need for future right-turn lanes or intersection widening when choosing the final location of the signal standards. Poles should also be located outside of sight triangles for turning traffic.

If conditions allow and optimal locations are not compromised, pedestrian displays and pedestrian detectors can be installed on the vehicular display supports. However, pole placement cannot encroach on pedestrian access route or maneuvering space requirements. Pole mounted appurtenances, such as pushbuttons, terminal cabinets, and displays, need to be taken into consideration in regards to their encroachment into accessible spaces.

Another important consideration that can influence the position of signal standards is the presence of overhead and underground utilities. Verify the location of these lines during the preliminary design stage to avoid costly changes during construction:

a. **Underground Utilities:** Underground utilities must be located, marked, and surveyed. If any underground utility is within 10 feet of any foundation, consider potholing for the utility to find its actual location. Field locates are rarely precise and must be verified if a potential conflict exists.

b. **Overhead Utilities:** Signal standards may be located within close proximity to overhead communications lines (phone, cable, fiber-optic), but the lines should not touch the any part of the signal system and should not pass in front of any displays. Overhead power lines require a minimum 10-foot circumferential clearance for lines rated at 50KV or below, including the neutral. For lines rated over 50KV, the minimum clearance is 10 feet plus 0.4 inches for each KV over 50KV. Overhead utilities may have to be relocated if a suitable location for signal equipment cannot be found.

Once pole locations have been selected, a soils investigation is required to determine the lateral bearing pressure, the friction angle of the soil, and whether groundwater may be encountered. Standard foundations may be used if the soil lateral bearing pressure is at least 1,000 psf, the friction angle is at least 17°, and the ground slope is 2H : 1V or flatter. Standard foundation information is found in the *Standard Plans*, and depends on the type of support system being used.

Special foundation designs are required if the soil lateral bearing pressure is less than 1,000 psf, the friction angle is less than 17°, or the ground slope is steeper than 2H : 1V. The region materials group works with the HQ Materials Laboratory to determine the bearing pressure and friction angle of the soil at the proposed foundation locations. If soils do not meet these minimum values for lateral bearing pressure and friction angle, the signal standard charts and soil conditions report (summary of geotechnical conditions for foundations) must be forwarded to the HQ Bridge and Structures Office with a request for special foundation design. The HQ Bridge and Structures Office designs foundations for the regions and reviews designs submitted by others.

Where poles are installed on structures, the anchorage must be designed by the Bridge designer. Coordinate with the Bridge designer for placement and design of pole anchorages on structures.

Do not place any signal standard in a median area. The sole exception is a Type PS or Type PPB signal standard as required for median refuge areas for pedestrians.

Coordinate with all stakeholders (Maintenance, Signal Operations, Civil Design Engineer, Drainage Engineer, and so on) in the placement of signal equipment to avoid any possible conflicts. Arrange field reviews with the appropriate stakeholders as necessary.

1330.04(5)(a) Mast Arm Signal Standards and Foundation Design

Mast arm signal standards are designated by the following types:

- Type II: Single mast arm with no luminaire mount.
- Type III: Single mast arm with luminaire mount.
- Type SD: Double mast arm, with or without luminaire mount.

Mast arm signal standards are normally located on the far right corner of the intersection from approaching traffic. A typical mast arm signal standard only has one mast arm, however two may be used. If the angle between the two arms is not exactly 90 degrees, the design must be sent to the bridge and structures office. In most cases, two arms at 90 degrees can support the necessary display positioning. Additionally, signal standards on mast arms may be rotated up to 30 degrees from center. Do not allow a mast arm for one direction to cross in front of the mast arm for a different direction if possible, as it results in a visual obstruction of the signal displays. Where two double arm signal standards are installed on opposite corners, the preferred location for the two poles are the far right corners of the mainline roadway. This way, the mast arms for the mainline traffic will not cross in front of each other.

Mast arm signal standards have a typical arm attachment point of 18 to 20 feet in height. This height range needs to be taken into consideration when placing signal displays in order to ensure that the display height requirements shown in 1330.04(3) are met. The attachment point height may be adjusted throughout this range as necessary, but increments of 0.5 feet are recommended for ease of fabrication. Connection points outside of this range are a special design, and require design support from the Bridge and Structures Office.

Mast arm signal standards are designed based on the total wind load moment on the mast arm. The moment is a function of the surface area of each appurtenance (signal display or sign), X * Y, and the distance between the vertical centerline of each appurtenance and the vertical centerline of the signal pole Z. This determines the total wind load moment, referred to as an XYZ value and measured in cubic feet, which is used to select the appropriate mast arm fabrication plan and foundation design. Preapproved mast arm fabrication plans are available at http://www.wsdot.wa.gov/Bridge/Structures/LSS.htm, and will be listed in the Contract Provisions. To determine the XYZ value for a signal standard, the XYZ value of each appurtenance must be calculated. These values are then totaled to determine the overall XYZ value for the signal standard. For signal standards with two mast arms at 90 degrees apart, the larger of the two XYZ values calculated for each mast arm is used for the overall pole XYZ value.

When determining the XYZ values, use the worst-case scenarios for signal display and sign placements. All signal displays and mast arm-mounted signs, including street name signs, must be included in this calculation. Emergency preemption detectors, preemption indicator lights, cameras, and radar detectors are negligible and are not included in determining the XYZ values. For mast arm-mounted signs, use the actual sign area (in square feet) to determine the XYZ value. For poles with luminaire supports, the luminaire and arm is also included in the total XYZ calculation. Surface areas for vehicle displays are shown in Exhibit 1330-15. Signs are limited in size as follows:

- Street name signs may be a maximum of 36 inches in height and 36 square feet in total area. Design the mast arm to support the widest sign that will fit within these limits (up to 144 inches wide), regardless of the actual sign size needed. This allows for future changes to the street name sign. Street name signs are mounted such that the edge of the pole is no less than 1 foot but no more than 2.5 feet from the vertical pole centerline, as shown in the *Standard Plans*. Use the offset necessary for the largest possible sign in the signal standard chart for the XYZ value, but refer to the *Standard Plans* for actual sign installation requirements using construction notes in the Contract Plans.
- Other mast arm mounted signs may not exceed 36 inches in height and 7.5 square feet in area.
- Signs mounted on the vertical pole may not exceed 36 inches in width and 15 square feet in area. These signs are not included in the XYZ calculation.

After calculating the total XYZ value, round this up to the next standard foundation XYZ value or 2850 ft^3, whichever is lower, to determine the design XYZ value. The design XYZ builds in some flexibility for future modifications. If the total XYZ value exceeds 2850 ft^3, a special design signal support is required. Preserve traffic signal support calculations as required by 1330.07 Documentation.

Exhibit 1330-15 Signal Display Surface Areas

Signal Display	Area
Vertical 3-section	9.2 sq ft
Vertical 4-section	11.6 sq ft
Vertical 5-section	14.1 sq ft
5-section cluster	14.4 sq ft

After the total XYZ value is determined, if a standard foundation may be used, select the correct foundation depths for the XYZ values from the table in the *Standard Plans*, using the next higher total XYZ value. For WSDOT systems, only the 700, 1350, 1900, 2600, and 3000 columns may be used. All five foundation options should be provided unless there is a known constraint preventing the use of one of the options, such as insufficient space for 4 ft diameter foundation or expected loose soil requiring the use of the Alternate 2 foundation construction.

1330.04(5)(b) Span Wire Signal Standards and Foundation Design

Span Wire Systems use poles and aerial wires to support signal displays, signs, and emergency preemption equipment. Cameras, radar detectors, and street name signs are installed on the vertical strain poles. When laying out span wires, the preferred layout is similar to mast arm supports. Displays for an approach should be installed on a span on the far side of the intersection, with poles on the two far corners. Do not use diagonal spans unless absolutely necessary, as they are extremely difficult to maintain and if the wire is broken, the entire signal system is lost and blocks the entire intersection, rather than the equipment for only one approach.

Span wire signal standards include both steel and timber strain poles. Steel and timber strain poles are designated by pole class, which is based on the horizontal tension load the pole will support. The loads and resultant forces imposed on strain poles are calculated and a pole class greater than that load is specified. Steel Pole Classes and their allowed tension loads are listed in the *Standard Plans*. Exhibit 1330-16 lists the pole classes and tension loading available for timber strain poles.

Headquarters Traffic and Headquarters Bridge and Structures office support is required for determining span tension load and pole classes. Provide the pole and span layout, the locations and sizes of all signal displays and span wire mounted signs, and the soils report. Span wire mounted signs are limited to a maximum of 36 inches in height and 7.5 square feet in area. Emergency preemption equipment locations do not need to be submitted, as they are not included in load calculations. Spans should not exceed 150 feet, if possible, in order to reduce the complexity of the design.

After the pole classes are provided by the Headquarters Bridge and Structures office, select the appropriate foundation information from the *Standard Plans* using the pole classes and soil conditions. If a standard foundation cannot be used, a foundation design will be provided along with the pole class information.

Exhibit 1330-16 Timber Strain Pole Classes

Pole Class	Tension Load Limit (lbs)
4	2400
3	3000
2	3700
1	4500
H1	5400
H2	6400
H3	7500

Pole Classes from ANSI Standard O5.1

1330.04(5)(c) Special Case Signal Supports

Special case signal supports include signal bridges and structure (typically bridge) mounts. These should only be selected if absolutely necessary, as they are difficult to design, construct, and maintain, and they frequently result in signal display locations that are difficult for drivers to see.

Signal bridges function the same as a diagonal span wire system, with the two supports on opposite corners of the intersection. Signal bridges require windload calculations similar to mast arm signal standards, so display and sign locations and offsets must be provided. Signal bridge foundations must be designed by the Headquarters Bridge and Structures office.

Signal displays and other equipment may be installed on structures when there is insufficient clearance below the structure to allow for a different type of signal support. Coordinate with the Bridge designer to place mounts and determine routing paths for conduit and wiring out of the structure. Structure mounts are not desirable, as they typically cannot be modified without reconstruction of the structure itself, and any equipment embedded in the structure is inaccessible after the structure is complete.

Signal displays may not be installed on sign structures such as cantilever sign structures or sign bridges. Signal displays also may not be installed on railroad cantilever structures unless the signal system and the railroad are owned by the same jurisdiction and maintained by the same staff.

1330.04(5)(d) Vertical Steel Shaft Supports

Vertical steel shaft supports include the following types of signal standards:

(a) Type PPB: Sometimes referred to as a “stub pole”, this pole is typically 5 feet tall and 3 inches in diameter. It is used strictly to support pedestrian pushbuttons. Due to the frequency of damage, regardless of location, it is recommended that breakaway bases always be used.

(b) Type PS, I, RM, and FB: These poles are effectively identical, with the difference being the total height to the slipfitter top.

- Type PS are 8 ft tall and may only have pedestrian displays mounted on the top.
- Type I are 10 ft tall and may have vehicle displays mounted on the top and pedestrian displays mounted on the side. Type RM are identical to Type I but are used for ramp meter systems only.
- Type FB are 14 feet tall, and may be used like Type I when additional height is needed for the vehicle display(s).

Placement of vertical steel shaft supports will depend on visibility requirements for displays and accessibility requirements of pedestrian features. Generally, these supports should be located at back of sidewalk, as they are farther from traffic and more likely to be out of both the pedestrian access route and the path of any users. Fixed bases should be used when located at the back of sidewalk, but slip bases may be used if circumstances recommend it. Supports located within sidewalk (includes planter strips) or in locations with only paved shoulders should always use slip bases.

1330.04(6) Vehicle Detection Systems

Vehicle detection systems are necessary for the efficient operation of traffic signals. By responding to the presence of traffic, signal systems do not have to use fixed timing. This improves efficiency by removing unnecessary delay and not providing service to an approach or movement with no traffic.

1330.04(6)(a) Vehicle Detection Zone Placement

The detection system at a traffic-actuated signal installation provides the control unit with information regarding the presence or movement of vehicles, bicycles, and pedestrians. Vehicle detection systems perform two basic functions: queue clearance and the termination of phases. Depending on the specific intersection characteristics, either of these functions can take priority. The merits of each function are considered and a compromise might be necessary.

There are two basic types of detection zones: stop bar and advance. Stop bar detection is a zone that extends from the stop line to a point 30 to 40 feet in advance of that location. Advance detection is a discrete zone (or zones) placed in advance of the stop line at a distance dependent on vehicle speed.

Basic vehicle detection requirements depend upon the speeds of the approaching vehicles:

(a) When the posted speed is below 35 mph, provide stop bar detection or one advance detection zone. See Exhibit 1330-17 for advance detection zone distances.

(b) When the posted speed is at or above 35 MPH, provide stop bar detection and at least two advance detection zones. Multiple advance detection zones are normally required to accommodate decision zone detection.

(c) Side street advance detection is not required for WSDOT owned signal systems, but may be provided through means that do not require equipment to be installed off of WSDOT right of way. For signals owned by other jurisdictions, the use of side street advance detection is at the discretion of the owning jurisdiction.

A decision zone is a location along the intersection approach where a motorist is forced to make a decision between two alternatives. As applied to vehicle detection design, this situation can occur when two vehicles are approaching a traffic signal and the signal indication turns yellow. The motorist in each vehicle must decide whether to continue through the intersection or stop prior to the intersection. If the lead vehicle decides to brake and the following vehicle does not, there may be a rear-end collision.

For posted speeds of 35 MPH or higher, there are two options for placing advance detectors to address the decision zone:

1. Fixed locations based on posted speed, which is generally the 85th percentile speed. Place loops according to the table in Exhibit 1330-17.
2. Calculated locations based on calculated decision zone detection design. This design increases the opportunity for a range of vehicles from the 90th percentile speed vehicle to the 10th percentile speed vehicle to either clear the intersection or decelerate to a complete stop before reaching the intersection. The method of calculating the decision zone and the required detection loops is shown in Exhibit 1330-18.

Although the exhibits reference loops, advance detectors may be of any approved type.

For new intersection construction where there is no existing traffic, the fixed locations based on posted (target design) speed are to be used. Fixed locations based on posted speed use the same methods as the calculated decision zone detection design, but set V90 at 5 MPH above posted speed and V10 at 5 MPH below posted speed. Engineering judgment based on similar intersections (such as geometrics and traffic volumes) may justify modifying the V90 and V10 speeds used in the calculation, with concurrence from the region Signal Operations Engineer.

Both methods require a study of the approach speeds at the intersection. For intersection approaches, conduct the speed study as follows:

- Collect data at the approximate location or just upstream of the decision zone;
- Collect data during off-peak hours in free-flow and favorable weather conditions;
- Collect data during regular commuting hours in a high volume signalized corridor during favorable weather conditions
- Only document the speed of the lead vehicle in each platoon.

It is important that the person conducting the speed study remain inconspicuous so they do not influence drivers to slow down. Normal driving patterns are needed for proper speed studies. Prior speed-study information obtained at this location may be used if it is less than 18 months old and driving conditions have not changed significantly in the area.

Preserve detection zone placements and any supporting calculations as required by 1330.07 Documentation.

Exhibit 1330-17 Fixed Vehicle Detection Placement

Fixed Detection Placement – Below 35 MPH

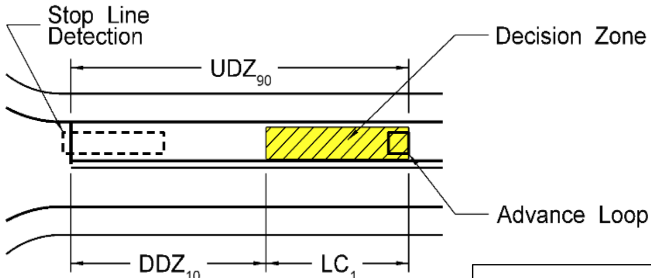
V_{85} =		V_{90} =		V_{10} =		UDZ_{90}	DDZ_{10}	LC_1	P_{MID}	LC_2	Calculated Loop 1	Rounded Loop 1
MPH	ft/s	MPH	ft/s	MPH	ft/s	ft	ft	s	ft	s	ft	ft
25	36.7	30	44.00	20	29.33	165.00	50.84	3.9	107.92	1.9	107.92	105
30	44	35	51.33	25	36.67	216.03	70.28	4	143.15	2	143.15	140

For posted speeds below 35 MPH, only the PMID detection location is used.

Fixed Detection Placement – 35 MPH and Above

V_{85} =		V_{90} =		V_{10} =		UDZ_{90}	DDZ_{10}	LC_1	P_{MID}	LC_2	Calculated Loop 1	Calculated Loop 2	Rounded Loop 1	Rounded Loop 2
MPH	ft/s	MPH	ft/s	MPH	ft/s	ft	ft	s	ft	s	ft	ft	ft	ft
35	51.33	40	58.67	30	44.00	273.78	92.40	4.1	183.09	2.1	183.09	273.78	180	275
40	58.67	45	66.00	35	51.33	338.25	117.21	4.3	227.73	2.2	227.73	338.25	225	340
45	66	50	73.33	40	58.67	409.44	144.71	4.5	277.08	2.3	277.08	409.44	275	410
50	73.33	55	80.67	45	66.00	487.36	174.90	4.7	331.13	2.4	331.13	487.36	330	490
55	80.67	60	88.00	50	73.33	572.00	207.78	5	389.89	2.5	389.89	572.00	385	575
60	88	65	95.33	55	80.67	663.36	243.34	5.2	453.35	2.6	453.35	663.36	450	665

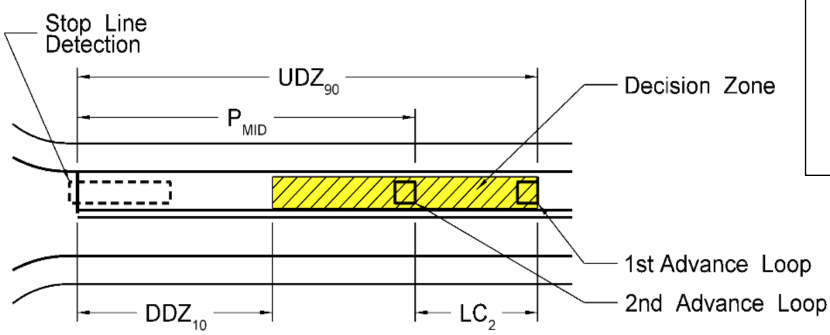
Exhibit 1330-18 Decision Zone Detection Placement



Single Advanced Loop Design

Use when $LC_1 \le 3$ seconds

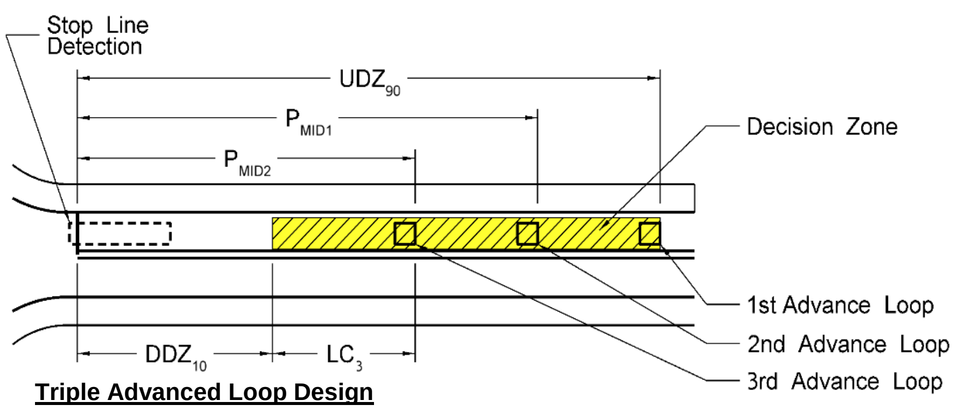
$$LC_1 = \frac{UDZ_{90} - DDZ_{10}}{V_{10}}$$



Double Advanced Loop Design

Use when $LC_2 \le 3$ seconds

$$P_{MID} = \frac{UDZ_{90} + DDZ_{10}}{2} \qquad LC_2 = \frac{UDZ_{90} - P_{MID}}{V_{10}}$$



Triple Advanced Loop Design

Use when $LC_3 \le 3$ seconds

$$LC_3 = \frac{UDZ_{90} - DDZ_{10}}{3V_{10}} \qquad P_{MID1} = \frac{[2(UDZ_{90}) + DDZ_{10}]}{3} \qquad P_{MID2} = \frac{[UDZ_{90} + 2(DDZ_{10})]}{3}$$

Decision Zone Endpoint Calculation

(for all loop arrangements)

Where grades are flatter than +/- 4%:

$$UDZ_{90} = \frac{(V_{90})^2}{16} + V_{90}$$

$$DDZ_{10} = \frac{(V_{10})^2}{40} + V_{10}$$

Where grades are +/- 4% or steeper:

$$UDZ_{90} = \frac{(V_{90})^2}{2(8+32.2G)} + V_{90}$$

$$DDZ_{10} = \frac{(V_{10})^2}{2(20+32.2G)} + V_{10}$$

Where:

V_{90} = 90th percentile speed, in feet per second

V_{10} = 10th percentile speed, in feet per second

UDZ_{90} = Upstream end of decision zone, for 90th percentile speed

DDZ_{10} = Downstream end of decision zone, for 10th percentile speed

G = Grade of roadway, in decimal form, including + or – (Example: -4% = -0.04)

LC_1 = V_{10} travel time to DDZ_{10}

LC_2 = V_{10} travel time from UDZ_{90} to P_{MID}

LC_3 = V_{10} travel time from P_{MID2} to DDZ_{10}

1330.04(6)(b) Vehicle Detector Types

There are two basic categories of vehicle detectors:

- **Non-Invasive**: These are detectors installed outside of the roadway, typically overhead in a strategic location. These include camera (optical and infra-red) and radar systems.
- **In-Pavement**: These are detectors which are installed in the road itself. These include induction loops and wireless in-pavement sensors.

Non-invasive detection is generally recommended over in-pavement detection, due to the ability to revise non-invasive detection at any time and the ease of installation, repair, and replacement – particularly when supporting traffic control and impacts are taken into account. Additionally, pavement damage due to regular wear or construction activities will disable in-pavement detection, whereas non-invasive detectors will continue to function, and can even be adjusted to accommodate revised lane configurations.

Stop line detection should use non-invasive systems for detection. Although induction loop detectors are typically the most reliable for detecting cars and trucks, they do not consistently detect bicycles and motorcycles. RCW 47.36.025 specifically requires that vehicle-activated traffic control signals be capable of detecting motorcycles and bicycles.

Advanced detection may be either non-invasive or in-pavement, as these improve efficiency of the signal systems but are not as critical as stop line detection. Non-invasive is recommended for posted speeds of 45 MPH or lower, as they are currently only effective for up to about 600 feet from the location of the detector. The advantage is that advance detection can be installed at the intersection, rather than trenching long distances to place advanced detectors in pavement. For speeds over 45 MPH, non-invasive detection systems may be considered, but in-pavement systems will probably be more effective. Advance detection does not need to detect bicycles.

Selection of detector types will depend on a variety of environmental factors and locations available for placement.

1. **Radar Detectors**

   Radar detectors are located on either the signal mast arms or the signal vertical strain poles, depending on lane configuration, detector type, and location availability. Radar detectors are not affected by weather, and are typically minimally affected by mast arm motion in high wind. Consult the detector manufacturer's installation guidance for placement details. One detector can normally cover all lanes of an approach for that type of detection (stop line or advance).

2. **Video Detectors**

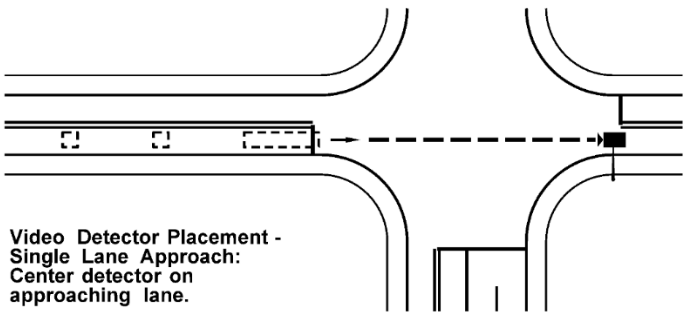
   Placement of video detectors depends on the function of the detector. Exhibit 1330-19 provides placement examples.

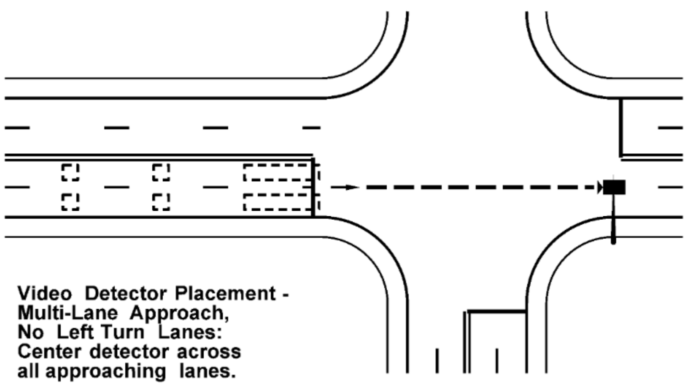
   Stop line detectors should be installed on the same mast arm as the vehicle displays for that approach. The detector should be placed on an extension of the wide line between the left turn and through lanes, if present; if there is no wide line, the detector should be centered on the through lanes. One detector can cover all lanes of an approach for that type of detection (stop line or advance).

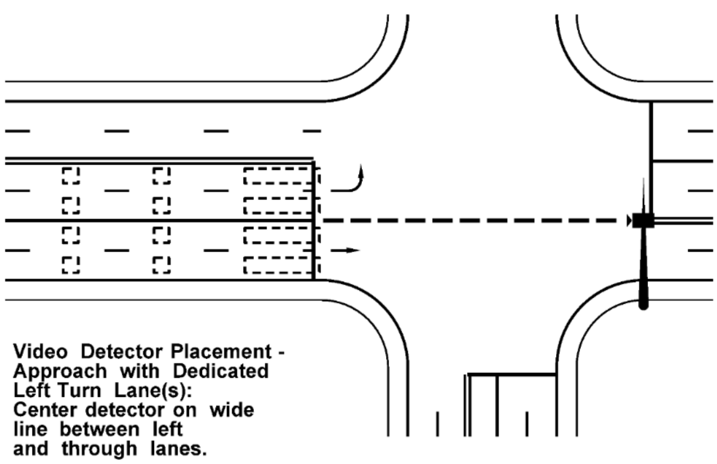
Advance detectors should be installed on a luminaire arm, preferably on the adjacent corner to the approaching lanes, as the effectiveness of the advance detection depends on height. Consider requiring a luminaire arm even if no luminaire is needed, in order to provide an optimal installation site for the detector. Advance detectors may be installed on a mast arm, but will typically have less effective range.

Both infra-red and optical cameras are available, but optical cameras are not recommended due to the adverse effects of rain, snow, fog, sun glare, and sharp shadows on their effectiveness. However, infra-red cameras may still be affected by heavy fog or other major thermal events. All video detection may be affected by mast arm motion due to high winds.

Exhibit 1330-19 Video Detector Placement







3. **Induction Loops**

   Induction Loops are coils of wire in the roadway that use the magnetic properties of vehicles to detect them. Induction loops can last a very long time when undisturbed. However, induction loops require bicycles to be in a very specific location in order to be detected, and may not detect carbon fiber bicycles. Induction loops must be installed with one per lane per detection zone – stop line loops may be larger or series loops. Where induction loops are used, loops need to be numbered in order to keep track of the wiring and lanes they are detecting. See 1330.04(2) for detector numbering requirements.

4. **Wireless In-Pavement Sensors**

   Wireless in-pavement sensors are compact detectors installed in pavement, and use either radar or magnetics to detect vehicles. They use a wireless connection to the signal cabinet. The sensors rely on a battery for operation, and require replacement of the entire unit when they fail. Sensor placement is similar to induction loops – one per lane per detection zone. The magnetic versions are subject to the same difficulties with bicycles as loop detectors. All wireless sensors are also subject to various factors that impact wireless signals such as range, signal obstructions, and possible signal interference from other radios depending on the frequency used.

Non-invasive detectors are preferred with concrete (Portland cement concrete pavement) roadway surfaces. In-pavement detectors installed in concrete panels typically cannot be revised or replaced until all affected concrete panels are replaced. In-pavement detectors installed in bridge decks must be installed when the bridge deck is constructed, and cannot be replaced unless the bridge deck is replaced. Non-invasive detection is also useful for approaches where advance detection is desired, but the approach is outside the jurisdiction of the agency that owns the signal, or for non-standard approaches such as driveways.

Temporary detection should be installed for all stop lines where existing detection will be disabled or ineffective (such as lane shifts) during construction. Temporary advance detection is recommended for high speed (45 MPH or higher) approaches where the decision zone detection will be disconnected for an extended period of time. Consult with the Signal Operations Engineer to determine if temporary advance detection should be used. Temporary advance detection zone placement should take into account any temporary speed limit revisions.

1330.04(7) Preemption Systems

1330.04(7)(a) Emergency Vehicle Preemption

Emergency vehicle preemption (EVP) is required for all traffic signals unless approved otherwise by the region Traffic Engineer. WSDOT is responsible for installing EVP detection equipment at new and rebuilt signalized intersections on state highways. At existing signalized intersections that do not have EVP detection equipment, or where an emergency service agency requests additional equipment beyond the basic required equipment, the emergency service agency is responsible for all material and installation costs. The emergency service agency is responsible for preemption emitters in all cases.

Optically activated EVP systems are used to ensure compatibility with all area emergency service agency emitters. Approval by the State Traffic Engineer is required for the installation of any other type of emergency vehicle preemption system.

Locate optical detectors facing each approach to the intersection – only one detector per approach – with a clear view of the approaching roadway. Detectors have a cone of vision of approximately 8 degrees, and an effective range of 200 to 2500 feet. Detectors should have an unobstructed view of the approach for a minimum of 1800 feet. Primary detectors are normally installed on the same support as the vehicle displays for that approach. Place the detector between the left turn lane and through lane displays on approaches with left turn lanes, or centered on the approaching lanes where left turn lanes are absent.

When the approach is in a horizontal or vertical curve, or there are other sight obstructions, non-standard placement of the primary detector or additional supplemental detectors may be necessary. Primary detectors may be located on other signal display supports (arms or spans) or vertical strain poles, depending on visibility requirements. Supplemental detectors may also be located on separate Type I or Type FB poles in advance of the intersection. On higher speed roadways, supplemental detectors can provide extended detection range – one mile in advance of the intersection is usually sufficient.

Preserve any documentation associated with the EVP system, including system type selected and any associated agreements or approvals, as required by 1330.07 Documentation.

1330.04(7)(b) Railroad Preemption

Railroad preemption is used when a railroad is in close proximity to a signalized intersection. If railroad tracks are within 1/4 mile of a signalized intersection, then a Railroad Crossing Evaluation Team is formed to determine the need (if any) for railroad preemption, interconnection, simultaneous preemption, advanced preemption, and so on. The Railroad Crossing Evaluation Team should consist of region and HQ Signal Design Engineers, region and HQ Signal Operations Engineers, HQ Railroad Liaison, HQ Rail Office representative, region Utilities Engineer, region Traffic Design Engineer, region Maintenance Superintendent, and the affected railroad representative. Where the signal is owned, operated, or maintained by a local agency, a local agency representative should also be included.

The Railroad Crossing Evaluation Team will determine what design considerations are needed at all signalized intersections near railroad crossings. For locations where the railroad tracks are located greater than 500 feet from the signalized intersection, and it can be demonstrated that the 95% maximum queue length(s) will not extend to within 200 feet of the tracks, railroad preemption may be omitted with the approval of the Railroad Crossing Evaluation Team. Include the demonstration and approval in the documentation required by 1330.07 Documentation.

Railroad preemption and interconnection are recommended when any of the following conditions occurs:

- The distance from the stop bar to the nearest rail is less than or equal to 200 feet.
- There is no dedicated left turn lane and the distance from the stop bar to the nearest rail is less than or equal to 500 feet.
- The 95% maximum queue lengths from the intersection stop bar are projected to cross the tracks. (Use a queue arrival/departure study or a traffic analysis “micro-simulation model” to determine 95% maximum queue lengths.)

- The 95% maximum queue lengths from the railroad are projected to affect an upstream traffic signal. (Use a queue arrival/departure study or a traffic analysis "micro-simulation model" to determine 95% maximum queue lengths.)

If it is determined that advanced preemption is needed, the HQ and region Signal Operations Engineers will calculate the amount of railroad preemption time required using the *Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings (TxDOT Form 2304)*.

The addition of a pre-signal is recommended when any of the following conditions occurs:

- The distance from the stop bar to the nearest rail is less than 88 feet but is at least 40 feet. (For reference, the 88 feet is derived from: the longest design vehicle permitted by statute (75 feet) + front overhang (3 feet) + rear overhang (4 feet) + downstream clear storage (6 feet)).
- The distance from the stop bar to the nearest rail is > 88 feet and < 120 feet and there are no gates for the railroad crossing.
- The sight distance triangle in Chapter 1350, Exhibit 1350-1 (Sight Distance at Railroad Crossing), cannot be met, and the railroad crossing does not have active control (lights or gates).

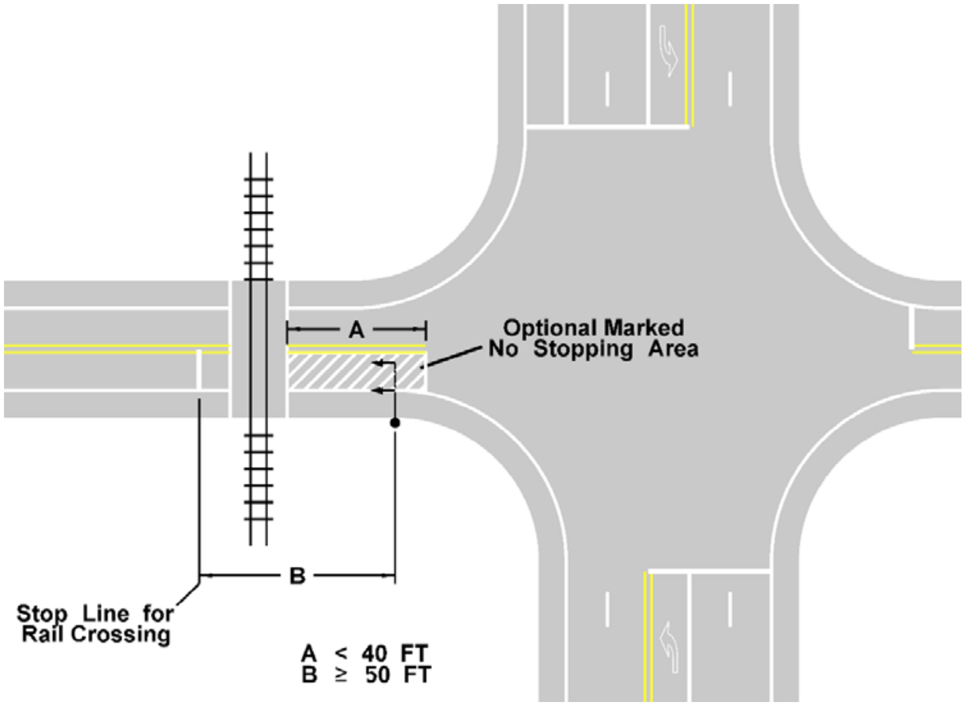
When pre-signals are used, two stop lines are used: one for the rail crossing, and one for the intersection. The pre-signal displays stop traffic at the rail crossing stop line, and the second set of signal displays stop traffic at the intersection. Use louvers on the intersection displays so that they are not visible from the stop line for the rail crossing. Optically programmed displays may be used in place of louvers, but are not recommended due to the limited benefits, complexity of installation and maintenance, and high cost.

Where the distance between the normal location for the stop bar and the approach is less than 40 feet, the same stop bar should be used for both the traffic signal and the rail crossing. Install vehicle displays on the near side of the intersection, but on the far side of the tracks from the stop line, to improve visibility and discourage drivers from stopping between the tracks and the intersection. Do not install vehicle displays on the far side of the intersection.

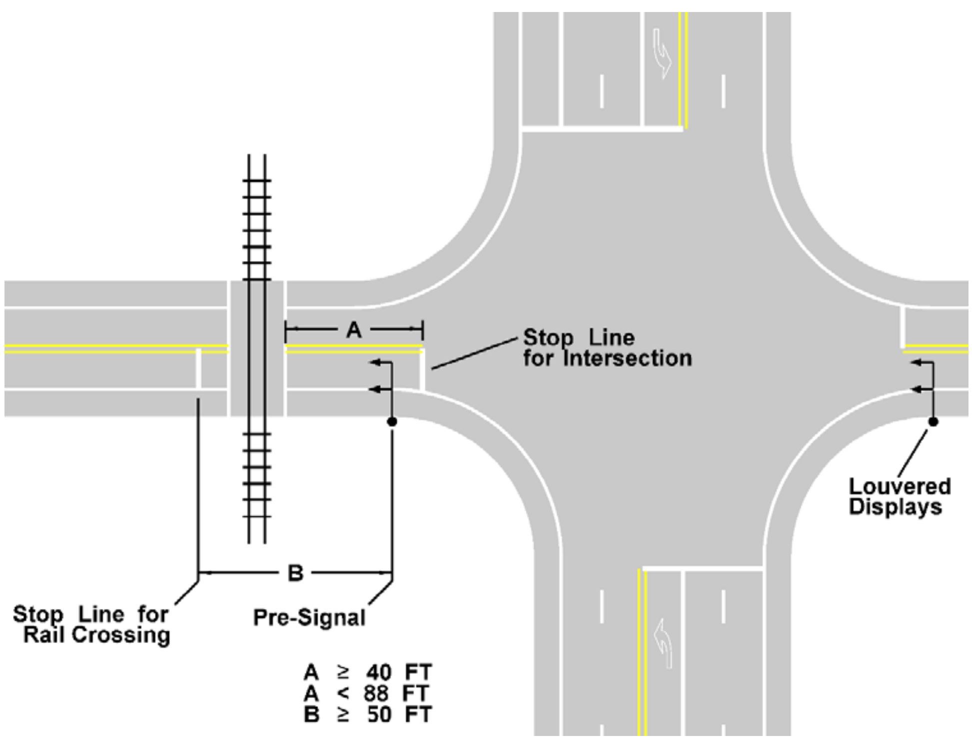
Exhibit 1330-20 shows examples of the distances and typical system layouts referenced above.

The Railroad Crossing Evaluation Team has final review and approval authority for all PS&E documents for signal design and operation at all signalized intersections near railroad crossings. All documentation associated with railroad preemption and a memo with each team member's concurrence with the PS&E documents must be preserved as required by 1330.07 Documentation.

Exhibit 1330-20 Signal Display Layout for Rail Crossings



Display Placement
Less than 40 feet between tracks (dynamic envelope marking) and intersection



Display Placement
40 to 88 feet between tracks and intersection

1330.04(7)(c) Transit Priority Preemption

Transit Priority Preemption allows for transit operations to influence signal timing, similar to emergency vehicle preemption. This can be included in mobility projects, but the transit agency assumes all costs for providing, installing, and maintaining this preemption equipment. WSDOT's role is limited to approving preemption operational strategies (phasing, timing, software, and so on) and verifying the compatibility of the transit agency's equipment with the traffic signal control equipment. Preserve all transit priority preemption decisions and agreements as required by 1330.07 Documentation.

1330.04(8) Control Equipment

The standard WSDOT Signal Controller type for traffic signals is the Type 2070 Controller. Some agencies use National Electrical Manufacturers Association (NEMA) controllers (Type TS1 or TS2). Although not normally used for new construction, WSDOT Ramp Meters and some older systems still use Type 170 Controllers. All traffic signal controllers have the following basic functions:

- Dual ring phase operation
- Eight vehicle phases
- Four pedestrian phases
- Four overlap phases
- Four emergency vehicle preemption channels
- Railroad preemption
- Start and end daylight savings time dates
- Transit preemption (some older controllers may not support this)

Type 2070 controllers and newer NEMA controllers are functionally equivalent for basic signal operations. However, Type 2070 controllers and NEMA controllers use different operating software and communications protocols, and therefore cannot be interconnected together. The type of controller should be specified as follows:

1. For WSDOT traffic signals, specify Type 2070 controllers, unless:
    a. The signal is interconnected with other signals. If the other controllers in the interconnected system are not being replaced, specify a controller (2070, NEMA, or other) that matches the rest of the interconnected system.
    b. The signal is operated by another agency. In this case, work with WSDOT and the other agency's maintenance staff to determine the appropriate controller type.
2. For traffic signals owned by other agencies, specify the controller type used by that agency.

The region or operating agency will determine the controller brand and operating software, which are included in the cabinet specifications. Each region or operating agency will provide specifications for their cabinets and the equipment contained therein. For 2070 controllers, double-width cabinets (two racks) should be specified if physically possible to allow for future communications and ITS equipment.

It is often beneficial for one of the agencies to assume responsibility for the operation of the traffic signals. This is accomplished by negotiating an agreement with the other agency. The designer needs to check region policy and make sure someone initiates the process for setting up an operational agreement with the other agency or modifying an existing agreement when applicable. (See the *Agreements Manual* for more information on signal systems and maintenance agreements.) At a new intersection, where the state owns the signal, but WSDOT has agreed to let another agency operate the signal, the controller should be compatible with that agency's system. When installing a new controller in an existing interconnected corridor, the controller should be capable of operating with the existing controllers in the corridor. In situations where it is necessary to coordinate the traffic movements with another agency, it is important that the agencies work together.

Intersections within ½ mile of each other on state highways should be interconnected. Perform an operational analysis to determine need for interconnection where intersections are within 1 mile of each other on state highways with a posted speed of 45 MPH or higher. The preferred method for interconnection is fiber optic cable, but other methods such as IP over copper or wireless interconnect may be considered after discussion with maintenance staff and approval by the region Traffic Engineer. Where fiber optic cable is used, it must be routed through pull boxes and cable vaults – bending fiber optic cable through standard junction boxes typically results in the cable being broken. Consider using a separate pull box or vault for coiling the fiber optic interconnect cable to allow for the large-bend radii. Add a construction note in the plans stating to coil additional cable in the adjacent pull box or vault, not the controller cabinet. This will save on space in the controller cabinet and provides additional cable in case an errant vehicle hits the cabinet.

Coordinate with the operations and maintenance staff to determine the optimum controller cabinet location and the cabinet door orientation. The controller cabinet is positioned to provide the best maintenance access and clearest view of the intersection possible. Preferred visibility allows for as many signal displays and roadway approaches visible as possible from a single location. Cabinets should not be placed where they might block the view of turning traffic (intersection sight triangle). If possible, position the controller where it will not be affected by future highway construction.

Cabinets require a minimum of 36 inches of level space in front of each door, including the concrete pad. Do not place cabinets where flooding might occur or where the cabinet might be hit by errant vehicles. If there is a steep down slope or drop off near the cabinet, personnel fall protection (such as fencing) is required in accordance with standards established by the Department of Labor and Industries. Fall protection may not encroach on the required clear space for the cabinet. The location must also have adequate room for a maintenance vehicle to park near the cabinet. Sufficient space for a bucket truck to park is preferable.

If a telephone line (voice or DSL), fiber optic, wireless, or other connection is desired for remote access to the equipment in the cabinet, provide the appropriate equipment in the controller cabinet and/or nearby junction box or cable vault with separate conduits and junction boxes for the remote communications equipment. Communications connections to outside utilities require their own separate conduit and box/vault system.

Consult with maintenance and operations staff to determine if a backup power source, such as an Uninterruptible Power Supply (UPS) or backup generator, is needed for the signal cabinet. Install the backup power supply on the same concrete pad as the signal cabinet. Service and other cabinets may also be installed on the same concrete pad as the signal cabinet (see the

Standard Plans for concrete cabinet pad layouts). Refer to Chapter 1040 for electrical service types, overcurrent protection, and descriptions and requirements for other components.

1330.04(9) Wiring, Conduit, and Junction Boxes

Consider cost, flexibility, construction requirements, and ease of maintenance when laying out the electrical circuits for the traffic signal system. Consolidate roadway crossings (signal, illumination, ITS conduits, and so on) whenever possible to minimize the number of crossings and take advantage of single crossing construction (joint trenches or consolidated directional boring). Include all electrical design calculations in the Project File.

1330.04(9)(a) System Wiring

Traffic signal systems use multi-conductor cables to connect most of the equipment. Single conductor cable is limited to cabinet power and street lighting circuits.

The following describes typical WSDOT wire type selection:

- 5c cables for signal displays. One 5c per signal phase may connect the signal cabinet to the terminal cabinet on the pole. Separate 5c cables should connect each signal display to the terminal cabinet. Protected / permissive displays may either use one 7c cable or two 5c cables (one for each phase on the shared display).
- 5c cables for pedestrian displays. Consult with region maintenance to determine if the same 5c cable is used for associated pedestrian detection.
- 3cs cables for emergency preemption detectors.
- 2c cables for induction loop detectors. Shielded cable is not required for modern loop detector cards. Older systems may still need shielded cable (2cs), but it is recommended to replace the loop detector cards instead.
- Manufacturer specified cables for video and radar detectors. Video detectors typically use a combined RG9/5c (#18) cable. Radar detectors typically use proprietary 6c and 8c cables. These cables are roughly the size of 7c cables (for calculating conduit fill).
- Use 2c cables for isolated pedestrian detectors (separate pole from associated pedestrian display). For connecting 4-wire APS units, a 7c cable may be used between the PPB post and the signal pole with the pedestrian display (where the APS control unit is located).

To simplify potential repairs for smaller signal standards (Type FB and smaller), consider routing signal display and detection conductors through terminal cabinets on larger signal standards (Type II and larger) before connecting to smaller signal standards. This reduces the amount of wire which may need to be replaced if a smaller signal standard is knocked down and the wiring damaged.

1330.04(9)(b) Conduit

Refer to the Standard Specifications for conduit installation requirements. At existing intersections, where roadway reconstruction is not proposed, conduits are to be placed beyond the paved shoulder or behind existing sidewalks to reduce installation costs. All conduits shall be a minimum of 2 inches in size, with the following exceptions:

1. Conduits entering Type PPB signal standards shall be 1 inch. This may be increased to 1 1/4 inch when two APS PPBs are installed on the same pole.
2. Lighting conduits entering pole foundations (signal or light standards) shall be a minimum of 1 inch. See Chapter 1040 for additional requirements for light standards with slip bases.
3. Conduits entering Type PS, I, RM, and FB poles may be a minimum of 1-inch and a maximum of 2-inch.
4. The conduit for the service grounding electrode conductor may be a minimum of ½-inch.

Install spare conduits at all road crossings. Spare conduits at road crossings should be a minimum of one 3-inch conduit or two 2-inch conduits. Install a minimum 2-inch (preferably 3-inch) spare conduit into the controller cabinet.

It is recommended to use full inch conduit sizes to simplify construction and reduce the different types of conduits required for the system. This helps to provide future capacity and reduce costs through bulk material purchasing. Size all conduits to provide 26% maximum conductor fill for new signal installations. A 40% fill area can be used when installing conductors in existing conduits. (See Exhibit 1330-21 for conduit and signal conductor sizes.)

Exhibit 1330-21 Conduit and Conductor Sizes

Conduit Sizing Table			
Trade Size	Inside Diam. (inches)	Maximum Fill (inch^2)	
		26%	40%
1/2"	0.632	0.08	0.13
3/4"	0.836	0.14	0.22
1"	1.063	0.23	0.35
1 1/4"	1.394	0.40	0.61
1 1/2"	1.624	0.54	0.83
2"	2.083	0.89	1.36
2 1/2"	2.489	1.27	1.95
3"	3.09	1.95	3.00
3 1/2"	3.57	2.60	4.00
4"	4.05	3.35	5.15

Conductor Size Table			
Size (AWG)	Area (inch^2)	Size (AWG)	Area (inch^2)
# 14 USE	0.021	2cs (# 14)	0.090
# 12 USE	0.026	3cs (# 20)	0.070
# 10 USE	0.033	4cs (# 18)	0.060
# 8 USE	0.056	5c (# 14)	0.140
# 6 USE	0.073	7c (# 14)	0.170
# 4 USE	0.097	10c (# 14)	0.290
# 3 USE	0.113	6pcc (# 19)	0.320
# 2 USE	0.133		

Minimize roadway crossings whenever possible. Usually only three crossings are needed (one main line) for a four-leg intersection, and only two roadway crossings are needed for a T intersection. In most cases, the conduit should cross both the main line and side street from the corner where the controller is located.

Directional boring should normally be used when crossing the state route (main line). Open cut trenching may only be used to install conduits under the following circumstances:

1. Existing roadways where the roadway is being resurfaced.
2. Existing roadways where substantial obstacles under the roadway will be encountered.
3. Where there is insufficient room for jacking or boring pits at the edges of the roadway.

Open cut trenching is not permitted across limited access roadways unless the entire pavement surface is being replaced. Sign or signal bridges may not be used for roadway crossings.

1330.04(9)(c) Junction Boxes

Provide junction boxes at the following locations:

- Adjacent to the signal cabinet. A pull box or larger vault may be used in place of multiple junction boxes.
- Adjacent to each signal pole. One box may serve multiple poles. The distance from a pole to the first junction box should not exceed 10 feet without concurrence from maintenance staff. Pole bases may not be used as junction boxes.
- Adjacent to each set of detector loops. These boxes contain the detector loop splices. One box may serve multiple lanes, but the box should be no more than 50 feet from the detector loop.
- At the end of each road crossing.
- In the middle of conduit runs where the number of bends would equal or exceed 360°.

Where possible, locate junction boxes out of paved areas and adjacent to (but not in) sidewalks. New junction boxes may not to be placed in the pedestrian curb ramp or ramp landing of a sidewalk. If a new junction box must be placed within sidewalk, locate it at the edge of the sidewalk and designate it to be slip-resistant. Existing junction boxes located within new or existing sidewalk, including ramps or landings, must be revised as follows:

- Existing junction boxes containing power conductors for the traffic signal (not including street lighting), or wiring for the signal displays, may remain in place, even if they will be within a sidewalk ramp or ramp landing.
- Existing junction boxes containing detector wiring may remain in sidewalks, but must be relocated outside of sidewalk ramps and ramp landings. Designate that the relocation work, including conduit adjustments and rewiring, be completed within a single shift or provide temporary detection using another conduit path.
- All junction boxes which will be within sidewalk, sidewalk ramps, or ramp landings, must be slip-resistant junction boxes. This includes replacing existing junction boxes with slip-resistant junction boxes.
- Under no circumstances may a junction box be located in a grade break for a sidewalk ramp. Either the ramp must be redesigned or additional accommodations made in construction to allow for the box to be relocated.

The fundamental principle is that if relocating a junction box requires shutting down a traffic signal system, the junction box may remain in its existing location but must be replaced with a slip-resistant junction box. See Chapter 1510 for additional ADA requirements.

Do not place junction boxes within the traveled way unless absolutely necessary. Make every effort to locate new junction boxes and to relocate existing junction boxes outside the travel lane or paved shoulder. If there is no way to avoid locating the junction box in the traveled way or paved shoulder, heavy-duty junction boxes must be used. Avoid placing junction boxes in areas of poor drainage. Do not place junction boxes within 2 feet of ditch bottoms or drainage areas, or within vegetative filter strips or similar water treatment features which may be present. The maximum conduit capacities for various types of junction boxes are shown in the *Standard Plans*.

1330.05 Preliminary Signal Plan

Develop a preliminary signal plan for the Project File. Include a brief discussion of the issue that is being addressed by the project. Provide sufficient level of detail on the preliminary signal plan to describe all aspects of the signal installation, including proposed channelization modifications. Use a plan scale of “1 inch = 20 feet” and include:

(a) Stop lines.

(b) Crosswalks.

(c) Sidewalk locations, including curb ramps.

(d) Guardrail locations.

(e) Drainage items.

(f) Left-turn radii, including beginning and ending points.

(g) Corner radii, including beginning and ending points.

(h) Vehicle detector locations and proposed detector types, including exclusive bicycle detectors.

(i) Pedestrian detector (PPB) locations.

(j) Signal standard types and locations.

(k) Vehicle signal displays.

(l) Pedestrian signal displays.

(m) Phase diagram, including pedestrian movements.

(n) Emergency vehicle preemption requirements.

(o) Railroad preemption requirements.

(p) Illumination treatment, including a calculation summary showing the average light level, average/minimum uniformity ratio, and maximum veiling luminance ratio. (See Chapter 1040 for more information on illumination design requirements.)

(q) Cabinet locations with door orientations.

(r) Traffic counts, including left-turn movements.

(s) Speed study information indicating 90th and 10th percentile speeds for all approaches (if used for detector spacing).

(t) Utilities information.

Submit a copy of the preliminary signal plan to the State Traffic Engineer for review and comment. Allow two to three weeks for review of the preliminary signal plan. After addressing all review comments, finalize the plan and preserve as required by 1330.07 Documentation. Prepare the contract plans in accordance with the *Plans Preparation Manual*.

If HQ Traffic Design is preparing the contract Plans, Specifications, and Estimate (PS&E) package for the signal system portion of the project, submit the above preliminary signal plan with the following additional items:

(u) Contact person.

(v) Charge numbers.

(w) Critical project schedule dates.

(x) Existing and proposed utilities, both underground and overhead.

(y) Existing intersection layout, if different from the proposed intersection.

(z) Turning movement traffic counts (peak hour for isolated intersections) and a.m., midday, and p.m. peak-hour counts if there is another intersection within 500 feet.

(aa) Electrical service location, source of power, and utility company connection requirements.

After the PS&E is prepared, the entire package is transmitted to the region for incorporation into its contract documents.

1330.06 Operational Considerations for Design

This section describes operational guidance for traffic signals. These operational requirements will directly affect the design of the traffic signal, particularly in regards to signal display types and locations.

All traffic signals should be periodically re-evaluated, to determine if timing or phasing changes would result in more efficient operation of the traffic signal, or in the case of interconnected systems, the corridor or network. Changes in traffic volumes, posted speeds, or other factors may influence turning movement phasing operations (protected, protected/permissive, or permissive), green times, yellow change intervals, and other operational parameters.

1330.06(1) Left-Turn Phasing

Left-turn phasing can either be permissive, protected/permissive, or protected. It is not necessary that the left-turn mode for an approach be the same throughout the day. Varying the left-turn mode on an approach among the permissive only, protected/permissive, and protected-only left-turn modes during different periods of the day is acceptable. Examples are included in the phase diagrams shown in Exhibit 1330-22 and Exhibit 1330-23.

1. **Permissive Left-Turn Phasing**

   Permissive left-turn phasing requires the left-turning vehicle to yield to opposing through traffic and pedestrians. Permissive left-turn phasing is used when the following are true:

   a. Turning volume is minor.

   b. Adequate gaps occur in the opposing through movement.

   c. Adequate sight distance beyond the intersection is provided.

This phasing is more effective on minor streets where providing separate protected turn phasing might cause significant delays to the higher traffic volume on the main street. On single-lane approaches with a posted speed of 45 mph or above, or where sight distance approaching the intersection is limited, channelization should include a separate left-turn storage lane for the permissive movement to reduce the potential for rear-end-type collisions and delay to through movements.

Unless there is a dedicated left-turn lane, do not provide a separate display for permissive left turns. When there is a dedicated left-turn lane, a three-section flashing yellow arrow display (with steady red arrow, steady yellow arrow, and flashing yellow arrow displays) is recommended for the left-turn lane, as this provides a more positive indication of the permissive turning movement.

2. Protected/Permissive Left-Turn Phasing

Protected/permissive left-turn phasing provides both a protected phase and a permissive phase for the same lane, using the same signal display. Where left-turn phasing will be installed and conditions do not warrant protected-only operation, consider protected/permissive left-turn phasing. Protected/permissive left-turn phasing can result in increased efficiency at some types of intersections, particularly "T" intersections, ramp terminal intersections, and intersections of a two-way street with a one-way street where there are no opposing left-turn movements.

Protected/permissive left-turn phasing is NOT allowed under the following conditions:

a. For new signals, on an approach where Warrant 7 is met and there are five or more left-turning collisions on that approach included in the warranting collisions. This condition requires protected left turn phasing.

b. For existing signals, when documentation shows that existing protected left-turn phasing was installed due to left-turn collisions.

c. When sight distance for left-turning vehicles, as outlined in AASHTO's *A Policy on the Geometric Design of Highways and City Streets*, cannot be met.

d. On intersection approaches where the opposing approach has three or more lanes (including right-turn lanes) and either the posted speed limit or 85th percentile speeds for the opposing approach are at or above 45 mph.

e. On intersection approaches that have dual left-turn lanes, including approaches with left only and through-left lanes.

Where there is a separate left-turn lane, protective/permissive displays may use either of the following display arrangements:

- A dedicated four-section arrow display, with steady red arrow, steady yellow arrow, flashing yellow arrow, and steady green arrow displays (four-section FYA). A three-section display with a bi-modal flashing yellow arrow / steady green arrow may only be used if the signal support cannot accommodate a four-section signal display.
- A shared five-section cluster (doghouse) display, placed over the wide line between the left turn lane and the adjacent through lane.

Where there is no separate left-turn lane, only a five-section vertical (recommended) or cluster display may be used. The five-section display is used in place of the left of the two required through displays for that approach.

Protected/permissive displays may run as lead or lag. The display cycle will depend on the display type and whether the protected left leads or lags:

- Leading 4-section FYA: steady green arrow, steady yellow arrow, steady red arrow, flashing yellow arrow, steady yellow arrow, steady red arrow.
- Leading 5-section: green arrow, yellow arrow, red ball, green ball, yellow ball, red ball. Option: green ball may come up with green arrow, but the arrow and ball displays should cycle to yellow and red together (similar to lagging 5-section)
- Lagging 4-section FYA: flashing yellow arrow, steady green arrow, steady yellow arrow, steady red arrow
- Lagging 5-section: green ball, green ball with green arrow, yellow ball with yellow arrow, red.

A permissive left turn phase shall not terminate separately from the conflicting phase(s) (typically, the opposing through phase). This is to prevent placing left turning traffic in a yellow trap.

3. Protected Left-Turn Phasing

Protected left-turn phasing provides the left-turning vehicle a separate phase, and conflicting movements are required to stop.

Use protected left-turn phasing under the following conditions:

a. Multi-lane left turn movements, including left and through-left from the same approach.

b. The left-turn is onto a roadway with a rail crossing.

c. Where Warrant 7 is met and there are five or more left-turning collisions on that approach included in the warranting collisions. Protected left-turn phasing is recommended even when there are as few as three left-turning collisions on that approach. This includes left-turning collisions involving pedestrians.

d. Where the peak-hour turning volume exceeds the storage capacity of the left-turn lane and one or more of the following conditions is present:

   i. The posted speed or the 85th percentile speed of the opposing traffic is 45 mph or higher.

   ii. The sight distance to oncoming traffic is less than 250 feet when the posted or 85th percentile speed is 35 mph or below, or less than 400 feet when the posted or 85th percentile speed is above 35 mph.

   iii. The left-turn movement crosses three or more lanes (including right-turn lanes) of opposing traffic.

   iv. Geometry or channelization is confusing, such as skewed intersections, offset-T intersections, or intersections which require unusual maneuvers to traverse.

There are three typical operational arrangements for protected left turns:

- Leading Lefts: The left turns are served before the associated through movements. This is the most common operational arrangement. Example: Phases 1 and 5 (major street lefts) are served first, then phases 2 and 6 (major street throughs) are served.
- Lagging Lefts: The left turns are served after the associated through movements. Example: Phases 4 and 8 (minor street throughs) are served first, then phases 3 and 7 (minor street lefts) are served.
- Offset (or Lead/Lag) Lefts: One left turn is served before the associated through movements, and the opposing left turn is served after the associated through movements. Example: Phase 1 (one major left turn) is served first (phase 6 may be served at the same time), then phases 2 and 6 (major throughs) are served, and then phase 5 (opposing major left turn) is served (phase 2 may still be served with phase 5).

Check that all turning movements provide turning clearance for opposing turn phases. If the opposing left-turning vehicle paths do not have 4-foot minimum—12-foot desirable—separation between them, split or offset (lead/lag) phasing will have to be used.

1330.06(2) Right-Turn Phasing

Right turns typically do not operate with their own phasing unless there is a dedicated right turn lane. When there is no dedicated right turn lane, right turns are normally a permissive movement from the right most through lane, depending on pedestrian phases in use. When there is a dedicated right turn lane, right-turn phasing effectively operates the same as left-turn phasing.

Dedicated right turn lanes may be operated the same as left turn lanes: permissive, protected/permissive, or protected. However, right turn phase operation needs to take into account any pedestrian crossing on the receiving side of the right turn. If there is a conflicting pedestrian phase – typically a pedestrian phase running concurrent with the through phase from which the right turn is being made – the right turn phase may only be operated as permissive.

Dedicated right turn lanes operated as permissive and protected/permissive are recommended to have their own displays, but may use a shared display with the adjacent through lane. Dedicated right turn lanes operated as protected must use their own display. Right turn displays are arranged and operated the same as those listed for left turns in 1330.06(1).

Separate right turn phasing also needs to consider some additional operational modes and issues:

1. Right-Turn Overlapped Phasing

A right turn overlap is when a protected right turn is allowed at the same time as a complementary protected left turn, and is recommended when the lane and phase configuration will support this operation. When this operation is used, the left turn must be signed that U-turns are prohibited.

When right turn overlaps are used, the wiring of the right turn displays will depend on the operating mode of each display section:

- Permissive: Connect permissive display sections to the same terminals as the associated through phase.
- Protected: Protected display sections may either be:
  - (a) Connected to the complementary left turn phase. Use this arrangement when the protected right turn will only be run concurrent with the complementary left turn phase.
  - (b) Connected to an overlap phase. Use this arrangement when the protected right turn will be run with both the complementary left turn phase and with the through phase associated with the right turn.

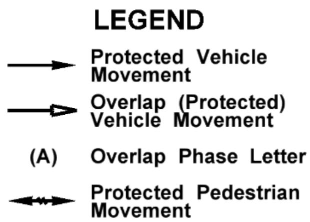
2. Multiple-Lane Right-Turn Phasing

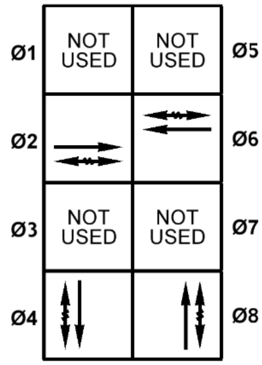
Multiple-lane right turns may be run independent or overlapped as described above. Multiple-lane right turns can cause operational challenges when “right turn on red” is permitted at the intersection. Verify that there is adequate sight distance and adequate receiving lanes are available to minimize the possibility of collisions. In most cases, a single unrestricted “right-turn-only” lane approach with a separate receiving lane (auxiliary lane) will have a similar capacity as the two lane right-turn phasing.

1330.06(3) Typical Signal Phasing Arrangements

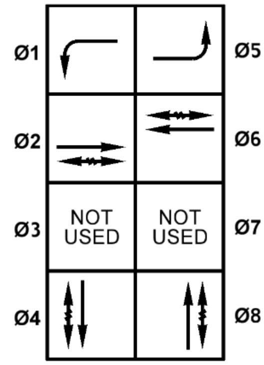
The following diagrams show typical phasing diagrams for four-way and three-way intersections.

Exhibit 1330-22 Phase Diagrams: Four-Way Intersections

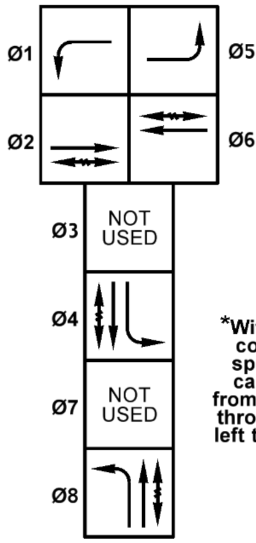




Basic Four Phase Operation
All permissive left turns

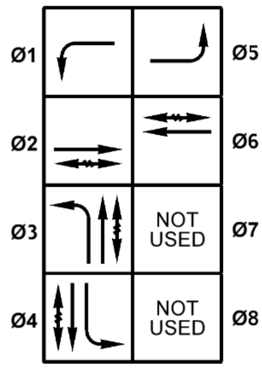


Six Phase Operation
Main Street protected lefts
Minor Street permissive lefts

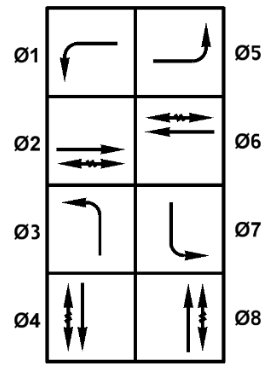


Split Phase (Six Phase) Operation*
Main Street protected lefts
Minor Street split - protected lefts
with concurrent through

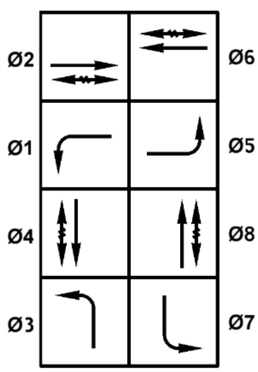
***With modern controllers, split phases can be run from either the through or the left turn phase.**



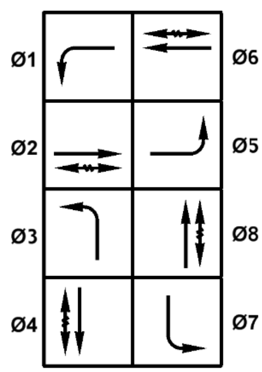
Split Phase (Six Phase) Operation*
(Alternate Arrangement)
Main Street protected lefts
Minor Street split - protected lefts
with concurrent through



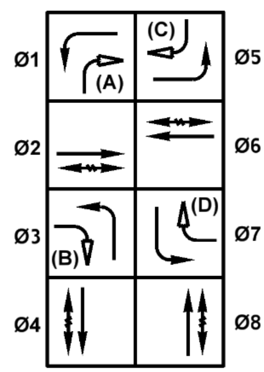
Eight Phase Operation:
Typical
Leading protected left turns



Eight Phase Operation:
Lagging Lefts
Lagging protected left turns



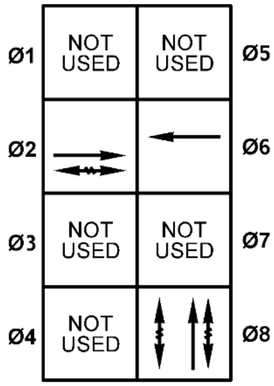
Eight Phase Operation:
Split Lefts
Opposing left turns split
between leading and lagging



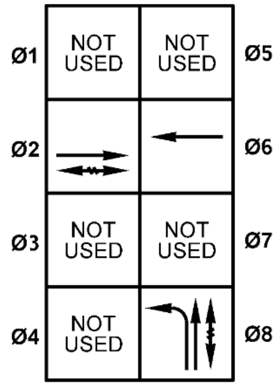
Eight Phase Operation:
Overlaps
Leading protected left turns with overlapped protected right turns. Right turns may be permissive with associated through phase.

If right turns are protected with concurrent through phase, negative pedestrian overlaps must be used.

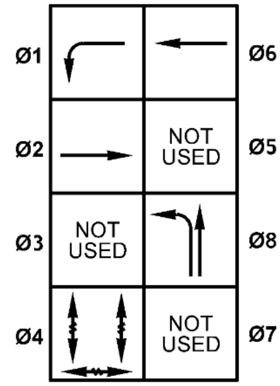
Exhibit 1330-23 Phase Diagrams: Three-Way Intersections



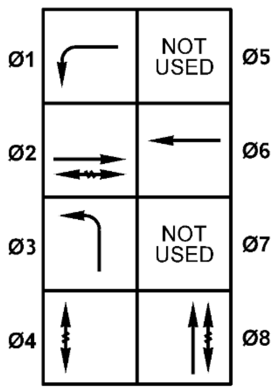
Basic Three Phase Operation
All permissive turns



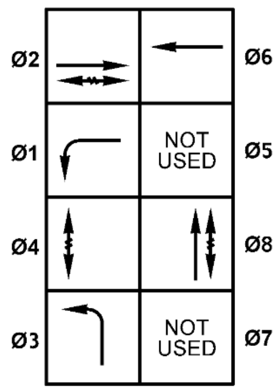
Three Phase Operation: Restricted Peds
Protected left turn from side street by removing conflicting pedestrian phase (and crossing)



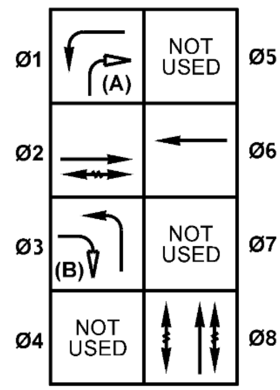
Five Phase Operation: Exclusive Peds
All pedestrian crossings run together as separate phase



Six Phase Operation: Typical
Leading protected left turns



Six Phase Operation: Lagging Lefts
Lagging protected left turns



Six Phase Operation: Overlaps
Leading protected left turns with overlapped protected right turns. Right turns may be permissive with associated through phase.

If right turns are protected with concurrent through phase, negative pedestrian overlaps must be used.

LEGEND

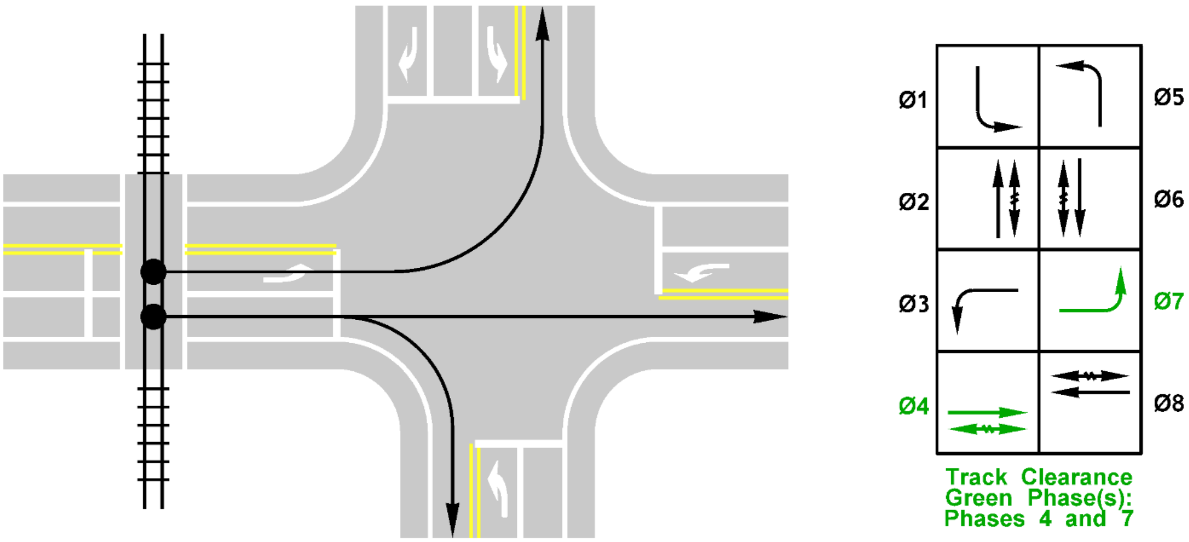
- **Protected Vehicle Movement**
- **Overlap (Protected) Vehicle Movement**
- (A) **Overlap Phase Letter**
- **Protected Pedestrian Movement**

1330.06(4) Phasing at Railroad Crossings

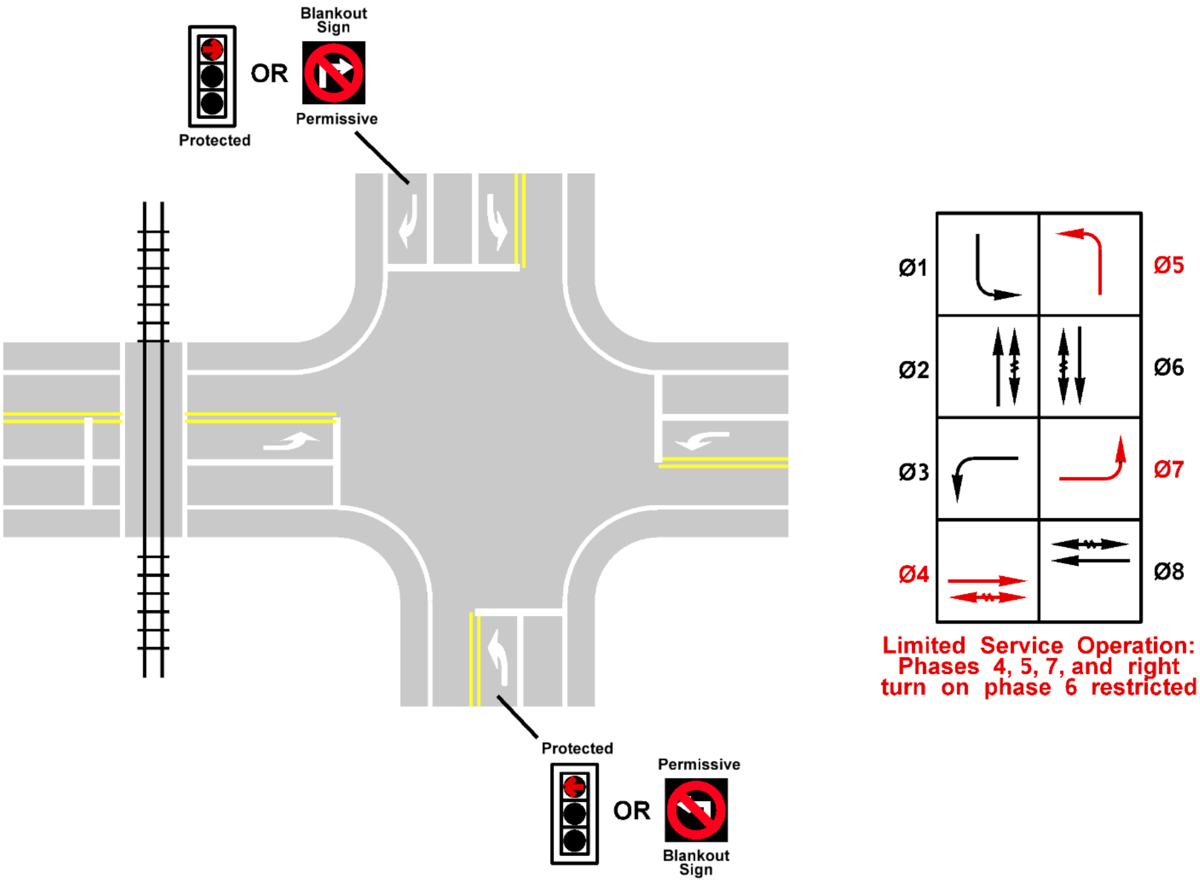
Traffic signals near railroad crossings have additional special phasing arrangements. To provide for efficient signal operations during a rail crossing, ensure that there are dedicated turn lanes for movements turning onto the tracks. These turn lanes should be on their own dedicated phases, so that they may be omitted from the signal timing (held in red) during the rail crossing. This allows for as many of the other intersection movements as possible to continue to operate – a timing scheme referred to as “Limited Service Operation” (LSO).

Just prior to LSO, when railroad preemption is used, the traffic signal will shift to a “Track Clearance Green” (TCG) phase. TCG shifts non-conflicting phases to green to allow vehicles to clear the railroad tracks. Examples of a TCG phase and LSO are shown in Exhibit 1330-24. Standalone queue cutter signals do not have a TCG phase – contact the HQ Traffic Office for operational guidance on standalone queue cutter signals.

Exhibit 1330-24 Phasing at Railroad Crossings



Track Clearance Green



Limited Service Operation

1330.07 Documentation

The following original signal design documents shall be included in a Signal System file and provided to the region Traffic Office or owning agency:

1. Signal Permit, including Signal Warrant Analysis and supporting documentation.
2. FHWA Approval for Experimentation.
3. Signal Standard Design Chart, including signal support engineering calculations.
4. Signal Detection Zone Placement. Include calculations if used.
5. Signal Wiring Diagram and Conduit Fill calculations.
6. Railroad preemption calculation and interconnect setup.
7. Any third party documentation provided.
8. Approved Preliminary Signal Plan.
9. Emergency Preemption Equipment selected.
10. Transit Priority Preemption and associated agreements.

Copies of items 1 and 2 are also required to be included in the Design Documentation Package (DDP). Copies of items 3 through 10 are also required to be included in the Project File (PF).

Refer to Chapter 300 for additional design documentation requirements.

1330.08 References

The following references are used in the planning, design, construction, and operation of traffic control signals installed on state highways. The RCWs noted are specific state laws concerning traffic control signals, and conformance to these statutes is required.

1330.08(1) Federal/State Laws and Codes

Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35)

Revised Code of Washington (RCW) 35.77, Streets – Planning, establishment, construction, and maintenance

RCW 46.04.450, Railroad sign or signal

RCW 46.04.600, Traffic control signal

RCW 46.04.62250, Signal preemption device

RCW 46.61.050, Obedience to and required traffic control devices

RCW 46.61.055, Traffic control signal legend

RCW 46.61.060, Pedestrian control signals

RCW 46.61.065, Flashing signals

RCW 46.61.070, Lane-direction-control signals

RCW 46.61.072, Special traffic control signals – Legend

RCW 46.61.075, Display of unauthorized signs, signals, or markings

RCW 46.61.080, Interference with official traffic-control devices or railroad signs or signals

RCW 46.61.085, Traffic control signals or devices upon city streets forming part of state highways – Approval by department of transportation

RCW 46.61.340, Approaching train signal

RCW 47.24.020(6) and (13), Jurisdiction, control

RCW 47.36.020, Traffic control signals

RCW 47.36.060, Traffic devices on county roads and city streets

Washington Administrative Code (WAC) 468 18-040, Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings

WAC 468-18-050, Policy on the construction, improvement and maintenance of intersections of state highways and city streets

"City Streets as Part of State Highways: Guidelines Reached by the Washington State Department of Transportation and the Association of Washington Cities on the Interpretation of Selected Topics of RCW 47.24 and Figures of WAC 468-18-050 for the Construction, Operations and Maintenance Responsibilities of WSDOT and Cities for Such Streets," April 30, 1997.

1330.08(2) Design Guidance

A Policy on the Geometric Design of Highways and City Streets (Green Book), AASHTO

Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings (TxDOT Form 2304) and Instructions for Form 2304 (TxDOT Form 2304-I), Texas Department of Transportation
http://www.txdot.gov/inside-txdot/forms-publications/forms/rail.html

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

Plans Preparation Manual, M 22-31, WSDOT

Revised Draft Guidelines for Accessible Public Rights-of-Way, (PROWAG), November 23, 2005, United States Access Board

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21 01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

WSDOT Traffic Design Resources
www.wsdot.wa.gov/design/traffic/

1360.01 General

The primary purpose of an interchange is to reduce conflicts caused by vehicle crossings and minimize conflicting left-turn movements. Provide interchanges on all Interstate highways and freeways, and at other locations where traffic cannot be controlled efficiently by intersections at grade.

For additional information, see the following chapters:

Chapter	Subject
520	Access control
530	Limited access
550	Interchange justification report
1103	Design controls
1106	Design element dimensions
1240	Turning widths
1250	Cross Slope and Superelevation
1310	Intersections
1410	HOV lanes
1420	HOV direct access connections

1360.02 Interchange Design

1360.02(1) General

All freeway exits and entrances, except HOV direct access connections, are to connect on the right of through traffic. Variations from this will be considered only for special conditions.

HOV direct access connections may be constructed on the left of through traffic when they are designed in accordance with Chapter 1420.

Provide complete ramp facilities for all directions of travel wherever possible. However, give primary consideration to the basic traffic movement function that the interchange is to fulfill.

Complications are rarely encountered in the design and location of rural interchanges that simply provide a means of exchanging traffic between a limited access freeway and a local crossroad. Carefully consider the economic and operational effects of locating traffic interchanges along a freeway through a community, particularly with respect to local access, to provide convenient local service without reducing the capacity of the major route(s).

Where freeway-to-freeway interchanges are involved, do not provide ramps for local access unless they can be added conveniently and without detriment to efficient traffic flow or reduction of capacity, either ramp or freeway main line. When exchange of traffic between freeways is the basic function, and local access is prohibited by access control restrictions or traffic volume, separate interchanges for local service may be needed.

1360.02(2) Interchange Patterns

Basic interchange patterns have been established that can be used under certain general conditions and modified or combined to apply to many more. Consider alternatives in the design of a specific facility; however, the conditions in the area and on the highway involved govern the final design of the interchange.

Selection of the final design is based on a study of projected traffic volumes, site conditions, geometric controls, criteria for intersecting legs and turning roadways, driver expectancy, consistent ramp patterns, continuity, and cost.

The patterns most frequently used for interchange design are those commonly described as directional, semidirectional, cloverleaf, partial cloverleaf, diamond, and single point (urban) interchange (see Exhibit 1360-1).

1360.02(2)(a) Directional

A directional interchange is the most effective design for connection of intersecting freeways. The directional pattern has the advantage of reduced travel distance, increased speed of operation, and higher capacity. These designs eliminate weaving and have a further advantage over cloverleaf designs in avoiding the loss of sense of direction drivers experience in traveling a loop. This type of interchange is costly to construct, commonly using a four-level structure.

1360.02(2)(b) Semidirectional

A semidirectional interchange has ramps that loop around the intersection of the highways. This results in multiple single-level structures and more area than the directional interchange.

1360.02(2)(c) Cloverleaf

The full cloverleaf interchange has four loop ramps for the left-turning traffic. Outer ramps provide for the right turns. A full cloverleaf is the minimum type interchange for a freeway-to-freeway interchange. Cloverleaf designs often incorporate a C-D road to minimize signing difficulties and remove weaving conflicts from the main roadway.

The principal advantage of this design is the elimination of all left-turn conflicts with one single-level structure. Because all movements are merging movements, it is adaptable to any grade line arrangement.

The cloverleaf has some major disadvantages. The left-turn movement has a circuitous route on the loop ramp, the speeds are low on the loop ramp, and there are weaving conflicts between the loop ramps. The cloverleaf also needs a large area. The weaving and the radius of the loop ramps are a capacity constraint on the left-turn movements.

1360.02(2)(d) Partial Cloverleaf (PARCLO)

A partial cloverleaf has loop ramps in one, two, or three quadrants that are used to eliminate the major left-turn conflicts. These loops may also serve right turns for interchanges where ramp cannot be built in one or two quadrants. Outer ramps are provided for the remaining turns. Design the grades to provide sight distance between vehicles approaching these ramps.

1360.02(2)(e) Diamond

A diamond interchange has four ramps that are essentially parallel to the major arterial. Each ramp provides for one right-turn and one left-turn movement. Because left turns are made at grade across conflicting traffic on the crossroad, intersection sight distance is a primary consideration.

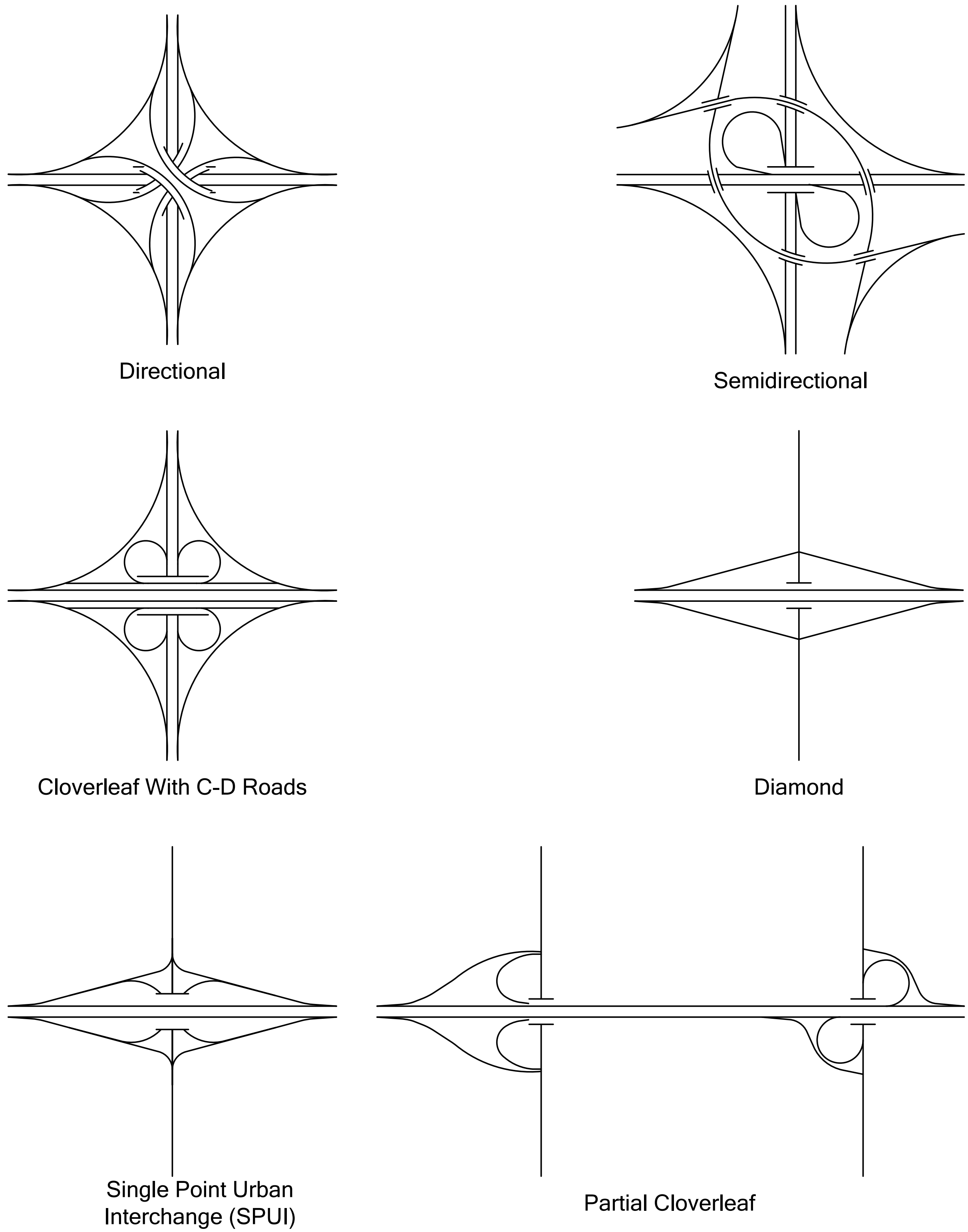
The diamond design is the most generally applicable and serviceable interchange configuration and usually has a smaller footprint than any other type. Consider this design first unless another design is clearly dictated by traffic, topography, or special conditions.

1360.02(2)(f) Single Point Urban (SPUI)

A single point urban interchange is a modified diamond with all of its ramp terminals on the crossroad combined into one signalized at-grade intersection. This single intersection accommodates all interchange and through movements.

A single point urban interchange can improve the traffic operation on the crossroad with less right of way than a typical diamond interchange, but a larger structure.

Exhibit 1360-1 Basic Interchange Patterns



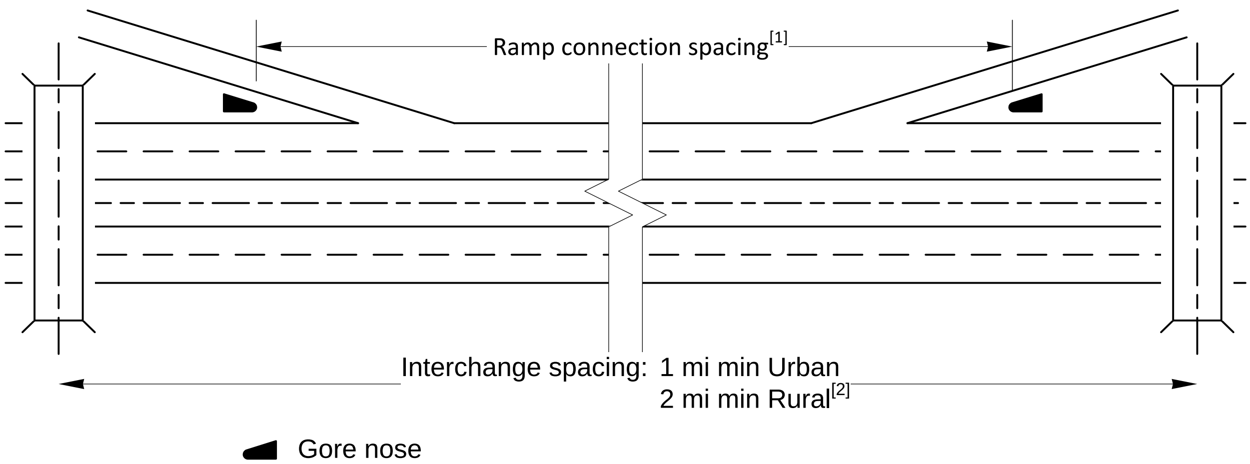
1360.02(3) Spacing

To avoid excessive interruption of main line traffic, consider each proposed facility in conjunction with adjacent interchanges, intersections, and other points of access along the route as a whole.

The minimum spacing between adjacent interchanges is 1 mile in urban areas, 3 miles on the Interstate in rural areas, and 2 miles on non-Interstate in rural areas (see Exhibit 1360-2). In urban areas, spacing less than 1 mile may be used with C-D roads or grade-separated (braided) ramps. Interchange spacing is measured along the freeway centerline between the centerlines of the crossroads.

The spacing between interchanges may also be dependent on the spacing between ramp connections. The minimum spacing between the gore noses of adjacent ramps is given in Exhibit 1360-3.

Exhibit 1360-2 Interchange Spacing



Notes:

[1] As a minimum, provide length for weaving and signing, but not less than given in Exhibit 1360-3.

[2] 3 miles on the Interstate System.

Consider either frontage roads or C-D roads to facilitate the operation of near-capacity volumes between closely spaced interchanges or ramp terminals. C-D roads may be needed where cloverleaf loop ramps are involved or where a series of interchange ramps have overlapping speed change lanes. Base the distance between successive ramp terminals on capacity. Check the intervening sections by weaving analyses to determine whether capacity, sight distance, and effective signing can be provided without the use of auxiliary lanes or C-D roads.

Provide justifications for existing interchanges with less-than-desirable spacing or ramp connection spacing to remain in place.

1360.02(4) Route Continuity

Route continuity is providing the driver of a through route a path on which lane changes are minimized and other traffic operations occur to the right.

In maintaining route continuity, interchange configuration may not favor the heavy traffic movement, but rather the through route. In this case, design the heavy traffic movements with multilane ramps, flat curves, and reasonably direct alignment.

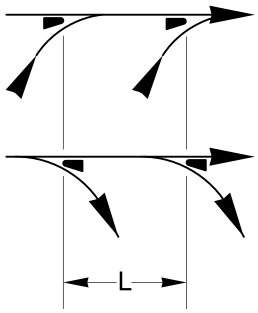
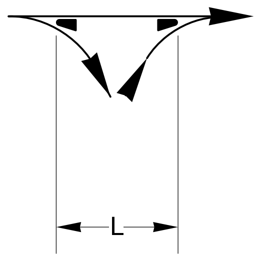
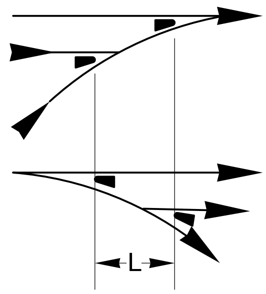
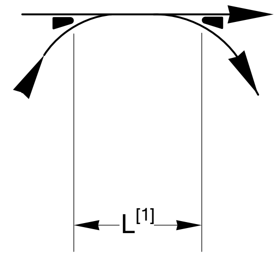
1360.02(5) Drainage

Avoid interchanges located in proximity to natural drainage courses. These locations often result in complex and unnecessarily costly hydraulic structures. The open areas within an interchange can be used for stormwater detention facilities.

1360.02(6) Uniformity of Exit Pattern

While interchanges are of necessity custom-designed to fit specific conditions, it is desirable that the pattern of exits along a freeway have some degree of uniformity. From the standpoint of driver expectancy, it is desirable that each interchange have only one point of exit, located in advance of the crossroad.

Exhibit 1360-3 Minimum Ramp Connection Spacing

On-On or Off-Off		Off-On		Turning Roadways		On-Off (Weaving)			
									
Freeway	C-D Road	Freeway	C-D Road	System[2] Interchange	Service[3] Interchange	A	B	C	D
1,000	800	500	400	800	600	2000	1600	1600	1000

Gore nose

L = Minimum distance in feet from gore nose to gore nose.

A = Between two interchanges connected to a freeway: a system interchange[2] and a service interchange.[3]

B = Between two interchanges connected to a C-D road: a system interchange[2] and a service interchange.[3]

C = Between two interchanges connected to a freeway: both service interchanges.[3]

D = Between two interchanges connected to a C-D road: both service interchanges.[3]

Notes:

These values are based on operational experience, need for flexibility, and signing. Check them in accordance with Exhibit 1360-12 and the procedures outlined in the *Highway Capacity Manual*, and use the larger value.

[1] With justification, these values may be reduced for cloverleaf ramps.

[2] A system interchange is a freeway-to-freeway interchange.

[3] A service interchange is a freeway-to-local road interchange.

1360.03 Ramps

1360.03(1) Ramp Design Speed

The design speed for a ramp is based on the design speed for the freeway main line.

It is desirable that the ramp design speed at the connection to the freeway be equal to the free-flow speed of the freeway. Meet or exceed the upper range values from Exhibit 1360-4 for the design speed at the ramp connection to the freeway. Transition the ramp design speed to provide a smooth acceleration or deceleration between the speeds at the ends of the ramp. However, do not reduce the ramp design speed below the lower-range speed of 25 mph. For loop ramps, use a design speed as high as feasible, but not lower than 25 mph.

These design speed guidelines do not apply to the ramp in the area of the ramp terminal at-grade intersection. In the area of the intersection, use a design speed of 15 mph for turning traffic or 0 mph for a stop condition. Use the allowed skew at the ramp terminal at-grade intersection to minimize ramp curvature.

For freeway-to-freeway ramps and C-D roads, the design speed at the connections to both freeways is the upper range values from Exhibit 1360-4; however, with justification, the midrange values from Exhibit 1360-4 may be used for the remainder of the ramp. When the design speed for the two freeways is different, use the higher design speed.

Existing ramps meet design speed criteria if acceleration or deceleration criteria are met (see Exhibit 1360-9 or 1360-10) and superelevation meets the criteria in Chapter 1250.

Exhibit 1360-4 Ramp Design Speed

Main Line Design Speed (mph)		50	55	60	65	70	80
Ramp Design Speed (mph)	Upper Range	45	50	50	55	60	70
	Midrange	30	40	45	45	50	60
	Lower Range	25	25	25	25	25	25

1360.03(2) Sight Distance

Design ramps in accordance with the provisions in Chapter 1260 for stopping sight distances.

1360.03(3) Grade

The maximum grade for ramps for various design speeds is given in Exhibit 1360-5.

Exhibit 1360-5 Maximum Ramp Grade

Ramp Design Speed (mph)		25 – 30	35 – 40	45 and above
Ramp Grade (%)	Desirable	5	4	3
	Maximum *	7	6	5
* On one-way ramps, downgrades may be 2% greater				

1360.03(4) Cross Section

Provide the ramp widths given in Exhibit 1360-6. Ramp traveled ways may need additional width when operational needs exist.

Cross slope and superelevation criteria for ramp traveled ways and shoulders are as given in Chapter 1250 for roadways. At ramp terminals, the intersection lane and shoulder width design guidance shown in Chapter 1310 may be used.

Whenever feasible, make the ramp cross slope at the ramp beginning or ending station equal to the cross slope of the through lane pavement. Where space is limited and superelevation runoff is long, or when parallel connections are used, the superelevation transition may be ended beyond (for on-ramps) or begun in advance of (for off-ramps) the ramp beginning or ending station, provided that the algebraic difference in cross slope at the edge of the through lane and the cross slope of the ramp does not exceed 4%. In such cases, provide smooth transitions for the edge of traveled way.

Exhibit 1360-6 Ramp Widths

Number of Lanes			1	2
Ramp Width (ft)	Traveled Way [1]		11-13 [5]	23-25 [3] [5]
	Shoulders	Right	4-8 [2] [5]	4-8 [2] [5]
		Left	2	2-4
	Medians [4]		6	6-8

Notes:

[1] Evaluate shoulder use to accommodate offtracking, if determined inadequate for operational performance needs, apply turning roadway widths in Chapter 1240.

[2] Provide width necessary to accommodate offtracking by large vehicles.

[3] Add 12 ft for each additional lane.

[4] The minimum two-way ramp median width (including shoulders) is given. Wider medians may be required for signs or other traffic control devices and their respective clearances. When either the on- or off-ramp is single-lane, use the one-lane column. If both directions are two lanes, use the two-lane column.

[5] Use the mode/function/performance approach described in Chapter 1106 to choose between the range of widths given.

Ramp shoulders may be used by large trucks for offtracking and by smaller vehicles cutting to the inside of curves. Evaluate the need to pave shoulders full depth for larger vehicle offtracking using turn simulation software on one-way ramps to accommodate this type of use. If operational performance needs demonstrate that accommodation of offtracking on shoulders is inadequate apply turning roadway widths in Chapter 1240.

1360.03(5) Two-Way Ramps

Two-way ramps are on- and off-ramps on a single roadway. Design two-way ramps as separate one-way ramps. Provide a raised median to physically separate the on- and off- ramps. Wider medians than given in Exhibit 1360-6 may be required for signing or other traffic control devices and their clearances. (For signs, it is sign width plus 4 feet.) Where wider medians are required, provide a 2-foot clearance between the face of curb and the edge of traveled way. Where additional width is not required, the raised median width may be reduced to a double-faced mountable or extruded curb. Traffic barrier or a depressed median may be provided in place of the raised median.

1360.03(6) Ramp Lane Increases

When off-ramp traffic and left-turn movement volumes at the ramp terminal at-grade intersection cause excessive queue length, it may be desirable to add lanes to the ramp to reduce the queue length caused by congestion and turning conflicts. Make provision for the addition of ramp lanes whenever ramp exit or entrance volumes are expected to result in an undesirable mobility or safety performance. (See Chapter 1210 for width transition design.)

1360.03(7) Ramp Meters

Ramp meters are used to allow a measured or regulated amount of traffic to enter the freeway. When operating in the “measured” mode, they release traffic at a measured rate to keep downstream demand below capacity and improve system travel times. In the “regulated” mode, they break up platoons of vehicles that occur naturally or result from nearby traffic signals. Even when operating at near capacity, a freeway main line can accommodate merging vehicles one or two at a time, while groups of vehicles will cause main line flow to break down.

The location of the ramp meter is a balance between the storage and acceleration criteria. Locate the ramp meter to maximize the available storage and so that the acceleration lane length, from a stop to the freeway main line design speed, is available from the stop bar to the merging point. With justification, the average main line running speed during the hours of meter operation may be used for the highway design speed to determine the minimum acceleration lane length from the ramp meter. (See 1360.04(4) for information on the design of on-connection acceleration lanes and Chapter 1050 for additional information on the design of ramp meters.)

Driver compliance with the signal is required for the ramp meter to have the desired results. Consider enforcement areas with metered ramps.

Consider HOV bypass lanes with ramp meters. (See Chapter 1410 for design data for ramp meter bypass lanes.)

1360.04 Interchange Connections

To the extent practicable, provide uniform geometric design and uniform signing for exits and entrances in the design of a continuous freeway. Do not design an exit ramp as an extension of a main line tangent at the beginning of a main line horizontal curve.

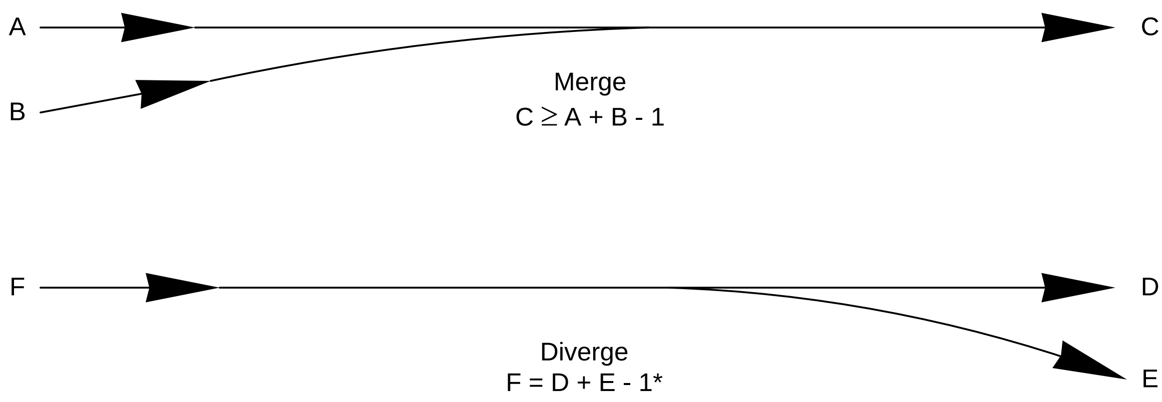
Provide spacing between interchange connections as given in Exhibit 1360-3.

Avoid on-connections on the inside of a main line curve, particularly when the ramp approach angle is accentuated by the main line curve, the ramp approach results in a reverse curve to connect to the main line, or the elevation difference will cause the cross slope to be steep at the nose.

Keep the use of mountable curb at interchange connections to a minimum.

Provide justification when curb is used adjacent to traffic with a design speed of 40 mph or higher.

Exhibit 1360-7a Lane Balance



*Note: Number of lanes (F) may increase by one lane, when the lane is an auxiliary lane between closely spaced entrance and exit ramps.

1360.04(1) Lane Balance

Design interchanges to the following principles of lane balance:

1360.04(1)(a) Entrances

At entrances, make the number of lanes beyond the merging of two traffic streams not less than the sum of all the lanes on the merging roadways less one (see Exhibit 1360-7a).

1360.04(1)(b) Exits

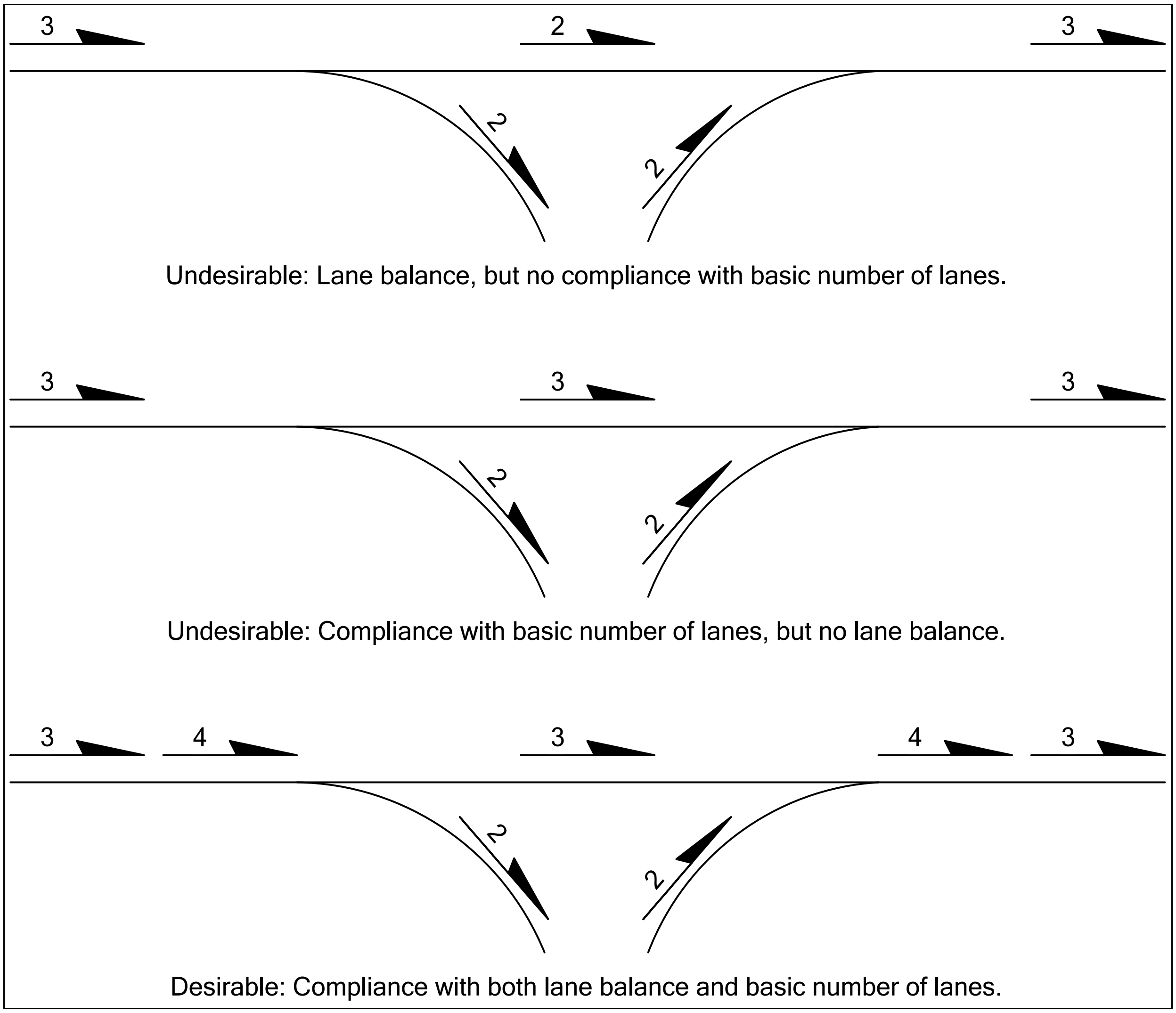
At exits, make the number of approach lanes equal the number of highway lanes beyond the exit plus the number of exit lanes less one (see Exhibit 1360-7a). Exceptions to this are:

- At a cloverleaf.
- At closely spaced interchanges with a continuous auxiliary lane between the entrance and exit.

In these cases, the auxiliary lane may be dropped at a single-lane, one-lane reduction off-connection (Exhibit 1360-14c), with the number of approach lanes being equal to the sum of the highway lanes beyond the exit and the number of exit lanes. Closely spaced interchanges have a distance of less than 2,100 feet between the end of the acceleration lane and the beginning of the deceleration lane.

Maintain the basic number of lanes, as described in Chapter 1210, through interchanges. When a two-lane exit or entrance is used, maintain lane balance with an auxiliary lane (see Exhibit 1360-7b). The exception to this is when the basic number of lanes is changed at an interchange.

Exhibit 1360-7b Lane Balance



1360.04(2) Main Line Lane Reduction

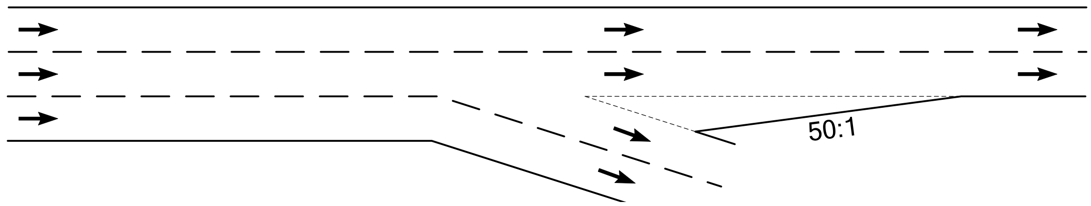
The reduction of a basic lane or an auxiliary lane may be made at a two-lane exit or may be made between interchanges. When a two-lane exit is used, provide a recovery area with a normal acceleration taper. When a lane is dropped between interchanges, drop it 1,500 to 3,000 feet from the end of the acceleration taper of the previous interchange. This allows for signing but will not be so far that the driver becomes accustomed to the number of lanes and will be surprised by the reduction (see Exhibit 1360-8).

Reduce the traveled way width of the freeway by only one lane at a time.

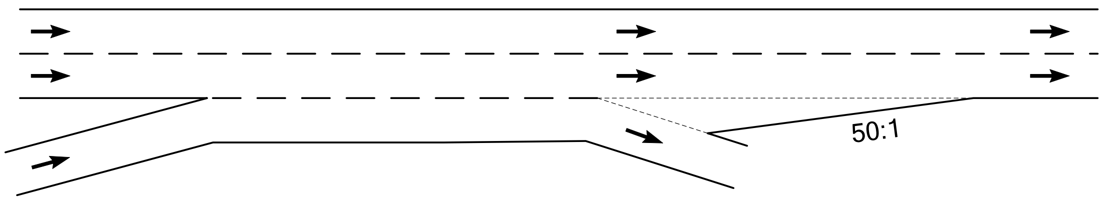
1360.04(3) Sight Distance

Locate off-connections and on-connections on the main line to provide decision sight distance for a speed/path/direction change as described in Chapter 1260.

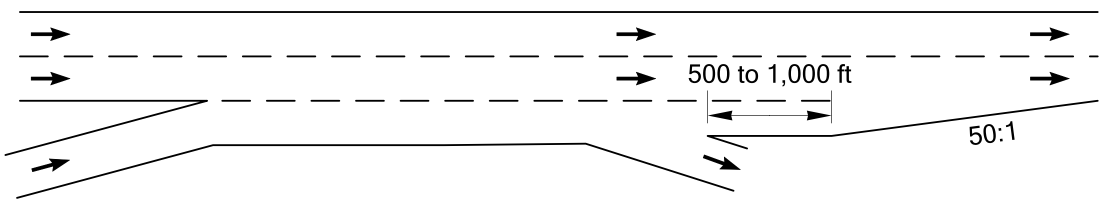
Exhibit 1360-8 Main Line Lane Reduction Alternatives



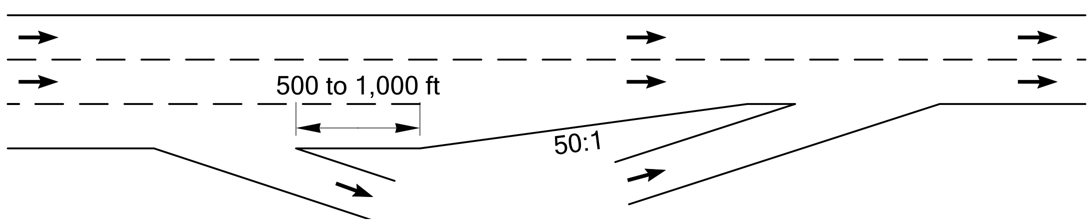
Lane dropped at two-lane off-connection



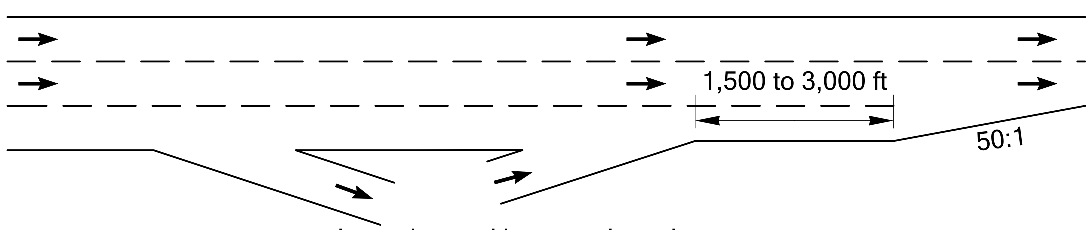
Lane between closely spaced ramps
dropped at single-lane off-connection
(lane imbalance for weaving)



Lane between closely spaced ramps
dropped at single-lane off-connection
(lane balance for weaving)



Lane dropped within intersection



Lane dropped between interchanges

1360.04(4) On-Connections

On-connections are the paved areas at the end of on-ramps that connect them to the main lane of a freeway. They have two parts: an acceleration lane and a taper. The acceleration lane allows entering traffic to accelerate to the freeway speed and evaluate gaps in the freeway traffic. The taper is for the entering vehicle to maneuver into the through lane.

On-connections are either tapered or parallel. The tapered on-connection provides direct entry at a flat angle, reducing the steering control needed. The parallel on-connection adds a lane adjacent to the through lane for acceleration with a taper at the end. Vehicles merge with the through traffic with a reverse curve maneuver similar to a lane change. While less steering control is needed for the taper, the parallel is narrower at the end of the ramp and has a shorter taper at the end of the acceleration lane.

1360.04(4)(a) Acceleration Lane

Provide the minimum acceleration lane length, given in Exhibit 1360-9, for each ramp design speed on all on-ramps. When the average grade of the acceleration lane is 3% or greater, multiply the distance from the Minimum Acceleration Lane Length table by the factor from the Adjustment Factor for Grades table.

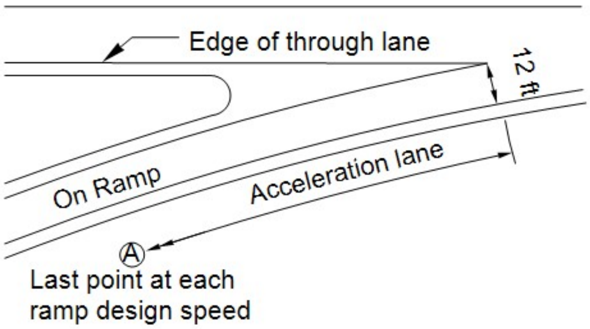
For existing ramps that do not have significant crashes in the area of the connection with the freeway, the freeway posted speed may be used to calculate the acceleration lane length for Preservation projects. If corrective action is indicated, use the freeway design speed to determine the length of the acceleration lane.

The acceleration lane is measured from the last point designed at each ramp design speed (usually the PT of the last curve for each design speed) to the last point of the ramp width. Curves designed at higher design speeds may be included as part of the acceleration lane length.

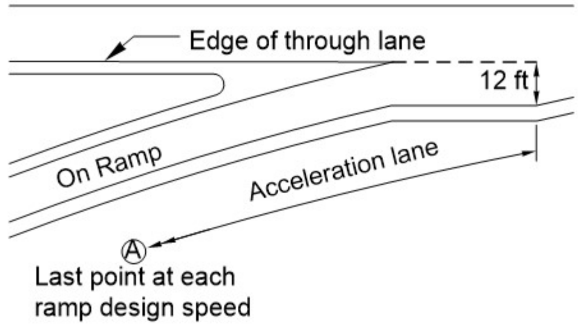
1360.04(4)(b) Gap Acceptance

For parallel on-connections, provide the minimum gap acceptance length (Lg) to allow entering motorists to evaluate gaps in the freeway traffic and position their vehicles to use the gap. The length is measured beginning at the point that the left edge of traveled way for the ramp intersects the right edge of traveled way of the main line to the ending of the acceleration lane (see Exhibits 1360-13b and 13c). The gap acceptance length and the acceleration length overlap, with the ending point controlled by the longer of the two.

Exhibit 1360-9 Acceleration Lane Length



Tapered On-Connection



Parallel On-Connection

Highway Design Speed (mph)	Ramp Design Speed (mph)										
	0	15	20	25	30	35	40	45	50	60	70
30	180	140									
35	280	220	160								
40	360	300	270	210	120						
45	560	490	440	380	280	160					
50	720	660	610	550	450	350	130				
55	960	900	810	780	670	550	320	150			
60	1200	1140	1100	1020	910	800	550	420	180		
65	1410	1350	1310	1220	1120	1000	770	600	370		
70	1620	1560	1520	1420	1350	1230	1000	820	580	210	
80	2000	1950	1890	1830	1730	1610	1380	1200	970	590	210

Minimum Acceleration Lane Length (ft)

Highway Design Speed (mph)	Grade	Upgrade				Downgrade
		Ramp Design Speed				All Ramp Design Speeds
		20	30	40	50	
40	3% to less than 5%	1.3	1.3			0.70
45		1.3	1.35			0.675
50		1.3	1.4	1.4		0.65
55		1.35	1.45	1.45		0.625
60		1.4	1.5	1.5	1.6	0.60
70		1.5	1.6	1.7	1.8	0.60
40	5% or more	1.5	1.5			0.60
45		1.5	1.6			0.575
50		1.5	1.7	1.9		0.55
55		1.6	1.8	2.05		0.525
60		1.7	1.9	2.2	2.5	0.50
70		2.0	2.2	2.6	3.0	0.50

Adjustment Factors for Grades Greater Than 3%

Note: Lane widths are shown for illustrative purposes. Determine lane widths based on Exhibit 1360-6.

1360.04(4)(c) Single-Lane On-Connections

Single-lane on-connections may be either tapered or parallel. The tapered is desirable; however, the parallel may be used with justification. Design single-lane tapered on-connections as shown in Exhibit 1360-13a and single-lane parallel on-connections as shown in Exhibit 1360-13b.

1360.04(4)(d) Two-Lane On-Connections

For two-lane on-connections, the parallel is desirable. Design two-lane parallel on-connections as shown in Exhibit 1360-13c. A capacity analysis will normally be the basis for determining whether a freeway lane or an auxiliary lane is to be provided.

Justify the use of a two-lane tapered on-connection. Design two-lane tapered on connections in accordance with Exhibit 1360-13d.

1360.04(5) Off-Connections

Off-connections are the paved areas at the beginning of an off-ramp, connecting it to a main lane of a freeway. They have two parts: a taper for maneuvering out of the through traffic and a deceleration lane to slow to the speed of the first curve on the ramp. Deceleration is not assumed to take place in the taper.

Off-connections are either tapered or parallel. The tapered is desirable because it fits the normal path for most drivers. When a parallel connection is used, drivers tend to drive directly for the ramp and not use the parallel lane. However, when a ramp is on the outside of a curve, the parallel off-connection is desirable. An advantage of the parallel connection is that it is narrower at the beginning of the ramp.

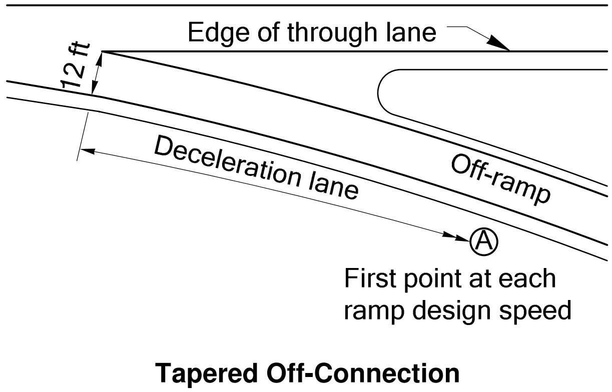
1360.04(5)(a) Deceleration Lane

Provide the minimum deceleration lane length given in Exhibit 1360-10 for each design speed for all off-ramps. Also, provide deceleration lane length to the end of the anticipated queue at the ramp terminal. When the average grade of the deceleration lane is 3% or greater, multiply the distance from the Minimum Deceleration Lane Length table by the factor from the Adjustment Factor for Grades table.

For existing ramps that do not have significant crashes in the area of the connection with the freeway, the freeway posted speed may be used to calculate the deceleration lane length for Preservation projects. If corrective action is indicated, use the freeway design speed to determine the length of the deceleration lane.

The deceleration lane is measured from the point where the taper reaches the selected ramp lane width to the first point designed at each ramp design speed (usually the PC of the first curve for each design speed). Curves designed at higher design speeds may be included as part of the deceleration lane length.

Exhibit 1360-10 Deceleration Lane Length



Highway Design Speed (mph)	Ramp Design Speed (mph)										
	0	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**60**	**70**
30	235	200	170	140							
35	280	250	210	185	150						
40	320	295	265	235	185	155					
45	385	350	325	295	250	220	155				
50	435	405	385	355	315	285	225	175			
55	480	455	440	410	380	350	285	235	180		
60	530	500	480	460	430	405	350	300	240		
65	570	540	520	500	470	440	390	340	280	185	
70	615	590	570	550	520	490	440	390	340	240	
80	735	710	690	670	640	610	555	510	465	360	265

Minimum Deceleration Lane Length (ft)

Grade	Upgrade	Downgrade
3% to less than 5%	0.9	1.2
5% or more	0.8	1.35

Adjustment Factors for Grades Greater Than 3%

Note: Lane widths are shown for illustrative purposes. Determine lane widths based on Exhibit 1360-6.

1360.04(5)(b) Gores

Gores (see Exhibits 1360-11a and 11b) are decision points. Design them to be clearly seen and understood by approaching drivers. In a series of interchanges along a freeway, it is desirable that the gores be uniform in size, shape, and appearance.

The paved area between the physical nose and the gore nose is the reserve area. It is reserved for the installation of an impact attenuator. The minimum length of the reserve area is controlled by the design speed of the main line (see Exhibits 1360-11a and 11b).

In addition to striping, raised pavement marker rumble strips may be placed for additional warning and delineation at gores. (See the *Standard Plans* for striping and rumble strip details.)

Keep the unpaved area beyond the gore nose as free of obstructions as possible to provide a clear recovery area. Grade this unpaved area as nearly level with the roadways as possible. Avoid placing obstructions such as heavy sign supports, luminaire poles, and structure supports in the gore area.

When an obstruction is placed in a gore area, provide an impact attenuator (see Chapter 1620) and barrier (see Chapter 1610). Place the beginning of the attenuator as far back in the reserve area as possible, desirably after the gore nose.

1360.04(5)(c) Single-Lane Off-Connections

For single-lane off-connections, the tapered is desirable. Use the design shown in Exhibit 1360-14a for tapered single-lane off-connections. Justify the use of a parallel single-lane off-connection, as shown in Exhibit 1360-14b.

1360.04(5)(d) Single-Lane Off-Connection With One Lane Reduction

The single-lane off-connection with one lane reduction, shown in Exhibit 1360-14c, is used when the conditions from lane balance for a single-lane exit, one-lane reduction, are met.

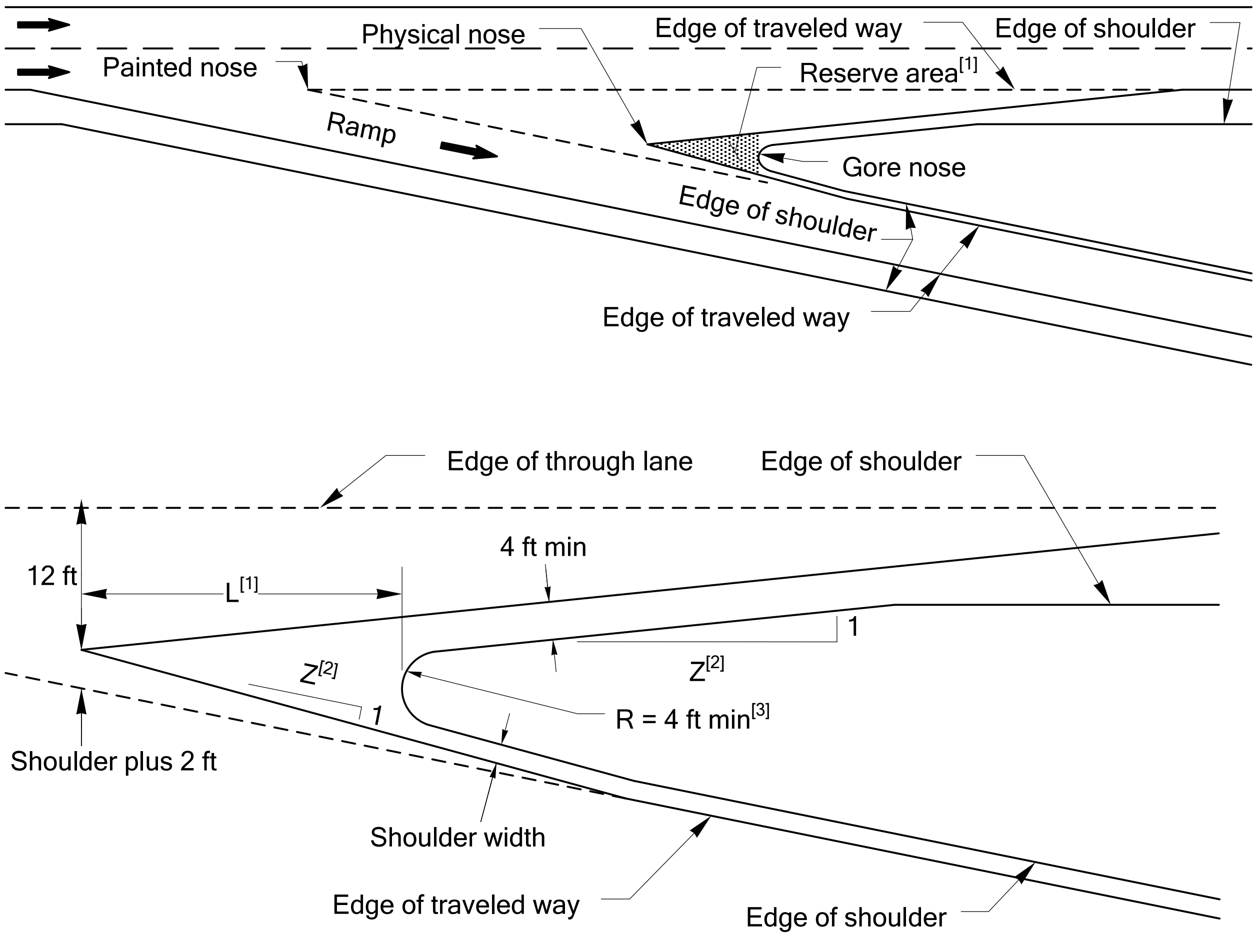
1360.04(5)(e) Tapered Two-Lane Off-Connection

The tapered two-lane off-connection design, shown in Exhibit 1360-14d, is desirable where the number of freeway lanes is reduced or where high-volume traffic operations will be improved by the provision of a parallel auxiliary lane and the number of freeway lanes is unchanged.

1360.04(5)(f) Parallel Two-Lane Off-Connection

The parallel two-lane off-connection, shown in Exhibit 1360-14e, allows less operational flexibility than the taper, requiring more lane changes. Justify the use of a parallel two-lane off-connection.

Exhibit 1360-11a Gore Area Characteristics



Single-Lane Off-Connections: No Lane Reduction

Notes:

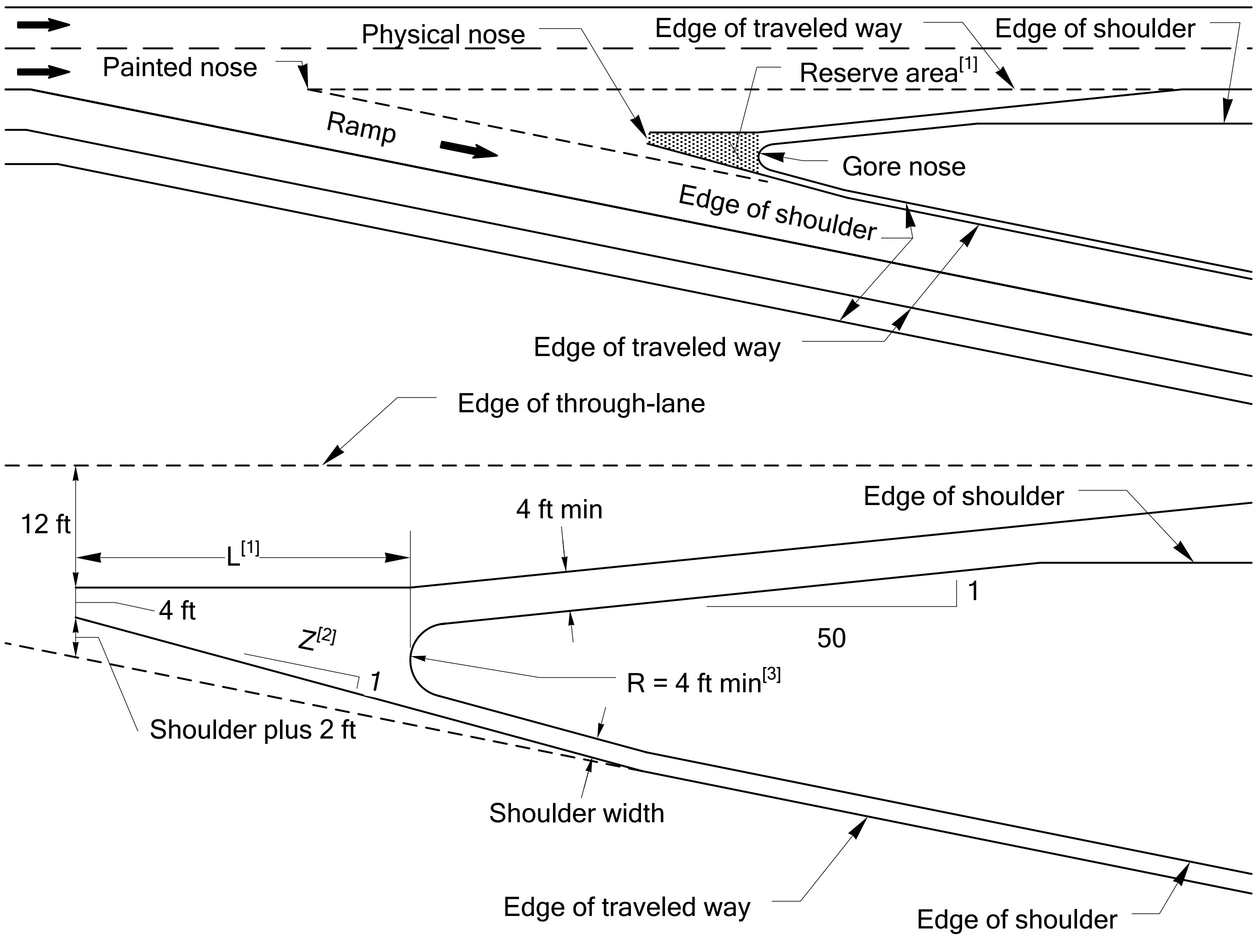
[1] The reserve area length (L) is not less than:

Main Line Design Speed (mph)	40	45	50	55	60	65	70	80
L (ft)	25	30	35	40	45	50	55	70

[2] $Z = \frac{\text{Design Speed}}{2}$, design speed is for the main line.

[3] Radius may be reduced, when protected by an impact attenuator.

Exhibit 1360-11b Gore Area Characteristics



Single-Lane, One-Lane Reduction Off-Connections
and All Two-Lane Off-Connections

Notes:

[1] The reserve area length (L) is not less than:

Main Line Design Speed (mph)	40	45	50	55	60	65	70	80
L (ft)	25	30	35	40	45	50	55	70

[2] $Z = \frac{\text{Design Speed}}{2}$, design speed is for the main line.

[3] Radius may be reduced, when protected by an impact attenuator.

1360.04(6) Collector-Distributor (C-D) Roads

A C-D road can be within a single interchange, through two closely spaced interchanges, or continuous through several interchanges. Design C-D roads that connect three or more interchanges to be two lanes wide. Other C-D roads may be one or two lanes in width, depending on capacity. Consider intermediate connections to the main line for long C-D roads.

a. Exhibit 1360-15a shows the designs for collector-distributor outer separations. Use Design A, with concrete barrier, when adjacent traffic in either roadway is expected to exceed 40 mph. Design B, with mountable curb, may be used when adjacent posted speed does not exceed 40 mph.

b. The details shown in Exhibit 1360-15b apply to single-lane C-D road off-connections. Design a two-lane C-D road off-connection, with the reduction of a freeway lane or an auxiliary lane, as a normal two-lane off-connection in accordance with 1360.04(5).

c. Design C-D road on-connections in accordance with Exhibit 1360-15c.

1360.04(7) Loop Ramp Connections

Loop ramp connections at cloverleaf interchanges are distinguished from other ramp connections by a low-speed ramp on-connection, followed closely by an off-connection for another low-speed ramp. The loop ramp connection design is shown in Exhibit 1360-16. The minimum distance between the ramp connections is dependent on a weaving analysis. When the connections are spaced far enough apart that weaving is not a consideration, design the on-connection in accordance with 1360.04(4) and the off-connection in accordance with 1360.04(5).

1360.04(8) Weaving Sections

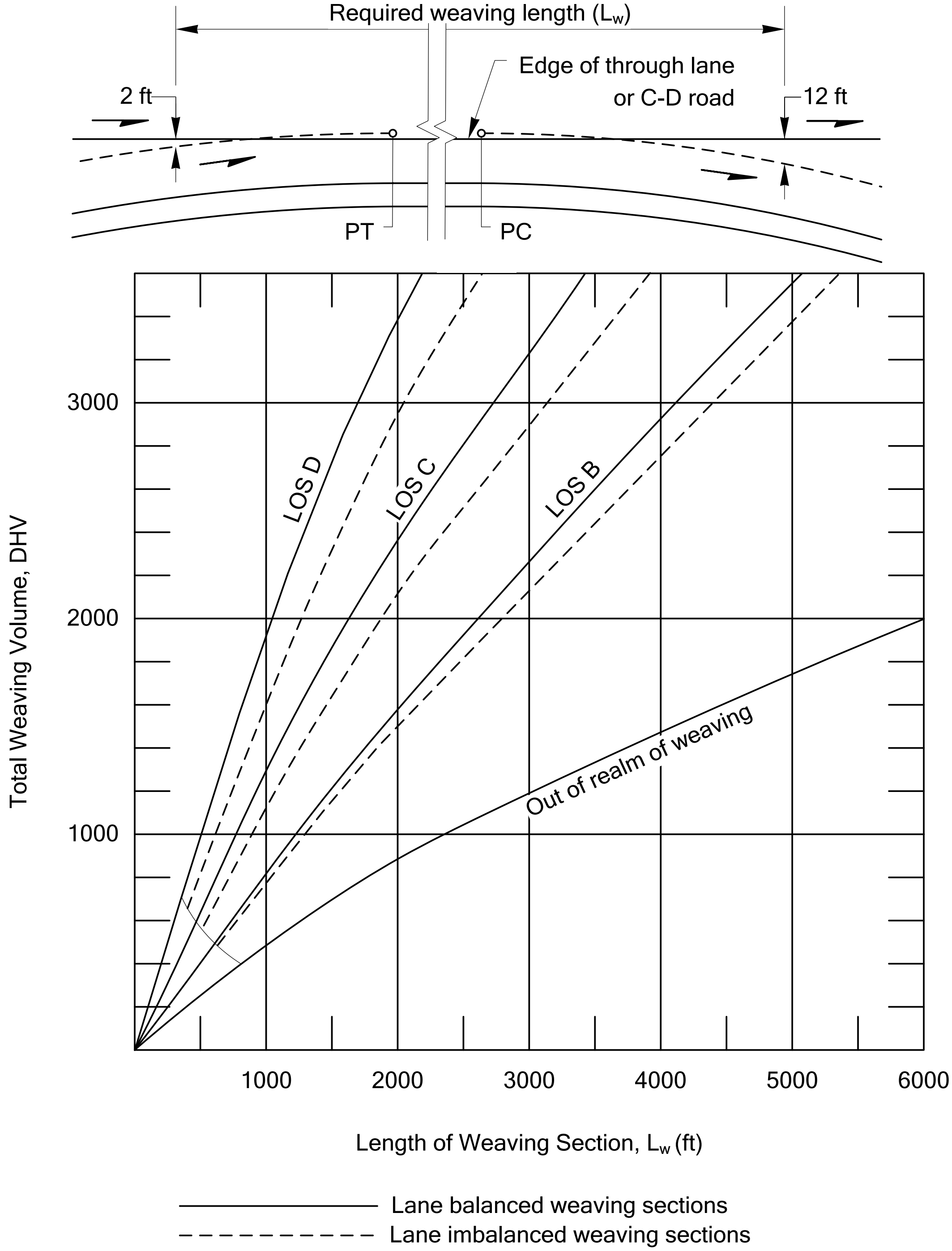
Weaving sections may occur within an interchange, between closely spaced interchanges, or on segments of overlapping routes. Exhibit 1360-12 gives the length of the weaving section for preliminary design. The total weaving traffic is the sum of the traffic entering from the ramp to the main line and the traffic leaving the main line to the exit ramp in equivalent passenger cars. For trucks, a passenger car equivalent of two may be estimated. Use the Highway Capacity Manual for the final design of weaving sections.

Because weaving sections cause considerable turbulence, interchange designs that eliminate weaving or remove it from the main roadway are desirable. Use C-D roads for weaving between closely spaced ramps when adjacent to high-speed highways. C-D roads are not needed for weaving on low-speed roads.

1360.05 Ramp Terminal Intersections at Crossroads

Design ramp terminal intersections at grade with crossroads as intersections at grade (see Chapter 1300). Whenever possible, design ramp terminals to discourage wrong-way movements. Locate ramp terminal intersections at grade with crossroads to provide signal progression if the intersection becomes signalized in the future. Provide intersection sight distance as described in Chapters 1310 or 1320.

Exhibit 1360-12 Length of Weaving Sections



Note:

To determine whether or not lane balance for weaving exists, see Exhibit 1360-8.

1360.06 Interchanges on Two-Lane Highways

Occasionally, the first stage of a conventional interchange will be built with only one direction of the main roadway and operated as a two-lane two-way roadway until the ultimate roadway is constructed.

The design of interchanges on two-lane two-way highways may vary considerably from traditional concepts due to the following conditions:

- The potential for cross-centerline crashes due to merge conflicts or motorist confusion.
- The potential for wrong-way or U-turn movements.
- Future construction considerations.
- Traffic type and volume.
- The proximity to multilane highway sections that might influence a driver's impression that these roads are also multilane.

Provide the deceleration taper for all interchange exit ramps on two-lane highways. Design the entering connection with either the normal acceleration taper or a "button hook" configuration with a stop condition before entering the main line. Consider the following items:

- Design the stop condition connection in accordance with a tee (T) intersection as shown in Chapter 1310. Use this type of connection when an acceleration lane is not possible. Provide decision sight distance as described in Chapter 1260.
- Since designs may vary from project to project, analyze each project for the most efficient signing placement, such as one-way, two-way, no passing, do not enter, directional arrows, guideposts, and traffic buttons.
- Prohibit passing through the interchange area on two-lane highways by means of signing, pavement marking, or a combination of both. The desirable treatment is a 4 foot median island, highlighted with raised pavement markers and diagonal stripes. When using a 4-foot median system, extend the island 500 feet beyond any merging ramp traffic acceleration taper. The width for the median can be provided by reducing each shoulder 2 feet through the interchange (see Exhibit 1360-17).
- Include signing and pavement markings to inform both the entering and through motorists of the two-lane two-way characteristic of the main line.
- Use as much of the ultimate roadway as possible. Where this is not possible, leave the area for future lanes and roadway ungraded.
- Design and construct temporary ramps as if they were permanent unless second-stage construction is planned to rapidly follow the first stage. Design the connection to meet the needs of the traffic.

1360.07 Interchange Plans for Approval

Exhibit 1360-18 is a sample showing the general format and data for interchange design plans.

Compass directions (W-S Ramp) or crossroad names (E-C Street) may be used for ramp designations.

Include the following, as applicable:

- Design speeds (see Chapter 1103) for main line and crossroads.
- Curve data on main line, ramps, and crossroads.
- Numbers of lanes and widths of lanes and shoulders on main line, crossroads, and ramps.
- Superelevation diagrams for the main line, the crossroad, and all ramps; these may be submitted on separate sheets.
- Channelization.
- Stationing of ramp connections and channelization.
- Proposed right of way and access control treatment (see Chapters 510, 520, and 530).
- Delineation of all crossroads, existing and realigned.
- Traffic data for the proposed design; include all movements.
- For HOV direct access connections on the left, include the statement that the connection will be used solely by HOVs or will be closed.

Prepare a preliminary contour grading plan for each completed interchange. Show the desired contours of the completed interchange, including details of basic land formation, slopes, graded areas, or other special features. Coordinate the contour grading with the drainage design and the roadside development plan.

1360.08 Documentation

Refer to Chapter 300 for design documentation requirements.

1360.09 References

1360.09(1) Design Guidance

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

Plans Preparation Manual, M 22-31, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21 01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

1360.09(2) Supporting Information

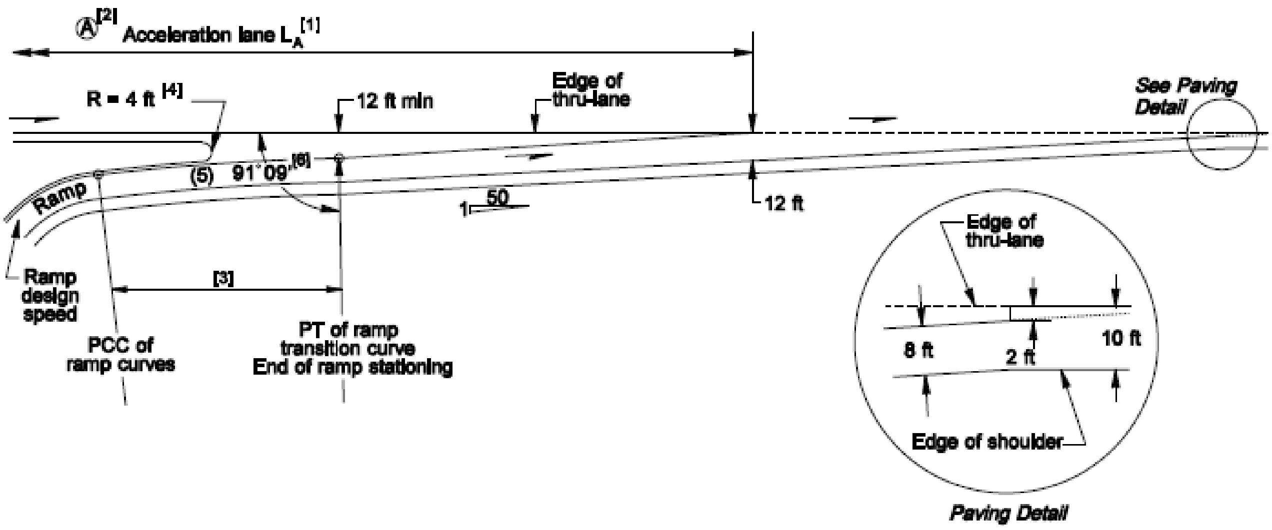
A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition

A Policy on Design Standards – Interstate System, AASHTO, 2005

Highway Capacity Manual (Special Report 209), Transportation Research Board

Procedure for Analysis and Design of Weaving Sections: A User's Guide, Jack E. Leisch, October 1985

Exhibit 1360-13a On-Connection: Single-Lane, Tapered



Notes:

[1] For acceleration lane length L_A, see Exhibit 1360-9.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] A transition curve with a minimum radius of 3000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3000-ft radius to tangent to the main line.

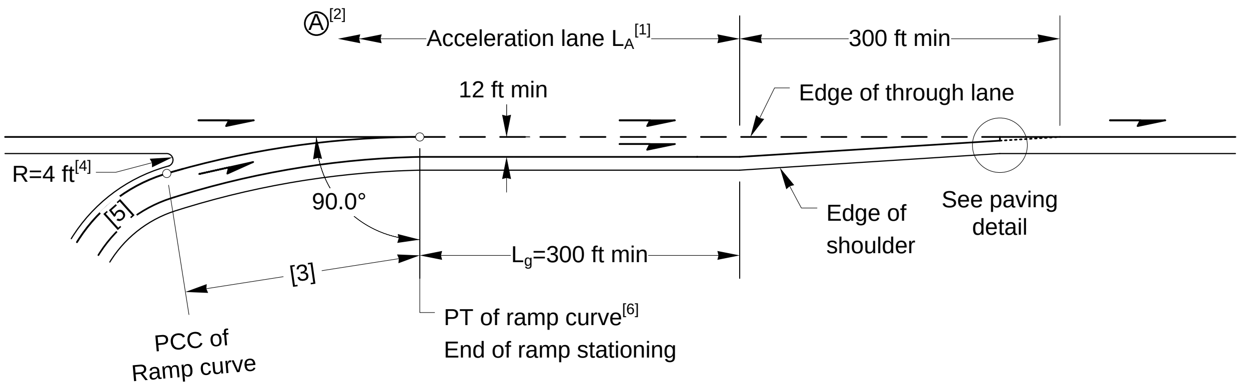
[4] Radius may be reduced when concrete barrier is placed between the ramp and main line.

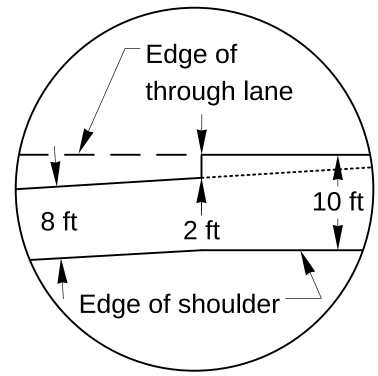
[5] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

[6] Approximate angle to establish ramp alignment.

General: For striping, see the *Standard Plans*.

Exhibit 1360-13b On-Connection: Single-Lane, Parallel





Paving detail

Notes:

[1] For acceleration lane length L_A, see Exhibit 1360-9.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] A transition curve with a minimum radius of 3000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3000-ft radius to tangent to the main line. The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.

[4] Radius may be reduced when concrete barrier is placed between the ramp and main line.

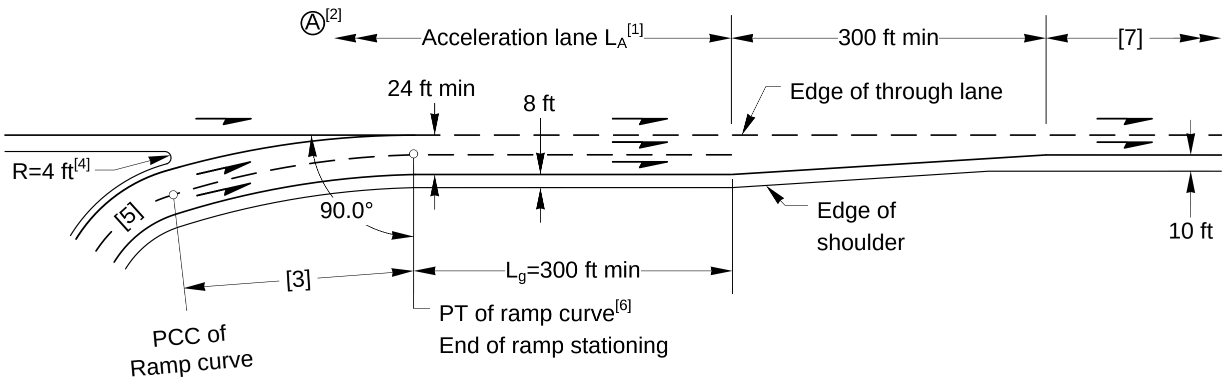
[5] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

[6] Ramp stationing may be extended to accommodate superelevation transition.

General:

For striping, see the *Standard Plans*.

Exhibit 1360-13c On-Connection: Two-Lane, Parallel



Notes:

[1] For acceleration lane length L_A, see Exhibit 1360-9.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] A transition curve with a minimum radius of 3000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3000-ft radius to tangent to the main line. The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.

[4] Radius may be reduced when concrete barrier is placed between the ramp and main line.

[5] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

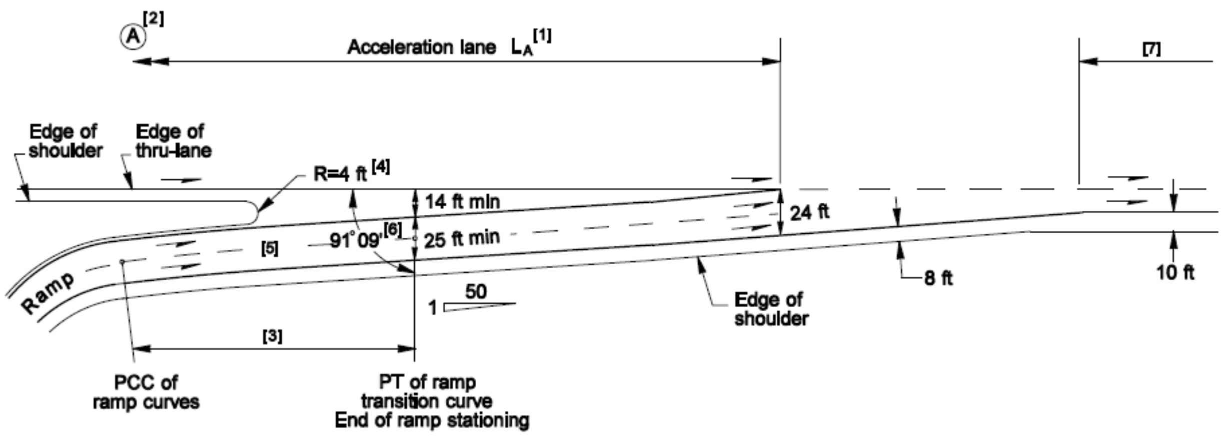
[6] Ramp stationing may be extended to accommodate superelevation transition.

[7] Added lane or 1,500-ft auxiliary lane plus 600-ft taper.

General:

For striping, see the *Standard Plans*.

Exhibit 1360-13d On-Connection: Two-Lane, Tapered



Notes:

[1] For acceleration lane length L_A, see Exhibit 1360-9.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] A transition curve with a minimum radius of 3000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3000-ft radius to tangent to the main line.

[4] Radius may be reduced when concrete barrier is placed between the ramp and main line.

[5] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

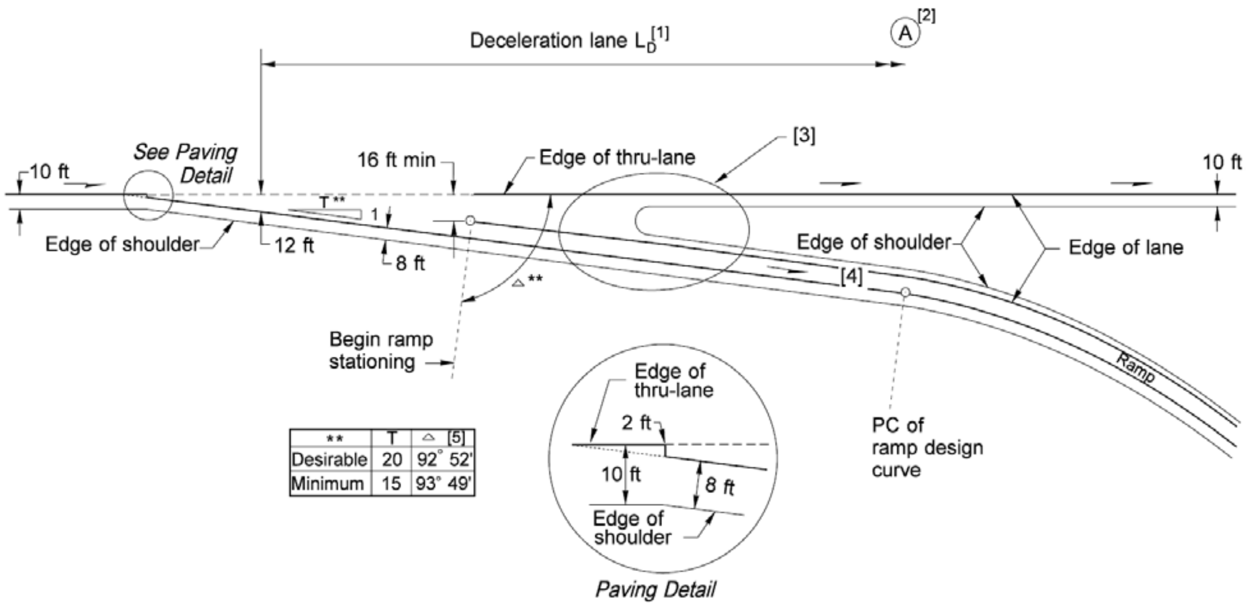
[6] Approximate angle to establish ramp alignment.

[7] Added lane or 1,500-ft auxiliary lane plus 600-ft taper.

General:

For striping, see the *Standard Plans*

Exhibit 1360-14a Off-Connection: Single-Lane, Tapered



Notes:

[1] For deceleration lane length L_D, see Exhibit 1360-10.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] For gore details, see Exhibit 1360-11a.

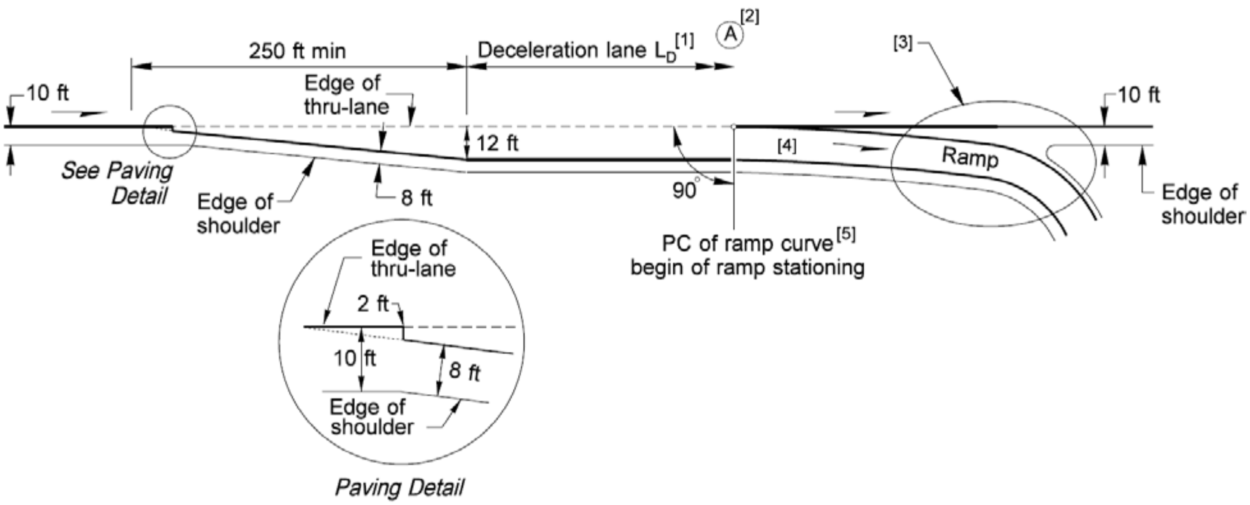
[4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

[5] Approximate angle to establish ramp alignment.

General:

For striping, see the *Standard Plans*.

Exhibit 1360-14b Off-Connection: Single-Lane, Parallel



Notes:

[1] For deceleration lane length L_D, see Exhibit 1360-10.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] For gore details, see Exhibit 1360-11a.

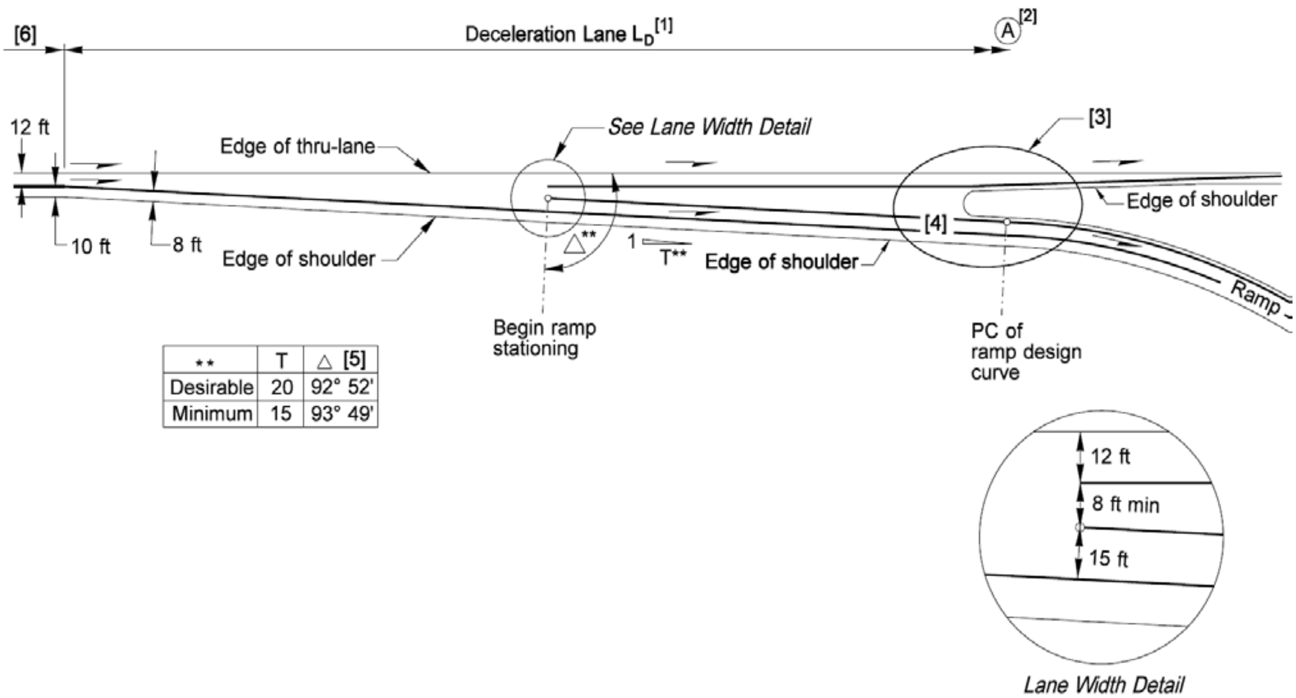
[4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

[5] Ramp stationing may be extended to accommodate superelevation transition.

General:

For striping, see the *Standard Plans*.

Exhibit 1360-14c Off-Connection: Single-Lane, One-Lane Reduction



**	T	△ [5]
Desirable	20	92° 52'
Minimum	15	93° 49'

Notes:

[1] For deceleration lane length L_D, see Exhibit 1360-10.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] For gore details, see Exhibit 1360-11b.

[4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

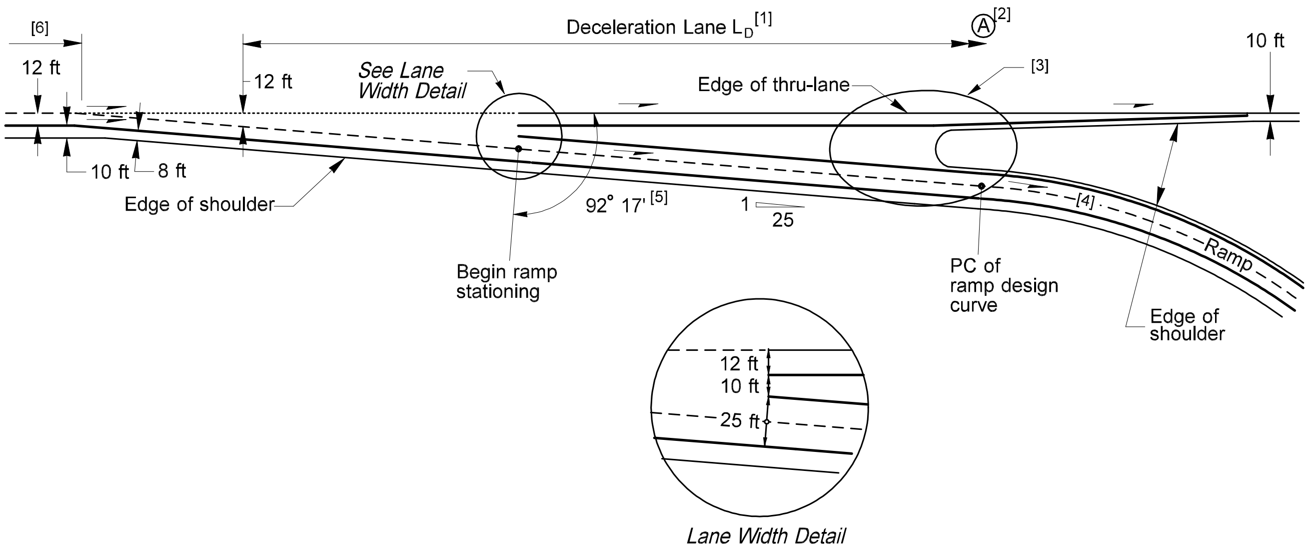
[5] Approximate angle to establish ramp alignment.

[6] Auxiliary lane between closely spaced interchanges to be dropped.

General:

For striping, see the *Standard Plans*.

Exhibit 1360-14d Off-Connection: Two-Lane, Tapered



Notes:

[1] For deceleration lane length L_D, see Exhibit 1360-10.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] For gore details, see Exhibit 1360-11b.

[4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

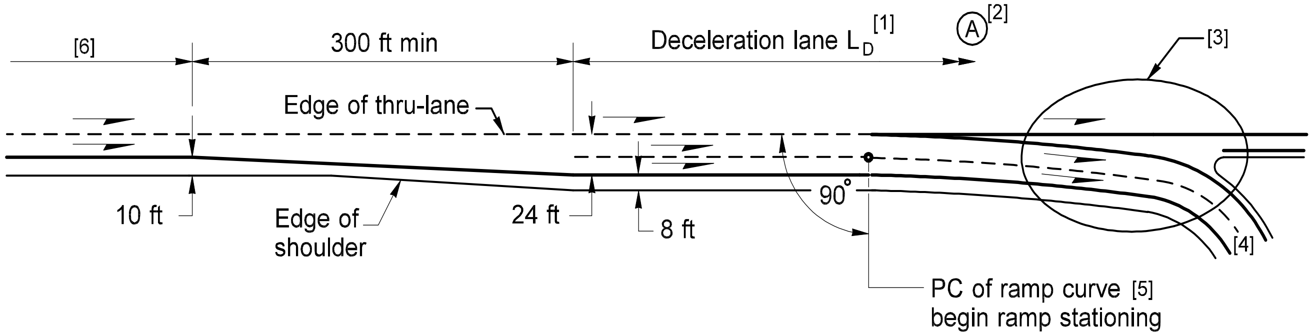
[5] Approximate angle to establish ramp alignment.

[6] Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300-ft taper.

General:

For striping, see the *Standard Plans*.

Exhibit 1360-14e Off-Connection: Two-Lane, Parallel



Notes:

[1] For deceleration lane length L_D, see Exhibit 1360-10.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] For gore details, see Exhibit 1360-11b.

[4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

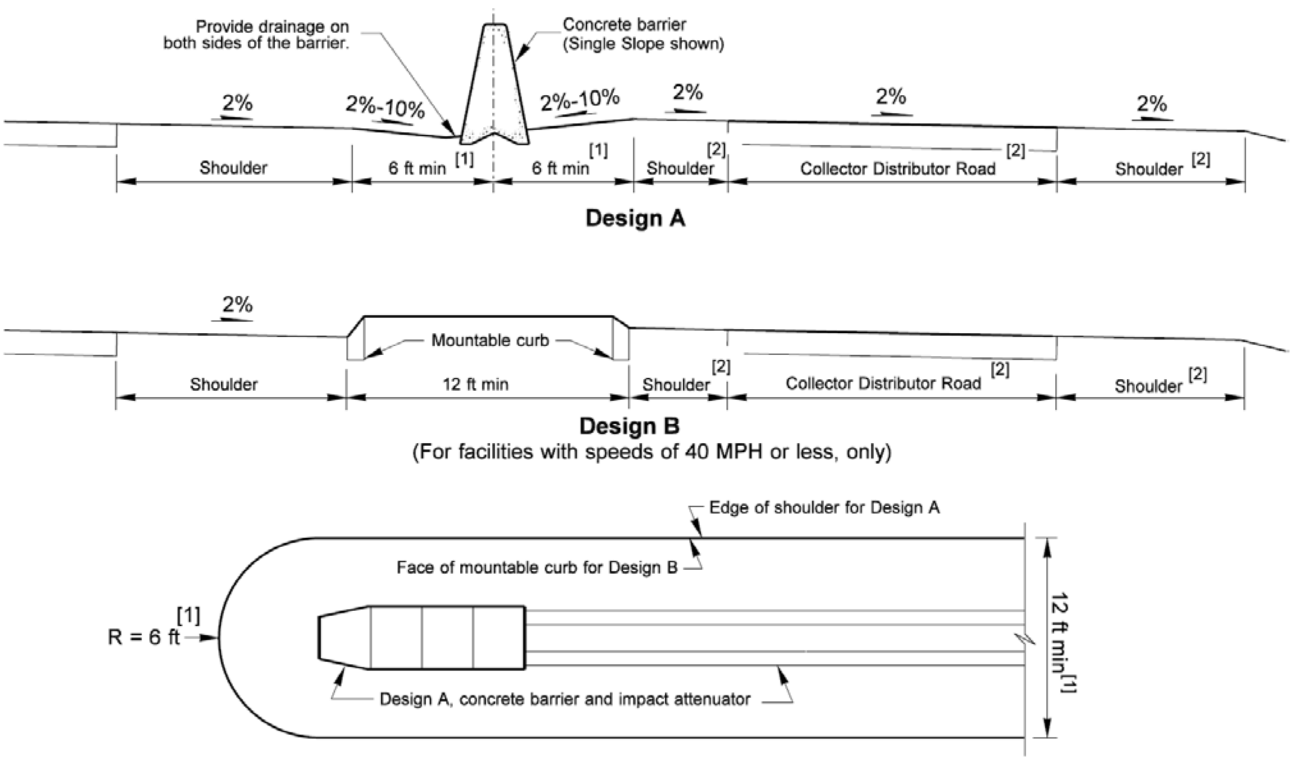
[5] Ramp stationing may be extended to accommodate superelevation transition.

[6] Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300-ft taper.

General:

For striping, see the *Standard Plans*.

Exhibit 1360-15a Collector-Distributor: Outer Separations

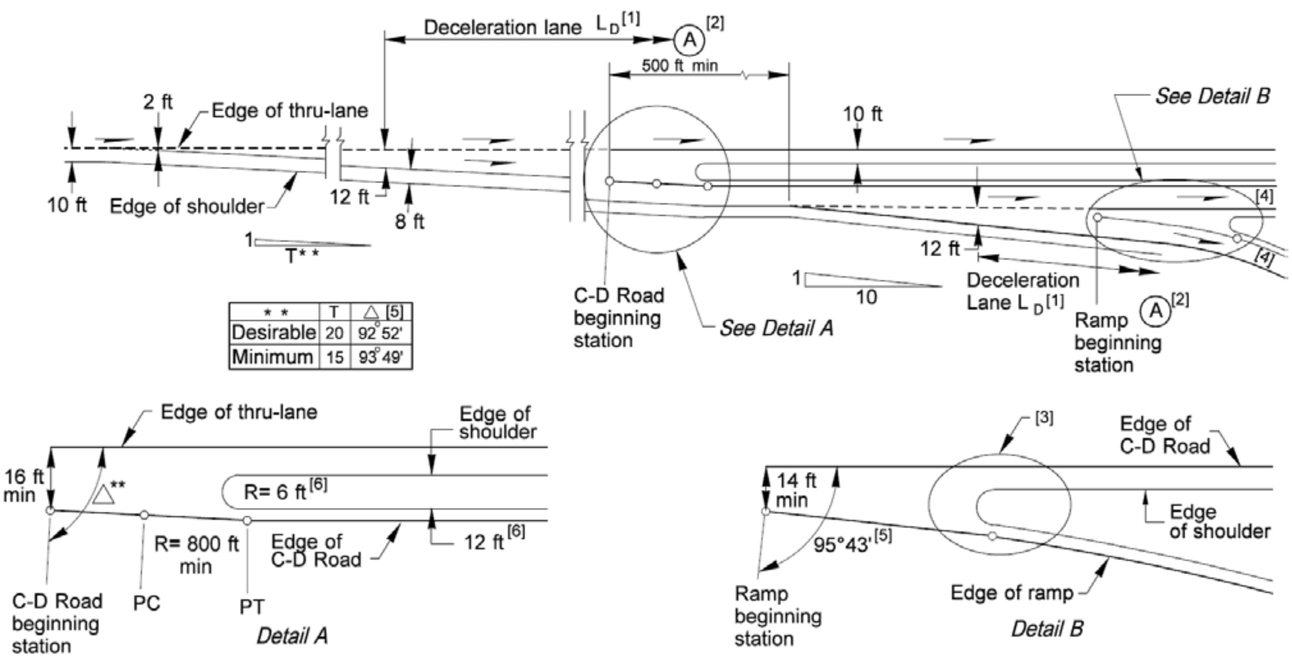


Notes:

[1] With justification, the concrete barrier may be placed with 2 ft between the edge of either shoulder and the face of barrier. This reduces the width between the edge of through-lane shoulder and the edge of C-D road shoulder to 6 ft and the radius at the nose to 3 ft.

[2] For collector-distributor road lane and shoulder widths, see ramp lane and shoulder widths, Exhibit 1360-6.

Exhibit 1360-15b Collector Distributor: Off-Connections



**	T	△ [5]
Desirable	20	92°52'
Minimum	15	93°49'

Notes:

[1] For deceleration lane length L_D, see Exhibit 1360-10.

[2] Point Ⓐ is the point controlling the C-D road or ramp design speed.

[3] For gore details, see Exhibit 1360-11a.

[4] For C-D road and ramp lane and shoulder widths, see Exhibit 1360-6.

[5] Approximate angle to establish alignment.

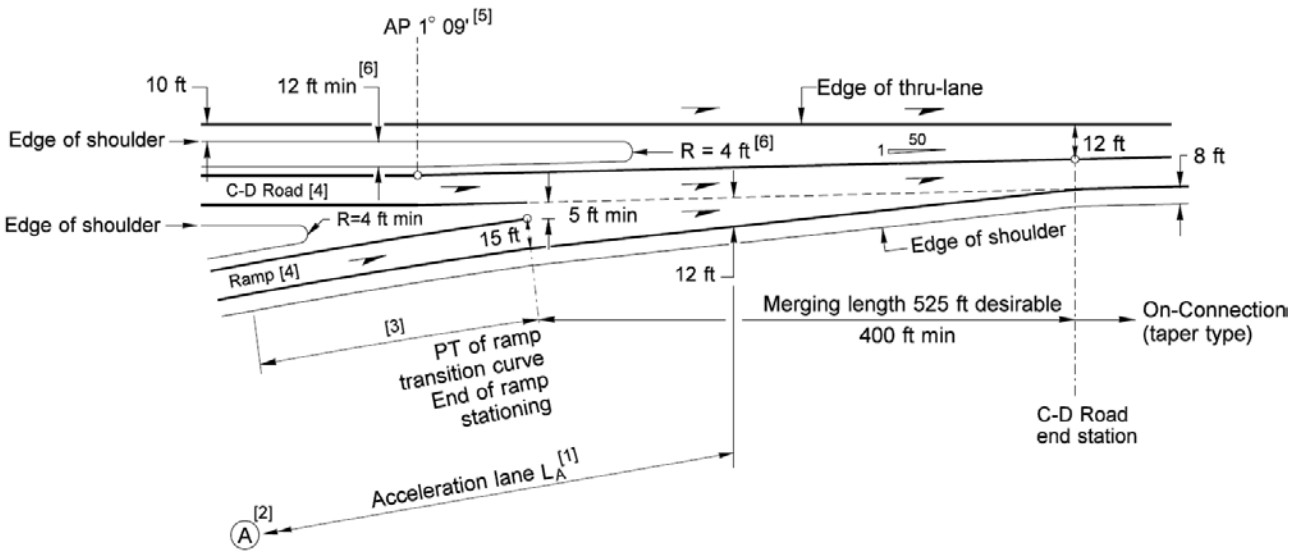
[6] May be reduced with justification (see Exhibit 1360-15a).

General:

For striping, see the Standard Plans.

Lane and shoulder widths are shown for illustrative purposes. Determine lane and shoulder widths based on Exhibit 1360-6.

Exhibit 1360-15c Collector Distributor: On-Connections



Notes:

[1] For acceleration lane length L_A, see Exhibit 1360-9.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] A transition curve with a minimum radius of 3000 ft is desirable. The desirable length is 300 ft. When the C-D road is on a curve to the left, the transition may vary from a 3000-ft radius to tangent to the C-D road.

[4] For C-D road and ramp lane and shoulder widths, see Exhibit 1360-6.

[5] Approximate angle to establish alignment.

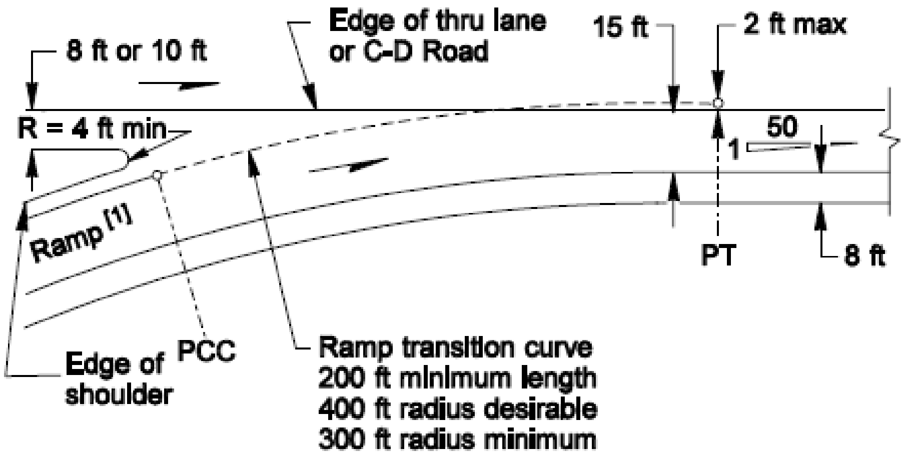
[6] May be reduced with justification (see Exhibit 1360-15a).

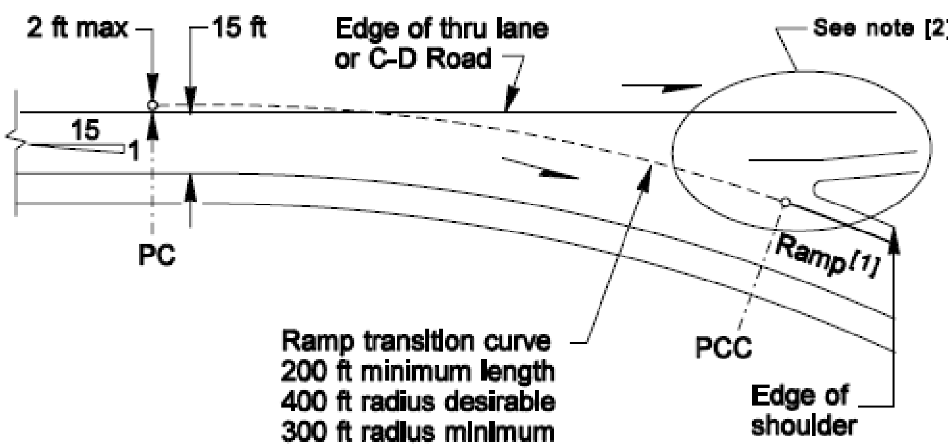
General:

For striping, see the Standard Plans..

Lane and shoulder widths are shown for illustrative purposes. Determine lane and shoulder widths based on Exhibit 1360-6.

Exhibit 1360-16 Loop Ramp Connections





Notes:

[1] For minimum weaving length, see Exhibit 1360-12.

[2] Lane and shoulder widths are shown for illustrative purposes. For minimum ramp lane and shoulder widths, see Exhibit 1360-6.

[3] For gore details, see Exhibit 1360-11b.

General:

For gore details, see Exhibit 1360-11b.

Exhibit 1360-17 Temporary Ramps

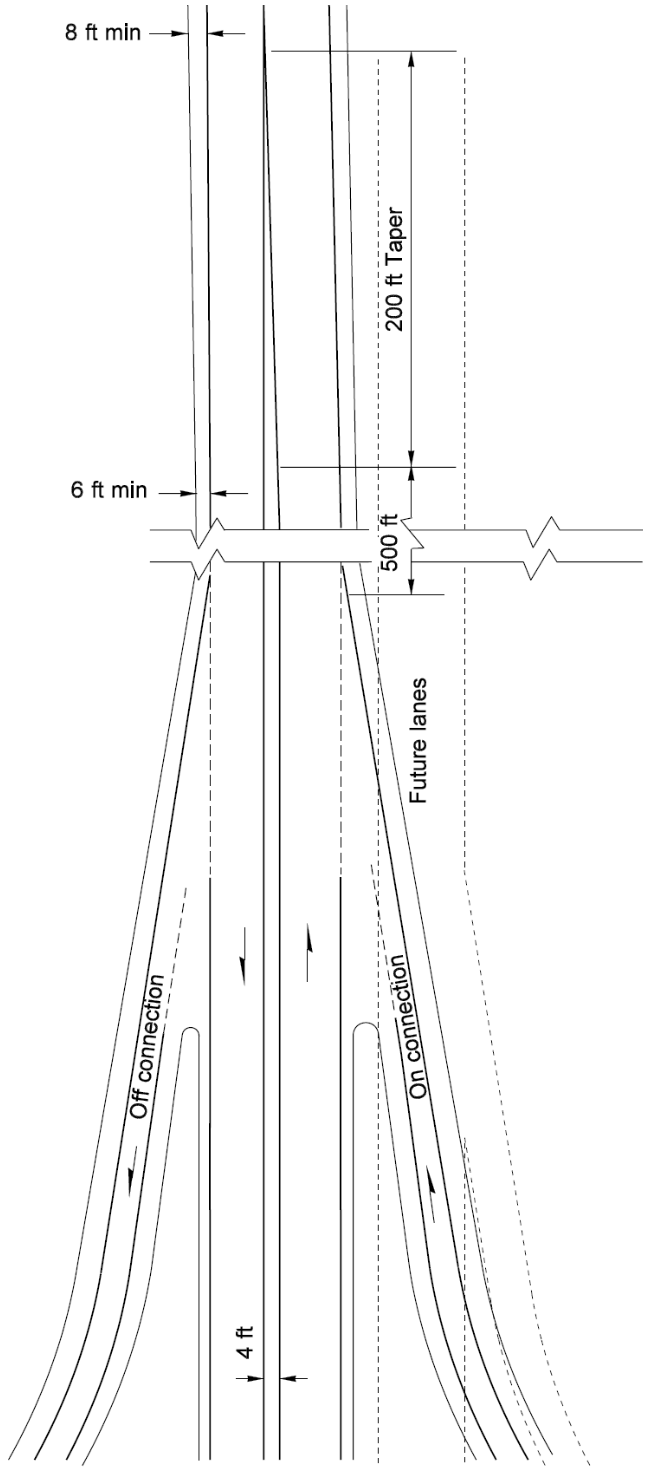
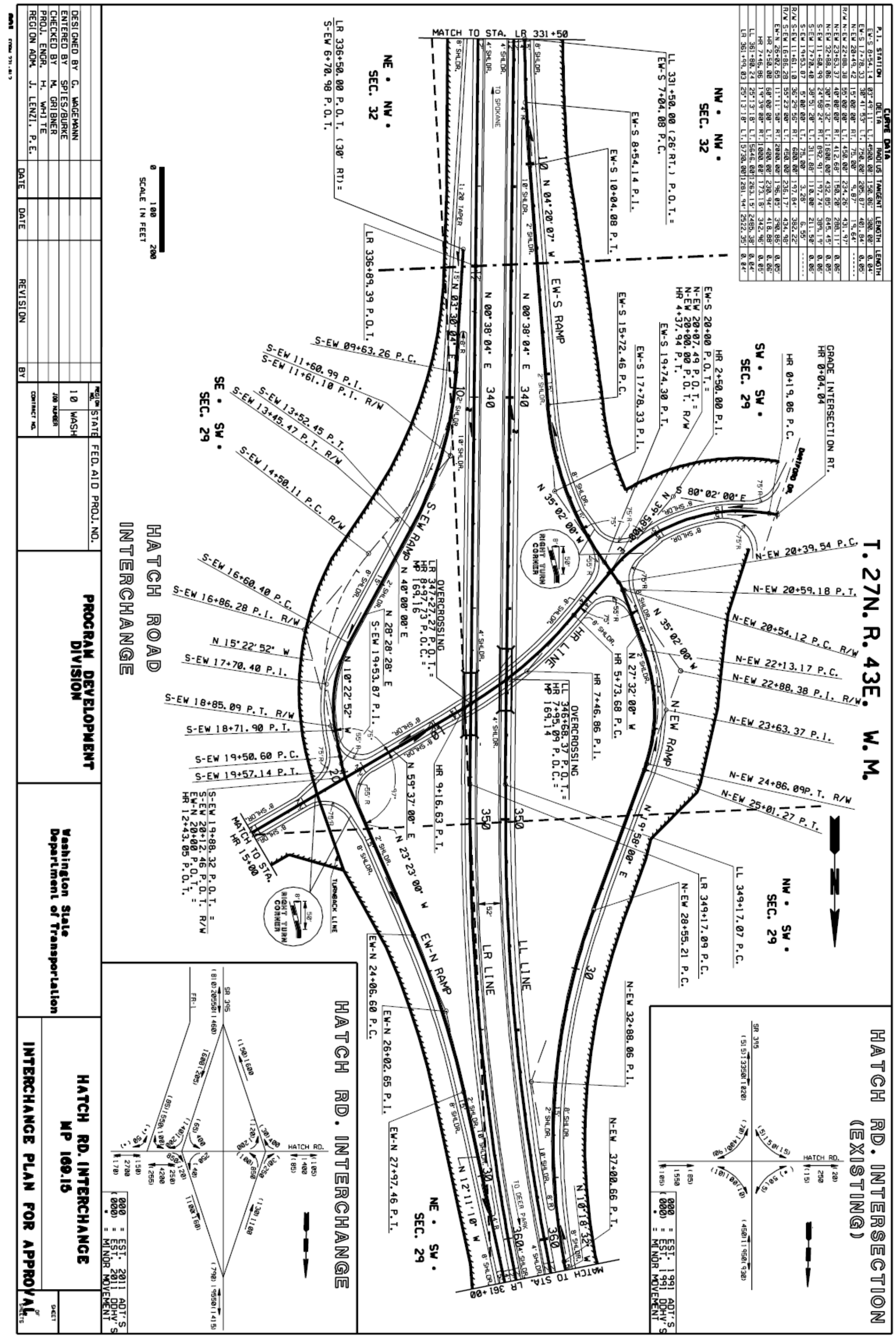


Exhibit 1360-18 Interchange Plan



When evaluating alternatives, consider a combination of alternatives to provide the optimum solution for the corridor. Also, incorporate flexibility into the design in order not to preclude potential changes in operation, such as changing an outside lane to an inside lane or a reversible facility to two-way operations. Access, freeway-to-freeway connections, and enforcement will have to be accommodated for such changes. Document the operational alternatives.

(a) **Inside vs. Outside HOV Lane**

System continuity and consistency of HOV lane placement along a corridor are important, and they influence facility development decisions. Other issues include land use, trip patterns, transit vehicle service, HOV volume, ramp volume, congestion levels, enforcement, and direct access to facilities.

The inside (left) HOV lane is most appropriate for a corridor with long-distance trip patterns, such as a freeway providing mobility to and from a large activity center. These trips are characterized by long-distance commuters and express transit service. Maximum capacity for an effective inside HOV lane is approximately 1,500 vehicles per hour. When HOVs weaving across the general-purpose lanes cause severe congestion, consider providing HOV direct access ramps, separated HOV roadways, or a higher-occupancy designation. Inside lanes are preferred for HOV lanes on freeways.

The outside (right) HOV lane is most appropriate for a corridor with shorter, more widely dispersed trip patterns. These trip patterns are characterized by transit vehicle routes that exit and enter at nearly every interchange. The maximum capacity for an effective outside HOV lane is reduced and potential conflicts are increased by heavy main line congestion and large entering and exiting general-purpose volumes.

(b) **Conversion of a General-Purpose Lane**

The use of an existing general-purpose lane for an HOV lane is an undesirable option; however, conversion of a lane to an HOV lane might be justified when the conversion provides greater people-moving capability on the roadway. Use of an existing freeway lane as an HOV lane will be considered only with a Design Analysis.

Given sufficient existing capacity, converting a general-purpose lane to an HOV lane can provide for greater people moving capability in the future without significantly affecting the existing roadway operations. The fastest and least expensive method for providing an HOV lane is through conversion of a general-purpose lane. Restriping and signing are sometimes all that is needed. Converting a general-purpose lane to HOV use will likely have environmental benefits. This method, however, is controversial from a public acceptance standpoint. Public support might be gained through an effective public involvement program (see Chapter 210).

Do not convert a general-purpose lane to an HOV lane unless it enhances the corridor's people-moving capacity. Conduct an analysis that includes:

- Public acceptance of the lane conversion.
- Current and long-term traffic impacts on the adjacent general-purpose lanes and the HOV lane.
- Impacts to the neighboring streets and arterials.
- Legal, environmental, and safety impacts.

(c) **Use of Existing Shoulder**

When considering the alternatives in order to provide additional width for an HOV lane, the use of the existing shoulder is an undesirable option. Use of the shoulder on a freeway or freeway ramp as an HOV lane will be considered only with a Design Analysis.

Consider shoulder conversion to an HOV lane when traffic volumes are heavy and the conversion is a temporary measure. Another alternative is to use the shoulder as a permanent measure to serve as a transit-only or queue bypass lane during peak hours and then revert to a shoulder in off-peak hours.

The use of the shoulder creates special signing, operational, and enforcement issues. An agreement is required with the transit agency to limit transit vehicle use of the shoulder to peak hours. Provide signing that clearly defines the use of the shoulder. Institute special operations to clear the shoulder for the designated hours.

The existing shoulder pavement is often not designed to carry heavy volumes of vehicles, especially transit vehicles. As a result, repaving and reconstruction of the shoulder might be required.

(d) **HOV Direct Access Ramps**

To improve the efficiency of an HOV system, exclusive HOV access connections for an inside HOV lane may be considered. (See Chapter 1420 for information on HOV direct access connections.) Direct access reduces the need for HOVs to cross the general-purpose lanes from right-side ramps. Transit vehicles will be able to use the HOV lane and provide service to park & ride lots, flyer stops, or other transit stops by the HOV direct access ramps.

(e) **Queue Bypass Lanes**

A queue bypass lane allows HOVs to save time by avoiding congestion at an isolated bottleneck. An acceptable time saving for a queue bypass is one minute or more. Typical locations for queue bypasses are at ramp meters, signalized intersections, toll plaza or ferry approaches, and locations with isolated main line congestion. By far the most common use is with ramp metering. Queue bypass lanes can be built along with a corridor HOV facility or independently. In most cases, they are relatively low cost and easily implemented. Where feasible, include HOV bypasses on ramp metering sites, or make provisions for their future accommodation unless specific location conditions dictate otherwise.

(f) **Flyer Stops**

Flyer stops reduce the time required for express transit vehicles to serve intermediate destinations. However, passengers must travel greater distances to reach the loading platform. (See Chapter 1420 for information on flyer stops.)

(g) **Hours of Operation**

An HOV designation on freeway HOV lanes 24 hours a day provides benefits to users during off-peak periods, minimizes potential confusion, makes enforcement easier, and simplifies signing and striping. However, 24-hour operation also might result in a lane not used during off-peak periods, negative public opinion, and the need for full-time enforcement.

1420.03(3) Sight Distance

Provide stopping sight distance in accordance with Chapter 1260. This provides sight distance for an automobile. The longer distance needed for a bus to stop is compensated for by the greater eye height of the driver, with the resulting vertical curve length about equal to that for an automobile.

Sag vertical curves may be shortened where necessary. (See Chapter 1220 for guidance.)

1420.03(4) Grades

Grades for ramps are covered in Chapter 1360. Deviations will be considered for:

- Downgrade on-ramps with grades increased by an additional 1%.
- Upgrade off-ramps with grades increased by an additional 2%.

These increased grades help when geometrics are restricted, and they assist transit vehicles with the acceleration when entering and the deceleration when exiting the freeway.

1420.03(5) Ramp Widths

1420.03(5)(a) Lane Widths

Use widths for separated roadway HOV facilities. (See Minimum Traveled Way Widths for Articulated Buses in Chapter 1410.) On tangents, the minimum lane width may be reduced to 12 feet.

1420.03(5)(b) Shoulder Widths

Ramp shoulder width criteria are modified as follows:

- The minimum width for the sum of the two shoulders is 10 feet for one-lane ramps and 12 feet for two or more lanes.
- The minimum width for one of the shoulders is 8 feet for disabled vehicles. The minimum width for the other shoulder is 2 feet. (See Chapter 1239 for lateral clearance to curb and barrier.)
- The wider shoulder may be on the left or the right. Maintain the wide shoulder on the same side throughout the ramp.

Minimum Ramp Widths for Articulated Buses	
R (ft)*	**W_R (ft)**
Tangent	21
500	23
400	23
300	24
200	26
150	27
100	30
75	34
50	40
*R is to the curve inside edge of traveled way	

1420.03(5)(c) Total Ramp Widths

When an A-BUS is the intersection design vehicle at the ramp terminal, make the total width of the ramp (lane width plus shoulders) wide enough to allow an A-BUS to pass a stalled A-BUS. This width has two components:

- The vehicle width (U = 8.5 feet on tangent) for each vehicle
- Lateral clearance (C = 2 feet) for each vehicle

The vehicle width and the lateral clearance are about the width of an A-BUS from edge of mirror to edge of mirror.

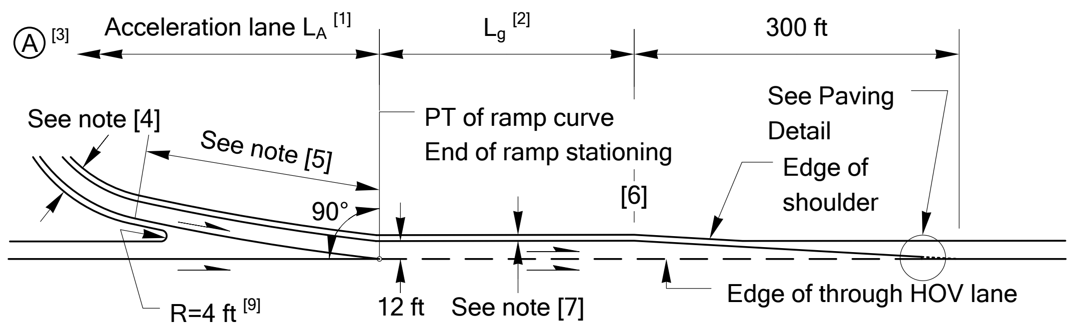
The table above gives the minimum ramp width (W_R), including shoulders, at various radii (R) for an articulated bus. For ramp locations on a tangent section or on a curve with a radius greater than 150 feet, consider the W_R width when requesting a reduced lane or shoulder width. For ramp curves with a radius less than 150 feet, check the total ramp width and, if necessary, widen the shoulders to provide the W_R width.

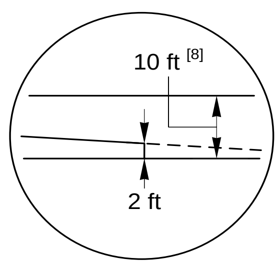
1420.03(6) On-Connections

1420.03(6)(a) Parallel On-Connections

For left-side on-connections, use the parallel on-connection.

A parallel on-connection adds a parallel lane that is long enough for the merging vehicle to accelerate in the lane and then merge with the through traffic. This merge is similar to a lane change and the driver can use side and rear view mirrors to advantage.





Paving Detail

Notes:

[1] For acceleration lane length L_A, see 1420.03(6)(b). Check L_A for each ramp design speed.

[2] L_g is the gap acceptance length. Begin L_g at the beginning of the parallel lane, as shown, but not before the end of the acceleration lane L_A. (See 1420.03(6)(c) for the length L_g.)

[3] Point Ⓐ is the point controlling the ramp design speed or the end of the transit stop zone or other stopping point.

[4] For ramp lane and shoulder widths, see 1420.03(5).

[5] A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the right, the transition may vary from a 3,000 ft radius to tangent to the main line. The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.

[6] Angle point for width transitions, when required. (See Chapter 1210 for pavement transitions.)

[7] For ramp shoulder width, see 1420.03(5)(b).

[8] The 10 ft left shoulder is the minimum width; 14 ft is desirable. Maintain this shoulder width for at least 500 ft; 1,000 ft is desirable.

[9] Radius may be reduced when concrete barrier is placed between the ramp and main line.

General:
For striping, see the *Standard Plans*.

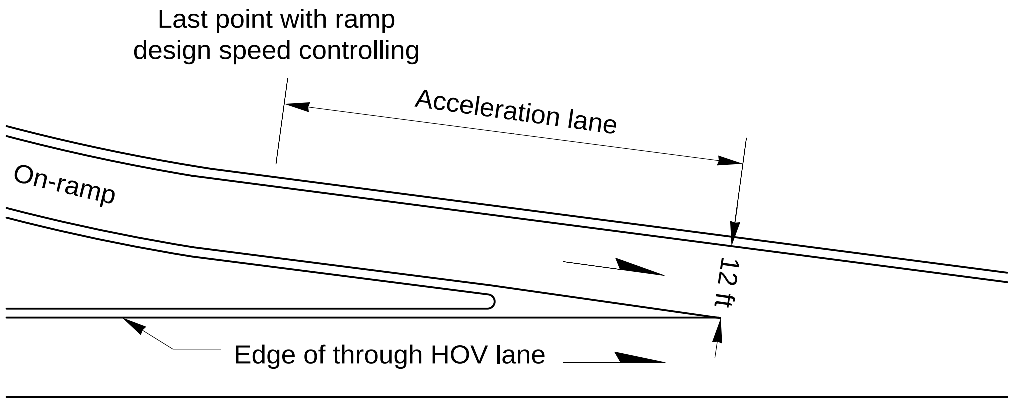
Ramp lane width shown for illustrative purposes. Determine lane width according to 1420.03(5). Verify ramp width selection with transit providers that may utilize these connections.

1420.03(6)(b) Acceleration Lanes

The table below gives the minimum acceleration lane length (L_A) for left-side HOV direct access on-connections.

The buses using HOV direct access ramps merge with high-speed traffic. Acceleration lanes that are longer than normally used are needed.

For left-side on-connections, consider at least the normal 10-foot-wide (14-foot desirable) left shoulder for the main line for a minimum length of 500 feet (1,000 feet desirable) beyond the end of the on-connection taper. This gives additional room for enforcement, merging, and erratic maneuvers.



Freeway Speed (mph)	Ramp Design Speed								
	0	15	20	25	30	35	40	45	50
40	555	480	420	340	185				
45	835	760	700	615	470	290			
50	1,230	1,160	1,100	1,020	865	685	310		
55	1,785	1,715	1,655	1,575	1,420	1,235	875	410	
60	2,135	2,085	2,040	1,985	1,875	1,735	1,440	995	460
70	3,045	3,015	2,985	2,945	2,860	2,745	2,465	2,050	1,515
80	4,505	4,465	4,420	4,370	4,250	4,095	3,745	3,315	2,780

Acceleration Length (LA) for Buses (ft)

Notes: For the adjustment factors for grade, see acceleration lane in Chapter 1360.
Ramp lane width shown for illustrative purposes. Determine ramp lane widths according to 1420.03(5). Verify ramp width selection with transit providers that may utilize these connections.

1420.03(6)(c) Gap Acceptance Length

Gap acceptance length is a minimum distance traveled while a merging driver finds a gap in the through traffic and begins the merge. For left-side parallel on-connections, the gap acceptance length is added to the acceleration length. The L_g values are given in the table below. These values are larger than for right-side on-connections to account for drivers' visibility constraints.

Highway Posted Speed (mph)	Gap Acceptance Length, L_g (ft)
45	550
50	625
55	700
60	775
65	850
70	925

1420.03(6)(d) Urban On-Connection Design

Design left-side HOV direct access on-connections in urban areas as follows:

1. Use the parallel design for left-side on-connections.
2. Add the Gap Acceptance Length for Parallel On-Connections (see 1420.03(6)(c)) for a freeway speed of 60 mph to the acceleration length.
3. Use Acceleration Length for Buses (see 1420.03(6)(b)) with a 60 mph freeway speed and the ramp design speed (see 1420.03(2)) for acceleration length.

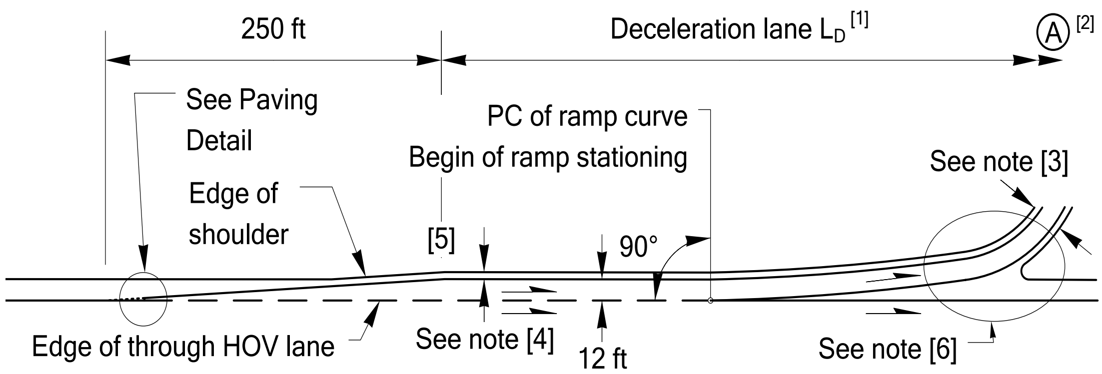
1420.03(6)(e) Rural On-Connection Design

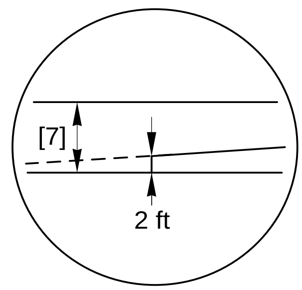
Design left-side HOV direct access on-connections in rural areas using mainline design speed.

1420.03(7) Off-Connections

1420.03(7)(a) Parallel Off-Connection

The parallel off-connection is desirable for left-side direct access off-connections. For freeway-to freeway off-connections, provide a parallel lane with a length sufficient for signing and deceleration. The desirable minimum length is not less than the gap acceptance length (see 1420.03(6)(c)).





Notes:

[1] For deceleration lane length LD, see 1420.03(7)(c). Check LD for each ramp design speed.

[2] Point Ⓐ is the point controlling the ramp design speed or the end of the transit stop zone or other stopping point.

[3] Ramp lane width shown for illustrative purposes. Determine lane and shoulder widths according to 1420.03(5). Verify ramp width selection with transit providers that may utilize these connections.

[4] For ramp shoulder width, see 1420.03(5)(b).

[5] Angle point for width transitions, when required. (See Chapter 1210 for pavement transitions.)

[6] Gore area characteristics at drop ramp connections are shown on 1420.02(3)(a). (See Chapter 1360 for gore details at other connection types.)

[7] The desirable shoulder width is 10 ft.

General:

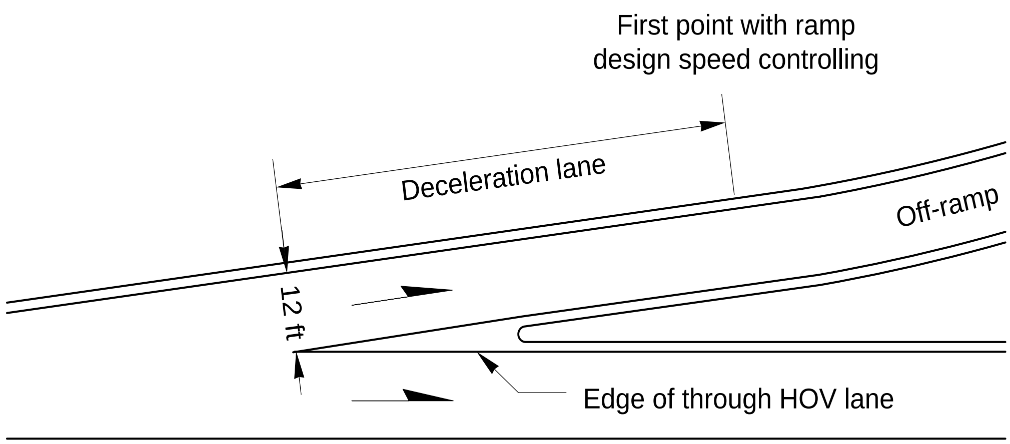
For striping, see the *Standard Plans*.

1420.03(7)(b) Tapered Off-Connection

The tapered off-connection may be used, with justification. (See Chapter 1360 for the design of tapered off-connections.)

1420.03(7)(c) Deceleration Lanes

Bus passenger comfort requires longer deceleration lanes. Use the deceleration lane lengths from the table below for HOV direct access facilities.



Freeway Speed (mph)	Ramp Design Speed								
	0	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
40	390	330	290	240	170	100			
45	470	420	380	330	260	190	90		
50	570	520	480	430	360	290	190	100	
55	680	620	590	540	470	400	300	210	110
60	800	740	700	660	580	520	420	330	230
70	990	930	900	850	780	710	610	520	420
80	1,210	1,150	1,110	1,060	990	920	830	740	640

Deceleration Length (L_D) for Buses (ft)

Notes: For the adjustment factors for grade, see deceleration lane in Chapter 1360. Ramp lane width shown for illustrative purposes. Determine lane width according to 1420.03(5). Verify ramp width selection with transit providers that may utilize these connections.

1420.03(7)(d) Urban Off-Connection Design

Design left-side HOV direct access off-connections in urban areas as follows:

1. Either the parallel (desirable) or the taper (with justification) design may be used.
2. Use the longer deceleration length of: the Deceleration Length for Buses (see 1420.03(7)(c)) from a 60 mph freeway speed to the ramp design speed (see 1420.03(2)) or the Minimum Deceleration Length given in Chapter 1360 from the freeway design speed to the ramp design speed.

1420.03(7)(e) Rural Off-Connection Design

Design left-side HOV direct access off-connections in rural areas using mainline design speed.

For more information, see *Understanding Flexibility in Transportation Design – Washington*. It is complementary to the content in this chapter, and provides more insights to modal designs, environment and aesthetics, community engagement, jurisdictional coordination.

1430.04(2)(d) Drainage

Provide sufficient slope for surface drainage, as ponding of water in a lot is undesirable for both vehicles and pedestrians. This is particularly true in cold climates where freezing may create icy spots. The maximum grade is 2%. Install curb, gutter, and surface drains and grates where needed. Coordinate designs for drainage and pedestrian access routes to avoid conflicts. Coordinate drainage design with the local agency to make sure appropriate codes are followed. For additional drainage information, see *Design Manual* Chapter 800 and the *Roadside Manual*.

1430.04(2)(e) Pavement Design

Design pavement to conform to design specifications for each of the different uses and loadings that a particular portion of a lot or roadway is expected to handle. Bus lanes are typically Portland cement concrete pavement. Within the parking area, HMA-type pavements are typically used. Coordinate the pavement designs with the local transit agency and local jurisdiction. Consult with the Region Materials Engineer on pavement section requirements. There may be benefits to permeable pavement if space for stormwater facilities is limited.

1430.04(2)(f) Driver Guidance

Provide a well thought out design for traffic movements within the lot using the proper pavement markings and signage for safe and efficient use by all users of the lot. Typically, reflectorized markings for centerlines, lane lines, channelizing lines, and lane arrows are needed to guide or separate patron and transit traffic. Install park and ride identification signs. For signing and pavement markings, see Chapters 1020 and 1030 and the MUTCD.

1430.04(2)(g) Shelters

Coordinate with the transit agency on the need, location, design, and installation of pedestrian shelters. To satisfy local needs, shelters may be individually designed, provided by the transit agency, or selected from a variety of commercially available designs. These designs must meet ADA accessibility requirements. Consider the following features in shelter design:

- Select open locations with good visibility for user safety.
- Situate enclosed shelters away from edges of driveways and roadways to keep users dry.
- Select materials and locations where the bus driver can see waiting passengers.
- Avoid using doors, for ease of maintenance and to limit vandalism opportunities.
- Allow for a small air space along the bottom of the enclosure panels, to permit air circulation and reduce debris collection.
- Optional features you may provide are: lighting; heat; telephone; static or electronic travel information (schedules); electronic fare collection equipment; commercial advertisements for revenue generation; and trash receptacles.

For additional information on passenger amenities, see 1430.03.

1430.04(2)(h) Illumination, Safety, and Security

Lighting is important from a safety standpoint and as a deterrent to criminal activity in both the parking area and the shelters. For guidance, see *Design Manual* Chapter 1040, Chapter 630 of the *Roadside Manual*, local agency criteria, and AASHTO.

The *Guide for Geometric Design of Transit Facilities on Highways and Streets*, AASHTO, 2014, states: "Security at stations and major stops—both manned and unmanned—should be achieved by closed circuit television monitoring, provision of call boxes, good visibility and lighting, police surveillance, and effective designs. Both the actual security and the passengers' perceptions of security are important for a viable service or operation." (See the Guide for more information.)

1430.04(2)(i) Planting Areas

Selectively preserve existing vegetation and provide new plantings to afford a balanced environment for the park and ride lot user. For guidance and policy, see the *Roadside Manual* and the *Roadside Policy Manual*, respectively.

1430.04(2)(j) Fencing

For fencing guidelines, see Chapter 560 and discuss with the partnering transit agency.

1430.04(2)(k) Maintenance

Maintenance of park and ride lots outside state right of way is the responsibility of the local transit authority. Negotiate maintenance agreements with local transit authorities or other appropriate parties during the design phase, to identify the requirements and responsibilities for the maintenance. A Cooperative Agreement is written by HQ Real Estate Services for the purpose of assigning maintenance and/or operational responsibilities for a WSDOT park and ride lot to a transit agency or local governmental agency. (See the *Agreements Manual* and the HQ Real Estate Services Cooperative Agreement form.)

Consider the following in the maintenance plan:

- Cost estimate
- Periodic inspection
- Pavement repair
- Traffic control devices (signs and pavement markings)
- Lighting
- Mowing
- Cleaning of drainage structures
- Sweeping/trash pickup
- Landscaping
- Shelters
- Snow and ice control

Understanding Flexibility in Transportation Design – Washington, 2005 provides more information on many of the above topics.

Chapter 1510 Pedestrian Facilities

1510.01 General

Pedestrian travel is a vital transportation mode. It is used at some point by nearly everyone and is a critical link to everyday life for many. Designers must be aware of the various physical needs and abilities of pedestrians in order to ensure facilities provide universal access.

Section 504 of the Rehabilitation Act and the Americans with Disabilities Act of 1990 (ADA) require pedestrian facilities to be designed and constructed so they are readily accessible to and usable by persons with disabilities. This chapter provides accessibility criteria for the design of pedestrian facilities that meet applicable state and federal standards.

The pedestrian facilities included in a project are determined during the planning phase based on: access control of the highway; local transportation plans; comprehensive plans and other plans (such as Walk Route Plans developed by schools and school districts); the roadside environment; pedestrian volumes; user age group(s); and the continuity of local walkways along or across the roadway.

When developing pedestrian facilities within a limited amount of right of way, designers can be faced with multiple challenges. It is important that designers become familiar with the ADA accessibility criteria in order to appropriately balance intersection design with the often competing needs of pedestrians and other roadway users.

Similar to the roadway infrastructure, pedestrian facilities (and elements) require periodic maintenance in order to prolong the life of the facility and provide continued usability. Title II of the ADA requires that all necessary features be accessible and maintained in operable working condition for use by individuals with disabilities.

1510.02 References

1510.02(1) Federal/State Laws and Codes

ADA – 28 Code of Federal Regulations (CFR) Part 35, as revised September 15, 2010

23 CFR Part 652, Pedestrians and Bicycle Accommodations and Projects

49 CFR Part 27, Nondiscrimination on the Basis of Disability in Programs or Activities Receiving Federal Financial Assistance (Section 504 of the Rehabilitation Act of 1973 implementing regulations)

Revised Code of Washington (RCW) 35.68, Sidewalks, gutters, curbs and driveways – All cities and towns

RCW 35.68.075, Curb ramps for persons with disabilities – Required – Standards and Requirements

RCW 46.04.160, Crosswalk (definition)

RCW 46.61, Rules of the Road

RCW 47.24.020, City streets as part of state highways – Jurisdiction, control

1510.02(2) Design Guidance

ADA Standards for Accessible Design, U.S. Department of Justice (USDOJ), 2010; consists of 28 CFR parts 35 & 36 and the *ADA and Architectural Barriers Act (ABA) Accessibility Guidelines for Buildings and Facilities* (ADA-ABAAG; also referred to as the 2004 ADAAG), July 23, 2004, U.S. Access Board as modified by USDOT for entities receiving USDOT funding per 49 CFR Part 27. (Applies to new construction or alterations as of November 29, 2006 for entities receiving USDOT funding per 49 CFR Part 27.) https://www.access-board.gov/guidelines-and-standards/transportation/facilities/ada-standards-for-transportation-facilities

ADA Standards for Transportation Facilities, USDOT, 2006; consists of 49 CFR Parts 37, 38, & 39, the *ADA Accessibility Guidelines for Transportation Vehicles, September 6, 1991*, and the *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (ADA-ABAAG; also referred to as the 2004 ADAAG), July 23, 2004, U.S. Access Board as modified by USDOT. (For transit, light rail, and similar public transportation facilities under Federal Transit Administration jurisdiction.)

- https://www.access-board.gov/guidelines-and-standards/transportation/facilities/ada-standards-for-transportation-facilities
- https://www.access-board.gov/guidelines-and-standards/transportation/vehicles/adaag-for-transportation-vehicles

Department of Justice/Department of Transportation Joint Technical Assistance on the Title II of the Americans with Disabilities Act Requirements to Provide Curb Ramps when Streets, Roads, or Highways are Altered through Resurfacing, USDOJ and USDOT, July 2013

- http://www.ada.gov/doj-fhwa-ta.htm
- http://www.ada.gov/doj-fhwa-ta-glossary.htm
- https://www.ada.gov/doj-fhwa-ta-supplement-2015.html

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD) www.wsdot.wa.gov/publications/manuals/mutcd.htm

Revised Draft Guidelines for Accessible Public Rights-of-Way (PROWAG), November 23, 2005, U.S. Access Board. The current best practices for evaluation and design of pedestrian facilities in the public right of way per the following FHWA Memoranda:

- https://www.fhwa.dot.gov/environment/bicycle_pedestrian/resources/prwaa.cfm
- http://www.fhwa.dot.gov/civilrights/memos/ada_memo_clarificationa.htm
- https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/background/revised-draft-guidelines

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT www.wsdot.wa.gov/publications/manuals/m21-01.htm

1510.02(3) Supporting Information

1991 ADA Standards for Accessible Design, USDOJ; consists of 28 CFR parts 35 & 36 and the *ADA Accessibility Guidelines for Buildings and Facilities* (ADAAG), July 1991, U.S. Access Board. (For buildings and on-site facilities: Expired for new construction and alterations. To be used only for evaluating the adequacy of new construction or alteration that occurred prior to November 29, 2006 for entities receiving USDOT funding per 49 CFR Part 27.)
https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/background/adaag

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, Current version adopted by FHWA

Field Guide for Accessible Public Rights of Way, WSDOT, November 1, 2012
http://www.wsdot.wa.gov/publications/fulltext/roadside/ada_field_guide.pdf

Guide for the Planning, Design, and Operation of Pedestrian Facilities, AASHTO, 2004. Provides guidance on the planning, design, and operation of pedestrian facilities along streets and highways. Specifically, the guide focuses on identifying effective measures for accommodating pedestrians on public rights of way. It can be purchased through the AASHTO website.

Highway Capacity Manual, Transportation Research Board (TRB), 2000

Pedestrian Facilities Guidebook: Incorporating Pedestrians Into Washington's Transportation System, OTAK, 1997 www.wsdot.wa.gov/publications/manuals/fulltext/m0000/pedfacgb.pdf

Pedestrian Facilities Users Guide – Providing Safety and Mobility, FHWA, 2002. Provides useful information regarding walkable environments, pedestrian crashes and their countermeasures, and engineering improvements for pedestrians.
http://drusilla.hsrc.unc.edu/cms/downloads/pedfacility_userguide2002.pdf

Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way, July 26, 2011, U.S. Access Board. Federal Notice of Proposed Rule Making that gives a preview of potential future revisions to the PROWAG. https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines

"Special Report: Accessible Public Rights-of-Way – Planning & Design for Alterations," Public Rights-of-Way Access Advisory Committee, July 2007
www.access-board.gov/prowac/alterations/guide.htm

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005
www.wsdot.wa.gov/research/reports/600/638.1.htm

Washington State Bicycle Facilities and Pedestrian Walkways Plan
www.wsdot.wa.gov/bike/bike_plan.htm

Terminal Design Manual, Chapter 300 Accessibility, WSDOT, Washington State Ferries Division www.wsdot.wa.gov/publications/manuals/m3082.htm

1510.03 Definitions

Refer to the "ADA / Pedestrian Terms" section of the *Design Manual* Glossary for definitions of many of the terms used in this chapter.

1510.04 Policy

1510.04(1) General

It is WSDOT policy to provide appropriate pedestrian facilities along and across sections of state routes as an integral part of the transportation system. Federal Highway Administration (FHWA) and WSDOT policy is that bicycle and pedestrian facilities be given full consideration in the planning and design of new construction and reconstruction highway projects, except where bicycle and pedestrian use is prohibited.

1510.04(2) Jurisdiction

Proposed projects in public rights of way must address ADA compliance as described in this chapter. (See 1510.05 for ADA requirements by project type.) Regardless of which public agency has jurisdiction within the right of way, the public agency that is sponsoring the project is responsible for ensuring ADA compliance is addressed on its project.

On all state routes outside of incorporated cities and on those with limited access (full, partial, and modified) within incorporated cities, jurisdiction remains with the state unless modified by a maintenance agreement. In turnback areas where the turnback agreement has not been completed, the state maintains full jurisdiction (see Chapters 510, 520, and 530).

When project work occurs on a managed access state route inside an incorporated city that has jurisdiction beyond the curbs (RCW 47.24.020), design pedestrian facilities using the city design standards adopted in accordance with RCW 35.78.030 and the most current ADA requirements. Document the coordination with the city in the Design Documentation Package (DDP). Refer to Chapter 300 for information about the DDP.

1510.04(3) Transition Planning

Section 504 of the Rehabilitation Act and the ADA require all public entities to conduct a self-evaluation of their programs and activities, including sidewalks, curb ramps, and other pedestrian facilities and elements within the public right of way, to determine if barriers exist that prevent people with disabilities from being able to access these programs and activities.

If barriers are identified, agencies with 50 or more employees must develop and implement a transition plan that describes the barriers, the modifications needed, and a schedule for when the needed work will be accomplished.

1510.04(4) Maintenance

As noted in 1510.01, Title II of the ADA requires that a public entity maintain in operable working condition those features of facilities and equipment that are required to be readily accessible to and usable by persons with disabilities.

1510.05 ADA Requirements by Project Type

Wherever pedestrian facilities are intended to be a part of the transportation facility, federal regulations (28 CFR Part 35) require that those pedestrian facilities meet ADA guidelines. All new construction or alteration of existing transportation facilities must be designed and constructed to be accessible to and usable by persons with disabilities. FHWA is one of the federal agencies designated by the Department of Justice to ensure compliance with the ADA for transportation projects.

1510.05(1) New Construction Projects

New construction projects address the construction of a new roadway, interchange, or other transportation facility where none existed before. For these projects, pedestrians' needs are assessed and included in the project. All pedestrian facilities included in these projects must fully meet the accessibility criteria when built.

1510.05(2) Alteration Projects

Any project that affects or could affect the usability of a pedestrian facility is classified as an alteration project. Alteration projects include, but are not limited to, renovation; rehabilitation; reconstruction; historic restoration; resurfacing of circulation paths or vehicular ways; and changes or rearrangement of structural parts or elements of a facility. Where existing elements or spaces are altered, each altered element or space within the limits of the project shall comply with the applicable accessibility requirements to the maximum extent feasible.

The following are some examples of project types that are classified as alteration projects and can potentially trigger a variety of ADA requirements:

- HMA overlay or inlay
- Traffic signal installation or retrofit
- Roadway widening
- Realignment of a roadway (vertical or horizontal)
- Sidewalk improvements
- PCCP panel repair/replacement
- Bridge replacement
- Raised channelization

The following are not considered alterations:

- Spot pavement repair
- Liquid-asphalt sealing, chip seal (BST), or crack sealing
- Lane restriping that does not alter the usability of the shoulder

If there is uncertainty as to whether a project meets the definition of an alteration project, consult with the Regional ADA Coordinator.

The following apply to alteration projects:

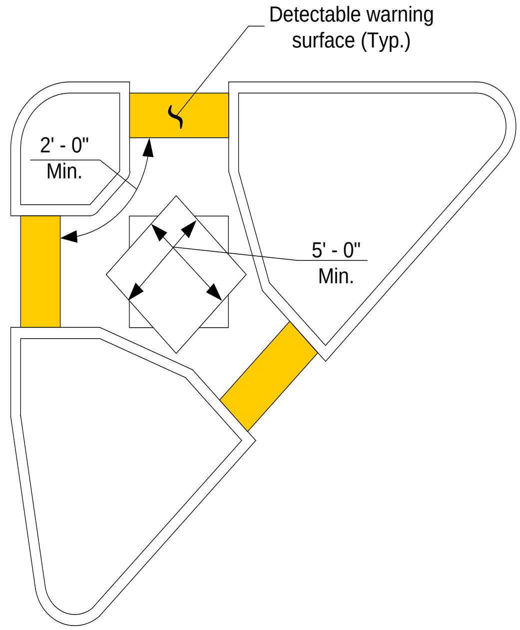
- All new pedestrian facilities included in an alteration project that are put in place within an existing developed right of way must meet applicable accessibility requirements to the maximum extent feasible.
- All existing pedestrian facilities disturbed by construction of an alteration project must be replaced. The replacement facilities must meet applicable accessibility requirements to the maximum extent feasible.
- An alteration project shall not decrease or have the effect of decreasing the accessibility of a pedestrian facility or an accessible connection to an adjacent building or site below the ADA accessibility requirements in effect at the time of the alteration.
- Within the construction impact zone of an alteration project, any existing connection from a pedestrian access route to a crosswalk (marked or unmarked) that is missing a required curb ramp must have a curb ramp installed that meets applicable accessibility requirements to the maximum extent feasible. (See 1510.09(2) for curb ramp accessibility criteria.)

- A crosswalk served by a curb ramp must also have an existing curb ramp in place on the receiving end unless there is no curb or sidewalk on that end of the crosswalk (RCW 35.68.075). If there is no existing curb ramp in place on the receiving end, an accessible curb ramp must be provided. This requirement must be met regardless of whether the receiving end of the crosswalk is located within the project's limits.
- Within the construction impact zone of an alteration project, evaluate all existing curb ramps to determine whether curb ramp design elements meet the accessibility criteria. (See 1510.09(2) for curb ramp accessibility criteria.) Modify existing curb ramps that do not meet the accessibility criteria to meet applicable accessibility requirements to the maximum extent feasible. This may also trigger modification of other adjacent pedestrian facilities to incorporate transitional segments in order to ensure specific elements of a curb ramp will meet the accessibility criteria.
- Within the construction impact zone of an alteration project that includes hot mix asphalt overlay (or inlay) of an existing roadway and *does not* include reconstruction, realignment, or widening of the roadway, evaluate all existing marked and unmarked crosswalks. (See 1510.10(2) for crosswalk accessibility criteria.) If it is not possible to meet the applicable accessibility requirements for crosswalks, document this in the DDP.
- Within the construction impact zone of an alteration project that includes reconstruction, realignment, or widening of the roadway, evaluate all existing crosswalks (marked or unmarked) to determine whether crosswalk design elements meet the accessibility criteria. (See 1510.10(2) for crosswalk accessibility criteria.) Modify crosswalk slopes to meet the applicable accessibility requirements to the maximum extent feasible.

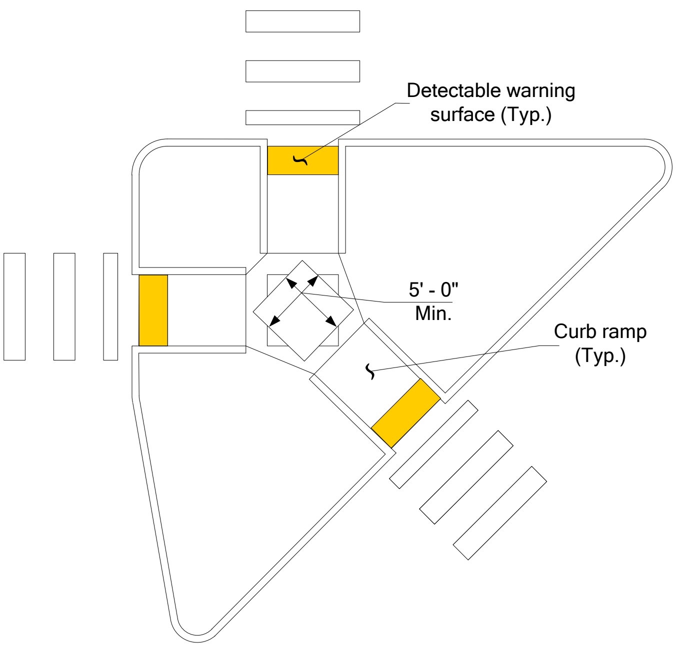
It may not always be possible to fully meet the applicable accessibility requirements during alterations of existing facilities. If such a situation is encountered, consult with the Regional ADA Coordinator to develop a workable solution to meet the accessibility requirements to the maximum extent feasible. Cost is not to be used as a justification for not meeting the accessibility criteria. Physical terrain or site conditions that would require structural impacts, environmental impacts, or unacceptable impacts to the community in order to achieve full compliance with the accessibility criteria are some of the factors that can be used to determine that the maximum extent feasible is achieved. If it is determined to be virtually impossible to meet the accessibility criteria for an element, document the decision in one of the following ways, as applicable:

- Within the construction impact zone of an alteration project that does not include reconstruction, realignment, or widening of the roadway, document the following deficient elements in the DDP:
    - Perpendicular curb ramp or parallel curb ramp landing cross slope that is constrained by the existing roadway gutter profile and exceeds 2%, but is less than or equal to 5%, that cannot be constructed to fully meet applicable accessibility requirements.
    - Flared side of a perpendicular curb ramp that is constrained by the existing roadway gutter profile and has a slope that exceeds 10%, but is less than or equal to 16.7%, that cannot be constructed to fully meet applicable accessibility requirements.
- For any deficient element that does not match the preceding description, document the decision via a Maximum Extent Feasible (MEF) document. The MEF document will be reviewed by the appropriate Assistant State Design Engineer (ASDE) and the Headquarters (HQ) ADA Compliance Manager. If acceptable, the MEF document will be approved and included in the DDP.

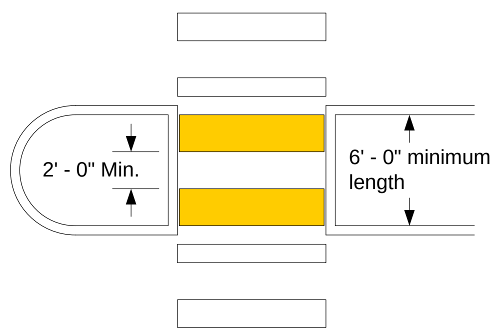
Island Cut-Through



Island Cut-Through



Raised Traffic Island With Curb Ramps



Median Island Cut-Through (full width shown)
(See 1510.11(1) for minimum accessibility criteria.)

See the *Standard Plans* for details.

Raised Islands With Curb Ramps and Pedestrian Cut-Throughs
Exhibit 1510-22

1510.12 Pedestrian Pushbuttons at Signals

When designing pedestrian signals, consider the needs of all pedestrians, including older pedestrians and pedestrians with disabilities who might walk at a significantly slower pace than the average pedestrian. Determine whether there are pedestrian generators in the project vicinity that might attract older people and pedestrians with disabilities, and adjust signal timing accordingly. When pedestrian signals are newly installed, replaced, or significantly modified, include accessible pedestrian signal (APS) pushbuttons and countdown pedestrian displays as described in 1510.12(2).

Typical Pedestrian Pushbutton
Exhibit 1510-23

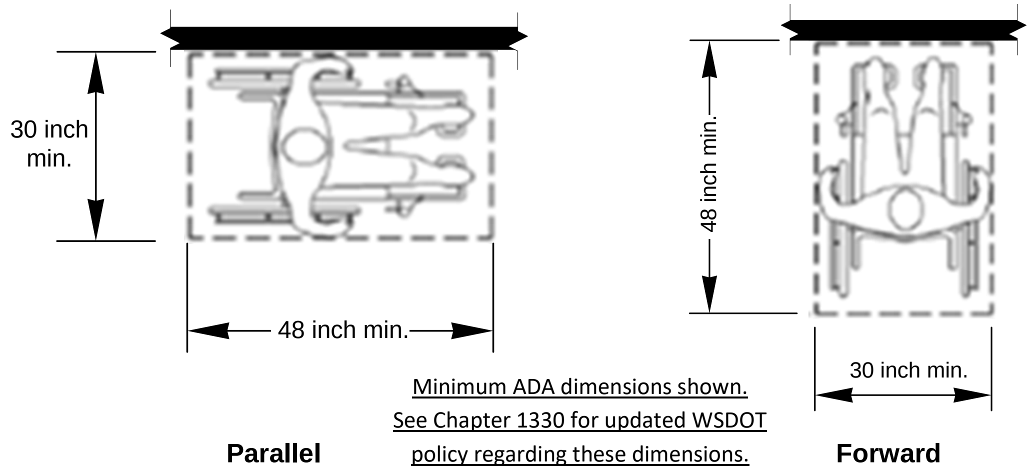
1510.12(1) Accessibility Criteria for All Pedestrian Pushbuttons (including APS)

1510.12(1)(a) Location Requirements

- Not greater than 5 feet from the crosswalk line (extended) that is farthest from the center of the intersection.
- Between 1½ feet and 10 feet from the edge of the curb, shoulder, or pavement.
- Mounting height: 42 inches desirable, 48 inches maximum, 15 inches minimum.

1510.12(1)(b) Clear Space Requirements

- Grade: 2% maximum running and cross slopes.
- Clear space dimensions: 30 inches minimum width by 48 inches minimum length (see Exhibit 1510-24). [Note: These are minimum ADA dimensions. See Chapter 1330 for updated WSDOT policy regarding these dimensions.]
- Clear space is allowed to overlap other PAR elements (i.e., sidewalk/curb ramp landing).
- Clear space must be connected to the crosswalk served by the pedestrian pushbutton with a PAR.
- Additional maneuvering space may be required if the clear space is constrained on three sides (see PROWAG).



Note: A desirable clear space accommodates the full spectrum of wheeled mobility device users approaching the pedestrian pushbutton from multiple directions. Consider providing 36 inches width and up to 84 inches length designed for a parallel approach with the pedestrian pushbutton centered within the length.

Clear Space Parallel and Forward Approach Orientation
Exhibit 1510-24

1510.12(1)(c) Reach Range Requirements

[Minimum ADA criteria. See Chapter 1330 for updated WSDOT policy.]

- The provided clear space must be within reach range of the pedestrian pushbutton.
- For a parallel approach pedestrian pushbutton that has a mounting height greater than 46 inches and not more than 48 inches, the reach range is 10 inches maximum.
- For a parallel approach pedestrian pushbutton that has a mounting height 46 inches or less, the reach range is 24 inches maximum; however, design for 10 inches or less reach range whenever possible.
- For a forward approach pedestrian pushbutton, the reach range is 0 (zero) inches maximum regardless of mounting height. The pushbutton must either be placed at the very edge of the clear space or extend into the clear space while providing knee and toe clearance for a wheeled mobility device user (see PROWAG).

Note: Due to the challenges associated with providing reach range, it is desirable to design clear space for a parallel approach whenever possible.

1510.12(2) Accessible Pedestrian Signals (APS)

At all locations where pedestrian signals are newly installed, replaced, or significantly modified, the installation of accessible pedestrian signals and countdown pedestrian displays is required. ***Note:*** Simply moving existing pedestrian pushbuttons to satellite poles to improve accessibility is not by itself considered a significant modification of the pedestrian signal.

When APS and countdown pedestrian display improvements are made, they shall be made for all locations associated with the system being improved. APS includes audible and vibrotactile indications of the WALK interval. Installation of these devices may require improvements to existing sidewalks and curb ramps to ensure ADA compliance.

Accessible Pedestrian Signal Pushbutton Stations
Exhibit 1510-25

1510.12(3) Accessibility Criteria for Accessible Pedestrian Signals (APS)

In addition to the general pedestrian pushbutton accessibility criteria described in 1510.12(1), the following criteria apply to APS installations:

- APS pushbuttons shall have a locator tone that operates during the DON’T WALK and the flashing DON’T WALK intervals only.
- APS pushbuttons must have both audible and vibrotactile indications of the WALK interval.
- APS pushbutton controls and signs shall be installed facing the intersection and be parallel to the crosswalk served.
- An APS pushbutton shall have a tactile arrow that indicates the crossing direction activated by the pushbutton.
- An APS pushbutton provides high contrast (light-on-dark or dark-on-light) against its background.
- If extended pushbutton press features are available, the APS pushbutton shall be marked with three braille dots forming an equilateral triangle in the center of the pushbutton.
- If additional crossing time is provided by an extended pushbutton press feature, then an R10-32P (MUTCD) plaque shall be mounted adjacent to or integral with the APS pushbutton.
- If the pedestrian clearance time is sufficient only to cross from the curb or shoulder to a median to wait for the next cycle, then an additional APS pushbutton shall be provided in the median.
- The desirable spacing between the APS pushbuttons is 10 feet minimum (5 feet minimum spacing on medians and islands), if feasible.
- If the spacing between the APS pushbuttons is 10 feet or greater, the audible WALK indication shall be a percussive tone.
- If the spacing between the APS pushbuttons is less than 10 feet, the audible WALK indication shall be a speech walk message, and a speech pushbutton information message shall be provided.

Refer to the MUTCD for further design guidance. Also, consult with HQ Traffic Operations and either region or city maintenance personnel (as appropriate) for current equipment specifications and additional maintenance requirements.

Chapter 1600 Roadside Safety

1600.01 General

Roadside safety addresses the area outside the roadway and is an important component of total highway design. There are numerous reasons why a vehicle leaves the roadway, including driver error and behaviors. Regardless of the reason, a roadside design can reduce the severity and subsequent consequences of a roadside encroachment. From a crash reduction and severity perspective, the ideal highway has roadsides and median areas that are flat and unobstructed by objects. It is also recognized that different facilities have different needs and considerations, and these issues are considered in any final design.

It is not possible to provide a clear zone free of objects at all locations and under all circumstances. The engineer faces many tradeoffs in design decision-making, balancing needs of the environment, right of way, and different modes of transportation. The fact that recommended values for guardrail are presented in this chapter does not require the Washington State Department of Transportation to modify or upgrade locations to meet the specified or new criteria; those locations are addressed as appropriate through the priority array. On some projects, an analysis of roadside crash potential will be needed. See Chapter 321.

Elements such as sideslopes, fixed objects, and water are features that a vehicle might encounter when it leaves the roadway. These features present varying degrees of deceleration to the vehicle and its occupants. Unfortunately, geography and economics do not always allow ideal highway conditions. The mitigative measures to be taken depend on the probability of a crash occurring, the likely severity, and the priority array.

In order of priority, the mitigative measures the Washington State Department of Transportation (WSDOT) uses are:

1. Remove
2. Redesign (a fixed object) so it can be traversable
3. Relocate
4. Reduce impact severity (using breakaway features or making it traversable)
5. Shielding with a traffic barrier; or
6. Delineate (if the previous options are not appropriate or feasible)

Factors for selecting a mitigative measure include, but may not be limited to:

- Cost (initial and life cycle costs)
- Maintenance needs
- Crash severity potential

Use traffic barriers when other measures cannot reasonably be accomplished and conditions are appropriate based on an engineering analysis. See Chapter 1610 for additional information on traffic barriers.

1600.02 Clear Zone

A clear roadside border area is a primary consideration when analyzing potential roadside and median features (as defined in 1600.03). The intent is to provide as much clear, traversable area for a vehicle to recover as practicable given the function and context of the roadway and the potential tradeoffs. The Design Clear Zone is used to evaluate the adequacy of the existing clear area and proposed modifications of the roadside. When considering the placement of new objects along the roadside or median, evaluate the potential for impacts and try to select locations with the least likelihood of an impact by an errant vehicle.

In situations where the Design Clear Zone is beyond WSDOT right of way, evaluate options on a case-by-case basis. Consider the nature of the objects within the Design Clear Zone, the roadway geometry, traffic volume, and crash history. Coordinate with adjacent property owners when proposed options include any work beyond WSDOT right of way. At a minimum, provide clear zone to the limits of the WSDOT right of way.

Clear zone is measured from the edge of the through traveled way. Auxiliary lanes longer than 400 ft generally operate the same as a through lane and should be considered. Any project that changes the relationship between the through lane and the roadside by widening or realignment has changed the clear zone and requires evaluation.

1600.02(1) Design Clear Zone on Limited Access State Highways and Other State Highways Outside Incorporated Cities and Towns

Use the Design Clear Zone Inventory form (Exhibit 1600-3) to identify potential features to be mitigated and propose corrective actions.

Guidance for establishing the Design Clear Zone for highways outside incorporated cities is provided in Exhibit 1600-2. This guidance also applies to limited access facilities within the city limit. Providing a clear recovery area that is consistent with this guidance does not require any additional documentation. However, there might be situations where it is not practicable to provide these recommended distances. In these situations, document the decision as a Design Analysis as discussed in Chapter 300.

There is flexibility in establishing the Design Clear Zone in urbanized areas where operating speeds are 35 mph or less. To achieve this flexibility, use a Design Analysis to establish the Design Clear Zone that presents the tradeoffs associated with the decision. Provide information on the benefits and impacts of the Design Clear Zone selected in the Design Analysis, including safety, aesthetics, the environment, economics, modal needs, and access control. Although not a WSDOT policy document on clear zone, Chapter 10 of the AASHTO *Roadside Design Guide* provides information to consider when performing a Design Analysis in urban areas.

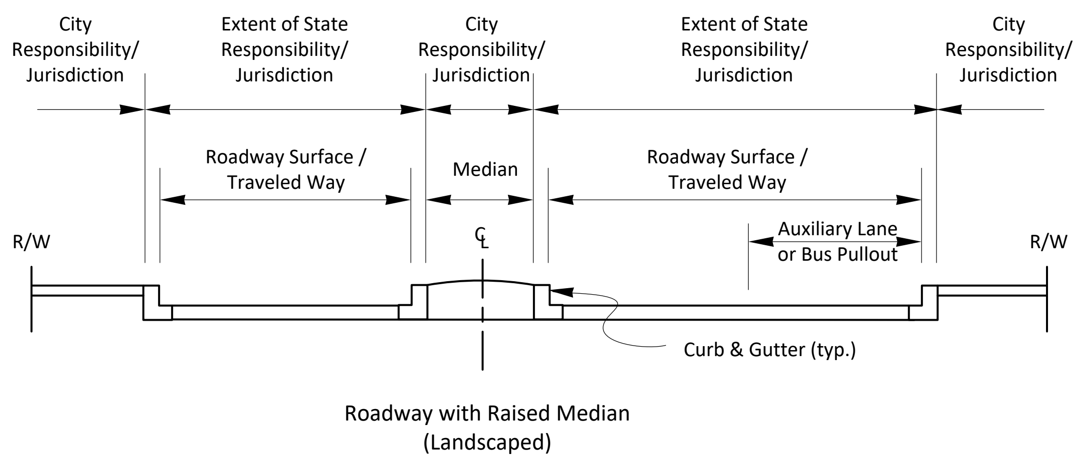
In curbed sections, and where applicable (e.g. parking), provide an 18-inch operational offset beyond the face of curb for lateral clearance to accommodate opening car doors or large side mirrors.

1600.02(2) Design Clear Zone Inside Incorporated Cities and Towns

For managed access state highways within an urban area, it might not be practicable to provide the Design Clear Zone distances shown in Exhibit 1600-2. Roadways within an urban area generally have curbs and sidewalks and might have objects such as trees, poles, benches, trash cans, landscaping, and transit shelters along the roadside.

For projects on city streets as state highways that include work in those areas that are the city's responsibility and jurisdiction (see Exhibit 1600-1), design the project using the city's development/design Standards. The standards adopted by the city must meet the requirements set by the City Design Standards Committee for all arterial projects, bike projects, and federal-aid projects. See the Local Agency Guidelines Chapter 42 for more information on this Committee.

Exhibit 1600-1 City and State Responsibilities and Jurisdictions



1600.02(2)(a) Roadside and Median

For managed access state highways inside incorporated cities, it is the city's responsibility to establish an appropriate Design Clear Zone in accordance with guidance contained in the City and County Design Standards (*Local Agency Guidelines*, Chapter 42.) Exhibit 1600-1 shows an example of state and city responsibilities and jurisdictions. Document the Design Clear Zone established by the city in the Design Documentation Package. Have the responsible transportation official from the city (e.g., City Engineer) document the Design Clear Zone, and their acknowledgement and acceptance of the design and maintenance responsibilities for project roadsides and medians, in a letter addressed to WSDOT, and file this letter as part of the local agency coordination in the Design Documentation Package. Respond to the sender by letter acknowledging receipt.

1600.02(3) Design Clear Zone and Calculations

Use Exhibit 1600-2 to determine the Design Clear Zone for posted speed, sideslope, and traffic volume at any given location. Note that there are no clear zones distances in the table for 3H:1V fill slopes. Although fill slopes between 4H:1V and 3H:1V are considered traversable if free of fixed objects, these slopes are defined as nonrecoverable slopes. A vehicle might be able to begin recovery on the shoulder, but likely will not be able to further this recovery until reaching a flatter area (4H:1V or flatter) at the toe of the slope. Under these conditions, the Design Clear

Zone distance is called a recovery area. The method used to calculate the recovery area and an example are shown in Exhibit 1600-4.

For ditch sections, the following criteria determine the Design Clear Zone:

(a) For ditch sections with foreslopes 4H:1V or flatter (see Exhibit 1600-5, Case 1, for an example), the Design Clear Zone distance is the greater of the following:

- The Design Clear Zone distance for a 10H:1V cut section based on speed and the average daily traffic (ADT); or
- A horizontal distance of 5 feet beyond the beginning of the backslope.

When a backslope steeper than 3H:1V continues for a horizontal distance of 5 feet beyond the beginning of the backslope, it is not necessary to use the 10H:1V cut slope criteria.

(b) For ditch sections with foreslopes steeper than 4H:1V and backslopes steeper than 3H:1V, the Design Clear Zone distance is 10 feet horizontal beyond the beginning of the backslope (see Exhibit 1600-5, Case 2, for an example).

(c) For ditch sections with foreslopes steeper than 4H:1V and backslopes 3H:1V or flatter, the Design Clear Zone distance is the distance established using the recovery area formula (see Exhibit 1600-4; also see Exhibit 1600-5, Case 3, for an example).

1600.03 Mitigation Guidance

There are three general categories of features to be mitigated: sideslopes, fixed objects, and water. This section provides guidance for determining when these objects present a significant risk to an errant motorist. For each case, the following conditions need added consideration:

- Locations with high expected crash frequency.
- Locations with pedestrian and bicycle usage (See Chapters 1510, Pedestrian Facilities, 1515, Shared-Use Paths, and 1520, Roadway Bicycle Facilities).
- Playgrounds, monuments, and other locations with high social or economic value.
- Redirectional landforms, also referred to as earth berms, were installed to mitigate objects located in depressed medians and at roadsides. They were constructed of materials that provided support for a traversing vehicle. With slopes in the range of 2H:1V to 3H:1V, they were intended to redirect errant vehicles. The use of redirectional landforms has been discontinued as a means for mitigating fixed objects. Where redirectional land forms currently exist as mitigation for a fixed object, provide designs where the landforms, and the feature(s) they were intended to mitigate, are removed, relocated, made crashworthy, or shielded with barrier. Landforms may be used to provide a smooth surface at the base of a rock cut slope.

The use of a traffic barrier for features other than those described below requires justification.

1600.03(1) Side Slopes

1600.03(1)(a) Fill Slopes

Fill slopes can present a risk to an errant vehicle with the degree of severity dependent upon the slope and height of the fill. Providing fill slopes that are 4H:1V or flatter can mitigate this condition. If flattening the slope is not feasible or cost-effective, the installation of a barrier might be appropriate. Exhibit 1600-6 represents a selection procedure used to determine whether an existing fill sideslope constitutes a condition for which a barrier is a cost-effective mitigation. The curves are based on the severity indexes and represent the points where total costs associated with a traffic barrier are equal to the predicted cost of crashes over the service life for selected slope heights without traffic barrier. If the ADT and height of fill intersect on the "Barrier Recommended" side of the embankment slope curve, then provide a barrier if flattening the slope is not feasible or cost-effective.

Do not use Exhibit 1600-6 for slope design. Design slopes consistent with guidance in Chapter 1239, evaluating designs with clear, traversable slopes before pursuing a barrier option. Also, if Exhibit 1600-6 indicates that barrier is not recommended at an existing slope, that result is not justification for a Design Analysis. For example, if the ADT is 4,000 and the embankment height is 10 feet, barrier might be cost-effective for a 2H:1V slope, but not for a 2.5H:1V slope. This process only addresses the potential risk of exposure to the slope. Obstacles on the slope can compound the condition. Where barrier is not cost-effective, use the recovery area formula to evaluate fixed objects on critical fill slopes less than 10 feet high.

1600.03(1)(b) Cut Slopes

A traversable cut slope reduces crash potential. The exception is a rock cut with a rough face that might cause vehicle snagging rather than providing relatively smooth redirection.

Analyze the location and evaluate the roadside characteristics, crash potential, and other benefits of treatment of rough rock cuts located within the Design Clear Zone. Conduct an individual investigation for each rock cut or group of rock cuts. A cost-effectiveness analysis that considers the consequences of doing nothing, removal, smoothing of the cut slope, and other viable options to reduce the severity of the condition can be used to determine the appropriate treatment. Some potential options are:

- Graded landform along the base of a rock cut
- Flexible barrier
- More rigid barrier
- Rumble strips

1600.03(2) Fixed Objects

Use engineering judgment when considering the following objects for mitigation:

- Wooden poles or posts with cross-sectional areas greater than 16 square inches that do not have breakaway features.
- Signs, illumination, cameras, weather stations, and other items mounted on nonbreakaway poles, cantilevers, or bridges.
- Trees with a diameter of 4 inches or more, measured at 6 inches above the ground surface.

- Fixed objects extending above the ground surface by more than 4 inches; for example, boulders, concrete bridge rails, signal/electrical/ITS cabinets, piers, and retaining walls.
- Drainage items, such as culvert and pipe ends.

1600.03(2)(a) Trees

When evaluating new plantings or existing trees, consider the maximum allowable diameter of 4 inches, measured at 6 inches above the ground when the tree has matured. When removing trees within the Design Clear Zone, complete removal of stumps is preferred. However, to avoid significant disturbance of the roadside vegetation, larger stumps may be mitigated by grinding or cutting them flush to the ground and grading around them.

Removal of trees may reduce the impacts of roadway departure, and clear zone encroachments. It is recognized that different facilities have different needs and considerations, and these issues are considered in any final design. For instance, removal of trees within the Design Clear Zone may not be desirable in urban areas, or in other land use contexts such as within areas having high level of non-motorized uses, a forest, park, or within a scenic and recreational highway. In these situations, analyze crash reports' contributing factors to determine whether roadside vegetation is contributing to the severity of crashes. If large vegetation is removed, replace with shrubs or groundcover or consult guidance contained in established vegetation management plans or corridor plans. Additional guidance for maintenance of roadside vegetation can be found in the Memorandum of Understanding between the US Forest Service and WSDOT, *Highways Over National Forest Lands*, dated July 2002. In incorporated cities, refer to guidance in 1600.02(2).

1600.03(2)(b) Mailboxes

For mailboxes located within the Design Clear Zone, provide supports and connections as shown in the *Standard Plans*. The height from the ground to the bottom of the mailbox is 3 feet 3 inches. This height may vary from 3 feet 3 inches to 4 feet if requested by the mail carrier. If the desired height is to be different from 3 feet 3 inches, provide the specified height in the contract plans. (See Exhibit 1600-7 for installation guidelines.) Coordinate with homeowners when upgrading mailboxes.

In urban areas where sidewalks are prevalent, contact the postal service to determine the most appropriate mailbox location. Locate mailboxes on limited access highways in accordance with Chapter 530, Limited Access. A turnout, as shown in Exhibit 1600-7, is not needed on limited access highways with shoulders of 6 feet or more where only one mailbox is to be installed. On managed access highways, mailboxes are to be on the right-hand side of the road in the postal carrier's direction of travel. Avoid placing mailboxes along high-speed, high-volume highways. Locate Neighborhood Delivery and Collection Box Units outside the Design Clear Zone.

1600.03(2)(c) Culvert Ends

Provide a traversable end treatment when the culvert end section or opening is on the roadway sideslope and within the Design Clear Zone. This can be accomplished for small culverts by beveling the end to match the sideslope, with a maximum of 4 inches extending out of the sideslope.

Bars might be needed to provide a traversable opening for larger culverts. Place bars in the plane of the culvert opening in accordance with the *Standard Plans* when:

- Single cross-culvert opening exceeds 40 inches, measured parallel to the direction of travel.
- Multiple cross-culvert openings that exceed 30 inches each, measured parallel to the direction of travel.
- Culvert approximately parallel to the roadway that has an opening exceeding 24 inches, measured perpendicular to the direction of travel.

Bars are permitted where they will not significantly affect the stream hydraulics and where debris drift is minor. Consult the region Maintenance Office to verify these conditions. If debris drift is a concern, consider options to reduce the amount of debris that can enter the pipe (see the *Hydraulics Manual*). Other treatments are extending the culvert to move the end outside the Design Clear Zone or installing a traffic barrier.

1600.03(2)(d) Signposts

Whenever possible, locate signs behind the standard run, but not the end terminals, of existing or planned traffic barrier installations to eliminate the need for breakaway posts, and place them such that the sign face is behind the barrier. When barrier is not present, use terrain features where practicable to reduce the likelihood of an errant vehicle striking the signposts. (See Chapter 1020 for additional information regarding the placement of signs.) Use the MUTCD to guide placement of the warning sign.

Signposts with cross-sectional areas greater than 16 square inches that are within the Design Clear Zone and not located behind a barrier are to have breakaway features as shown in the *Standard Plans*.

Sign bridges and cantilever sign supports are designed for placement outside the Design Clear Zone or must be shielded by barrier.

1600.03(2)(e) Traffic Signal Standards/Posts/Supports

Breakaway signal posts generally are not feasible or desirable, and barrier is not generally an option due to constraints that are typically found at intersection locations. To reduce potential for contact with vehicles, or impede the movement of pedestrian or bicycle traffic in the vicinity, locate posts in accordance with Chapter 1330.

For ramp meter systems, single lane ramp meters use breakaway Type RM signal standards. Multilane ramp meters normally use Type II signal standards, which must either be located outside of clear zone for all adjacent roadways or be protected by some type of barrier.

1600.03(2)(f) Fire Hydrants

Fire hydrants are typically allowed on WSDOT right of way by franchise or permit. Fire hydrants that are made of cast iron can be expected to fracture on impact and can therefore be considered a breakaway device. Any portion of the hydrant that will not be breakaway must not extend more than 4 inches above the ground. In addition, the hydrant must have a stem that will shut off water flow in the event of an impact. Provide mitigation to address potential vehicle impact with hydrant types not expected to fracture on impact.

1600.03(2)(g) Utility Poles

Since utilities often share the right of way, utility objects such as poles are often located along the roadside. It is normally undesirable or infeasible to install barrier for all of these objects, so mitigation is usually in the form of relocation (underground or to the edge of the right of way) or delineation. In some instances where there is a history of impacts with poles and relocation is not possible, a breakaway design might be appropriate.

Evaluate roadway geometry and crash history as an aid in determining locations that exhibit the greatest need. Contact the Headquarters (HQ) Design Office for information on breakaway features. Coordinate with the HQ Utilities Unit when appropriate.

For policy and guidance on locating utility poles along state highways, also see Chapter 9 of the *Utilities Manual*. Document the determination of appropriate mitigative measures and coordination with the region Utilities Office.

1600.03(2)(h) Light Standards

Provide breakaway light standards unless fixed light standards can be justified. Fixed light standards may be appropriate in areas of extensive pedestrian concentrations, such as adjacent to bus shelters. Document the decision to use fixed bases in the Design Documentation Package.

1600.03(3) Water

Water with a depth of 2 feet or more and located with a likelihood of encroachment by an errant vehicle is to be considered for mitigation.

Perform a benefit-cost analysis that considers the consequences of doing nothing versus installing a longitudinal barrier to determine the appropriate treatment (see Chapter 321 for more information). For fencing considerations along water features, see Chapter 560.

1600.04 Medians

Median barriers are normally used on limited access, multilane, high-speed, high-volume highways. These highways generally have posted speeds of 45 mph or higher. Median barrier is not normally placed on collectors or other state highways that do not have limited access control. Providing access through median barrier results in openings, therefore, end treatments are needed.

Provide median barrier on full access control multilane highways with median widths of 50 feet or less and posted speeds of 45 mph or higher. Consider median barrier on highways with wider medians or lower posted speeds when there is a history of cross-median crashes. Contact the HQ Design Office for more information.

Provide a left-side shoulder when installing median barrier using width criteria given in Chapter 1230. Consider a wider shoulder area where the barrier might cast a shadow on the roadway and hinder the melting of ice. (See Chapter 1239 for additional criteria for placement of median barrier, Chapter 1610 for information on the types of barriers that can be used, and Chapter 1260 for lateral clearance on the inside of a curve to provide the needed stopping sight distance.) Consider the need to accommodate drainage as a result of the addition of median barrier treatments.

When median barrier is being placed in an existing median, identify the existing crossovers and enforcement observation points. Provide the needed median crossovers in accordance with Chapter 1370, considering enforcement needs. Chapter 1410 provides guidance on HOV enforcement.

1600.05 Other Roadside Safety Features

1600.05(1) Rumble Strips

Rumble strips are milled grooves or rows of raised pavement markers placed perpendicular to the direction of travel to alert inattentive drivers.

Depending on the pavement condition or type, rumble strips may have an adverse impact on pavement longevity or performance. Consult with the Region Materials Engineer to determine installation procedure and verify that the pavement structure is adequate. Installation should also be avoided in open-graded pavements. In locations where the pavement structure or type would preclude rumble strip installation, mill out a strip of the existing pavement, fill with hot mix asphalt (per Region Materials Engineer specification), and install new rumble strips in this strip. When installing both rumble strips and recessed lane markers, follow the Standard Plan to avoid overlapping the grindings.

Installing rumble strips in bituminous surface treatment (or BST) or other thin surface treatments can expose pavement structure and lead to delamination. In new rumble strip locations where BST will be applied on an HMA pavement, install the rumble strips in the HMA pavement before placing the BST. In existing rumble strip locations, note that a single application of BST on top of an existing rumble strip installation typically results in satisfactory rumble strip depth. Where rumble strips currently exist and an additional BST application is contemplated, evaluate whether the depth of the grooves following paving will support their continuing function to alert drivers. If not, or in the case of an HMA overlay, it may be necessary to remove existing rumble strips and install new ones.

Provide an offset to the longitudinal paving joint so that rumble strips are not ground into the joint where practicable.

For additional guidance on surface preparation and pavement stability, refer to the WSDOT Pavement Policy.

The noise created when vehicle tires contact a rumble strip can result noise in complaints from nearby residents. This commonly is a result from incidental contact where the vehicle might not have been heading toward a crash. For example, left-turning or passing vehicles, along with the off-tracking of large trucks or trailers may result in incidental contact with centerline rumble strips. With some specific attention to details, some of these contacts can be significantly reduced by discontinuing the rumble strip installations through intersections or frequently used road approaches. For roadways with limited passing opportunities, evaluate the frequency and position of neighboring residents and site-specific crash experience to determine if the rumble strip should be discontinued in a potential passing location. Attention to horizontal curvature, curve widening, and large-vehicle usage may help identify locations where the rumble strips may need to be discontinued through a tight radius curve. New rumble strip designs that reduce noise are under investigation. Contact HQ Design for more information.

There are three kinds of rumble strips: roadway, shoulder, and centerline, and each are described in the following sections.

1600.05(1)(a) Roadway Rumble Strips

Roadway rumble strips are placed transversely in the traveled way to alert drivers who are approaching a change of roadway condition or object that requires substantial speed reduction or other maneuvering. Some locations where advance roadway rumble strips may be placed include:

- Stop-controlled intersections
- Port of entry/customs stations
- Lane reductions where crash history shows a pattern of driver inattention, and
- Horizontal alignment changes where crash history shows a pattern of driver inattention.

They may also be placed at locations where the character of the roadway changes, such as at the end of a freeway.

Contact the HQ Design Office for additional guidance on the design and placement of roadway rumble strips.

Document decisions to use roadway rumble strips in the Design Documentation Package.

1600.05(1)(b) Shoulder Rumble Strips

Shoulder rumble strips (SRS) are placed parallel to the traveled way just beyond the edge line to warn drivers they are entering a part of the roadway not intended for routine traffic use. Shoulder rumble strips are effective in reducing run-off-the-road crashes when the contributing circumstances are human factors related, such as inattention, apparently fatigued, or apparently asleep.

When shoulder rumble strips are used, discontinue them where no edge stripe is present, such as at intersections and where curb and gutter are present. Discontinue shoulder rumble strips where shoulder driving is allowed.

Shoulder rumble strip patterns vary depending on the likelihood of bicyclists being present along the highway shoulder and whether they are placed on divided or undivided highways. Rumble strip patterns for undivided highways are shallower and may be narrower than patterns used on divided highways. They also provide gaps in the pattern, providing opportunities for bicycles to move across the pattern without having to ride across the grooves. There are four shoulder rumble strip patterns. Consult the Standard Plans for the patterns and construction details.

1. Divided Highways

Install shoulder rumble strips on both the right and left shoulders of rural Interstate highways. Consider them on both shoulders of rural divided highways. Use the Shoulder Rumble Strip Type 1 pattern on divided highways.

Shoulder rumble strips on rural Interstate highways may be omitted under any of the following conditions:

- When another project scheduled within two years of the proposed project will overlay or reconstruct the shoulders or will use the shoulders for detours.
- When a pavement analysis determines that installing shoulder rumble strips will result in inadequate shoulder strength.
- When overall shoulder width will be less than 4 feet wide on the left and 6 feet wide on the right.

Document the decision to omit rumble strips in a Design Analysis (see Chapter 300.)

2. Undivided Highways

Consider installing shoulder rumble strips on undivided highways during centerline rumble strip installation or rehabilitation. Apply the following criteria in evaluating whether or not to install shoulder rumble strips.

- Consider the impact on bicycle riders, especially on bike touring routes or other routes where bicycle events are regularly held.
- Use on rural highways only.
- Determine that shoulder pavement is structurally adequate to support milled rumble strips.
- Posted speed is 45 mph or higher.
- Provide for at least 4 feet of usable shoulder between the rumble strip and the outside edge of shoulder. If guardrail or barrier is present, increase the dimension to 5 feet of usable shoulder. Field-verify these dimensions.
- Preliminary evaluation indicates a run-off-the-road crash experience of approximately 0.6 crashes per mile per year. (This value is intended to provide relative comparison of crash experience and is not to be used as absolute guidance on whether rumble strips are appropriate.)
- Do not place shoulder rumble strips on downhill grades exceeding 4% for more than 500 feet in length along routes where bicyclists are frequently present.
- Consider approaches to reducing incidental contact where applicable (see Section 1600.05(1)).
- An engineering analysis indicates a run-off-the-road crash experience considered correctable by shoulder rumble strips.

Consult the region and Headquarters Bicycle and Pedestrian Coordinators to determine bicycle usage along a route, and involve them in the decision-making process when considering rumble strips on bike touring routes. When bicycle traffic on the shoulder is determined to be high, the Shoulder Rumble Strip Type 4 pattern is used. Document decisions to continue or discontinue shoulder rumble strip usage.

Consult the following website for guidance on conducting an engineering analysis:
http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1600.05(1)(c) Centerline Rumble Strips

Centerline rumble strips are placed on the centerline of undivided highways to alert drivers that they are entering the opposing lane. They are installed with no differentiation between passing permitted and no passing areas. Refresh pavement markings when removed by centerline rumble strips.

Centerline rumble strips are evaluated using a programmatic approach, starting with a preliminary review of each rural undivided highway as a potential installation site. The HQ Design Office conducts the preliminary review, evaluating cross-centerline crash history and pavement width. A list of sites is generated from this review and periodically updated and distributed to the regions for a more detailed analysis of each site. The presence of a particular site on the preliminary list does not imply that rumble strips must be installed.

The preliminary review conducted in the Design Office does not assess pavement structure; traffic volume and composition; type and volume of nonmotorized users; or proximity to roadside residents. Region project development staff are expected to evaluate these items, and to field-verify roadway widths and appropriate project limits. The final determination about the appropriateness of centerline rumble strips is the responsibility of region project development staff. Although these decisions are made in the region, it is important that they be evaluated in a consistent manner from region to region. Evaluate the following criteria in determining the appropriateness of centerline rumble strips.

Review the crash history to determine the frequency of crashes with human factors contributing circumstances such as inattention, apparently fatigued, apparently asleep, over the centerline, or on the wrong side of the road. These types of cross-centerline crashes are considered to be correctable with centerline rumble strips. Centerline rumble strips are most appropriate on rural roads, but with special consideration, may also be appropriate for urban roads. Some concerns specific to urban areas are more residents impacted by noise in more densely populated areas, the frequent need to interrupt the rumble strip pattern to accommodate left-turning vehicles, and a reduced effectiveness at lower speeds (35 mph and below). Centerline rumble strips are not appropriate where two way left-turn lanes exist.

Do not install centerline rumble strips when the combined lane and shoulder widths in either direction are less than 12 feet. See Chapter 1230 for guidance on lane and shoulder widths.

Where the combined lane and shoulder width is 14 feet or less, consider the level of bicycle and pedestrian use along the route When drivers shift their lane position away from centerline to avoid the rumble strips, they are moving closer to pedestrians and bicyclists on the shoulder. Also consider the roadside characteristics and the potential for a lane position adjustment to result in a run-off-the-road event, evaluating clear zone width along the route. Balance these issues with the frequency and severity of cross-centerline crashes.in the decision to install centerline rumble strips.

Noise for Roadside Residents

Consider approaches to reducing incidental contact where applicable (see 1600.05).

1600.05(2) Headlight Glare Considerations

Headlight glare from opposing traffic is most common between opposing main line traffic. Glare screens can be used to mitigate this condition. Other conditions for which glare screen might be appropriate are:

- Between a highway and an adjacent frontage road or parallel highway, especially where opposing headlights might seem to be on the wrong side of the driver.
- At an interchange where an on-ramp merges with a collector-distributor and the ramp traffic might be unable to distinguish between collector and main line traffic.
- Where headlight glare is a distraction to adjacent property owners. Playgrounds, ball fields, and parks with frequent nighttime activities might benefit from screening if headlight glare interferes with these activities.

Glare screening is normally not justifiable where the median width exceeds 20 feet, and the ADT is less than 20,000 vehicles per day. Document the decision to use glare screening using the following criteria:

- Higher frequency of night crashes compared to similar locations or based on statewide experience.
- Higher than normal ratio of night-to-day crashes.
- Unusual distribution or concentration of nighttime crashes.
- Over-representation of older drivers in night crashes.
- Combination of horizontal and vertical alignment, particularly where the roadway on the inside of a curve is higher than the roadway on the outside of the curve.
- Direct observation of glare.
- Public complaints concerning glare.

There are currently three basic types of glare screen available: chain link (see the *Standard Plans*), vertical blades, and concrete barrier (see Exhibit 1600-8).

When the glare is temporary (due to construction activity), consider traffic volumes, alignment, duration, presence of illumination, and type of construction activity. Glare screen may be used to reduce rubbernecking associated with construction activity, but less expensive methods, such as plywood that seals off the view of the construction area, might be more appropriate.

1600.06 Documentation

Refer to Chapter 300 for design documentation requirements.

1600.07 References

1600.07(1) Federal/State Laws and Codes

Revised Code of Washington (RCW) 47.24.020(2), Jurisdiction, control

RCW 47.32.130, Dangerous objects and structures as nuisances

1600.07(2) Design Guidance

Highway Safety Manual, AASHTO

Local Agency Guidelines (City and County Design Standards), M 36-63, WSDOT

Roadside Design Guide, AASHTO, 2011

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

1600.07(3) Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2011

Understanding Design Clear Zone – This e-learning course for WSDOT employees covers how to determine the appropriate Design Clear Zone for recoverable and nonrecoverable slopes as well as ditches. Request this training via the web-based Learning Management System.

Highways Over National Forest Lands, MOU, 2013, US Forest Service and WSDOT,
www.wsdot.wa.gov/publications/manuals/m22-50.htm

Utilities Manual, M 22-87, WSDOT. Chapter 9 provides Control Zone guidance for utilities in the WSDOT right of way.

Exhibit 1600-2 Design Clear Zone Distance Table

Posted Speed (mph)	Average Daily Traffic	Cut Section (Backslope) (H:V)						Fill Section (H:V)					
		3:1	4:1	5:1	6:1	8:1	10:1	3:1	4:1	5:1	6:1	8:1	10:1
35 or Less		The Design Clear Zone Distance is 10 ft											
40	Under 250	10	10	10	10	10	10	*	13	12	11	11	10
	251 – 800	11	11	11	11	11	11	*	14	14	13	12	11
	801 – 2,000	12	12	12	12	12	12	*	16	15	14	13	12
	2,001 – 6,000	14	14	14	14	14	14	*	17	17	16	15	14
	Over 6,000	15	15	15	15	15	15	*	19	18	17	16	15
45	Under 250	11	11	11	11	11	11	*	16	14	13	12	11
	251 – 800	12	12	13	13	13	13	*	18	16	14	14	13
	801 – 2,000	13	13	14	14	14	14	*	20	17	16	15	14
	2,001 – 6,000	15	15	16	16	16	16	*	22	19	17	17	16
	Over 6,000	16	16	17	17	17	17	*	24	21	19	18	17
50	Under 250	11	12	13	13	13	13	*	19	16	15	13	13
	251 – 800	13	14	14	15	15	15	*	22	18	17	15	15
	801 – 2,000	14	15	16	17	17	17	*	24	20	18	17	17
	2,001 – 6,000	16	17	17	18	18	18	*	27	22	20	18	18
	Over 6,000	17	18	19	20	20	20	*	29	24	22	20	20
55	Under 250	12	14	15	16	16	17	*	25	21	19	17	17
	251 – 800	14	16	17	18	18	19	*	28	23	21	20	19
	801 – 2,000	15	17	19	20	20	21	*	31	26	23	22	21
	2,001 – 6,000	17	19	21	22	22	23	*	34	29	26	24	23
	Over 6,000	18	21	23	24	24	25	*	37	31	28	26	25
60	Under 250	13	16	17	18	19	19	*	30	25	23	21	20
	251 – 800	15	18	20	20	21	22	*	34	28	26	23	23
	801 – 2,000	17	20	22	22	23	24	*	37	31	28	26	25
	2,001 – 6,000	18	22	24	25	26	27	*	41	34	31	29	28
	Over 6,000	20	24	26	27	28	29	*	45	37	34	31	30
65	Under 250	15	18	19	20	21	21	*	33	27	25	23	22
	251 – 800	17	20	22	22	24	24	*	38	31	29	26	25
	801 – 2,000	19	22	24	25	26	27	*	41	34	31	29	28
	2,001 – 6,000	20	25	27	27	29	30	*	46	37	35	32	31
	Over 6,000	22	27	29	30	31	32	*	50	41	38	34	33
70	Under 250	16	19	21	21	23	23	*	36	29	27	25	24
	251 – 800	18	22	23	24	26	26	*	41	33	31	28	27
	801 – 2,000	20	24	26	27	28	29	*	45	37	34	31	30
	2,001 – 6,000	22	27	29	29	31	32	*	50	40	38	34	33
	Over 6,000	24	29	31	32	34	35	*	54	44	41	37	36

Notes:

This exhibit applies to:

- All state highways outside incorporated cities.
- Limited access state highways within cities.

For Roadside and Median areas on managed access state highways within incorporated cities, see 1600.02 for guidance. Curb is not considered adequate to redirect an errant vehicle.

Design Clear Zone distances are given in feet, measured from the edge of traveled way.

*When the fill section slope is steeper than 4H:1V, but not steeper than 3H:1V, the Design Clear Zone distance is modified by the recovery area formula (see Exhibit 1600-4) and is referred to as the recovery area. The basic philosophy behind the recovery area formula is that the vehicle can traverse these slopes but cannot recover (control steering); therefore, the horizontal distance of these slopes is added to the Design Clear Zone distance to form the recovery area.

Exhibit 1600-3 Design Clear Zone Inventory Form (# 410-026 EF)

Washington State Department of Transportation

Design Clear Zone Inventory

Region	SR	Control Section	MP to MP	Date
Project Number	Project Title		Responsible Unit	

Item Number	MP to MP	Distance From Traveled Way L	Distance From Traveled Way R	Description	Corrective Actions Considered (2)	Estimated Cost to Correct	Correction Planned (1) Yes	Correction Planned (1) No

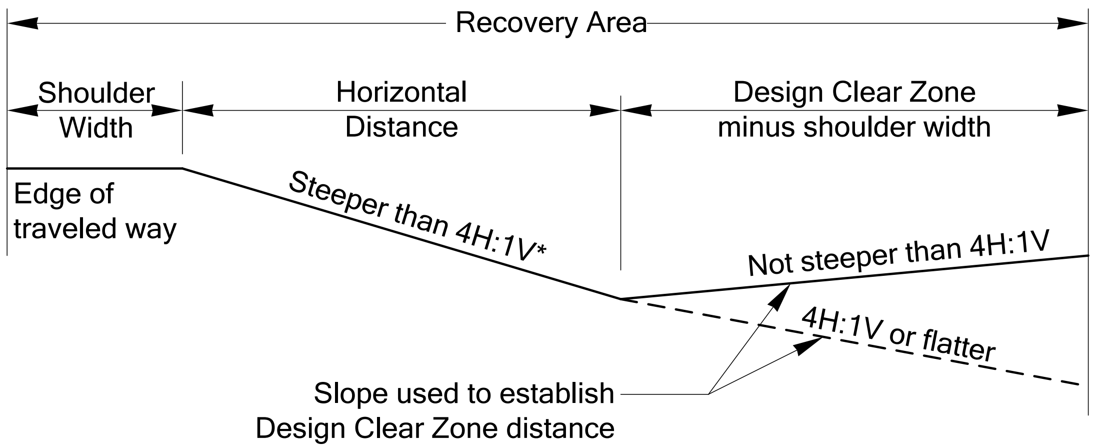
(1) Only one "Yes" or "No" per item number. Corrections not planned must be explained on reverse side.
(2) A list of Location 1 & 2 Utility Objects to be forwarded to the region Utility Office for coordination per Control Zone Guidelines.

DOT Form 410-026 EF
Revised 4/05

Item Number	Reasons for Not Taking Corrective Action

DOT Form 410-026 EF
Revised 4/05

Exhibit 1600-4 Recovery Area



* Recovery area normally applies to slopes steeper than 4H:1V, but not steeper than 3H:1V. For steeper slopes, the recovery area formula may be used as a guide if the embankment height is 10 ft or less.

Formula:

Recovery area = (shld. width) + (horizontal distance) + (Design Clear Zone distance – shld. width)

Example: Fill section (slope 3H:1V or steeper)

Conditions:

Speed = 45 mph

Traffic = 3,000 ADT

Slope = 3H:1V

Criteria:

Slope 3H:1V → Use recovery area formula

Recovery area = (shld. width) + (horizontal distance) + (Design Clear Zone distance – shld. width)

= 8 + 12 + (17-8)

Recovery area = 29 feet

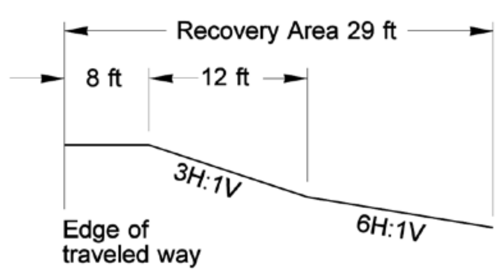


Exhibit 1600-5 Design Clear Zone for Ditch Sections

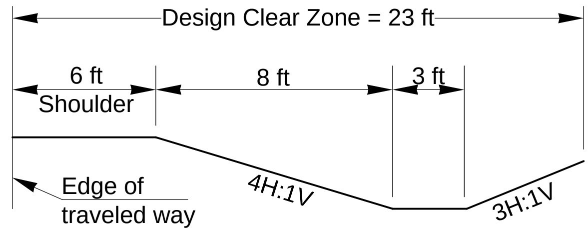
Case 1: Cut section with ditch (foreslope 4H:1V of flatter)

Conditions:

Speed = 55 mph

Traffic = 4,200 ADT

Slope = 4H:1V



Criteria:

Greater of:

(1) Design Clear Zone for 10H:1V cut section, 23 ft

(2) 5 feet horizontal beyond beginning of back slope, 22 feet

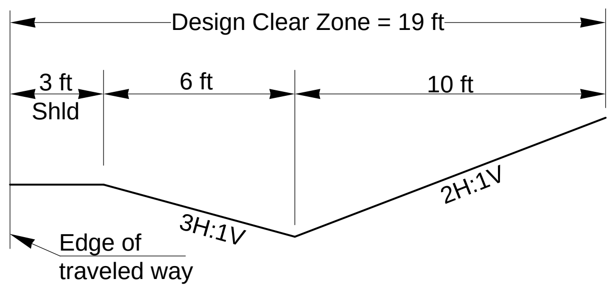
Design Clear Zone = 23 feet

Case 2: Cut section with ditch (foreslope steeper than 4H:1V and backslope steeper than 3H:1V)

Conditions: NA

Criteria: 10 feet horizontal beyond beginning of backslope

Design Clear Zone = 19 feet



Case 3: Cut section with ditch (foreslope 3H:1V or steeper and backslope not steeper than 3H:1V)

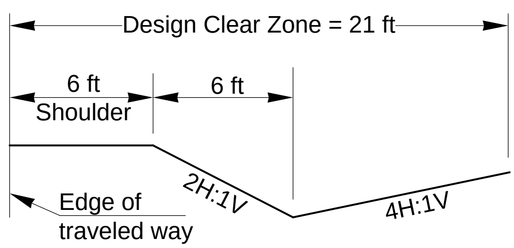
Conditions:

Speed = 45 mph

Traffic = 3,000 ADT

Foreslope = 2H:1V

Backslope = 4H:1V



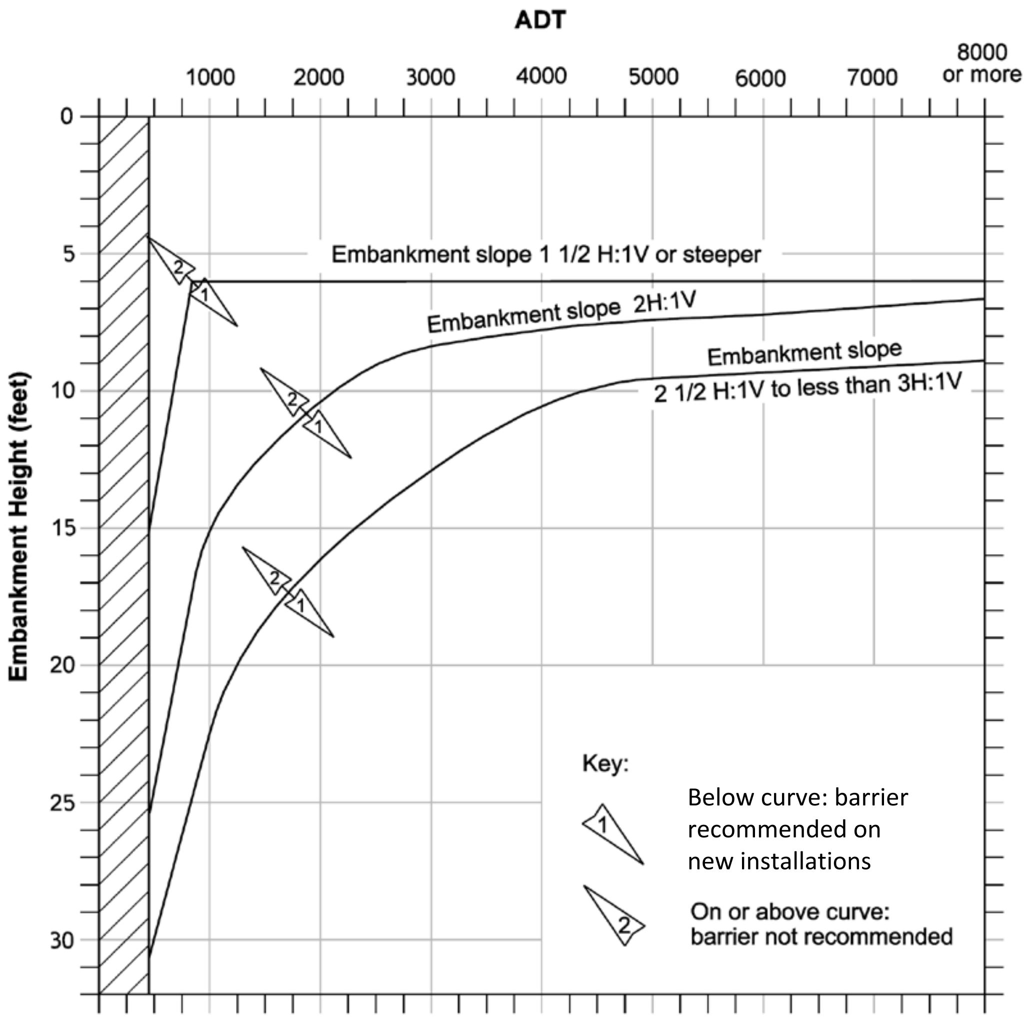
Criteria: Use recovery area formula

Recovery area = (shoulder width) + (horizontal distance) + (Design Clear Zone distance – shoulder width)

= 6 + 6 + (15 – 6) = 21

Recovery Area = 21 feet

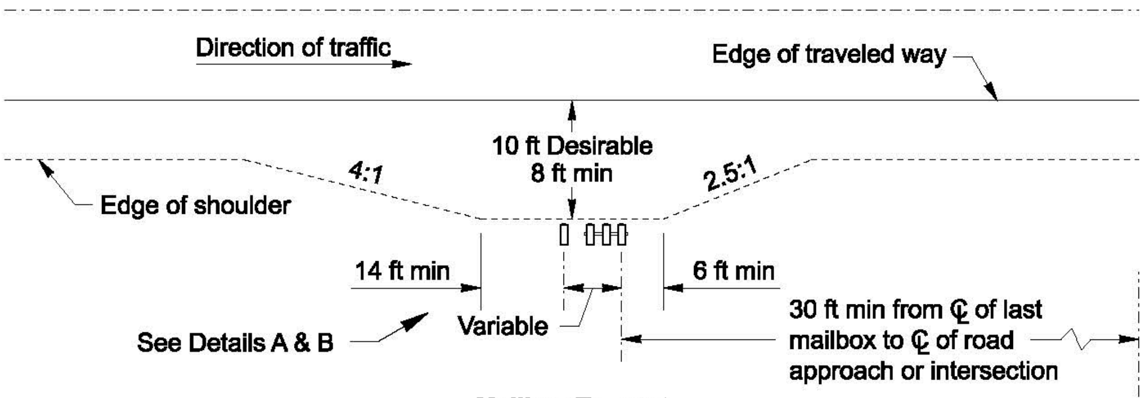
Exhibit 1600-6 Guidelines for Embankment Barrier



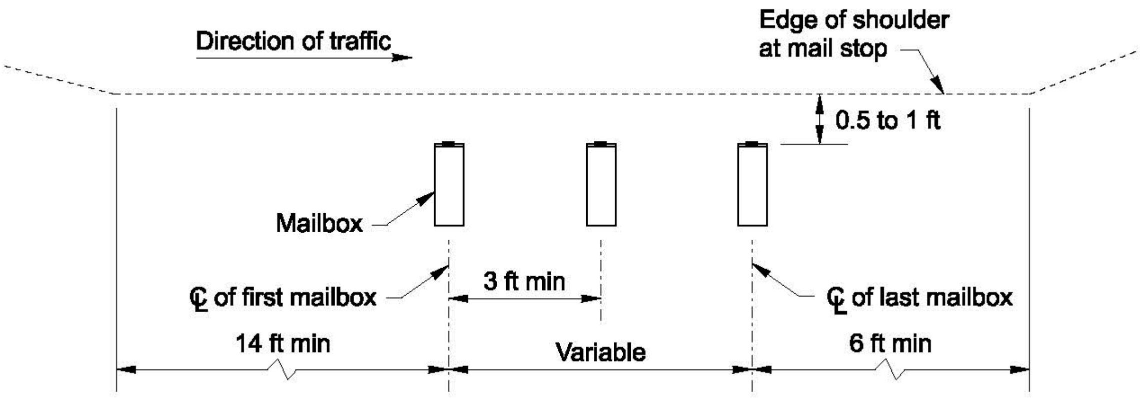
Note:

Routes with ADTs under 400 may be evaluated on a case-by-case basis.

Exhibit 1600-7 Mailbox Location and Turnout Design

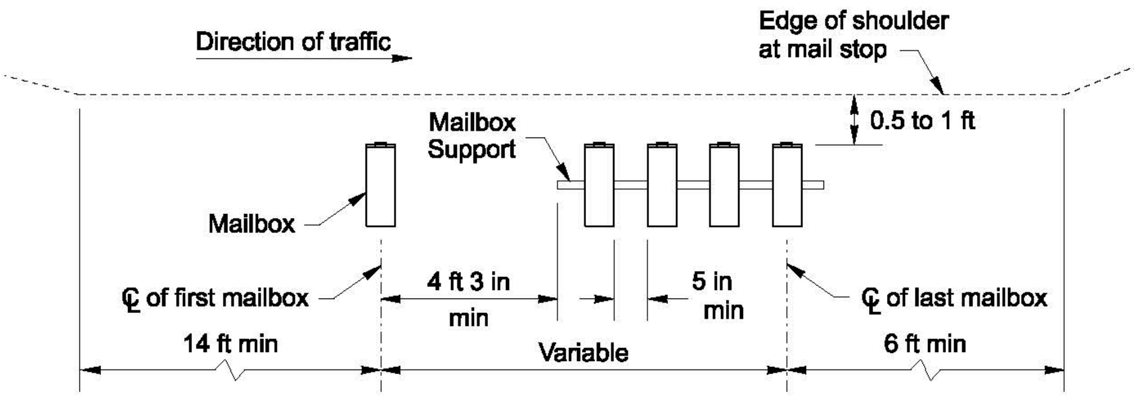


Mailbox Turnout



Mailbox Location: Single Box Design

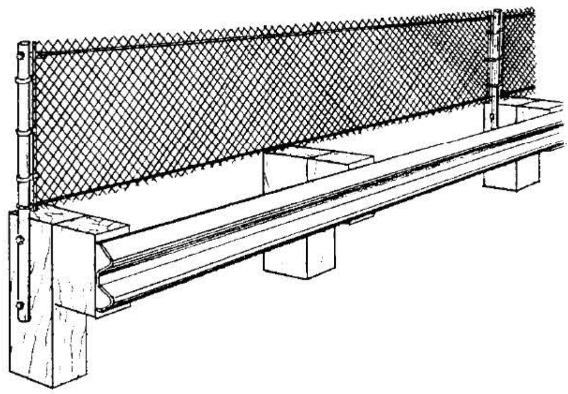
Detail A

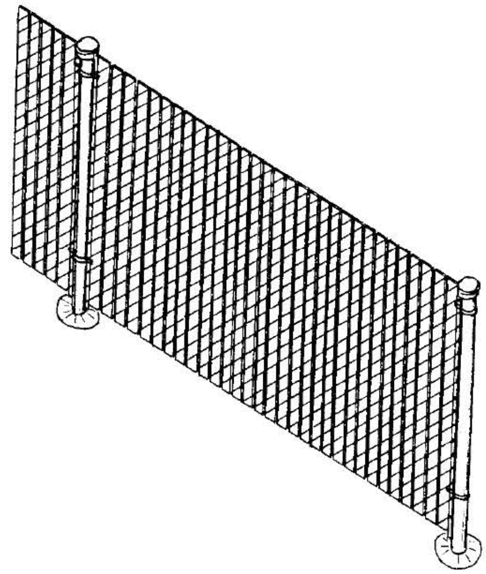


Mailbox Location: Multiple Box Design

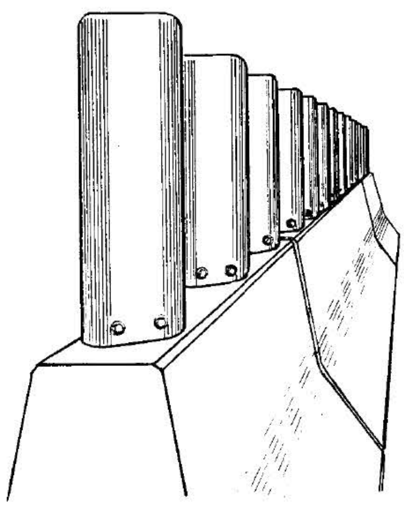
Detail B

Exhibit 1600-8 Glare Screens

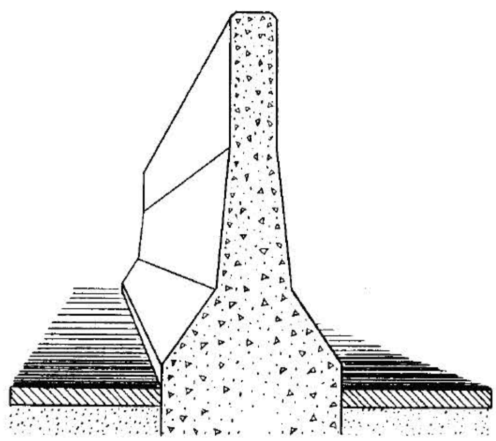




Chain Link



Vertical Blades



Concrete Barrier

Chapter 1610 Traffic Barriers

Chapter Organization: The first sections (Introduction and Barrier Impacts) present information to consider when deciding whether to install a barrier. The next section (General Barrier Design Considerations) contains guidance common to ALL barrier types, such as deflection distance, length of need and sight distance. The remaining sections present design information organized by specific barrier type (beam guardrail, cable barrier, etc.).

Refer to the *Design Manual* Glossary for many of the terms used in this chapter.

Refer to Chapter 300 for design documentation requirements.

1610.01 Introduction

The Washington State Department of Transportation (WSDOT) uses traffic barriers to reduce the overall severity of crashes. Consideration is given as to whether a barrier is preferable to the recovery area it may replace. In some cases, installation of a traffic barrier may result in more crashes as it presents an object that can be struck. Barriers are designed so that such encounters might be less severe and not lead to secondary or tertiary crashes. However, traffic barriers are not guaranteed to redirect an impacting vehicle without resulting injury to its occupants or triggering additional crashes. Barrier performance is affected by the characteristics of the vehicles that collide with them. Different vehicles will react differently given the characteristics and dynamics of the crash. Therefore, vehicles will be decelerated and redirected differently given the size, weight and direction of force imparted from the vehicle to the barrier.

Barriers are not placed with the assumption that the system will restrain or redirect all vehicles in all conditions. It is recognized that the designer cannot design a system that will address every potential crash situation. Instead, barriers are placed with the assumption that, under typical crash conditions, they might decrease the potential for excessive vehicular deceleration or excessive vehicle redirection when compared to the location without the barrier.

Traffic barriers do not prevent crashes or injuries from occurring. They often lower the potential severity for crash outcomes. Consequently, barriers should not be used unless a reduced crash severity potential is likely. No matter how well a barrier system is designed, optimal performance is dependent on drivers' proper maintenance and operation of their vehicles and the proper use of passenger restraint systems. The ultimate choice of barrier type and placement should be made by gaining an understanding of site and traffic conditions, having a thorough understanding of and applying the criteria presented in Chapters 1600 and 1610, and using engineering judgment.

Barrier systems and vehicle fleets continue to evolve. The choice of a barrier is based on the characteristics of today's vehicle fleet and testing criteria, not on speculative assumptions of future vehicle designs. This continuum of change does not allow engineers to predict the future with any degree of certainty. Consequently, engineering decisions need to be made based on the most reliable and current information.

Engineers are constantly striving to develop more effective design features to improve highway safety. However, economics, asset management and maintenance needs, and feasibility do not permit the deployment of new designs as soon as they become available on the market or are invented by a manufacturer. Further, most new designs only make marginal changes to systems and do not imply that old designs are unsafe or need modification.

Solutions may consider crash frequency and severity. As discussed previously, performance of the system relies on the interaction of the vehicle, driver, and system design at any given location. Additionally, the ability to safely access, maintain and operate over time is incorporated into the final barrier decision.

When barriers are crash-tested, it is impossible to replicate the innumerable variations in highway conditions under which the barrier applications occur. Therefore, barriers are crash-tested under standardized conditions. These standard conditions were previously documented in National Cooperative Highway Research Program (NCHRP) Reports 230 and 350. These guidelines have been updated and are now presented in the AASHTO publication, *Manual for Assessing Safety Hardware* (MASH).

As roadside safety hardware changes occur on the highway system they will use MASH crash testing criteria instead of NCHRP Report 350. To learn more about WSDOT's plan for implementing MASH-compliant hardware see the following website:
http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.01(1) Site Constraints

Site constraints play a major role in decisions regarding guardrail selection and placement. Depending on the location, these constraints may include (but are not limited to) environmental considerations, topographic challenges, restricted right-of-way, geologic concerns or conflicts with other infrastructure to name just a few. Document barrier location decisions, including any site constraints encountered that influenced those decisions. A decision to install barrier using criteria outside the guidance provided in this chapter requires a Design Analysis (See Chapter 300).

1610.02 Barrier Impacts

Engineering judgment is required in determining the appropriate placement of barrier systems, therefore consider the location of the system and the possible impacts the barrier may have to other highway objectives.

1610.02(1) Assessing Impacts to Stormwater and Wetlands

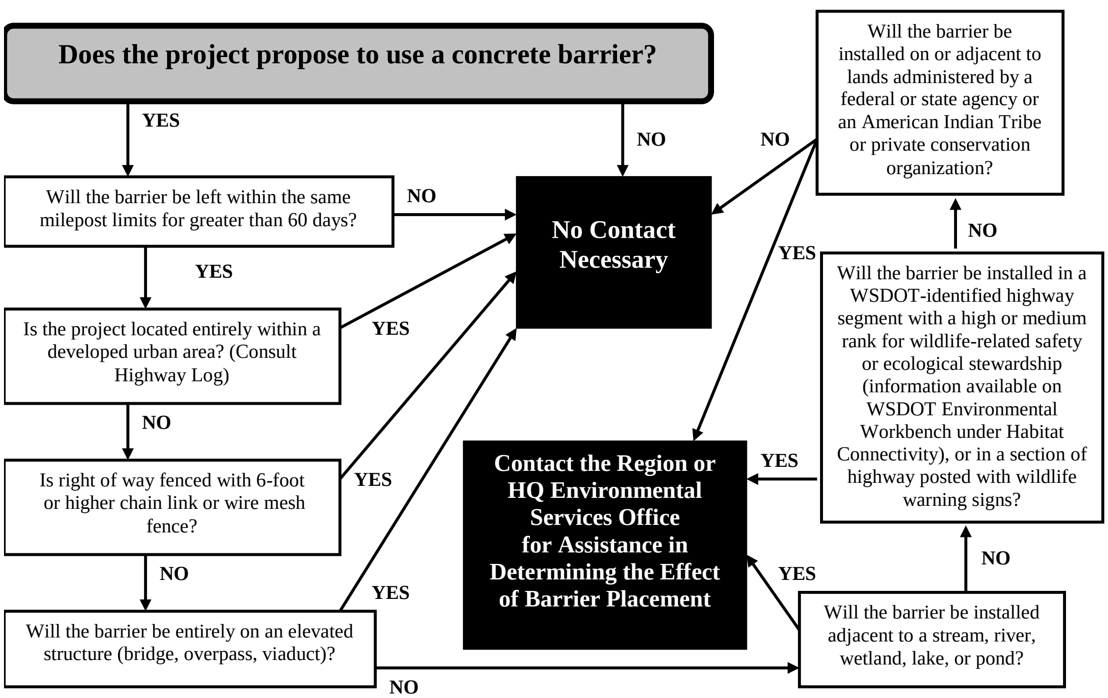
The presence of stormwater facilities or wetlands influence the choice and use of barrier systems. For example, the placement of concrete barrier may increase the amount of impervious surface, which could then result in retrofit or reconstruction of the existing retention/detention systems and environmental impact requirements and studies. Assess whether concrete barrier or beam guardrail placement will cause the need for an evaluation by the HQ Environmental Services Office. Conduct this evaluation early in the project's development process to allow adequate time for discussion of options.

1610.02(2) Assessing Impacts to Wildlife

The placement of concrete barriers in locations where wildlife frequently cross the highway can influence wildlife-vehicle crash potential. When wildlife encounters physical barriers that are difficult to see beyond or cross, such as concrete barriers, they often stop or move parallel to those barriers, increasing their time on the highway and their exposure.

Traffic-related wildlife mortality may play a role in the decline of some species listed under the Endangered Species Act. To address wildlife concerns, see Exhibit 1610-1 to assess whether barrier placement needs to have an evaluation by the HQ Environmental Services Office to determine its effect on wildlife. Conduct this evaluation early in the project development process to allow adequate time for discussion of options.

Exhibit 1610-1 Concrete Barrier Placement Guidance: Assessing Impacts to Wildlife



1610.03 General Barrier Design Considerations

See Chapter 1105 Design Element Selection for guidance regarding required design elements for the various different project types (programs and subprograms).

Chapter 1120 identifies those elements and features to be evaluated and potentially addressed during the course of a Preservation project.

Follow the guidance in this chapter for any project that introduces new barrier onto the roadside (including median section) and follow the guidance in Chapter 1600 for removal of barrier that is not needed. Slope flattening is recommended when the crash reduction benefit justifies the additional cost to eliminate the need for barrier.

When selecting a barrier, consider the barrier system's deflection characteristics, cost, maintainability and impacts to traffic flow during repair. Barriers are categorized as flexible, semi-rigid, or rigid depending on their deflection characteristics. (See Exhibit 1610-3). Barrier types include:

- Beam Guardrail
- Cable Barrier
- Concrete Barrier
- Bridge Traffic Barrier
- Other Barriers

Since non-rigid systems typically sustain more damage during an impact, consider the amount of traffic exposure maintenance crews might incur with the more frequent need for repairs.

The costs for procuring and maintaining the barrier system are important factors when considering what system to install. Considerations may include:

- Consultation with the Area Maintenance Superintendent to identify needs or recommendations.
- Drainage, alignment, and drifting snow or sand are considerations that can influence the selection of barrier type. Beam guardrail and concrete barrier can contribute to snow drifts. Consider long-term maintenance costs associated with snow removal at locations prone to snow drifting. Cable barrier is not an obstruction to drifting snow.
- Analysis of potential reduction of sight distance due to barrier selection and placement.
- Additional widening and earthwork requirements. With some systems, such as concrete barrier and beam guardrail, the need for additional shoulder widening or slope flattening is common. Selection of these types of barriers may require substantial environmental permitting or roadway reconstruction. Permits issued under the SEPA and NEPA processes may lead to the use of a barrier design, such as cable barrier, which has fewer potential environmental impacts and costs.
- For concrete barrier systems:
  - Lower maintenance costs than for other barrier types.
  - Deterioration due to weather and vehicle impacts is less than most other barrier systems.
  - Unanchored precast concrete barrier can usually be realigned or repaired after a vehicle impact. However, heavy equipment may be necessary to reposition or

replace barrier segments. Therefore, in medians, consider the shoulder width and the traffic volume when determining the acceptability of unanchored precast concrete barrier versus rigid concrete barrier. See Exhibit 1610-3 for deflection area requirements.

Consider the following for existing barrier systems:

- Install, replace, or modify transitions as discussed in 1610.04(6) Transitions and Connections.
- When installing new terminals, extend the guardrail to meet the length-of-need criteria found in 1610.03(5).
- When replacing damaged terminals, consider extending the guardrail to meet the length of need criteria in 1610.03(5)
- When the end of a barrier has been terminated with a small mound of earth, remove and replace with a terminal as described in 1610.06(3).
- Special use or aesthetic barriers may be used on designated Scenic Byway and Heritage Tour routes if funding, permits, and approvals can be arranged (see 1610.08).
- Design Manual Chapter 1120 identifies specific requirements to be addressed for a Preservation project. For other projects, address barrier runs that include:
  - W-beam guardrail with 12-foot 6-inch post spacing, or no blockouts, or both.
  - W-beam guardrail on concrete posts.
  - Cable barrier on wood or concrete posts.
  - Half-moon or C-shaped rail elements.

1610.03(1) Barrier Placement Considerations

Proper installation of a barrier system is required for the system to perform similar to the crash tests that resulted in its acceptance for use on our highways. Maximize the distance between the barrier and the travelled way.

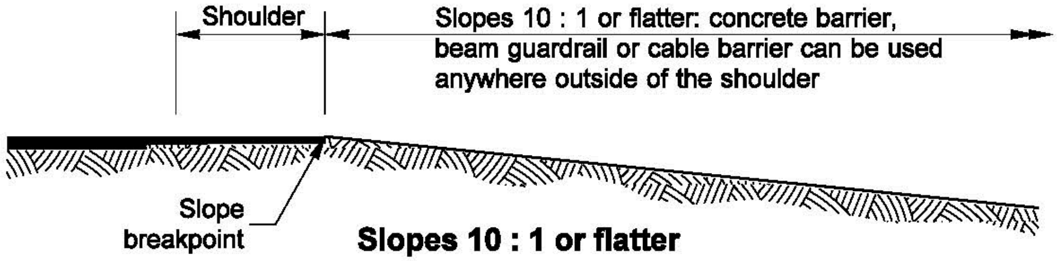
See Chapter 1239 for minimum lateral clearance requirements.

1610.03(1)(a) Placement on a Slope

Slopes may affect barrier placement. Considerations for barrier placement on a slope include:

- For slopes that are 10:1 or flatter, concrete barrier, beam guardrail or cable barrier can be installed anywhere beyond the edge of shoulder. See Exhibit 1610-2.
- For additional placement guidance see 1610.05(1) for cable barrier, see 1610.04(2) for beam guardrail, and see 1610.06 for concrete barrier.

Exhibit 1610-2 Traffic Barrier Locations on Slopes



1610.03(1)(b) Placement in Median Locations

Considerations for barrier placement in a median include:

- Address the design deflection characteristics of the barrier to avoid placement of barrier where the design deflection extends into oncoming traffic.
- Narrow medians provide little space for any maintenance activities, including repair or repositioning of the barrier. Installing barriers in medians that provide less than 8 feet from the edge of the traveled way to the face of the barrier will likely require temporarily closing the adjacent lane during maintenance activities. This will impact the travelling public and impact maintenance staff, and maintenance staff should be consulted. See Chapter 301 Design and Maintenance Coordination.
- At locations where the roadways are on independent alignments and there is a difference in elevation between the roadways, the slope from the upper roadway might be steeper than 6H:1V. In these locations, position the median barrier along the upper roadway and provide deflection and offset distance as discussed previously. Barrier is generally not needed along the lower roadway except where there are fixed features in the median.
- In wider medians, the selection and placement of barrier might depend on the slopes in the median. At locations where the median slopes are relatively flat (10H:1V or flatter), unrestrained precast concrete barrier, beam guardrail, and cable barrier can be used depending on the available deflection distance. At these locations, position the barrier as close to the center of the median as possible so that the recovery distance can be maximized for both directions. There may be a need to offset the barrier from the flow line to avoid impacts to the drainage flow.
- In general, cable barrier is recommended with medians that are 30 feet or wider. However, cable barrier may be appropriate for narrower medians if adequate deflection distance exists.
- When W-beam barrier is placed in a median as a countermeasure for cross-median crashes, design the barrier to be struck from either direction of travel. For example, the installation of beam guardrail might be double-sided (Type 31-DS).
- For additional placement guidance see 1610.05(1) for cable barrier, see 1610.04(2) for beam guardrail, and see 1610.06 for concrete barrier.

1610.03(2) Sight Distance

When selecting and placing a barrier system, consider the possible impact the barrier type and height may have on sight distance. In some cases, barriers may restrict the sight distances of road users entering the roadway, such as from road approaches, intersections, and other locations. In these cases, the barrier may need to be adjusted to meet the sight distance requirements at these locations.

1610.03(3) Barrier Deflections

Expect all barriers, except rigid barriers (such as concrete bridge rails, barrier integral to retaining walls, or embedded cast-in-place barriers), to deflect when hit by an errant vehicle. The amount of deflection is primarily dependent on the stiffness of the system. However, vehicle speed, angle of impact, and weight of the vehicle also affect the amount of barrier deflection. For flexible and semi-rigid roadside barriers, the deflection distance is designed to prevent the impacting vehicle from striking the object being shielded. For unrestrained rigid systems (unanchored precast concrete barrier), the deflection distance is designed to help prevent the barrier from being knocked over the side of a drop-off or steep fill slope (2H:1V or steeper).

In median installations, design systems such that the anticipated deflection will not enter the lane of opposing traffic. When evaluating new barrier installations, consider whether impacts would require significant traffic closures to accomplish maintenance. Use a rigid system where deflection cannot be accommodated, such as in narrow medians or at the edge of bridge decks or other vertical drop-off areas. Runs of rigid concrete barrier can be cast in place or extruded with appropriate footings.

In some locations, where deflection distance is limited, anchor precast concrete barrier. Unless the anchoring system has been designed to function as a fully rigid barrier, some movement can be expected and repairs may be more expensive. Use of an anchored or other deflecting barrier on top of a retaining wall without deflection distance provided requires approval from the HQ Design Office. See 1610.06 for more information on concrete barrier.

Refer to Exhibit 1610-3 for barrier deflection design values when selecting a longitudinal barrier. The deflection values for cable and beam guardrail are minimum distances, measured between the face of the barrier to the fixed feature. The deflection values for unanchored concrete barrier are minimum distances, measured from the back edge of the barrier to the fixed feature, drop-off or slope break.

Exhibit 1610-3 Longitudinal Barrier Deflection

Barrier Type	System Type	Deflection
High-tension cable barrier	Flexible	12 ft [1]
Beam guardrail, Types 1, 1a, 2, 10, and 31	Semi-rigid	3 ft (face of barrier to object)
Two-sided W-beam guardrail, Types 3, 4, and 31-DS	Semi-rigid	2 ft (nearest face of barrier to object)
Permanent concrete barrier, unanchored	Rigid Unrestrained	3 ft [2] (back of barrier to object)
Temporary concrete barrier, unanchored	Rigid Unrestrained	2 ft [3] (back of barrier to object)
Precast concrete barrier, anchored	Rigid Anchored	6 inches
Rigid concrete barrier	Rigid	No deflection

Notes:
[1] See 1610.05(2)
[2] When placed in front of a 2H:1V or flatter fill slope, the deflection distance can be reduced to 2 feet.
[3] When used as temporary bridge rail, anchor all barrier within 3 feet of a drop-off.

1610.03(4) Flare Rate

A roadside barrier is considered flared when it is not parallel to the edge of the traveled way.

Flare the ends of longitudinal barriers where site constraints allow (see 1610.01(1)). The four functions of a flare are to:

- Maximize the distance between the barrier (and its terminal) and the travelled way.
- Reduce the length of need.
- Redirect an errant vehicle.
- Minimize a driver's reaction to the introduction of an object near the traveled way.

Keeping flare rates as flat as site constraints allow preserves the barrier's redirectional performance and minimizes the angle of impact. It has also been shown that an object (or barrier) close to the traveled way might cause a driver to shift laterally, slow down, or both. The flare reduces this reaction by gradually introducing the barrier so the driver does not perceive the barrier as an object to be avoided. The flare rates in Exhibit 1610-4 are intended to satisfy the four functions listed above. Flares that are more gradual may be used. Flare rates are offset parallel to the edge of the traveled way. Transition sections are not flared.

Situations exist where hardware installations may have barrier flare rates different than shown in Exhibit 1610-4. If a *Standard Plan* for a barrier installation shows a different flare rate than is shown in Exhibit 1610-4, the flare rate shown on the *Standard Plan* can be used.

Exhibit 1610-4 Longitudinal Barrier Flare Rates

Posted Speed (mph)	Rigid & Rigid Anchored System	Unrestrained Rigid System	Semi-rigid
65–70	20:1	18:1	15:1
60	18:1	16:1	14:1
55	16:1	14:1	12:1
50	14:1	12:1	11:1
45	12:1	11:1	10:1
40 or below	11:1	10:1	9:1

1610.03(5) Length of Need

The length of traffic barrier needed to shield a fixed feature (length of need) is dependent on the location and geometrics of the object, direction(s) of traffic, posted speed, traffic volume, and type and location of traffic barrier. When designing a barrier for a fill slope (see Chapter 1600), the length of need begins at the point where the need for barrier is recommended. For fixed objects and water, Exhibit 1610-5 shows design parameters for determining the needed length of a barrier for both adjacent and opposing traffic on relatively straight sections of highway.

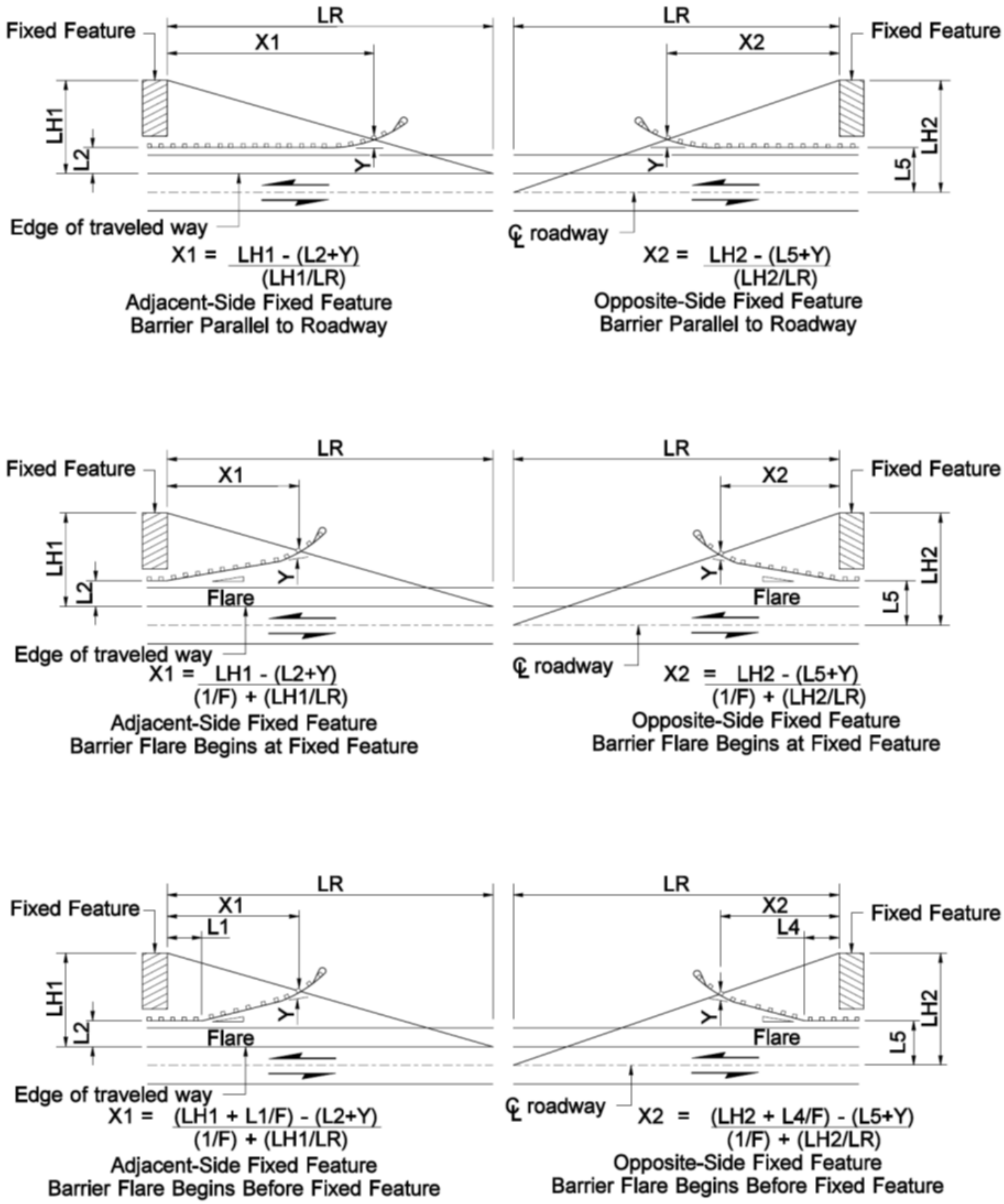
When barrier is to be installed on the outside of a horizontal curve, the length of need can be determined graphically as shown in Exhibit 1610-7. For installations on the inside of a curve, determine the length of need as though it were straight. Also, consider the flare rate, barrier deflection, and barrier end treatment to be used.

When beam guardrail is placed in a median, consider the potential for impact from opposing traffic when conducting a length of need analysis. When guardrail is placed on either side of objects in the median, consider whether the trailing end of each run of guardrail will shield the leading end of the opposing guardrail. Shield the leading end when it is within the Design Clear Zone of opposing traffic (see Exhibit 1610-8). This is also a consideration when objects are placed in the outer separations between the main line and collector-distributors.

Before the actual length of need is determined, establish the lateral distance between the proposed barrier installation and the object shielded. Provide a distance that is greater than or equal to the anticipated deflection of the longitudinal barrier. (See Exhibit 1610-3 for barrier deflections.) Place the barrier as far from the edge of the traveled way as possible while maintaining the deflection distance.

If the end of the length of need is near an adequate cut slope, extend the barrier and embed it in the slope (see 1610.04(5)). Avoid gaps of 300 feet or less. Short gaps are acceptable when the barrier is terminated in a cut slope. If the end of the length of need is near the end of an existing barrier, it is recommended that the barriers be connected to form a continuous barrier. Consider maintenance access issues when determining whether or not to connect barriers.

Exhibit 1610-5 Barrier Length of Need on Tangent Sections



Note: For supporting length of need equation factors, see Exhibit 1610-6

Exhibit 1610-6 Barrier Length of Need

Posted Speed (mph)	Design Parameters						
	ADT				Barrier Type		
	Over 10,000	5,000 to 10,00	1,000 to 4,999	Under 1,000	Rigid & Rigid Anchored Barrier	Rigid Unrestrained Barrier	Semi-rigid Barrier
	LR (ft)	LR (ft)	LR (ft)	LR (ft)	F	F	F
70	360	330	290	250	20	18	15
65	330	290	250	225	20	18	15
60	300	250	210	200	18	16	14
55	265	220	185	175	16	14	12
50	230	190	160	150	14	12	11
45	195	160	135	125	12	11	10
40	160	130	110	100	11	10	9
35	135	110	95	85	11	10	9
30	110	90	80	70	11	10	9
25	110	90	80	70	11	10	9

L1 = Length of barrier parallel to roadway from adjacent-side fixed feature to beginning of barrier flare. This is used if a portion of the barrier cannot be flared (such as a bridge rail and the transition).

L2 = Distance from adjacent edge of traveled way to portion of barrier parallel to roadway.

L4 = Length of barrier parallel to roadway from opposite-side fixed feature to beginning of barrier flare.

L5 = Distance from centerline of roadway to portion of barrier parallel to roadway. ***Note:*** If the fixed feature is outside the Design Clear Zone when measured from the centerline, it may only be necessary to provide a crash-tested end treatment for the barrier.

LH1 = Distance from outside edge of traveled way to back side of adjacent-side fixed feature. ***Note:*** If a fixed feature extends past the Design Clear Zone, the Design Clear Zone can be used as LH1.

LH2 = Distance from centerline of roadway to back side of opposite-side fixed feature. ***Note:*** If a fixed feature extends past the Design Clear Zone, the Design Clear Zone can be used as LH2.

LR = Runout length, measured parallel to roadway.

X1 = Length of need for barrier to shield an adjacent-side fixed feature.

X2 = Length of need for barrier to shield an opposite-side fixed feature.

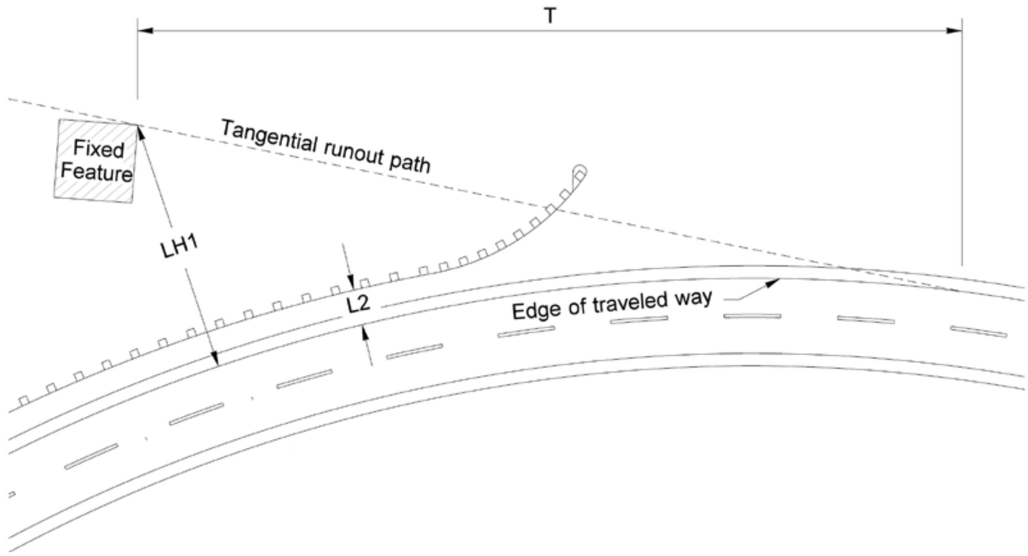
F = Flare rate value.

Y = Offset distance needed at the beginning of the length of need.

Different end treatments need different offsets:

- For the SRT 350 and FLEAT 350, use Y = 1.8 feet.
- For evaluating existing BCTs, use Y = 1.8 feet.
- For the FLEAT TL-2, use Y = 0.8 feet.
- No offset is needed for the non-flared terminals or impact attenuator systems. Use Y = 0.

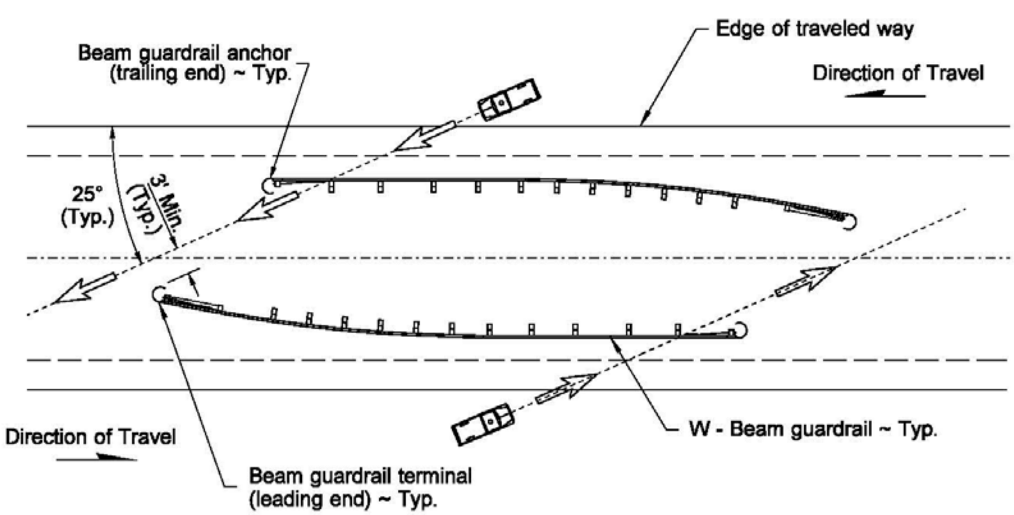
Exhibit 1610-7 Barrier Length of Need on Curves



Notes:

- This is a graphical method for determining the length of need for barrier on the outside of a curve.
- On a scale drawing, draw a tangent from the curve to the back of the fixed feature. Compare T to LR from Exhibit 1610-6 and use the shorter value.
- If using LR, follow Exhibits 1610-5 and 6.
- If using T, draw the intersecting barrier run to scale and measure the length of need.

Exhibit 1610-8 W-Beam Guardrail Trailing End Placement for Divided Highways



1610.03(6) Barrier Delineation

Refer to Chapter 1030 for barrier delineation requirements.

1610.04 Beam Guardrail

Strong post W-beam guardrail and thrie beam guardrail are semi-rigid barriers used predominantly on roadsides. They have limited application as median barrier. A strong-post W-beam (commonly referred to as W-Beam) guardrail system is the most common type of guardrail system used. The design uses wood or steel posts, rail, and blockouts to support the rail away from the post. The system resists a vehicle impact through a combination of the tensile and flexural stiffness of the rail and the bending or shearing resistance of the post.

Installed incorrectly, strong post W-beam guardrail can cause vehicle snagging or spearing. This can be avoided by lapping the rail splices in the direction of traffic (as shown in the *Standard Plans*), by using crash-tested end treatments, and by blocking the rail away from the posts.

Beam guardrail systems are shown in the *Standard Plans*.

1610.04(1) Beam Guardrail Systems

1610.04(1)(a) Type 31 Beam Guardrail

Use Type 31 guardrail for new runs. The Type 31 system uses many of the same components as the old WSDOT Type 1 system. The main differences are that the blockouts extend 12 inches from the posts, the rail height is 31 inches from the ground to the top of the rail, and the rail elements are spliced between posts.

Type 31 guardrail offers tolerance for future HMA overlays. The system allows a 3-inch tolerance from 31 inches to 28 inches without adjustment of the rail element.

Type 31 guardrail is available double-sided, which can be used in medians.

1610.04(1)(b) (Old) Type 1 Beam Guardrail

Previous WSDOT standard practice was to install W-beam guardrail at a rail height of 27 to 28 inches, and is referred to as “Type 1” guardrail. WSDOT is phasing out the use of Type 1 guardrail. Do not use Type 1 guardrail for new installations. For more information on (Old) Beam Guardrail Type 1, see: 🖰 http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

Existing runs of Type 1 guardrail are acceptable to leave in place and can be extended up to 50 ft (use Type 1 Alternate where future overlays are anticipated). If an existing run of Type 1 guardrail requires extending more than 50 ft, use the Beam Guardrail Type 31 to Beam Guardrail Type 1 Adaptor shown in the *Standard Plans*, and complete the guardrail extension using Type 31 guardrail.

1610.04(1)(c) Other Guardrail Types

W-beam guardrail Type 2 and Type 3 have a height of 30 inches and utilize a rubrail. A rubrail is a structural steel channel added below the W-beam rail and is used in these specific designs to reduce vehicle snagging on the post. Existing runs of Type 2 or Type 3 guardrail are acceptable to leave in place. If the existing run of Type 2 or 3 requires extending more than 50 ft, contact

WSDOT Design Office to identify appropriate extension methods to transition to the Type 31 double sided system.

Type 4 guardrail is a double-sided version of the Type 1 guardrail system. For new installation, use the Type 31 double-sided w-beam guardrail instead of Type 4 guardrail. Existing runs of Type 4 guardrail are acceptable to leave in place. If the existing run of Type 4 requires extending more than 50 ft, contact WSDOT Design Office to identify appropriate extension methods to transition to the Type 31 double-sided system.

Type 10 and Type 11 are thrie-beam guardrail systems. For new installations, see *Standard Plans*. Existing runs of Type 10 or 11 guardrail are acceptable to leave in place and may be extended as needed.

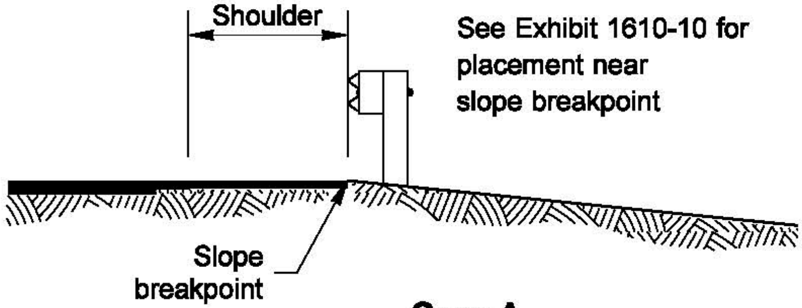
Weak post W-beam guardrail (Type 20) and thrie beam guardrail (Type 21) are flexible barrier systems primarily used in conjunction with Service Level 1 bridges. These systems use weak steel posts. For information on Type 20 and Type 21 guardrail see:
http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.04(2) Beam Guardrail Placement

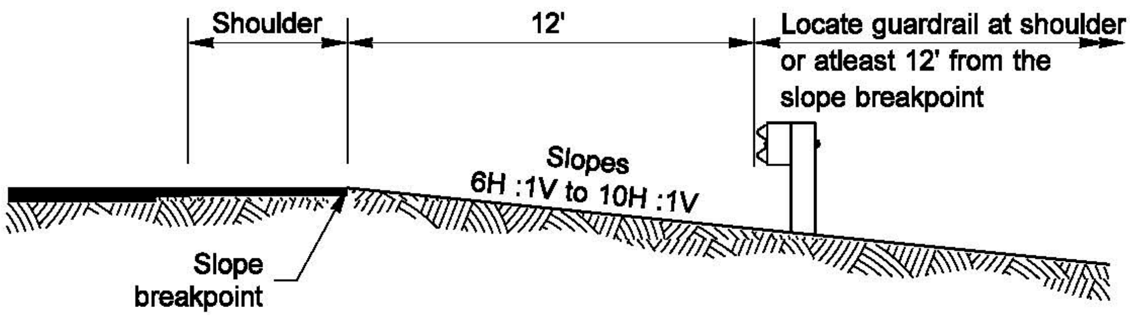
There a number of considerations regarding guardrail placement. These include:

- During the project development processes, consult with maintenance staff to help identify guardrail runs that may need to be modified.
- When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced by 4 inches to accommodate the 12-inch blockout. A Design Analysis is not required for the reduced shoulder width. If the remaining shoulder width is 4 feet or less, see Chapter 1030 for barrier delineation guidance.
- Keep the slope of the area between the edge of the shoulder and the face of the guardrail 10H:1V or flatter.
- On fill slopes 10:1 or flatter, beam guardrail can be placed anywhere outside of the shoulder.
- On fill slopes between 6H:1V and 10H:1V, place beam guardrail at the shoulder or at least 12 feet from the slope breakpoint (as shown in Exhibit 1610-9).
- Do not place beam guardrail on a fill slope steeper than 6H:1V
- On the high side of superelevated sections, place beam guardrail at the edge of shoulder prior to the slope breakpoint.
- For W-beam guardrail installed at or near the shoulder, 2 feet of shoulder widening behind the barrier is generally provided from the back of the post to the slope breakpoint of a fill slope (see Exhibit 1610-10, Case 2). If the slope is 2H:1V or flatter, this distance can be 2.5 feet measured from the face of the guardrail rather than the back of the post (see Exhibit 1610-10, Case 1).
- On projects where no roadway widening is proposed and site constraints prevent providing the 2-foot shoulder widening behind the barrier, long post installations are available as shown in Exhibit 1610-10, Cases 3, 4, 5, and 6. When installing guardrail where the roadway is to be widened or along new alignments, the use of Cases 5 and 6 requires a Design Analysis.

Exhibit 1610-9 Beam Guardrail Installation on 6:1 to 10:1 Slopes

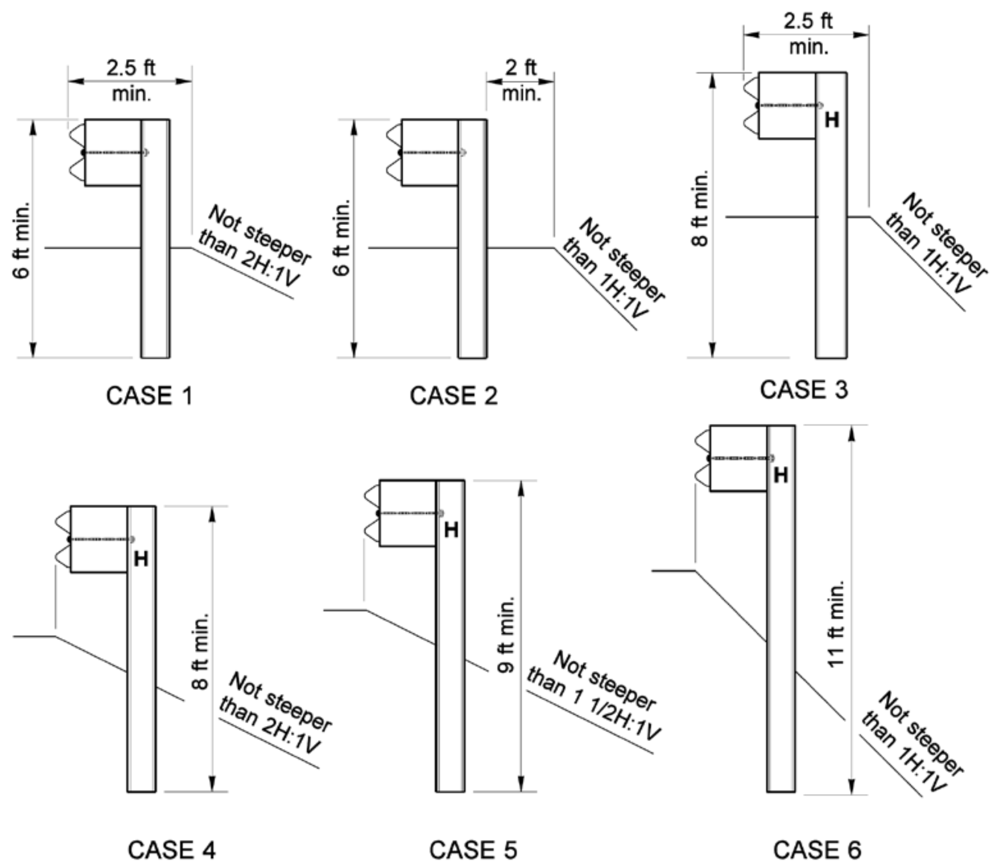


Case A



Case B

Exhibit 1610-10 Beam Guardrail Post Installation



Type 31 Shown

Notes:

- Use Cases 1 and 3 when there is a 2.5-foot or greater shoulder widening from face of guardrail to the slope breakpoint.
- Use Case 2 when there is a 4.0-foot or greater shoulder widening from the face of the guardrail to the slope breakpoint.
- Use Cases 4, 5, and 6 when there is less than a 2.5-foot shoulder widening from face of guardrail to the slope breakpoint.
- Cases shown do not apply to terminals, transition sections or anchors. Install terminals, transition sections and anchors per the *Standard Plans*.

1610.04(3) W-Beam Barrier Height

For existing Type 1 guardrail runs under 26.5 inches, adjust or replace the rail to a height of 28 inches minimum to 30 inches maximum, or replace the run with the 31-inch-high Type 31 beam guardrail.

For HMA Overlay Projects that will reduce the height of W-beam guardrail to less than 26.5 inches from the ground to the top of the rail element, adjust the height to a minimum of 28 inches and a maximum of 30 inches. A rail height of 30 inches is desirable to accommodate future overlays.

If Type 1 Alternative W-beam guardrail is present, raise the rail element after each overlay. If Type 1 Alternative is not present, the blockout and rail element may be raised up to 4 inches. This requires field drilling a new hole in the guardrail post. See the *Standard Plans*.

1610.04(4) Additional Guidance

Additional guidance related to w-beam guardrail:

- Locations where crossroads and driveways cause gaps in the guardrail create situations requiring special consideration. Elimination of the need for the barrier is the preferred solution. At these locations, a barrier flare might be needed to provide sight distance.
- Rail washers on beam guardrail are not normally used. If rail washers are present, removal is not necessary. However, if the rail element is removed for any reason, do not reinstall rail washers. In areas where heavy snow accumulations are expected to cause the bolts to pull out, specify snowload post washers and rail washers in the contract documents. (Snowload post washers are used to help prevent the bolts from pulling through the posts, and snowload rail washers are used to help prevent the bolt head from pulling through the rail). In other installations, it is normal to have the rail pull loose from the bolt head when impacted. Do not use rail washers within the limits of a guardrail terminal except, for some models, at the end post when they are needed for anchorage of the rail.
- The use of curb in conjunction with beam guardrail is discouraged. If a curb is needed, the 3 inch-high curb is preferred. If necessary, the 4-inch-high extruded curb can be used behind the face of rail for any posted speed. The 6-inch-high extruded curb can be used at locations where the posted speed is 50 mph or below. When replacing extruded curb at locations where the posted speed is above 50 mph, use 3 inch-high or 4-inch-high curb. (See the *Standard Plans* for extruded curb designs.)
- When curb is used in conjunction with Type 31 W-beam guardrail, an acceptable option is to place up to a 6-inch-high extruded curb at a maximum 6 inch offset in front of the face of the rail at any posted speed. Contact the WSDOT Design Office for more information.
- The installation of strong post W-beam guardrail posts in rigid surfacing such as asphalt or concrete pavement involves special details that will allow the posts to rotate. Contact the WSDOT Design Office for more information.
- For (Old) Guardrail Types 1, 2, 3,and 4, it is acceptable to use blockouts that extend the rail element from the post for a distance not to exceed 16 inches.

1610.04(5) Terminals and Anchors

A guardrail anchor is required at the end of a run of guardrail to develop tensile strength throughout its length. In addition, when the end of the guardrail is subject to head-on impacts, a crash-tested guardrail terminal is required (see the *Standard Plans*).

Replace guardrail terminals that do not have a crash-tested design with crash-tested guardrail terminals. Common features of systems that do not meet current crash-tested designs include:

- No cable anchor.
- A cable anchored into concrete in front of the first post.

- Second post not breakaway (CRT).
- Design A end section.
- Design C end sections may be left in place if the terminal is otherwise a crash-tested design —see the *Standard Plans* for end section details.
- Terminals with beam guardrail on both sides of the posts (two-sided).
- Buried guardrail terminals that slope down such that the guardrail height is reduced to less than 28 inches (measured in relation to a 10H:1V line extended from the breakpoint at edge of shoulder).

When the height of a terminal, as measured from the ground to the top of the rail element, will be affected by the project, adjust the terminal based upon the following criteria:

- If the height of the adjoining Type 1, 2, 3, or 4 guardrail will be reduced to less than 26.5 inches or increased to greater than 30 inches, adjust the height of the terminal to a minimum of 28 inches and a maximum of 30 inches. A terminal height of 30 inches is desirable to accommodate future overlays.
- If the height of the adjoining Type 31 guardrail will be reduced to less than 28 inches or increased to greater than 32 inches, adjust the height of the terminal to 31 inches.

When adjusting terminals that are equipped with CRT posts, the top-drilled holes in the posts need to remain at the surface of the ground.

One terminal that was used extensively on Washington's highways was the Breakaway Cable Terminal (BCT). This system used a parabolic flare similar to the Slotted Rail Terminal (SRT) and a Type 1 anchor (Type 1 anchor posts are wood set in a steel tube or a concrete foundation). For guidance regarding BCT's on Preservation projects see Chapter 1120. For non-Preservation projects replace BCTs with a currently approved terminal.

Information regarding (Old) Type 1 beam guardrail terminals can be found at:
🖰 http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.04(5)(a) Buried Terminal (BT) for Type 31 Beam Guardrail

A buried terminal is designed to terminate the guardrail by burying the end in a backslope. The BT is the preferred terminal because it eliminates the exposed end of the guardrail.

For new BT installations, use the Buried Terminal Type 2. Previously, another BT option (the Buried Terminal Type 1) was an available choice. For existing installations, it is acceptable to leave this option in service as long as height requirements and other design criteria is met. See the plan sheet at: 🖰 www.wsdot.wa.gov/design/standards/plansheet.

The BT uses a Type 2 anchor to develop the tensile strength in the guardrail. The backslope needed to install a BT is to be 3H:1V or steeper and at least 4 feet in height above the roadway. The entire BT can be used within the length of need for backslopes of 1H:1V or steeper if the barrier remains at full height in relation to the roadway shoulder to the point where the barrier enters the backslope.

For backslopes between 1H:1V and 3H:1V, design the length of need beginning at the point where the W-beam remains at full height in relation to the roadway shoulder—usually beginning at the point where the barrier crosses the ditch line. If the backslope is flatter than

1H:1V, provide a minimum 20-foot-wide by 75-foot-long distance behind the barrier and between the beginning length of need point at the terminal end to the mitigated object to be protected.

Flare the guardrail to the foreslope/backslope intersection using a flare rate that meets the criteria in 1610.03(4). Provide a 4H:1V or flatter foreslope into the face of the guardrail and maintain the full guardrail height to the foreslope/backslope intersection in relation to a 10H:1V line extending from edge of shoulder breakpoint. (See the *Standard Plans* for details.)

1610.04(5)(b) Non-flared Terminals for Type 31 Beam Guardrail

If a buried terminal cannot be installed as described in 1610.04(5)(a), install a non-flared terminal. These systems use W-beam guardrail with a special end piece that fits over the end of the guardrail. When hit head on, the end piece is pushed over the rail, absorbing the energy of the impacting vehicle in the process. An anchor is included for developing the tensile strength of the guardrail. The length of need does not begin at the impact head, but will vary by system. Non-flared terminals may be provided for two different design levels that are based on the posted speed of the highway. For highways with a posted speed of 50 mph or above, use only a TL-3 (Test Level 3) product. For highways with a posted speed of 45 mph or below, either a TL-2 or a TL-3 product is acceptable. See the *Standard Plans*.

The availability and acceptance of these systems is expected to change rapidly over time. Refer to the Type 31 Beam Guardrail Terminals website for the latest information on availability or acceptance of different systems (see
🖰 http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm).

Although non-flared terminals do not need to have an offset at the end, a flare is recommended so that the end piece does not protrude into the shoulder. See the *Standard Plans*.

Four feet of widening is needed at the end posts to properly anchor the systems (See the *Standard Plans*). When widening includes an embankment, properly placed and compacted fill material will be necessary for optimum terminal performance (see the *Standard Specifications* for embankment widening for guardrail).

For guardrail runs that are located more than 12 feet from the slope break (as shown in Exhibit 1610-9) no additional embankment widening is required at the terminal.

No snowload rail washers are allowed within the limits of these terminals.

WSDOT does not currently use a flared terminal system for the Type 31 guardrail system.

Note: Approved shop drawings for terminals can be found by accessing the following website:
🖰 http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.04(5)(c) Terminal Evolution Considerations

Some currently approved terminals have been in service for a number of years. During this time, there have been minor design changes. However, these minor changes have not changed the devices’ approval status. Previous designs for these terminals may remain in place.

Note: If questions arise concerning the current approval status of a device, contact the HQ Design Office for clarification when replacement is being considered.

1610.04(5)(d) Anchors

A guardrail anchor is needed at the end of a run of guardrail to develop tensile strength throughout its length.

- Use the Type 10 anchor to develop the tensile strength of the guardrail on the end of Type 31 guardrail runs where a crash-tested terminal is not needed.
- Anchors for (Old) Beam Guardrail Type 1 include Type 1, Type 3, Type 4, Type 5, and Type 7.

For more information on these anchor types used in run of (Old) Beam Guardrail Type 1, see:
http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

1610.04(6) Transitions and Connections

When there is an abrupt change from one barrier type to a more rigid barrier type, a vehicle hitting the more flexible barrier may be caught in the deflected barrier pocket and directed into the more rigid barrier. This is commonly referred to as "pocketing." A transition stiffens the more flexible barrier by decreasing the post spacing, increasing the post size, and using stiffer beam elements to reduce the possibility of pocketing.

When connecting beam guardrail to a more rigid barrier or a structure use the transitions and connections that are shown in Exhibits 1610-12 and 1610-13 and detailed in the *Standard Plans*.

When connecting a Type 21 Transition to an existing bridge rail, a special connection plate may be required. Coordinate with the WSDOT Bridge and Structures Office (BSO). The transition pay item includes the connection.

Exhibit 1610-12 Guardrail Connections

Condition	Connection
Unrestrained concrete barrier	A
Rigid, rigid anchored, untapered safety shape bridge rails or barriers [1]	B
Bridge rails with curbs 9 inches or less in width	B
Bridge rails with curbs between 9 and 18 inches wide	C
Vertical walls, single slope, or tapered safety shape barrier [1]	D

Note:
[1] New single slope and safety shape bridge rails are designed with the toe of the barrier tapered so that it does not project past the face of the approach guardrail.

Exhibit 1610-13 Transitions and Connections

Connecting W-Beam Guardrail to:			Transition Type*	Connection
Bridge Rail	New Installation		21	D
Bridge Rail	Existing Concrete	Concrete Parapet > (Greater Than) 20 in.	21, 4 [4]	Exh. 1610-12 [6]
Bridge Rail	Existing Concrete	Concrete Parapet < (Less Than) 20 in.	21, 2, 4 [4]	Exh. 1610-12 [6]
Bridge Rail	Existing Concrete	Existing W-Beam Transition	2 [1][5], 4 [4]	[1]
Bridge Rail	Thrie Beam at Face of Curb [3]	Approach End	23	n/a
Bridge Rail	Thrie Beam at Face of Curb [3]	Trailing End (two-way traffic only)	23	n/a
Bridge Rail	Thrie Beam at Bridge Rail (curb exposed) [3]	Approach End	22	n/a
Bridge Rail	Thrie Beam at Bridge Rail (curb exposed) [3]	Trailing End (two-way traffic only)	22	n/a
Bridge Rail	Weak Post Intersection Design (see http://www.wsdot.wa.gov/publications/fulltext/design/RoadsideSafety/Type1_Info.pdf Cases 12 & 13)		5	Exhibit 1610-12
Concrete Barrier	Rigid & Rigid Anchored		21	Exhibit 1610-12
Concrete Barrier	Unrestrained		21, 2, 4 [4]	A
Rigid Structures such as Bridge Piers	New Installation (see Cases 11–31)		21	n/a
Rigid Structures such as Bridge Piers	Existing W-Beam Transition		[2]	n/a
Connecting Thrie Beam Guardrail to:			**Transition Type***	**Connection**
Bridge Rail or Concrete Barrier	New Installation (for example: use with thrie beam guardrail bull nose terminal)		1B	Exhibit 1610-12

*Consult Section C of the *Standard Plans* for details on transition types.

Notes:

[1] If work creates the need for reconstruction or resetting of the transition, upgrade as shown above. Raising the guardrail is not considered reconstruction. If the transition is not being reconstructed, the existing connection may remain in place. When Type 3 anchors are encountered, see http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm for guidance.

[2] For new/reconstruction, use Case 11 (thrie beam). For existing modified Case 11 with W-beam, add a second W beam rail element.

[3] For Service Level 1 bridge rail, see http://www.wsdot.wa.gov/publications/fulltext/design/RoadsideSafety/Type1_Info.pdf, Case 14.

[4] Use on highways with posted speeds 45 mph or below.

[5] If an existing transition has the needed guardrail height and includes the three 10″ x 10″ (nominal) posts and three 6″ x 8″ (nominal) posts spaced 3′-1.5″ apart—it is acceptable if a W-beam element is added to make the element nested.

[6] When connecting a Type 21 Transition to an existing bridge rail, a special connection plate may be required. Contact the WSDOT BSO for details.

1610.04(7) Guardrail Placement Cases

The *Standard Plans* contain placement cases that show beam guardrail elements needed for typical situations. For new installations, use the appropriate Type 31 placement option.

Information regarding placement cases for (old) Type 1 beam guardrail can be found at http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

1610.04(7)(a) Beam Guardrail Type 31 Placements

- Case 1-31 is used where there is one-way traffic. It uses a crash-tested terminal on the approach end and a Type 10 anchor on the trailing end.
- Case 2-31 is used where there is two-way traffic. A crash-tested terminal is used on both ends.
- Case 3-31 is used at railroad signal supports on one-way or two-way roadways. A terminal is used on the approach end, but usually cannot be used on the trailing end because of its proximity to the railroad tracks. If there is a history of crossover collisions, consider additional protection such as an impact attenuator.
- Case 4-31 is used where guardrail on the approach to a bridge is to be shifted laterally to connect with the bridge rail. A terminal is used on the approach end and a transition is needed at the bridge end. Curves (bends) are shown in the guardrail to shift it to the bridge rail. However, the length of the curves are not critical. The criterion is to provide smooth curves that are not more abrupt than the allowable flare rate (see Exhibit 1610-4).
- Case 5-31 is a typical bridge approach where a terminal and a transition are needed.
- Case 6 is used on bridge approaches where opposing traffic is separated by a median that is 36 feet or wider. This case is designed so that the end of the guardrail will be outside the Design Clear Zone for the opposing traffic.
- Case 10 (A-31, B-31, and C-31) is used at roadside fixed features (such as bridge piers) when 3 or more feet are available from the face of the guardrail to the feature. The approach end is the same for one-way or two-way traffic. Case 10A-31 is used with two-way traffic; therefore, a terminal is needed on the trailing end. Case 10B-31 is used for one-way traffic when there is no need to extend guardrail past the bridge pier and a Type 10 anchor is used to end the guardrail. Case 10C-31 is used for one-way traffic when the guardrail will extend for a distance past the bridge pier.
- Case 11 (A-31, B-31, and C-31) is used at roadside fixed features (such as bridge piers) when the guardrail is to be placed within 3 feet of the feature. Since there is no room for deflection, the rail in front of the feature is to be considered a rigid system and a transition is needed. The trailing end cases are the same as described for Case 10.
- Beam Guardrail Type 31 (12'6", 18'9", or 25' Span) is used when it is necessary to omit one, two, or three posts. This application is typically used when guardrail is installed over a shallow buried obstruction, such as drainage structures. This design may be used in other situations where there are no above ground objects located behind the guardrail and within the lateral deflection distance. Three CRT posts are provided on each end of the omitted post(s).

- Guardrail Placement Strong Post – Type 31 is the "Strong Post Intersection Design for Type 31 barrier" that provides a more rigid barrier. This design is used at crossroads or road approaches where a barrier is needed and where the length of need cannot be achieved using standard components such as standard longitudinal barrier runs, transitions, and terminals.

1610.05 High-Tension Cable Barrier

Cable barrier is a flexible barrier system that can be used on a roadside or as a median barrier. Early cable barrier designs centered around low-tension cable systems. With research and crash analysis of these systems, the designs evolved into high-tension cable systems. These high-tension cable systems are primarily used in medians and are preferred for many installations due in part to high benefit-to-cost ratios. Read about advantages for selecting a cable barrier system here:
http://www.wsdot.wa.gov/publications/fulltext/design/Policy/CableBarriers.pdf.

There are a number of manufacturers of high-tension cable barrier systems. These systems have been designed using either three or four-cables fixed to metal posts placed at a fixed spacing. Each cable system has specially designed anchors placed at both ends of the barrier run to provide the proper tensioning in the cables. Currently, both three and four-cable high-tension cable barrier systems are installed along WSDOT state routes. See additional information about these approved cable barrier systems here:
http://www.wsdot.wa.gov/publications/fulltext/design/Policy/CableBarriers.pdf.

Use four-cable high-tension cable barrier systems for all new installations.

1610.05(1) High-Tension Cable Barrier Placement

High-tension cable barrier can be placed in a median or along the roadside.

Note: Additional placement cases are shown in the WSDOT *Standard Plans*. For non-typical installations, such as double runs of cable barrier or median ditch cross sections that differ significantly from those shown, contact the HQ Design Office for guidance.

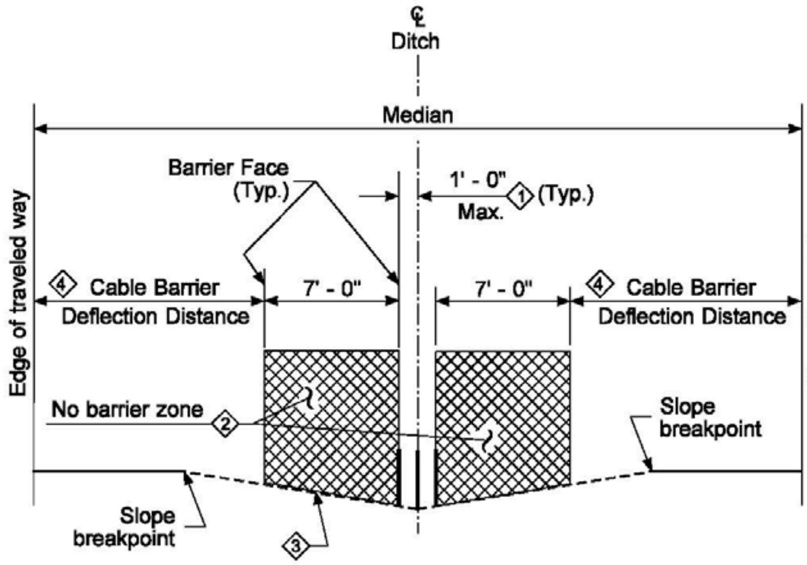
1610.05(1)(a) Median Applications

For typical cable barrier installations in a median, the following apply (see Exhibit 1610-14a):

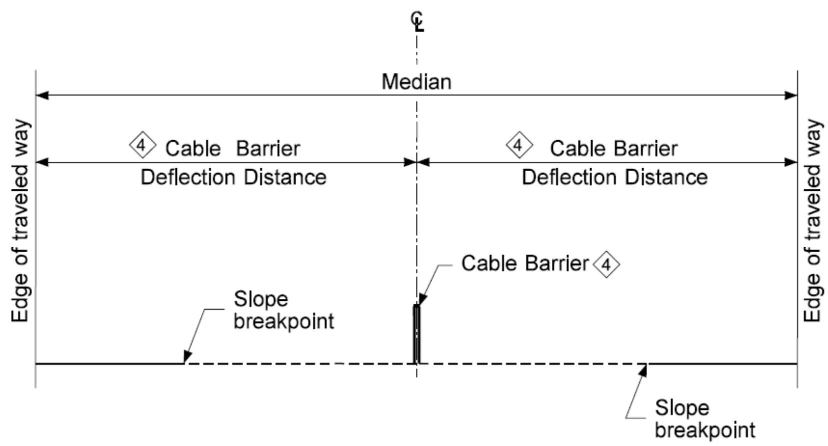
- Install the cable barrier as far from the edge of traveled way as site constraints allow. Consider a minimum placement distance of 8 feet from the edge of traveled way to allow vehicles to use this area for refuge.
- Install cable barrier on slopes 6H:1V or flatter.
- There are approved high-tension cable barrier systems that can be placed on slopes as steep as 4H:1V. The use of these systems requires special placement considerations, contact the HQ Design Office for guidance.
- Provide an obstruction free zone within the cable barrier system's lateral deflection distance (see 1610.05(2)).
- On tangent sections of a roadway where no ditch is present, consider installing the cable barrier in the middle of the median.

- Along horizontal curves, consider installing the cable barrier along the inside of the curve. Reduce the post spacing per manufacturer's recommendations.
- Where a ditch is present, install cable barrier at the centerline of the ditch or within 1-foot of the ditch centerline.
- Avoid installing cable barrier within the range between 1-foot to 8-foot offset from the ditch centerline to avoid "under-riding" of vehicles that cross the ditch (see Exhibit 1610-14a).
- In some situations, it may be advantageous to terminate a run of cable barrier on one side of the median (to provide maintenance access to a feature, for example) and then begin an adjacent cable barrier run on the opposite side of the median. In this application, it is important to provide adequate cable barrier overlap distance between the two runs. For placement guidance, see Exhibit 1610-15.
- Narrow medians provide little space for maintenance crews to repair or reposition the barrier. Wherever site conditions permit, provide at least 14 feet of clearance from the adjacent lane edge to the face of the cable barrier.

Exhibit 1610-14a Median Cable Barrier Placement



Cable Barrier Placement in Median with Ditch



Cable Barrier Placement in Median with No Ditch

Notes:

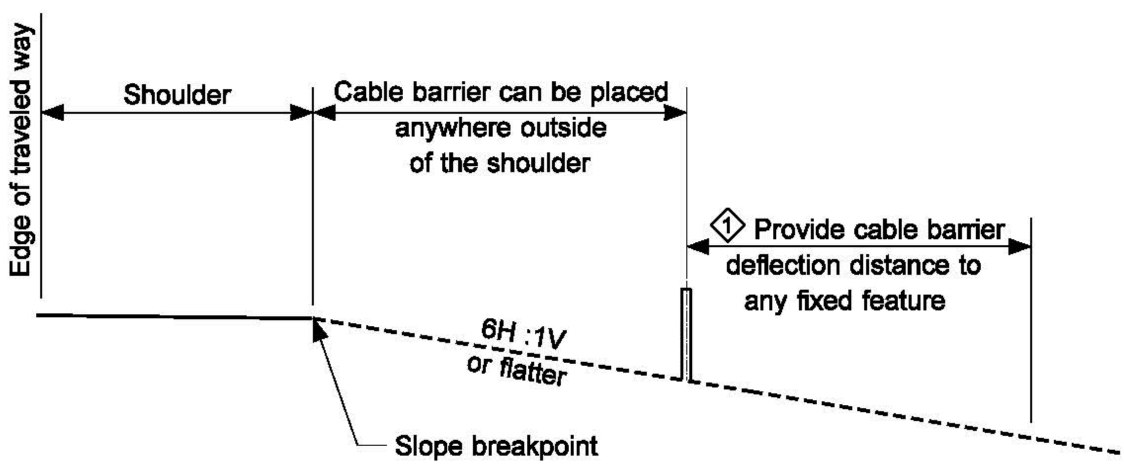
1. Cable barrier may be installed in the center of the ditch and from the ditch centerline a maximum of 1 foot (left or right).
2. Avoid installing cable barrier within a range of 1-foot to 8-foot offset from the ditch centerline.
3. Applies to slopes 6H:1V or flatter.
4. Provide an obstruction free zone within the cable barrier’s lateral deflection distance, see 1610.05(2)

1610.05(1)(b) Roadside Applications

For typical non-median roadside applications, the following apply (see Exhibit 1610-14b):

- Install the cable barrier as far from the edge of traveled way as site constraints allow.
- Consider a minimum placement distance of 8 feet from the edge of traveled way to allow vehicles to use this area for refuge.
- Install cable barrier on slopes 6H:1V or flatter
- There are approved high-tension cable barrier systems that can be placed on slopes as steep as 4H:1V. The use of these systems requires special placement considerations, contact the HQ Design Office for guidance.
- Along horizontal curves, consider installing along the inside of the curve. Reduce post spacing per manufacturer's recommendations
- Provide an obstruction free zone within the cable barrier system's lateral deflection distance, see 1610.05(2).

Exhibit 1610-14b Roadside Cable Barrier Placement



Notes:

1 Provide an obstruction free zone within the cable barrier's lateral deflection distance, see 1610.05(2)

1610.05(2) High-Tension Cable Barrier Lateral Deflection Distances

Depending on the high-tension cable barrier system, lateral deflection distances for each barrier system vary based upon the length of the barrier run, the spacing of the end anchors, and post spacing. Provide an obstruction free zone within the system's lateral deflection distance for the following situations:

1. In the direction of travel (located in the median or along roadside), locate the cable barrier system so that there are no fixed objects within the limits of the cable barrier lateral deflection distance.

2. For opposing traffic (where present), locate the cable barrier to provide lateral deflection distance to prevent a vehicle's encroachment into the opposite lane of travel.

Provide a minimum 12-feet for cable barrier lateral deflection distance and specify the minimum allowable lateral deflection distance in the contract documents in order for the contractor to select a cable barrier manufacturer that can meet the lateral deflection requirements.

Note: There are new high-tension cable barrier systems under development that may change selection and placement criteria. For example, newer systems may allow placement on steeper slopes or have reduced deflection distances. Contact the HQ Design Office for guidance.

1610.05(3) High-Tension Cable Barrier Height

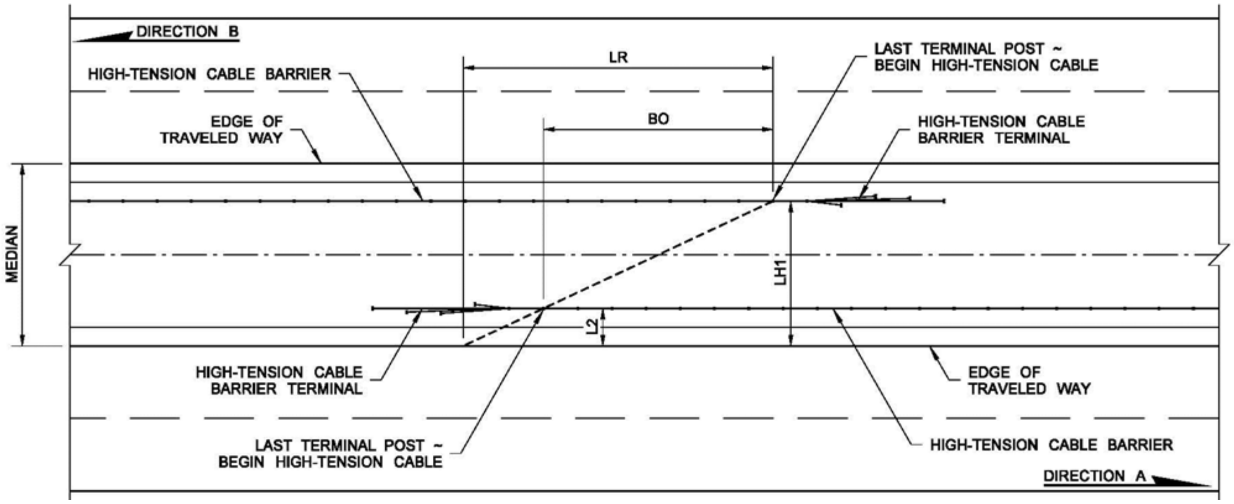
A high-tension four-cable barrier system shall provide a height to the center of the top cable of not less than 35 inches and a height to the center of the bottom cable not greater than 19 inches. Previous testing of cable barrier systems has shown that providing cables within the ranges specified typically restrains a vehicle traversing the various slopes and reduces the possibility of the vehicle either overriding or under riding the cable barrier.

1610.05(4) High-Tension Cable Barrier Termination

Manufacturers of high-tension four-cable barrier systems provide designed anchors for the ends of cable barrier runs. Other alternatives to end a cable barrier include:

- It is possible to terminate high-tension cable barrier systems by connecting directly to beam guardrail runs (such as transitions to bridge rails) or to a separate cable barrier anchorage system. Review field conditions, check local maintenance personnel needs, and then specify the required connection option in the contract documents. If a separate anchorage system is used, refer to Exhibit 1610-15 for placement guidance.
- When cable barrier is connected to a more rigid barrier, a transition section is typically needed. Contact the HQ Design Office for further details.

Exhibit 1610-15 Cable Barrier Placement for Divided Highways

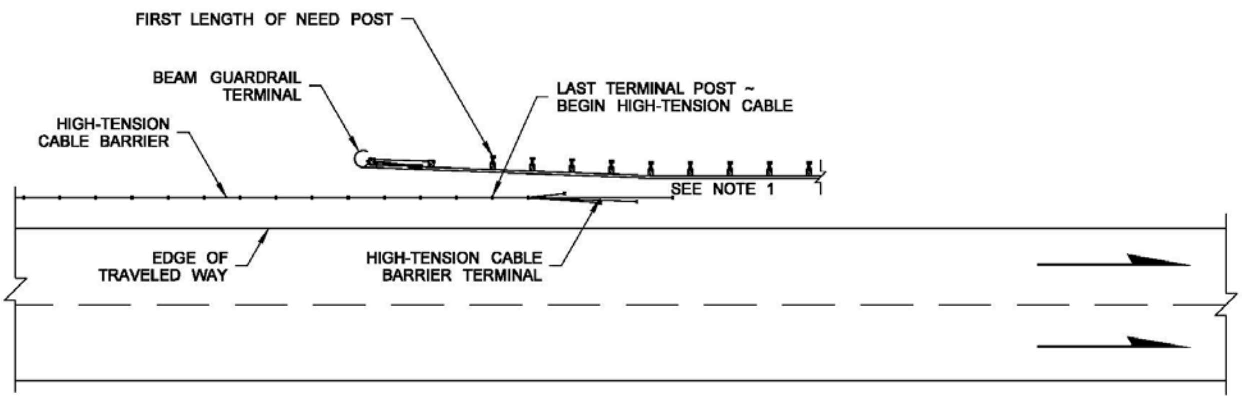


Cable Barrier Median Overlap

$$BO = \frac{LH1 - L2}{(LH1/LR)}$$ (Direction A shown)

Note:

Calculate barrier overlap (BO) from both directions of travel. Use the greatest value of BO obtained.



Cable Barrier Overlap with Beam Guardrails

Notes:

- The beam guardrail may need to be extended and flared to maintain adequate barrier overlap and shoulder width.
- Typical applications may be at either bridge transitions or where high-tension cable and beam guardrail systems end or begin.
- For supporting length of need equation factors, see Exhibit 1610-6.

1610.05(5) High-Tension Cable Barrier Curb Placement

Avoid the placement of curb in conjunction with high-tension cable barrier systems. Currently, there are no known acceptable cable barrier systems that have been successfully crash tested with this feature present.

1610.06 Concrete Barrier

Concrete barriers are identified as either rigid, rigid anchored, or unrestrained rigid systems. They are commonly used in medians and as shoulder barriers. These systems are stiffer than beam guardrail or cable barrier, and impacts with these barriers tend to be more severe. Consider the following when installing concrete barriers:

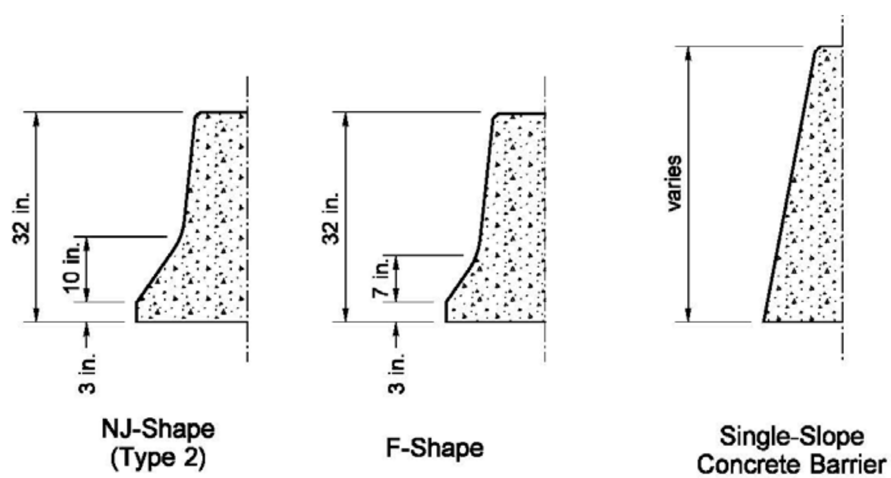
- For slopes 10H:1V or flatter, concrete barrier can be used anywhere outside of the shoulder.
- Do not use concrete barrier at locations where the foreslope into the face of the barrier is steeper than 10H:1V.
- Light standards mounted on top of precast concrete median barrier must not have breakaway features. (See the concrete barrier light standard section in the *Standard Plans*.)
- When considering concrete barrier use in areas where drainage and environmental issues (such as stormwater, wildlife, or endangered species) might be adversely impacted, contact the HQ Hydraulics Office and/or the appropriate environmental offices for guidance. Also, refer to 1610.02.

1610.06(1) Concrete Barrier Shapes

Concrete barriers use a single-slope or safety shape (New Jersey or F-Shape) to redirect vehicles while minimizing vehicle vaulting, rolling, and snagging. A comparison of these barrier shapes is shown in Exhibit 1610-16.

The single-slope barrier face is the recommended option for embedded rigid concrete barrier applications.

Exhibit 1610-16 Concrete Barrier Shapes



When the single-slope or F-Shape face is used on structures, and precast barrier is selected for use on the approaches, a cast-in-place transition section is needed so that no vertical edges of the barrier are exposed to oncoming traffic. For details on bridge rail designs, see the *Bridge Design Manual*.

For aesthetic reasons, avoid changes in the shape of the barrier face within a project or corridor.

The New Jersey shape and F-shape barriers are commonly referred to as "safety shapes." The New Jersey shape and F-shape have an initial overall height of 32 inches. This height includes provision for up to a 3-inch future pavement overlay that can reduce the barrier height to 29 inches minimum.

1610.06(1)(a) Safety Shape Barrier

The New Jersey shape face is primarily used on precast concrete barrier.

Concrete Barrier Type 2 (see the *Standard Plans*) is a freestanding precast barrier that has the New Jersey shape on two sides. It can be used for both median and shoulder installations. Unanchored units are connected with steel pins through wire rope loops. For permanent installation, this barrier is placed on a paved surface and a paved surface is provided beyond the barrier for deflection. See Exhibit 1610-3 for deflection requirements.

The cost of precast Type 2 barrier is significantly less than the cost of the cast-in-place barriers. Therefore, consider the length of the barrier run and the deflection needs to determine whether transitioning to precast Type 2 barrier is desirable. If precast Type 2 barrier is used for the majority of a project, use the New Jersey face for small sections that need cast-in-place barrier, such as for a light standard section, see the *Standard Plans* for additional details for transitioning the barrier faces.

Concrete barrier Type 4 is a precast, single-faced New Jersey shape barrier. These units are not freestanding and are to be placed against a rigid structure or anchored to the pavement. If Type 4 barriers are used back to back, fill any gap between them to prevent tipping.

Precast barrier can be anchored where a more rigid barrier is needed. (Anchoring methods are shown in the *Standard Plans*.) Anchors Type 1 and Type 2 are for temporary installations on a rigid pavement. Anchor Type 3 can be used in temporary or permanent installations on an asphalt pavement. Consult the WSDOT BSO for details when anchoring permanent precast concrete barrier to a rigid pavement.

Precast barrier used on the approach to bridge rail is to be connected to the bridge rail by installing wire rope loops embedded 1-foot 3-inches into the bridge rail with epoxy resin and as detailed in the *Standard Plans*.

Place unrestrained (unanchored) precast concrete barrier on slopes of 5% (20H:1V) or flatter where possible. The maximum slope for placement of concrete barrier is 10% (10H:1V).

In the past WSDOT used a Type 5 single-faced New Jersey shape for special applications, such as adjacent to bridge rails with similar shapes. The Type 5 barrier is seldom used by WSDOT. See the Plan Sheet Library for more information on Type 5 barrier:
🖰 http://www.wsdot.wa.gov/Design/Standards/PlanSheet/TB-5.htm.

1610.06(1)(b) Single-Slope Barrier

Single-slope barrier is available in various heights, as shown in the *Standard Plans*. Single-slope concrete barrier can be cast in place or precast. A primary benefit of using precast single-slope barrier is that it can be used as temporary barrier during construction and then reset into a permanent location. In temporary applications, the height of the single-slope barrier may also offer the added benefits of reducing headlight glare and providing reduced deflection characteristics over some other barrier types.

Single-slope barrier is considered a rigid system regardless of the construction method used provided the barrier is embedded a minimum of 3-inches in the roadway wearing surface on both sides. When precast single-slope barrier is installed on top of the roadway surface, it is considered a rigid unrestrained system and barrier deflection needs to be provided as shown in Exhibit 1610-3.

For new installations, the minimum height of single-slope barrier above the roadway is 2 feet 10 inches, which allows a 2-inch tolerance for future overlays. The minimum total height of the barrier section is 3 feet 6 inches (including embedment). This allows for use of the 3-foot-6-inch barrier between roadways with grade separations of up to 5 inches. A grade separation of up to 10 inches is allowed when using a 4-foot-6-inch high barrier section, as shown in the *Standard Plans*. The barrier is to have a depth of embedment equal to or greater than the grade separation. Contact the WSDOT BSO for grade separations greater than 10 inches.

1610.06(1)(c) High-Performance Concrete Barrier

High-Performance Concrete Barrier (HP Barrier) is a rigid barrier with a minimum height of 3-foot-6-inch above the roadway surface. This barrier is designed to function more effectively during heavy-vehicle crashes. This taller barrier may also offer the added benefits of reducing headlight glare and reducing noise in surrounding environments. WSDOT HP Barrier utilizes the single-slope shape. (See the *Standard Plans* for barrier details.)

Use HP Barrier in freeway medians of 22 feet or less. Also, use HP Barrier on Interstate or freeway routes where collision history suggests a need or where roadway geometrics increase the possibility of larger trucks hitting the barrier at a high angle (for example, on-ramps for freeway-to-freeway connections with sharp curvature in the alignment).

Consider the use of HP Barrier at other locations such as highways with narrow medians, near highly sensitive environmental areas, near densely populated areas, over or near mass transit facilities, or on vertically divided highways.

1610.06(1)(d) Low-Profile Barrier

Low-profile barrier designs are available for median applications where the posted speed is 45 mph or below. These barriers are normally used in urban areas. They are typically 18 to 20 inches high and offer sight distance benefits. For barrier designs, terminals, and further details, contact the HQ Design Office.

1610.06(2) Concrete Barrier Height

Overlays in front of safety shape concrete barriers can extend to the top of the lower, near-vertical face of the barrier before adjustment is necessary.

- Allow no less than 2-foot 5 inches from the pavement to the top of the safety shape barriers. Allow no less than 2-foot 8-inches from the pavement to the top of the single-slope barrier.

1610.06(3) Concrete Barrier Terminals

Whenever possible, bury the blunt end of a concrete barrier run into the backslope of the roadway. If the end of a concrete barrier run cannot be buried in a backslope or terminated as described below, terminate the barrier using a guardrail terminal and transition or an impact attenuator (see Chapter 1620).

To bury the blunt end of the barrier into a backslope, the following conditions must be met:

- The backslope is 3H:1V or steeper
- The backslope extends minimum of 4 feet in height above the edge of shoulder
- Flare the concrete barrier into the backslope using a flare rate that meets the criteria in 1610.03(4)
- Provide a 10H:1V or flatter foreslope into the face of the barrier and maintain the full barrier height until the barrier intersects with the backslope. This might create the need to fill ditches and install culverts in front of the barrier face.

The 7-foot-long precast concrete barrier Type 2 and the 10- to 12-foot single-slope barrier terminal (precast or cast-in-place) may be used for the following conditions:

- Outside the Design Clear Zone.
- On the trailing end of the barrier when it is outside the Design Clear Zone for opposing traffic.
- On the trailing end of one-way traffic.
- Where the posted speed is 25 mph or below.

See the *Standard Plans* for barrier terminal details.

1610.07 Bridge Traffic Barriers

Bridge traffic barriers redirect errant vehicles and help to keep them from going over the side of the structure. (See the *Bridge Design Manual* for information regarding bridge barrier on new bridges and replacement bridge barrier on existing bridges).

When considering work on a bridge traffic barrier consult the WSDOT BSO.

- For new bridge barrier installations, a 2-foot 10-inch-high single-slope or a 2-foot 8-inch-high safety shape (F Shape) bridge barrier may be required.
- Taller 3-foot 6-inch single-slope or safety shape bridge barriers may be required on Interstate or freeway routes where collision history suggests a need or where taller barrier is required on approaching roadways with narrow medians, as defined in 1610.06(1)(c).
- Also, the taller 3-foot 6-inch barrier may be required when geometrics increase the possibility of larger trucks hitting the barrier at a high angle (such as on-ramps for freeway-to-freeway connections with sharp curvature in the alignment).

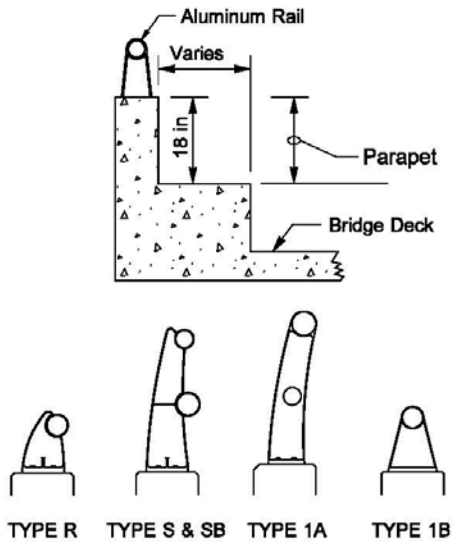
Approach barriers, transitions, and connections are usually needed on all four corners of bridges carrying two-way traffic and on both corners of the approach end for one-way traffic. (See 1610.04(6) for guidance on transitions). A transition is available to connect the Type 2 concrete barrier (New Jersey shape) and the bridge barrier (F-Shape.) (See the *Standard Plans* for further details).

Bridge railing attaches to the top of the bridge barrier. When bridge barrier is included in a project, the bridge rails, including crossroad bridge rail, are to be addressed. Consult the WSDOT BSO regarding bridge rail selection and design and for design of the connection to an existing bridge. Consider the following:

- Use an approved, crash-tested concrete bridge rail on new bridges or bridges to be widened. The *Bridge Design Manual* provides examples of typical bridge rails.
- An existing bridge rail on a highway with a posted speed of 30 mph or below may remain in place if it is not located on a bridge over a National Highway System (NHS) highway. When Type 7 bridge rail is present on a bridge over an NHS highway with a posted speed of 30 mph or below, it may remain in place regardless of the type of metal rail installed. Other bridge rails are to be evaluated for strength and geometrics. (See 1610.07(1) for guidance on retrofit techniques.)
- The Type 7 bridge rail is common. Type 7 bridge rails have a curb, a vertical-face parapet, and an aluminum top rail. The curb width and the type of aluminum top rail are factors in determining the adequacy of the Type 7 bridge rail, as shown in Exhibit 1610-17. Consult the WSDOT BSO for assistance in evaluating other bridge rails.

When considering an overlay on a bridge, consult the WSDOT BSO to verify the overlay depth can be placed on the bridge deck based on the type of traffic barrier. There may be instances where the height of the bridge barrier will not allow for the planned overlay depth without removal of existing pavement.

Exhibit 1610-17 Type 7 Bridge Rail Upgrade Criteria



Aluminum Rail Type	Curb Width	
	9 Inches or Less	Greater Than 9 Inches*
Type R, S, or SB	Bridge rail adequate	Bridge rail adequate
Type 1B or 1A	Bridge rail adequate	Upgrade bridge rail
Other	Consult the WSDOT BSO	

*When the curb width is greater than 9 inches, the aluminum be able to withstand a 5 kip load.

1610.07(1) Bridge Barrier Retrofit

If the bridge barrier system does not meet the criteria for strength and geometrics, modifications to improve its redirectional characteristics and its strength may be needed. Consult the WSDOT BSO to determine which retrofit method described below can be completed.

1610.07(1)(a) Concrete Safety Shape

Consult the WSDOT BSO to determine whether the existing bridge deck and other superstructure elements are of sufficient strength to accommodate this bridge barrier system and provide design details for the retrofit. Retrofitting with a new concrete bridge barrier is costly and requires authorization from Program Management when no widening is proposed.

1610.07(1)(b) Thrie Beam Retrofit

Retrofitting the bridge barrier with thrie beam is an economical way to improve the strength and redirectional performance of a bridge barrier. The thrie beam can be mounted to steel posts or the existing bridge barrier, depending on the structural adequacy of the bridge deck, the existing bridge barrier type, the width of curb (if any), and the curb-to-curb roadway width carried across the structure. Exhibit 1610-18 shows typical retrofit criteria.

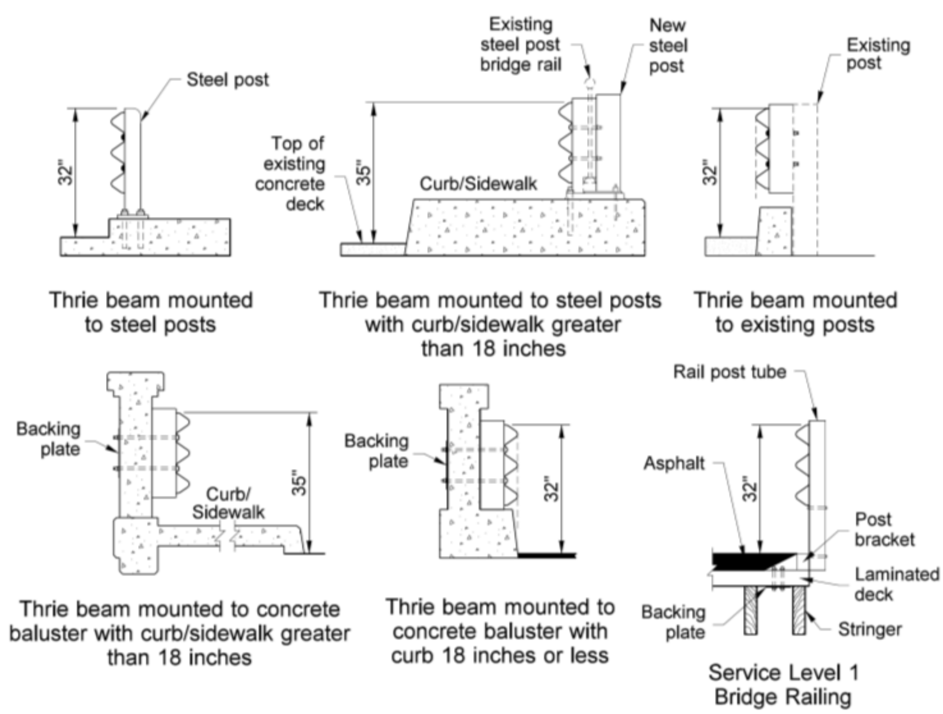
Consider the Service Level 1 (SL-1) system on bridges with wooden decks and for bridges with concrete decks that do not have the needed strength to accommodate the thrie beam system. Contact the HQ Bridge and Structures Office for information needed for the design of the SL-1 system.

If a thrie beam retrofit results in reduction in sidewalk width ensure ADA compliance is addressed, see Chapter 1510.

The funding source for retrofit of existing bridge rail is dependent on the length of the structure. Bridge rail retrofit for bridges less than 250 feet in length or a total bridge rail length of 500 feet is funded by the project (Guardrail Preservation or Improvement). For longer bridges, the retrofit will be included in the I-2 Bridge Rail upgrades program. Contact the HQ Program Development Office to determine whether funding is available.

Exhibit 1610-18 Thrie Beam Rail Retrofit Criteria

Curb Width	Bridge Width	Concrete Bridge Deck		Wood Bridge Deck or Low- Strength Concrete Deck
		Concrete Bridge Rail (existing)	**Steel or Wood Post Bridge Rail (existing)**	
<18 inches		Thrie beam mounted to existing bridge rail [2] and blocked out to the face of curb. Height = 32 inches.	Thrie beam mounted to steel posts [2] at the face of curb. Height = 32 inches	• Service Level 1 Bridge Rail. [2] • Height = 32 inches. • Curb or wheel guard needs to be removed.
>18 inches	**> 28 ft (curb to curb)**	Thrie beam mounted to steel posts[2] at the face of curb. [1] Height = 32 inches.		
>18 inches	**< 28 ft (curb to curb)**	Thrie beam mounted to existing bridge rail.[2] Height = 35 inches.	Thrie beam mounted to steel posts [2] in line with existing rail. Height = 35 inches.	



Notes:

[1] To maximize available curb/sidewalk width for pedestrian use, thrie beam may be mounted to the bridge rail at a height of 35 inches.

[2] Contact the WSDOT BSO for design details on bridge rail retrofit projects.

1610.08 Other Barriers

1610.08(1) Redirectional Landform

Redirectional landforms, also referred to as earth berms, were formerly installed to help mitigate crashes with fixed objects located in depressed medians and at roadsides. They were constructed of materials that provided support for a traversing vehicle. With slopes in the range of 2H:1V to 3H:1V, they were intended to redirect errant vehicles. The use of redirectional landforms has been discontinued. Where redirectional landforms currently exist as mitigation for a fixed object, provide alternative means of mitigation of the fixed object, such as remove, relocate, upgrade with crash-tested systems, or shield with barrier. Landforms may be used to provide a smooth surface at the base of a rock cut slope.

1610.08(2) Aesthetic Barrier Treatment

When designing a barrier for use on a Scenic Byway, consider barriers that are consistent with the recommendations in the associated corridor management plan (if one is available). Contact the region or HQ Landscape Architect Office to determine whether the project is on such a designated route. Low-cost options may be feasible, such as weathering agents, stains, colorants, or coatings applied to galvanized steel beam guardrail and its components. Higher-cost options, such as steel-backed timber rail and stone guardwalls, might necessitate a partnering effort to fund the additional costs. Grants might be available for this purpose if the need is identified early in the project definition phase.

1610.08(3) Steel-Backed Timber Guardrail

Steel-backed timber guardrails consist of a timber rail with a steel plate attached to the back to increase its tensile strength. There are several variations of this system that have passed crash tests. The nonproprietary systems use a beam with a rectangular cross section that is supported by either wood or steel posts.

A proprietary (patented) system, called the Ironwood Guardrail, is also available. This system uses a beam with a round cross section and is supported by steel posts with a wood covering to give the appearance of an all-wood system from the roadway. The incorporation of the Ironwood Guardrail will need to be documented. Consult with the Assistant State Design Engineer to determine what justification (proprietary or a public interest finding) will be required.

The most desirable method of terminating the steel-backed timber guardrail is to bury the end in a backslope, as described in 1610.04(5). When this type of terminal is not possible, use of the barrier is limited to highways with a posted speed of 45 mph or below. On these lower-speed highways, the barriers can be flared away from the traveled way as described in 1610.03(4) and terminated in a berm outside the Design Clear Zone.

For details on these systems, contact the HQ Design Office.

1610.08(4) Stone Guardwalls

Stone guardwalls function like rigid concrete barriers but have the appearance of natural stone. These walls can be constructed of stone masonry over a reinforced concrete core wall or of simulated stone concrete. These types of barriers are designed to have a limited textured projection of the stones to help aid in the redirectional characteristics of the barrier. The most desirable method of terminating this barrier is to bury the end in a backslope, as described in 1610.06(3). When this type of terminal is not possible, use of the barrier is limited to highways with a posted speed of 45 mph or below. On these lower-speed highways, the barrier can be flared away from the traveled way and terminated in a berm outside the Design Clear Zone.

For details on these systems, contact the HQ Design Office.

1610.08(5) Dragnet

The Dragnet Vehicle Arresting Barrier consists of chain link or fiber net that is attached to energy absorbing units. When a vehicle hits the system, the Dragnet brings the vehicle to a controlled stop with limited damage. Possible uses for this device include the following:

- Reversible lane entrances and exits
- Railroad crossings
- Truck escape ramps (instead of arrester beds—see Chapter 1270)
- T-intersections
- Work zones
- Swing span bridges

Coordinate with the HQ Design Office for design details.

1610.09 References

1610.09(1) Design Guidance

WSDOT Roadside Safety site: 🖰 http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

Bridge Design Manual LRFD, M 23-50, WSDOT

Roadside Design Guide, AASHTO, 2011 with Errata (July 2015)

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Traffic Manual, M 51-02, WSDOT

1610.09(2) Supporting Information

Manual for Assessing Safety Hardware (MASH), AASHTO, 2009

NCHRP 350, TRB, 1993

Determining Length of Need. This e-learning course for WSDOT employees covers the "Length of Need," which is a calculation of how much longitudinal barrier is necessary to shield objects on the roadside. Request this training via the web-based Learning Management System.

Acronyms

AADT	Annual average daily traffic
ACT	Alternatives Comparison Table
ADA	Americans with Disabilities Act of 1990
ADT	Annual daily traffic
ALJ	Administrative law judge
AOS	Apparent opening size
APS	Accessible pedestrian signal
AWDVTE	Average weekday vehicle trip ends
BAT	Business access transit
B/C	Benefit / cost
BLM	Bureau of Land Management
BOD	Basis of Design
BRT	Bus rapid transit
BST	Bituminous surface treatment
CAR	Collision Analysis Report
CE	Categorical Exemption (SEPA)
CE	Categorical Exclusion (NEPA)
CFA	Contributing Factors Analysis
CFR	Code of Federal Regulations
CIPP	Capital Improvement and Preservation Program
CLB	Current Law Budget
CMP	Corridor Management Plan
CPMS	Capital Program Management System
CRT	Controlled releasing terminal post
CSS	Context sensitive solutions
CTR	Commute Trip Reduction
CVISN	Commercial Vehicle Inf. System and Networks
DDHV	Directional design hour volume
DDP	Design Documentation Package
DHV	Design hourly volume
DNS	Determination of Nonsignificance (SEPA)
DS	Determination of Significance (SEPA)
EA	Environmental Assessment (NEPA)
E&EP	Environmental & Engineering Programs Division
EIS	Environmental Impact Statement
ERS	Environmental Review Summary
FAST	Freight Action Strategy
FGTS	Freight and Goods Transportation System
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact (NEPA)
FTA	Federal Transit Administration
GIS	Geographic Information System
GLO	General Land Office
GMA	Growth Management Act
HCM	Highway Capacity Manual
HCP	Highway Construction Program
HMA	Hot mix asphalt
HOT	High-occupancy toll
HOV	High-occupancy vehicle
HQ	WSDOT's Headquarters in Olympia
HSM	Highway Safety Manual
HSP	Highway System Plan (also SHSP)
HSS	Highways of Statewide Significance
ICA	Intersection Control Analysis
ICD	Inscribed circle diameter
IHSDM	Interactive Highway Safety Design Model
IJR	Interchange Justification Report
ITS	Intelligent transportation systems
L/A	Limited access
LOS	Level of service
MEF	Maximum extent feasible
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
MTIP	Metropolitan Transportation Improvement Program
MUTCD	Manual on Uniform Traffic Control Devices
NEPA	National Environmental Policy Act
NHS	National Highway System
PAR	Pedestrian access route
PATS	Priority Array Tracking System
PC&R	Project Control and Reporting
PCPH	Passenger cars per hour
PDMSG	Project Delivery Method Selection Guidance
PE	Preliminary engineering
PEL	Planning and Environmental Linkage
PF	Project File
PoDI	Project of Division Interest (FHWA)
PPH	Persons per hour
PS	Project Summary
PS&E	Plans, Specifications, and Estimates
RCW	Revised Code of Washington
RFP	Request for Proposal
ROD	Record of Decision
RTIP	Regional Transportation Improvement Program
RTPO	Regional Transportation Planning Organization
RV	Recreational vehicle
R/W	Right of way
SEPA	[Washington] State Environmental Policy Act
SHS	Sustainable Highway Safety
SIMMS	SIgnal Maintenance Management System
SOV	Single-occupant vehicle
SRA	Safety rest area
STIP	Statewide Transportation Improvement Program
STP	Surface Transportation Program
TIP	Transportation Improvement Program
TMA	Transportation Management Area
TMP	Transportation management plan
TRIPS	Transportation Information and Planning Support
TWLTL	Two-way left-turn lane
UPO	[Central Puget Sound] Urban Planning Office
USC	United States Code
VE	Value engineering
VECP	Value Engineering Change Proposal
VIC	Visitor Information Center
VPH	Vehicles per hour
WAC	Washington Administrative Code
WIM	Weigh in motion
WSDOT	Washington State Department of Transportation
WSPMS	Washington State Pavement Management System
WTP	Washington Transportation Plan

ADA / Pedestrian Terms

Note: This grouping of terms is used primarily in Chapters 1510 and 1515.

ADA / Pedestrian Terms	
accessible	Usable by persons with disabilities (ADA compliant).
accessible pedestrian signal (APS)	A device that communicates information about the “WALK” phase in audible and vibrotactile (vibrating surface that communicates information through touch, located on the accessible pedestrian signal button) formats.
accessible route	See *pedestrian access route*.
ADA	An abbreviation for the Americans with Disabilities Act of 1990. The ADA is a civil rights law that identifies and prohibits discrimination based on disability. Title II of the ADA requires public entities to design new pedestrian facilities or alter existing pedestrian facilities to be accessible to and usable by people with disabilities.
alternate pedestrian access route	A temporary accessible route to be used when the existing pedestrian access route is blocked by construction, alteration, maintenance, or other temporary condition(s).
alteration	A change to a facility in the public right of way that affects or could affect access, circulation, or use. Alterations include, but are not limited to: renovation; rehabilitation; reconstruction; historic restoration; resurfacing of circulation paths or vehicular ways; or changes or rearrangement of structural parts or elements of a facility. Alterations *do not* include: Spot pavement repair; liquid-asphalt sealing, chip seal (bituminous surface treatment), or crack sealing; or lane restriping that does not alter the usability of the shoulder.
buffer	A space measured from the back of the curb to the edge of the sidewalk that could be treated with plantings or alternate pavement, or be used for needs such as drainage treatment or utility placement.
clear width	The unobstructed width within a pedestrian circulation path. The clear width within a pedestrian circulation path must meet the accessibility criteria for a pedestrian access route.
construction impact zone	The area in which an alteration to an existing facility takes place (also known as the project footprint). If a crosswalk (marked or unmarked) will be reconstructed, paved (overlay or inlay), or otherwise altered as part of a project, then the curb ramps that serve that crosswalk are within the construction impact zone.
counter slope	The slope of the gutter or roadway at the foot of a curb ramp or landing where it connects to the roadway, measured along the axis of the running slope extended.
cross slope	The slope measured perpendicular to the direction of travel.

ADA / Pedestrian Terms	
crosswalk	A marked or unmarked pedestrian crossing, typically at an intersection, that connects the pedestrian access routes on opposite sides of a roadway. A crosswalk must meet accessibility criteria. A crosswalk is also defined as: • "…the portion of the roadway between the intersection area and a prolongation or connection of the farthest sidewalk line or in the event there are no sidewalks then between the intersection area and a line ten feet therefrom, except as modified by a marked crosswalk" (RCW 46.04.160). • "(a) That part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs or in the absence of curbs, from the edges of the traversable roadway, and in the absence of a sidewalk on one side of the roadway, the part of the roadway included within the extension of the lateral lines of the sidewalk at right angles to the center line; (b) any portion of a roadway at an intersection or elsewhere distinctly indicated as a pedestrian crossing by lines on the surface, which might be supplemented by contrasting pavement texture, style, or color" (MUTCD, 2003*; Guide for the Planning, Design, and Operation of Pedestrian Facilities*, AASHTO, 2004).
curb extension	A curb and sidewalk bulge or extension out into the parking lane used to decrease the length of a pedestrian crossing and increase visibility for the pedestrian and driver.
curb ramp	A combined ramp and landing to accomplish a change in level at a curb. This element provides street and sidewalk access to pedestrians with mobility impairments. • **parallel curb ramp** A curb ramp design where the sidewalk slopes down to a landing at road level with the running slope of the ramp in line with the direction of sidewalk travel • **perpendicular curb ramp** A curb ramp design where the ramp path is perpendicular to the curb and meets the gutter grade break at a right angle.
detectable warning surface	A tactile surface feature of truncated dome material built into or applied to the walking surface to alert persons with visual impairments of vehicular ways. Federal yellow is the color used on WSDOT projects to achieve visual contrast. Colors other than federal yellow that meet the light-on-dark/dark-on-light requirement may be used on projects where cities have jurisdiction. (Detectable warning surfaces are detailed in the *Standard Plans*.)
flangeway gap	The gap for the train wheel at a railroad crossing. The space between the inner edge of a rail and the pedestrian crossing surface.
grade break	The intersection of two adjacent surface planes of different grade.
landing	A level paved area, within or at the top and bottom of a stair or ramp, designed to provide turning and maneuvering space for wheelchair users and as a resting place for pedestrians.
maximum extent feasible (MEF)	From the U.S. Department of Justice, 28 CFR Part 36.402, Alterations. The phrase "to the maximum extent feasible" applies to "the occasional case where the nature of an existing facility makes it virtually impossible to comply fully with applicable accessibility standards through a planned alteration." This phrase also refers to a stand-alone piece of design documentation that WSDOT uses to record its reasons for not being able to achieve full ADA compliance in alteration projects (called a Maximum Extent Feasible document).
midblock pedestrian crossing	A marked pedestrian crossing located between intersections.

ADA / Pedestrian Terms	
passenger loading zone	An area provided for pedestrians to board/disembark a vehicle.
pedestrian	Any person afoot or using a wheelchair (manual or motorized) or means of conveyance (other than a bicycle) propelled by human power, such as skates or a skateboard.
pedestrian access route (PAR) (synonymous with *accessible route*)	A continuous, unobstructed walkway within a pedestrian circulation path that provides accessibility. Pedestrian access routes consist of one or more of the following pedestrian facilities: walkways/sidewalks, curb ramps (excluding flares), landings, crosswalks, pedestrian overpasses/underpasses, access ramps, elevators, and platform lifts. Note: Not all transportation facilities need to accommodate pedestrians. However, those that do accommodate pedestrians need to have an accessible route.
pedestrian circulation path	A prepared exterior or interior way of passage provided for pedestrian travel. Includes independent walkways, shared-use paths, sidewalks, and other types of pedestrian facilities. All pedestrian circulation paths are required to contain a continuous pedestrian access route that connects to all adjacent pedestrian facilities, elements, and spaces that are required to be accessible.
pedestrian facilities	Walkways such as sidewalks, walking and hiking trails, shared-use paths, pedestrian grade separations, crosswalks, and other improvements provided for the benefit of pedestrian travel. Pedestrian facilities are intended to be accessible routes.
pedestrian overpass or underpass	A grade-separated pedestrian facility, typically a bridge or tunnel structure over or under a major highway or railroad that allows pedestrians to cross.
pedestrian refuge island	An island in the roadway that physically separates the directional flow of traffic, provides pedestrians with a place of refuge, and reduces the crossing distance. Note: Islands with cut-through paths are more accessible to persons with disabilities than are raised islands with curb ramps.
pedestrian signal	An adaptation of a conventional traffic signal installed at established pedestrian crossings. It is used to provide a protected phase for pedestrians by terminating the conflicting vehicular movements to allow for pedestrian crossings.
person with disability	An individual who has an impairment, including a mobility, sensory, or cognitive impairment, that results in a functional limitation in access to and use of a building or facility.
raised median	A raised island in the center of a road used to restrict vehicle left turns and side street access. Note: Islands with cut-through paths are more accessible to persons with disabilities than are raised islands with curb ramps.
ramp	A walking surface with a running slope steeper than 20H:1V (5%).
running slope	A slope measured in the direction of travel, normally expressed as a percent.
sidewalk	A walkway along a highway, road, or street intended for use by pedestrians.
site	A parcel of land bounded by a property line or a designated portion of a public right of way.
street furniture	Sidewalk equipment or furnishings, including garbage cans, benches, parking meters, and telephone booths.
traffic calming	Design techniques that have been shown to reduce traffic speeds and unsafe maneuvers. These techniques can be stand-alone or used in combination, and they include lane narrowing, curb extensions, surface variations, and visual clues in the vertical plane.

ADA / Pedestrian Terms	
transitional segments	Segments of a pedestrian circulation path that blend between existing undisturbed pedestrian facilities and newly altered pedestrian facilities. Use of transitional segments may permit the work of the alteration to more nearly meet the new construction standards. At a later time, when other segments of the pedestrian circulation path are altered, the noncomplying transitional segments can be removed and replaced with pedestrian facilities that meet the accessibility criteria.
universal access	Access for all persons regardless of ability or stature.
walk interval	That phase of a traffic signal cycle during which the pedestrian is to begin crossing, typically indicated by a WALK message or the walking person symbol and its audible equivalent.
walkway	The continuous portion of the pedestrian access route that is connected to street crossings by curb ramps.

Main Glossary of Terms

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	Y	Z

A

access A means of entering or leaving a public road, street, or highway with respect to abutting property or another public road, street, or highway.

access break Any point from inside or outside the state limited access right of way limited access hachures that crosses over, under, or physically through the plane of the limited access, is an access break or "break in access," including, but not limited to, locked gates and temporary construction access breaks.

access connection An access point, other than a public road/street, that permits access to or from a managed access highway on the state highway system.

access connection permit A written authorization issued by the permitting authority for a specifically designed access connection to a managed access highway at a specific location; for a specific type and intensity of property use; and for a specific volume of traffic for the access connection based on the final stage of the development of the applicant's property. The actual form used for this authorization is determined by the permitting authority.

access control The limiting and regulating of public and private access to Washington State's highways, as required by state law. A *design control* (see Chapter 1103) – there are two categories of controlling access to state highways *limited access* and *managed access.*

Access Control Tracking System Limited Access and Managed Access Master Plan A database list, related to highway route numbers and mileposts, that identifies either the level of limited access or the class of managed access: www.wsdot.wa.gov/design/accessandhearings

access density the number of access points (driveways) per mile.

access design analysis A design analysis (see Chapter 300) that authorizes deferring or staging acquisition of limited access control, falling short of a 300-foot requirement, or allowing an existing access point to stay within 130 feet of an intersection on a limited access highway. Approval by the Director & State Design Engineer, Development Division, or designee, is required (see Chapter 530).

access hearing plan A limited access plan prepared for presentation at an access hearing.

access management The programmatic control of the location, spacing, design, and operation of driveways, median openings, interchanges, and street connections to a roadway.

access point Any point that allows private or public entrance to or exit from the traveled way of a state highway, including "locked gate" access and maintenance access points.

access point revision A new access point or a revision of an existing interchange/ intersection configuration. Locked gates and temporary construction breaks are also access point revisions.

access point spacing On a managed access highway, the distance between two adjacent access points on one side of the highway, measured along the edge of the traveled way from one access point to the next (see also corner clearance).

access report plan A limited access plan prepared for presentation to local governmental officials at preliminary meetings before preparation of the access hearing plan.

access rights Property rights that allow an abutting property owner to enter and leave the public roadway system.

adaptive lighting system A lighting system with a control system connected, allowing for dimming, on/off operation by time of night, and independent scheduling of individual lights for select hours of operation during nighttime hours.

affidavit of publication A notarized written declaration stating that a notice of hearing (or notice of opportunity for a hearing) was published in the legally prescribed manner.

affidavit of service by mailing A notarized written declaration stating that the limited access hearing packet was mailed at least 15 days prior to the hearing and entered into the record at the hearing.

alternative(s) Possible solutions to accomplish a defined purpose and need. These include local and state transportation system mode and design options, locations, and travel demand management and transportation system management-type improvements such as ramp metering, mass transit, and high-occupancy vehicle (HOV) facilities.

Alternatives Comparison Table (ACT) A table that documents and presents the tradeoffs among those performance metrics identified for each alternative under consideration on a project. The ACT is used to assist in analyzing the baseline and contextual performance tradeoffs and ultimately to select an alternative. It is a supplemental document to the "Alternatives Analysis" section of the *Basis of Design*.

ancillary services Those secondary services, also considered amenities, provided at safety rest areas that include, but are not limited to, vending machines, picnic areas, interpretive signing, telephones, recreational vehicle (RV) sanitary disposal facilities, trails, scenic viewpoints, commercial and public information displays, and visitor information centers.

annual average daily traffic (AADT) The total volume of traffic passing a point or segment of a highway facility in both directions for one year divided by the number of days in the year.

annual daily traffic (ADT) The volume of traffic passing a point or segment of a highway, in both directions, during a period of time, divided by the number of days in the period, and factored to represent an estimate of traffic volume for an average day of the year.

application for an access connection An application provided by the permitting authority to be completed by the applicant for access to a managed access highway.

approach An access point, other than a public road/street, that allows access to or from a limited access highway on the state highway system.

approach and access connection These terms are listed under the specific access section to which they apply. The first section below is for limited access highways and uses the term approach. The second section below is for managed access highways and uses the term access connection. Approaches and access connections include any ability to leave or enter a highway right of way other than at an intersection with another road or street.

(a) ***limited access highways: approach*** An access point, other than a public road/street, that allows access to or from a limited access highway on the state highway system. There are five types of approaches to limited access highways that are allowed:

- ***Type A*** An off and on approach in a legal manner, not to exceed 30 feet in width, for the sole purpose of serving a single-family residence. It may be reserved by the abutting owner for specified use at a point satisfactory to the state at or between designated highway stations. This approach type is allowed on partial and modified control limited access highways.
- ***Type B*** An off and on approach in a legal manner, not to exceed 50 feet in width, for use necessary to the normal operation of a farm, but not for retail marketing. It may be reserved by the abutting owner for specified use at a point satisfactory to the state at or between designated highway stations. This approach type is allowed on partial and modified control limited access highways. This approach type may be used for wind farms when use of the approach is limited to those vehicles necessary to construct and maintain the farm for use in harvesting wind energy.
- ***Type C*** An off and on approach in a legal manner, for a special purpose and width to be agreed upon. It may be specified at a point satisfactory to the state at or between designated highway stations. This approach type is allowed on partial and modified control limited access highways and on full control limited access highways where no other reasonable means of access exists, as solely determined by the department.
- ***Type D*** An off and on approach in a legal manner, not to exceed 50 feet in width, for use necessary to the normal operation of a commercial establishment. It may be specified at a point satisfactory to the state at or between designated highway stations. This approach type is allowed only on modified control limited access highways.
- ***Type E*** This type is no longer allowed to be constructed because of the requirements that there be only one access point per parcel on a limited access state highway.
- ***Type F*** An off and on approach in a legal manner, not to exceed 30 feet in width, for the sole purpose of serving a wireless communication site. It may be specified at a point satisfactory to the state at or between designated highway stations. This approach type is allowed only on partial control limited access highways. (See WAC 468 58 080(vi) for further restrictions.)

(b) ***managed access highways: access connection*** An access point, other than a public road/street, that permits access to or from a managed access highway on the state highway system. There are five types of access connection permits:

- ***conforming access connection*** A connection to a managed access highway that meets current WAC and WSDOT location, spacing, and design criteria.

- ***grandfathered access connection*** Any connection to the state highway system that was in existence and in active use on July 1, 1990, and has not had a significant change in use.
- ***joint-use access connection*** A single connection to a managed access highway that serves two or more properties.
- ***nonconforming access connection*** A connection to a managed access highway that does not meet current WSDOT location, spacing, or design criteria, pending availability of a future conforming access connection.
- ***variance access connection*** A connection to a managed access highway at a location not normally allowed by current WSDOT criteria.

(c) ***managed access connection category*** There are four access connection permit categories for managed access connections to state highways: Category I, Category II, Category III, and Category IV (see Chapter 540).

approach design speed The design speed of the roadway leading into the roundabout.

approach lanes The lane or set of lanes for traffic approaching the roundabout (see Chapter 1320).

area of influence The area that will be directly impacted by the proposed action: freeway main line, ramps, crossroads, immediate off-system intersections, and state and local roadway systems.

articulated bus A two-section bus that is permanently connected at a joint.

auxiliary aids and services (1) Qualified interpreters, notetakers, transcription services, written materials, telephone handset amplifiers, assistive listening devices, assistive listening systems, telephones compatible with hearing aids, open and closed captioning, telecommunications devices for deaf persons (TDDs), videotext displays, or other effective methods for making aurally delivered materials available to individuals with hearing limitations; (2) Qualified readers, taped texts, audio recordings, Brailled materials, large print materials, or other effective methods for making visually delivered materials available to individuals with visual impairments; (3) Acquisition or modification of equipment or devices; (4) Other similar services and actions; and (5) Providing and disseminating information, written materials, and notices in languages other than English, where appropriate.

auxiliary lane The portion of the roadway adjoining the through lanes for parking, speed change, turning, storage for turning, weaving, truck climbing, and other purposes supplementary to through-traffic movement.

average daily traffic (ADT) The total volume during a given time period (in whole days): greater than one day and less than one year, divided by the number of days in that time period.

average light level The average of all light intensities within the design area.

average weekday vehicle trip ends (AWDVTE) The estimated total of all trips entering plus all trips leaving a road approach on a weekday for the final stage of development of the property served by the road approach.

B

backslope A sideslope that goes up as the distance increases from the roadway (cut slopes).

barrier terminal A crash-tested end treatment for longitudinal barriers that is designed to reduce the potential for spearing, vaulting, rolling, or excessive deceleration of impacting vehicles from either direction of travel. Barrier terminals include applicable anchorage.

baseline The approved time phased plan (for a project, a work breakdown structure component, a work package, or a schedule activity), plus or minus approved project scope, cost, schedule, and technical changes. Generally refers to the current baseline, but may refer to the original or some other baseline. Usually used with a modifier (e.g., cost baseline, schedule baseline, performance measurement baseline, technical baseline).

baseline performance metric A description of need in terms that can be measured or assessed in both the existing and proposed (future) state.

baseline performance need The primary reason a project has been proposed. It refers to the threshold determination at the project location resulting from a statewide biennial prioritization and funding process. It may also be the specific issue to be addressed by the project described by a partnering agency that is providing the funding.

basic number of lanes The minimum number of general purpose lanes designated and maintained over a significant length of highway.

Basis of Design (BOD) A document and template used to record information, decisions, and analysis needed in the development of a project design, including all factors leading to the development and selection of a project alternative, and the selection of design elements associated with that alternative.

benefit/cost analysis A method of valuing a proposition by first monetizing all current expenditures to execute—cost—as well as the expected yields into the future—benefit, then dividing the total benefit by the total cost, thus providing a ratio. Alternatives may be rendered and compared in this fashion where, typically, a higher ratio is preferable, indicating a better return on investment.

bicycle Any device propelled solely by human power upon which a person or persons may ride, having two tandem wheels, either of which is 16 inches or more in diameter, or three wheels, any one of which is more than 20 inches in diameter.

bicycle route A system of facilities that is used or has a high potential for use by bicyclists or that is designated as such by the jurisdiction having the authority. A series of bicycle facilities may be combined to establish a continuous route and may consist of any or all types of bicycle facilities.

bike lane A portion of a highway or street identified by signs and pavement markings as reserved for bicycle use.

break See access break.

buffer-separated HOV lane An HOV lane that is separated from the adjacent same direction general-purpose freeway lanes by a designated buffer.

bus A rubber-tired motor vehicle used for transportation, designed to carry more than ten passengers.

business access transit (BAT) lanes A transit lane that allows use by other vehicles to access abutting businesses.

bus pullout A bus stop with parking area designed to allow transit vehicles to stop wholly off the roadway.

bus rapid transit (BRT) An express rubber tired transit system operating predominantly in roadway managed lanes. It is generally characterized by separate roadway or buffer-separated HOV lanes, HOV direct access ramps, and a high-occupancy designation (3+ or higher).

bus shelter A facility that provides seating and protection from the weather for passengers waiting for a bus.

bus stop A place designated for transit vehicles to stop and load or unload passengers.

C

capacity The maximum sustainable flow rate at which vehicles or persons can reasonably be expected to traverse a point or uniform segment of a lane or roadway during a specified time period under given roadway, geometric, traffic, environmental, and control conditions. Capacity is usually expressed as vehicles per hour (vph), passenger cars per hour (pcph), or persons per hour (pph).

Capital Improvement and Preservation Program (CIPP) WSDOT's program of projects developed each biennium that delivers capital investments in highway, marine, and rail facilities that have been funded in part or in whole by the state Legislature. The CIPP is submitted to the Governor and, ultimately, by the Governor to the Legislature.

Capital Program Management System (CPMS) A computer database used to develop and manage the highway and marine construction programs. The CPMS allows users to establish and maintain project data and is used to manage and deliver statewide construction programs.

capture trips Trips that do not enter or leave the traveled ways of a project's boundary within a mixed-use development.

carpool/vanpool A group of people who share the use and cost of a car or van for transportation on a regular basis.

Categorical Exclusion (CE) (NEPA) or ***Categorical Exemption (CE)*** (SEPA) Actions that do not individually or cumulatively have a significant effect on the environment.

central island The area of the roundabout, including the truck apron, surrounded by the circulating roadway.

central island diameter The diameter of the central island, including the truck apron (see Chapter 1320).

circulating lane A lane used by vehicles circulating in the roundabout.

circulating roadway The traveled lane(s) adjacent to the central island and outside the truck apron, including the entire 360° circumference of the circle.

circulating roadway width The total width of the circulating lane(s) measured from inscribed circle to the central island (see Chapter 1320).

clear run-out area The area beyond the toe of a nonrecoverable slope available for use by an errant vehicle.

clear zone The total roadside border area, available for use by errant vehicles, starting at the edge of the traveled way and oriented from the outside or inside shoulder (in median applications) as applicable. This area may consist of a shoulder, a recoverable slope, a nonrecoverable slope, and/or a clear run-out area. The clear zone cannot contain a critical fill slope, fixed objects, or water deeper than 2 feet.

Climate Change Vulnerability The risk a transportation facility will be impacted by the effects of climate change.

climbing lane An auxiliary lane used for the diversion of slow traffic from the through lane.

collector A context description of a roadway intended to provide a mix of access and mobility performance. Typically low speed, collecting traffic from local roads and connecting them with destination points or arterials. This term is used in multiple classification systems, but is most commonly associated with the *Functional Classification* System.

collector-distributor road (C-D road) A parallel roadway designed to remove weaving from the main line and reduce the number of main line entrances and exits.

collector system Routes that primarily serve the more important intercounty, intracounty, and intraurban travel corridors; collect traffic from the system of local access roads and convey it to the arterial system; and on which, regardless of traffic volume, the predominant travel distances are shorter than on arterial routes (RCW 47.05.021).

Commercial Vehicle Information Systems and Networks (CVISN) A network that links intelligent transportation systems (ITS) to share information on commercial vehicles. When in operation at a weigh site, it can enable commercial vehicles to clear the facility without stopping.

complex ramp alignment and grade The exit advisory speed is 35 mph or lower than the posted main line speed, or there is a 6% or greater change in grade from existing main line grade to the ramp grade.

conflict An event involving two or more road users in which the action of one user causes the other user to make an evasive maneuver to avoid a crash.

conflict point A point where traffic paths cross, merge, or diverge.

connection See *approach and access connection*.

consider To think carefully about, especially in order to make a decision. The decision to document a consideration is left to the discretion of the engineer.

context refers to the environmental, economic, and social features that influence livability and travel characteristics. Context characteristics provide insight into the activities, functions, and performance that can be influenced by the roadway design. Context also informs roadway design, including the selection of design controls, such as target speed and modal priority, and other design decisions. See Chapter 1102.

context categories The naming convention used to describe either a land use or transportation context (see Chapter 1102).

context characteristic A distinguishing trait within a context, either land use or transportation. Chapter 1102 lists several common characteristics that help distinguish between one type of context versus another. There may be additional traits not covered in the chapter.

contextual performance metric A restatement of a contextual performance need in terms that can be measured or assessed in both the existing and proposed (future) state.

contextual performance need A statement of nee that applies to a project location which has not been identified as a baseline need.

context sensitive solutions (CSS) A collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic, and environmental resources while maintaining safety and mobility. CSS is an approach that considers the total context within which a transportation improvement project will exist.

contiguous parcels Two or more pieces of real property, under the same ownership, with one or more boundaries that touch and have similarity of use.

continuous load The electrical load on a circuit that lasts for a duration of three or more hours on any day.

contributing factors Those operational conditions, human factors, context conditions, design elements, design controls, or actions identified by data, engineering judgment, or the community that contribute to a performance need under evaluation.

controlled releasing terminal (CRT) post A standard-length guardrail post that has two holes drilled through it so it might break away when struck.

conventional traffic signal A permanent or temporary installation providing alternating right of way assignments for conflicting traffic movements. At least two identical displays are required for the predominant movement on each approach.

corner clearance On a managed access highway, the distance from an intersection of a public road or street to the nearest access connection along the same side of the highway. The minimum corner clearance distance (see Chapter 540) is measured from the closest edge of the intersecting road or street to the closest edge of the traveled way of the access connection, measured along one side of the traveled way (through lanes) (see also *access point spacing*).

corridor sketch an information source that describes the attributes of a state highway corridor, its current and future function, as well as its performance expectations. It will ultimately identify cost-effective strategies for future consideration. A completed corridor sketch may have information that is valuable at the project level in determining contextual performance needs, and project alternatives. A corridor sketch is not a substitute for detailed planning and analysis, nor is it a list of investments or projects.

corridor vision The future transportation context from a regional perspective. Practical Design considers and accounts for the contextual needs of the longer section of highway in the development and evaluation of alternatives to ensure a favorable outcome for the greater system.

countermeasure an action taken to counteract an existing or anticipated condition.

court reporter A person with a license to write and issue official accounts of judicial or legislative proceedings.

crash-accepted device A feature that has been proven acceptable for use under specified conditions, either through crash testing or in-service performance.

Crash Analysis Report (CAR) A template that is the basis for all crash analyses for all types of design documentation that need crash analyses, as described in Chapter 321.

critical fill slope A slope on which a vehicle is likely to overturn. Slopes steeper than 3H:1V are considered critical fill slopes.

crossroad The minor roadway at an intersection. At a stop-controlled intersection, the crossroad has the stop.

curb section A roadway cross section with curb and sidewalk.

D

decision sight distance The distance needed for a driver to detect an unexpected or difficult-to-perceive condition, recognize the condition, select an appropriate maneuver, and complete the maneuver based on design conditions and design speed.

deflection (in respect to roundabouts) The change in the path of a vehicle imposed by the geometric features of a roundabout resulting in a slowing of vehicles.

delineation Any method of defining the roadway operating area for the driver.

deliverable Any unique and verifiable product, result or capability to perform a service that must be produced to complete a process, phase, or project.

departure lanes The lane or set of lanes for traffic leaving the roundabout (see Chapter 1320).

Design Analysis a process and tool to record design element changes where the dimensions chosen do not meet the value, or lie within the range of values, provided for that element in the *Design Manual*. (see Chapters 300 and 1106).

Design Approval Documented approval of the design at this early milestone locks in design policy for three years. Design approval becomes part of the Design Documentation Package (see Chapter 300.)

design-bid-build The project delivery method where design and construction are sequential steps in the project development process (23 CFR 636.103).

design-build contract An agreement that provides for design and construction of improvements by a consultant/contractor team. The term encompasses design-build-maintain, design-build-operate, design-build-finance, and other contracts that include services in addition to design and construction. Franchise and concession agreements are included in the term if they provide for the franchisee or concessionaire to develop the project that is the subject of the agreement (23 CFR 636.103).

design-builder The firm, partnership, joint venture, or organization that contracts with WSDOT to perform the work.

design controls key parameters that critically shape design decisions and effect calculated dimensions for some design elements. Design controls are conscientiously selected and work together with the context characteristics to achieve a particular outcome (see Chapter 1103)

Design Clear Zone The minimum clear zone target value used in highway design.

Design Documentation Package (DDP) See *Project File*.

design element Any component or feature associated with roadway design that becomes part of the final product. Examples include lane width, shoulder width, alignment, and clear zone (see Chapter 1105.)

designer This term applies to WSDOT design personnel. Wherever "designer" appears in this manual, design-build personnel shall deem it to mean: Engineer of Record, Design Quality Assurance Manager, design-builder, or any other term used in the design-build contract to indicate design-build personnel responsible for the design elements of a design-build project, depending on the context of information being conveyed.

design hourly volume (DHV) Computed by taking the annual average daily traffic times the K-factor. It can only be accurately determined in locations where there is a permanent traffic recording device active 365 days of the year. It correlates to the peak hour (see *peak hour*), but it is not equivalent. In some circumstances, it is necessary to use the peak hour data instead of DHV because peak hour can be collected using portable traffic recorders.

design speed A design control; the speed used to determine the various geometric design features of the roadway.

design up An approach to developing project alternatives utilizing the smallest dimensions that meet the need by providing the desired performance.

design users A broad term intended to capture all modal users that currently utilize or are legally permitted on a roadway segment or node.

design variance Same as Design Analysis.

design vehicle See *intersection design vehicle*.

design year The forecast year used for design as described in Chapter 1103. See also *horizon year*.

desirable Design criteria that are recommended for inclusion in the design.

Determination of Nonsignificance (DNS) (SEPA) The written decision by the Regional Administrator that a proposal will not have a significant impact and no EIS is required.

Determination of Significance (DS) (SEPA) A written decision by the Regional Administrator that a proposal could have a significant adverse impact and an EIS is required.

directional design hour volume (DDHV) The traffic volume for the design hour in the peak direction of flow, in vehicles per hour. For example, if during the design hour, 60% of the vehicles traveled eastbound and 40% traveled westbound, then the DDHV for the eastbound direction would be the DHV x 0.60.

divided multilane A roadway with two or more through lanes in each direction and a median that physically or legally prohibits left turns, except at designated locations.

document (verb) The act of including a short note to the Design Documentation Package that explains a design decision.

dooring Describes a conflict with a parked vehicle door opening into a roadway bike facility.

double-lane roundabout A roundabout with a two-lane circulating roadway and one or more entry or exit legs with two lanes.

driveway A vehicular access point that provides access to or from a public roadway.

drop and ride An area of a park & ride lot or other multimodal facility where patrons are dropped off or picked up by private auto or taxi.

E

easement A documented right, as a right of way, to use the property of another for designated purposes.

element An architectural or mechanical component or design feature of a space, site, or public right of way.

emergency escape ramp A roadway leaving the main roadway designed for the purpose of slowing and stopping out-of-control vehicles away from the main traffic stream.

emergency vehicle signal A special adaptation of a conventional traffic signal installed to allow for the safe movement of authorized emergency vehicles. Usually, this type of signal is installed on the highway at the entrance into a fire station or other emergency facility. The signal ensures protected entrance onto the highway for the emergency vehicle. When not providing for this movement, the signal either operates continuously (consistent with the requirements for a conventional traffic signal) or displays continuous green, which is allowed at non-intersection locations only. At least two identical displays are required per approach.

enforcement observation point A place where a law enforcement officer may park and observe traffic.

entry angle The angle between the entry roadway and the circulating roadway measured at the yield point (see Chapter 1320).

entry curve The curve of the left edge of the roadway that leads into the circulating roadway (see Chapter 1320).

entry width The width of an entrance leg at the inscribed circle measured perpendicular to travel (see Chapter 1320).

Environmental Assessment (EA) (NEPA) A document prepared for federally funded, permitted, or licensed projects that are not categorical exclusions (CE), but do not appear to be of sufficient magnitude to require an EIS. The EA provides enough analysis to determine whether an EIS or a FONSI should be prepared.

Environmental Impact Statement (EIS) A detailed written statement of a proposed course of action, project alternatives, and possible impacts of the proposal.

Environmental Review Summary (ERS) (see *Project Summary*) Part of the Project Summary document, the ERS identifies environmental permits and approvals. It is prepared in the region and is required for Design Approval.

exit curve The curve of the left edge of the roadway that leads out of the circulating roadway (see Chapter 1320).

exit width The width of an exit leg at the inscribed circle (see Chapter 1320).

expressway A divided highway that has a minimum of two lanes in each direction for the exclusive use of traffic and that may or may not have grade separations at intersections. A transportation context characteristic that is designated for a divided highway with limited access that provides regional mobility.

extrude A procedure for applying marking material to a surface by forcing the material through a die to give it a certain shape.

F

facility All or any portion of buildings, structures, improvements, elements, and pedestrian or vehicular routes located in a public right of way.

feature A component of a pedestrian access route, such as a curb ramp, driveway, crosswalk, or sidewalk.

Federal Highway Administration (FHWA) The division of the U.S. Department of Transportation with jurisdiction over the use of federal transportation funds for state highway and local road and street improvements.

Federal Transit Administration (FTA) The division of the U.S. Department of Transportation with jurisdiction over the use of federal funds for financial assistance to develop new transit systems and improve, maintain, and operate existing systems.

feeder service Bus service that provides connections with other bus or rail services.

final design Any design activities following preliminary design; expressly includes the preparation of final construction plans and detailed specifications for the performance of construction work (23 CFR 636.103). Final design is also defined by the fact that it occurs after NEPA/SEPA approval has been obtained.

Finding of No Significant Impact (FONSI) (NEPA) A federal document indicating that a proposal will not significantly affect the environment and an EIS is not required.

findings and order A document containing the findings and conclusions of a limited access hearing approved by the Assistant Secretary, Engineering & Regional Operations (see Chapter 210).

findings and order plan A limited access plan, prepared after a limited access hearing, which is based on the hearing record.

fixed feature (object to be mitigated) A fixed object, a side slope, or water that, when struck, can result in impact forces on a vehicle's occupants that may result in injury or place the occupants in a situation that has a high likelihood of injury. A fixed feature can be either constructed or natural.

flare The widening of the approach to the roundabout to increase capacity and facilitate natural vehicle paths.

flasher warning assembly Flashing beacons that are used only to supplement an appropriate warning or regulatory sign or marker. The displays consist of two alternating flashing yellow indications.

flyer stop A transit stop inside the limited access boundaries.

footcandle (fc) The illumination of a surface one square foot in area on which a flux of one lumen is uniformly distributed. One footcandle equals one lumen per square foot.

foreslope A sideslope that goes down as the distance increases from the roadway (fill slopes and ditch inslopes).

freight corridor type Designations for a highway facility found in the Freight and Goods Transportation System (FGTS).

freeway A divided highway that has a minimum of two lanes in each direction for the exclusive use of traffic and with full control of access.

frontage road An auxiliary road that is a local road or street located beside a highway for service to abutting property and adjacent areas and for control of access.

functional classification The grouping of streets and highways according to the character of the service they are intended to provide.

G

geocomposites Prefabricated edge drains, wall drains, and sheet drains that typically consist of a cuspated or dimpled polyethylene drainage core wrapped in a geotextile. The geotextile wrap keeps the core clean so that water can freely flow through the drainage core, which acts as a conduit. Prefabricated edge drains are used in place of shallow geotextile-wrapped trench drains at the edges of the roadway to provide subgrade and base drainage. Wall drains and sheet drains are typically placed between the back of the wall and the soil to drain the soil retained by the wall.

Geographic Information System (GIS) A computerized geographic information system used to store, analyze, and map data. Data may be used with GIS if the data includes the Accumulated Route Mile (ARM) or State Route Milepost (SRMP) programs. Global Positioning System (GPS) technology provides a means of collecting data and is an alternative to ARM and SRMP. WSDOT's primary desktop tool to view and analyze GIS data is ArcGIS software. GIS is used to gather and analyze data to support the purpose and need as described in the Project Summary (http://wwwi.wsdot.wa.gov/gis/supportteam/default.asp).

geogrids A polymer grid mat constructed either of coated yarns or a punched and stretched polymer sheet. Geogrids usually have high strength and stiffness and are used primarily for soil reinforcement.

geomembranes Impervious polymer sheets that are typically used to line ponds or landfills. In some cases, geomembranes are placed over moisture-sensitive swelling clays to control moisture.

geonets Similar to geogrids, but typically lighter weight and weaker, with smaller mesh openings. Geonets are used in light reinforcement applications or are combined with drainage geotextiles to form a drainage structure.

geosynthetic erosion control The minimizing of surficial soil particle movement due to the flow of water over the surface of bare soil or due to the disturbance of soil caused by construction activities under or near bodies of water. This is the primary function of geotextiles used as silt fences or placed beneath riprap or other stones on soil slopes. Silt fences keep eroded soil particles on the construction site, whereas geotextiles placed beneath riprap or other stones on soil slopes prevent erosion from taking place at all. In general, the permanent erosion control methods described in Chapter 630 are only used where more natural means (like the use of biodegradable vegetation mats to establish vegetation to prevent erosion) are not feasible. These functions control some of the geosynthetic properties, such as apparent opening size (AOS) and permittivity, and in some cases load-strain characteristics. The application will also affect the geosynthetic installation conditions. These installation conditions influence the remaining geosynthetic properties needed, based on the survivability level required.

geosynthetic filtration The passage of water through the geosynthetic relatively unimpeded (permeability or permittivity) without allowing passage of soil through the geosynthetic (retention). This is the primary function of geotextiles in underground drainage applications.

geosynthetic survivability The ability of the geosynthetic to resist installation conditions without significant damage, such that the geosynthetic can function as intended. Survivability affects the strength properties of the geosynthetic required.

geotextiles (nonwoven) A sheet of continuous or staple fibers entangled randomly into a felt for needle-punched nonwovens and pressed and melted together at the fiber contact points for heat-bonded nonwovens. Nonwoven geotextiles tend to have low-to-medium strength and stiffness with high elongation at failure and relatively good drainage characteristics. The high elongation characteristic gives them superior ability to deform around stones and sticks.

geotextiles (woven) Slit polymer tapes, monofilament fibers, fibrillated yarns, or multifilament yarns simply woven into a mat. Woven geotextiles generally have relatively high strength and stiffness and, except for the monofilament wovens, relatively poor drainage characteristics.

gore The area downstream from the intersection of the shoulders of the main line and exit ramp. Although generally referring to the area between a main line and an exit ramp, the term may also be used to refer to the area between a main line and an entrance ramp.

gore nose At an exit ramp, the point at the end of the gore area where the paved shoulders of the main line and the ramp separate (see Chapter 1360) or the beginning of traffic barrier, not including any impact attenuator. Also, the similar point at an entrance ramp.

H

hearing An assembly to which the public is invited and at which participation is encouraged. Types of hearings include:

- ***administrative appeal hearing*** A formal process whereby a property owner may appeal WSDOT's implementation of access management legislation. The appeal is heard by an administrative law judge (ALJ), who renders a decision. (See Chapter 540 for administrative appeal hearing procedures.)
- ***combined hearing*** A hearing held when there are public benefits to be gained by combining environmental, corridor, design, and/or limited access subjects.
- ***corridor hearing*** A formal or informal hearing that presents the corridor alternatives to the public for review and comment before a commitment is made to any one route or location. This type of hearing is beneficial for existing corridors with multiple Improvement projects programmed over a long duration.
- ***design hearing*** A formal or informal hearing that presents the design alternatives to the public for review and comment before the selection of a preferred alternative.
- ***environmental hearing*** A formal or informal hearing documenting that social, economic, and environmental impacts have been considered and that public opinion has been solicited.
- ***formal hearing format*** A hearing conducted by a moderator using a formal agenda, overseen by a hearing examiner, and recorded by a court reporter, as required by law. Limited access hearings require the use of the formal hearing format (see Chapter 210).
- ***informal hearing format*** A hearing where oral comments are recorded by a court reporter, as required by law. An informal hearing often uses the "open house" format (see Chapter 210). A formal agenda and participation by a hearing examiner are optional.
- ***limited access hearing*** A formal hearing that gives local public officials, owners of abutting properties, and other interested persons an opportunity to be heard about the limitation of access to the highway system.

hearing agenda An outline of the actual public hearing elements, used with formal hearings. (See Chapter 210 for contents.)

Hearing Coordinator The HQ Access and Hearings Section Manager: (360) 705-7266.

hearing examiner An administrative law judge from the Office of Administrative Hearings, or a WSDOT designee, appointed to moderate a hearing.

hearing script A written document of text to be presented orally by department representatives at a hearing.

hearing summary Documentation prepared by the region and approved by Headquarters that summarizes environmental, corridor, and design hearings. (See Chapter 210 for content requirements.)

hearing transcript A document prepared by the court reporter that transcribes verbatim all oral statements made during the hearing, including public comments. This document becomes part of the official hearing record.

high-occupancy toll (HOT) lane A managed lane that combines a high-occupancy vehicle lane and a toll lane.

high-occupancy vehicle (HOV) A vehicle that meets the occupancy requirements of the facility as authorized by WAC 468-510-010.

high pavement type Portland cement concrete pavement or hot mix asphalt (HMA) pavement on a treated base.

high-speed roadway See *speed*.

highway A general term denoting a street, road, or public way for the purpose of vehicular travel, including the entire area within the right of way.

Highway Construction Program (HCP) A comprehensive multiyear program of highway Improvement and Preservation projects selected by the Legislature.

Highway System Plan (HSP) A WSDOT planning document that addresses the state highway system element of the Washington Transportation Plan (WTP). The HSP defines the service objectives, action strategies, and costs to maintain, operate, preserve, and improve the state highway system for 20 years. The HSP is the starting point for the state highway element of the CIPP and the state Highway Construction Program. It is periodically updated to reflect completed work and changing transportation needs, policies, and revenues. It compares highway needs to revenues, describes the "constrained" costs of the highway programs, and provides details of conceptual solutions and performance in the improvement program.

Highways of Statewide Significance (HSS) Include interstate highways and other principal arterials that are needed to connect major communities in the state. The designation helps assist with the allocation and direction of funding. (http://www.wsdot.wa.gov/planning/HSS)

Horizon year typically considered to be 20 years from the year construction is scheduled to begin, as described in Chapter 1103. See also design year.

HOV direct access ramp An on- or off-ramp exclusively for the use of HOVs that provides access between a freeway HOV lane and a street, transit support facility, or another freeway HOV lane without weaving across general-purpose lanes.

HOV facility A priority treatment for HOVs.

I

impact attenuator system A device that acts primarily to bring an errant vehicle to a stop at a deceleration rate tolerable to the vehicle's occupants or to redirect the vehicle away from a fixed feature.

incorporated city or town A city or town operating under RCW 35 or 35A.

inscribed circle The outer edge of the circulating roadway.

inscribed circle diameter (ICD) The diameter of the inscribed circle (see Chapter 1320).

intelligent transportation systems (ITS) An integrated system of advanced sensor, computer, electronics, and communication technologies and management strategies, used to increase the safety and efficiency of the surface transportation system.

interchange A system of interconnecting roadways, in conjunction with one or more grade separations, providing for the exchange of traffic between two or more intersecting highways or roadways.

Interchange Justification Report (IJR) The document used to propose a revision to limited access freeways.

intermediate pavement type Hot mix asphalt pavement on an untreated base.

Intermediate speed roadway See speed.

intersection An at-grade access point connecting a state highway with a road or street duly established as a public road or public street by the local governmental entity.

intersection angle The angle between any two intersecting legs at the point the centerlines intersect.

intersection area The area of the intersecting roadways bounded by the edge of traveled ways and the area of the adjacent roadways to the farthest point: (a) the end of the corner radii, (b) through any marked crosswalks adjacent to the intersection, (c) to the stop bar, or (d) 10 feet from the edge of shoulder of the intersecting roadway (see Chapter 1310).

intersection at grade The general area where a roadway or ramp terminal is met or crossed at a common grade or elevation by another roadway.

- ***four-leg intersection*** An intersection formed by two crossing roadways.
- ***split tee*** A four-leg intersection with the crossroad intersecting the through roadway at two tee intersections offset by at least the width of the roadway.
- ***tee (T) intersection*** An intersection formed by two roadways where one roadway terminates at the point it meets a through roadway.
- ***wye (Y) intersection*** An intersection formed by three legs in the general form of a "Y" where the angle between two legs is less than 60°.

intersection control beacon (also *flashing beacon*) A secondary control device, generally suspended over the center of an intersection, that supplements intersection warning signs and stop signs. One display per approach may be used; however, two displays per approach are desirable. Intersection control beacons are installed only at intersections that control two or more directions of travel.

intersection leg Any one of the roadways radiating from and forming part of an intersection.

- ***entrance leg*** The lanes of an intersection leg for traffic entering the intersection.
- ***exit leg*** The lanes of an intersection leg for traffic leaving the intersection.

Note: Whether an intersection leg is an entrance leg or an exit leg depends on which movement is being analyzed. For two-way roadways, each leg is an entrance leg for some movements and an exit leg for other movements.

intersection density The ratio of intersections per mile.

intersection design vehicle A specific selection of the vehicle to be used to dimension intersection design elements at an individual intersection.

intersection sight distance The length of roadway visible to the driver of a vehicle entering an intersection.

Interstate System A network of routes designated by the state and the Federal Highway Administration (FHWA) under terms of the federal-aid acts as being the most important to the development of a national system. The Interstate System is part of the principal arterial system.

island A defined area within an intersection, between traffic lanes, for the separation of vehicle movements or for pedestrian refuge.

J

justify Preparing a memo to the DDP identifying the reasons for the decision: a comparison of advantages and disadvantages of all options considered. A more rigorous effort than document.

K

K-factor The proportion of AADT occurring in the analysis hour is referred to as the K-factor, expressed as a decimal fraction (commonly called “K,” “K30,” or “K100”). The K30 is the thirtieth (K100 is the one-hundredth) highest peak hour divided by the annual average daily traffic. Normally, the K30 or K100 will be in the range of 0.09 to 0.10 for urban and rural areas. Average design hour factors are available on the web in the Statewide Travel and Collision Data Office’s Annual Peak Hour Report.

L

lamp lumens The total light output from a lamp, measured in lumens.

lane A strip of roadway used for a single line of vehicles.

lane control signal (reversible lanes) A special overhead signal that permits, prohibits, or warns of impending prohibition of lane use.

lane width The lateral design width for a single lane, striped as shown in the *Standard Plans* and the *Standard Specifications*. The width of an existing lane is measured from the edge of traveled way to the center of the lane line or between the centers of adjacent lane lines.

lateral clearance The distance from the edge of traveled way to a roadside object.

layered networks Roadway network arrangement where the objective is to separate modes onto different facilities with planned interconnection locations.

lead agency The public agency that has the principal responsibility for carrying out or approving a project.

left-cross Describes the intersection conflict between a motor vehicle left-turn and bicycle through movement in the opposing direction.

legal road approach A road approach that complies with the requirements of Chapter 530 for limited access facilities and Chapter 540 for managed access facilities.

length of need The length of a traffic barrier used to shield a fixed feature.

level of service (LOS) LOS is based on peak hour, except where noted. LOS assigns a rank (A – F) to facility sections based on traffic flow concepts like density, delay, and/or corresponding safety performance conditions. (See the Highway Capacity Manual and AASHTO's Geometric Design of Highways and Streets ["Green Book"] for further details.)

life cycle cost The total cost of a project or item over its useful life. This includes all of the relevant costs that occur throughout the life of a project or item, including initial acquisition costs (such as right of way, planning, design, and construction), operation, maintenance, modification, replacement, demolition, financing, taxes, disposal, and salvage value as applicable.

light emitting diode (LED) A two-lead semiconductor light source.

limited access (L/A) Full, partial, or modified access control is planned and established for each corridor and then acquired as the right to limit access to each individual parcel (see Chapter 520).

- ***acquired limited access control*** Access rights have been purchased.
- ***established limited access control*** An access hearing has been held and the Assistant Secretary, Engineering & Regional Operations, has adopted the findings and order, which establishes the limits and level of control.

- ***planned limited access control*** Limited access control is planned for some time in the future; however, no access hearing has been held.

Limited Access and Managed Access Master Plan A map of Washington State that shows established and planned limited access highways: www.wsdot.wa.gov/design/accessandhearings

limited access highway All highways listed as "Established L/A" on the Limited Access and Managed Access Master Plan and where the rights of direct access to or from abutting lands have been acquired from the abutting landowners.

- ***full access control*** This most restrictive level of limited access provides access, using interchanges, for selected public roads/streets only, and prohibits highway intersections at grade.
- ***partial access control*** The second most restrictive level of limited access. At grade intersections with selected public roads are allowed, and there may be some crossings and some driveway approaches at grade. Direct commercial access is not allowed.
- ***modified access control*** The least restrictive level of limited access. Characteristics are the same as for partial access control except that direct commercial access is allowed.

local roads Non-state highways that are publicly owned.

long tunnel A tunnel, lid, or underpass that is greater than 80' in length and has a length to vertical clearance ratio greater than 10:1.

low pavement type Bituminous surface treatment (BST).

low-speed roadway See *speed*

lumen The unit used to measure luminous flux.

luminaire A complete lighting unit comprised of a light bulb or light emitting Diode (LED) module, wiring, and a housing unit.

luminance The quotient of the luminous flux at an element of the surface surrounding the point and propagated in directions defined by an elementary cone containing the given direction, by the product of the solid angle of the cone and area of the orthogonal projection of the element of the surface on a plane perpendicular to the given direction. The luminous flux may be leaving, passing through, and/or arriving at the surface.

luminous flux The time rate of the flow of light.

M

managed access highway Highways where the rights of direct access to or from abutting lands have not been acquired from the abutting landowners.

managed lane A lane that increases efficiency by packaging various operational and design actions. Lane management operations may be adjusted at any time to better match regional goals.

managing project delivery A WSDOT management process for project delivery from team initiation through project closing.

maximum uniformity ratio The average light level within the design area divided by the minimum light level within the design area (see Chapter 1040).

maximum veiling luminance ratio The maximum veiling luminance divided by the average luminance over a given design area for an observer traveling parallel to the roadway centerline (see Chapter 1040).

mcd/m2/lux Pavement marking retroreflectivity is represented by the coefficient of retroreflected luminance (R_L) measured in millicandelas per square meter.

Measures of Effectiveness (MOEs) In the context of Chapter 320, examples are: speed, delay, density, LOS, QOS, person or vehicle throughput, cost vs. benefit, and queue. (See FHWA's MOE List.)

median The portion of a divided highway separating vehicular traffic traveling in opposite directions.

median functions one or more reason(s) for a median as described in Chapter 1239.

median opening An opening in a continuous median for the specific purpose of allowing vehicle movement.

Memorandum of Understanding (MOU) There is one MOU (Highways Over National Forest Lands) between the United States Forest Service (USFS) and WSDOT that requires the USFS to obtain a road approach permit for new access to a state highway that is crossing Forest Service land.

metering signal A signal used to control the predominant flow rate of traffic at an at-grade facility.

Methods and Assumptions Document A mandatory document developed at the beginning of the IJR phase to record IJR assumptions, methodologies, criteria, and decisions (see Chapter 550).

Metropolitan Planning Organization (MPO) A lead agency designated by the Governor to administer the federally required transportation planning process in a metropolitan area with a population over 50,000. The MPO is responsible for the 20 year long-range plan and Transportation Improvement Program (TIP).

minimum average light level The average of all light intensities within the design area, measured just prior to relamping the system (see Chapter 1040).

minimum light level The minimum light intensity of illumination at any single point within the design area measured just prior to relamping the system (see Chapter 1040).

minor arterial system A rural network of arterial routes linking cities and other activity centers that generate long distance travel and, with appropriate extensions into and through urban areas, form an integrated network providing interstate and interregional service (RCW 47.05.021).

minor operational enhancement projects These projects usually originate from the Q2 component of the Q Program and are quick responses to implement low-cost improvements. They are typically narrow in scope and focus on improvements to traffic operations and modifications to traffic control devices. Guidance on the type of work included in the Q subprograms is in the Chart of Accounts.

modal compatibility An assessment to determine which mode(s) need to be considered strictly based on the context characteristics present or planned. The assessment is independent of whether any particular mode is present on the segment, and intended to guide strategic investment opportunities on a segment.

modal priority Mode(s) that will be prioritized when making design decisions for the project, guided by the outcome of the modal compatibility assessment.

mode A specific type or form of transportation. Typically for roadway design the modes are: automobiles, transit, truck freight, pedestrians, skateboards, and bicycles.

monument As defined in Chapter 410, a monument is any physical object or structure that marks or references a survey point. This includes, but is not limited to, a point of curvature (P.C.), a point of tangency (P.T.), a property corner, a section corner, a General Land Office (GLO) survey point, a Bureau of Land Management (BLM) survey point, and any other permanent reference set by a governmental agency or private surveyor.

monument removal or destruction The physical disturbance or covering of a monument such that the survey point is no longer visible or readily accessible.

mounting height – luminaire The vertical distance between the surface of the design area and the center of the light source of the luminaire. Note: This is not to be confused with pole height (H1), but is the actual distance that the luminaire is located above the roadway edge line.

movable bridge signal (also drawbridge signal) A signal installed to notify traffic to stop when the bridge is opened for waterborne traffic. Movable bridge signals display continuous green when the roadway is open to vehicular traffic.

multilane approach An approach that has two or more lanes, regardless of the lane use designation.

multimodal connection The point where multiple types of transportation activities occur; for example, where transit buses and van pools drop off or pick up passengers (including passengers with bicycles).

N

National Highway System (NHS) The NHS was developed by the U.S. Department of Transportation (DOT) in cooperation with the states, local officials, and metropolitan planning organizations (MPOs).

The NHS includes the following subsystems of roadways (note that a specific highway route may be on more than one subsystem):

- ***Interstate*** The Eisenhower Interstate System of highways retains its separate identity within the NHS.
- ***Other Principal Arterials*** These are highways in rural and urban areas that provide access between an arterial and a major port, airport, public transportation facility, or other intermodal transportation facility.
- ***Strategic Highway Network (STRAHNET)*** This is a network of highways that are important to the United States' strategic defense policy and that provide defense access, continuity, and emergency capabilities for defense purposes.
- ***Major Strategic Highway Network Connectors*** These are highways that provide access between major military installations and highways that are part of the Strategic Highway Network.
- ***Intermodal Connectors*** These highways provide access between major intermodal facilities and the other four subsystems making up the National Highway System.

natural vehicle path The natural path that a driver navigates a vehicle given the layout of the intersection and the ultimate destination.

need A statement that identifies the transportation problem(s) or other performance gap

negative illumination Lighting the background and leaving the object dark to contrast with the light behind it as the driver views it.

network connectivity How the various roadways and other transportation facilities within a network interconnect in a defined geographic area.

nighttime The period of time from one-half hour after sunset to one-half hour before sunrise and any other time when persons or objects may not be clearly discernible at a distance of 500 feet (RCW 46.04.200).

no-build condition The baseline, plus state transportation plan and comprehensive plan improvements, expected to exist, as applied to the year of opening or the design year.

nonconforming road approach A road approach that does not meet current requirements for location, quantity, spacing, sight distance, or geometric elements.

nonrecoverable slope A slope on which an errant vehicle might continue until it reaches the bottom, without having the ability to recover control. Fill slopes steeper than 4H:1V, but not steeper than 3H:1V, are considered nonrecoverable.

nonseparated HOV lane An HOV lane that is adjacent to and operates in the same direction as the general-purpose lanes with unrestricted access between the HOV lane and the general-purpose lanes.

notice of appearance A form provided by WSDOT for anyone wanting to receive a copy of the findings and order and the adopted limited access plan (see Chapter 210).

notice of hearing (or hearing notice) A published advertisement that a public hearing will be held.

notice of opportunity for a hearing An advertised offer to hold a public hearing.

O

occupancy designation The minimum number of occupants required for a vehicle to use the HOV facility.

operating speed The speed at which drivers are observed operating their vehicles during free flow conditions.

order of hearing The official establishment of a hearing date by the Director & State Design Engineer, Development Division.

outer separation The area between the outside edge of traveled way for through traffic and the nearest edge of traveled way of a frontage road or collector-distributor (C-D) road.

overlapped displays Overlapped displays allow a traffic movement to operate with one or more nonconflicting phases. Most commonly, a minor street's exclusive right-turn phase is overlapped with the nonconflicting major street's left-turn phase. An overlapped display can be terminated after the parent phase (the main phase the overlap is associated with) terminates. An overlapped display programmed for two or more parent phases continues to display until all of the parent phases have terminated. An overlap is made up of two or more phases—not one phase controlling two movements.

P

painted nose The point where the main line and ramp lanes separate.

"pass-by" trips Pass-by trips are intermediate stops between an origin and a primary trip destination; for example, home to work, home to shopping.

passenger loading zone An area provided for pedestrians to board/disembark a vehicle.

passing lane An auxiliary lane on a two-lane highway used to provide the desired frequency of passing zones.

passing sight distance The distance (on a two-lane highway) needed for a vehicle driver to execute a normal passing maneuver based on design conditions and design speed.

pavement marking A colored marking applied to the pavement by spray, extrusion, adhesives, or glue to provide drivers with guidance and other information.

pavement marking beads ***Glass:*** Small glass spheres used in highway pavement markings to provide retroreflectivity. ***Composite:*** any non-glass bead intended to provide wet weather retroreflectivity.

pavement marking durability A measure of a pavement marking's resistance to wear and deterioration.

peak hour The 60-minute interval that contains the largest volume of traffic during a given time period. If a traffic count covers consecutive days, the peak hour can be an average of the highest hour across all of the days. An a.m. peak is simply the highest hour from the a.m., and the p.m. peak is the highest from the p.m. The peak hour correlates to the DHV, but is not the same. However, it is close enough on items such as intersection plans for approval to be considered equivalent.

performance-based decisions Decisions that are made based on performance, performance metrics, performance targets, and performance gaps. Also, decisions made using performance evaluation tools, such as Highway Safety Manual methodology for evaluating safety performance.

performance category Any broad area of performance important to an organization, project, or place. WSDOT's six performance categories: Economic Vitality, Preservation, Safety, Mobility, Environment, and Stewardship are a product of legislative policy.

performance evaluation tools Quantitative tools used to measure performance. Examples of these tools currently being used by WSDOT are *Highway Safety Manual* methodology (for safety performance) and *Highway Capacity Manual* (for mobility performance).

performance gap The difference between the measured and targeted performance unit for a performance metric. This gap is another way of describing the performance need(s) at a location.

performance metric Any measurable indicator used to assess the achievement of outcomes.

performance need See *baseline performance need* and *contextual performance need*

performance target(s) An outcome or desired state intended for a project. Performance targets are identified as either baseline or contextual (see Chapter 1101).

permit holder The abutting property owner or other legally authorized person to whom an access connection permit is issued by the permitting authority.

permitted access connection A connection for which an access connection permit has been issued by a permitting authority.

permitting authority The agency that has legal authority to issue managed access connection permits. For access connections in unincorporated areas, the permitting authority is WSDOT; for access connections within corporate limits, the permitting authority is a city or town.

physical nose The point, upstream of the gore, with a separation between the roadways of 16 to 22 feet (see Chapter 1360).

planning Transportation planning is a decision-making process required by federal and state law used to solve complex, interrelated transportation and land use problems.

Planning and Environmental Linkage (PEL) A collaborative and integrated approach to transportation decision-making that (1) considers environmental, community, and economic goals early in the planning process, and (2) uses the information, analysis, and products developed during planning to inform the environmental review process.

Plans, Specifications, and Estimates (PS&E) The project development activity that follows Project Definition and culminates in the completion of contract-ready documents and the engineer's cost estimate.

pole height (H1) The vertical distance from the light source to the pole base. This distance is specified in contracts and used by the pole manufacturers to fabricate the light standard.

policy point There are eight policy points addressed in the IJR:

- Need for the Access Point Revision
- Reasonable Alternatives
- Operational & Crash Analyses
- Access Connections & Design
- Land Use & Transportation Plans
- Future Interchanges
- Coordination
- Environmental Processes

portable traffic signal A type of conventional traffic signal used in work zones to control traffic. This signal is most commonly used on two-way two-lane highways where one lane has been closed for roadwork. This signal is most commonly operated in pairs, with one signal at each end of the work zone. This eliminates the need for 24-hour flagger control. The traffic signal provides alternating right of way assignments for conflicting traffic movements. The signal has an adjustable vertical support with two three-section signal displays and is mounted on a mobile trailer with its own power source.

positive illumination Lighting the surface of the object as the driver views it.

posted speed The maximum legal speed as posted on a section of highway using regulatory signs.

Practical Design/Practical Solutions An approach to making project decisions that focuses on the specific problem the project is intended to address. This performance-based approach looks for lower cost solutions that meet outcomes that WSDOT, partnering agencies, communities and stakeholders have identified. Practical design is a fundamental component to the vision, mission, values, goals, and reforms identified in Results WSDOT- WSDOT's Strategic Plan. With practical solutions, decision-making focuses on maximum benefit to the system, rather than maximum benefit to the project. Focusing on the specific project need minimizes the scope of work for each project so that system-wide needs can be optimized.

prehearing packet A concise, organized collection of all necessary prehearing data, prepared by the region and approved by the HQ Access and Hearings Section Manager prior to the hearing (see Chapter 210).

preliminary engineering (PE) A term used to describe the Project Delivery process from project scoping through PS&E review.

principal arterial system A connected network of rural arterial routes with appropriate extensions into and through urban areas, including routes designated as part of the Interstate System, that serves corridor movements with travel characteristics indicative of substantial statewide and interstate travel (RCW 47.05.021).

priority array A collection of similar needs identified in the HSP, prioritized based on the methodology adopted by WSDOT to meet the requirements of RCW 47.05.

Priority Array Tracking System (PATS) A database that allows tracking of highway needs and their solutions. The system is designed to ensure WSDOT addresses the highest-ranked transportation needs. Deficiencies are tracked for each strategy in the HSP.

product or service Any element of a project from concept through maintenance and operation. In all instances, the required function should be achieved at the lowest life cycle cost based on requirements for performance, maintainability, safety, environment, and aesthetics.

project The Project Management Institute defines a project to be "a temporary endeavor undertaken to create a unique product or service."

Project Change Request Form A form used to document and approve revisions to project scope, schedule, or budget from a previously approved Project Definition (see Project Summary). Include copies in the Design Documentation Package.

Project Control and Reporting (PC&R) The Headquarters (HQ) Project Control and Reporting Office is responsible for monitoring, tracking, and reporting delivery of the Highway Construction Program in coordination with the Program Management offices in each of the six WSDOT regions and the Urban Corridors Office.

Project Definition (see *Project Summary*)

Project Development Approval Final approval of all project development documents by the designated representative of the approving organization prior to the advertisement of a capital transportation project (see Chapter 300).

Project Engineer This term applies to WSDOT personnel. Wherever “Project Engineer” appears in this manual, the design-builder shall deem it to mean “Engineer of Record.”

Project File (PF) A file containing all documentation and data for all activities related to a project (see Chapter 300).

- ***Design Documentation Package (DDP)*** The portion of the Project File, including Design Approval and Project Development Approval that will be retained long term in accordance with WSDOT document retention policies. Depending on the scope of the project, it contains the Project Summary and some or all of the other documents discussed in Chapter 300. Technical reports and calculations are part of the Project File, but they are not designated as components of the DDP. Include estimates and justifications for decisions made in the DDP (see Chapter 300). The DDP explains how and why the design was chosen and documents approvals.

project management plan A formal, approved document that defines how the project is executed, monitored, and controlled. It may be in summary or detailed form and may be composed of one or more subsidiary management plans and other work planning documents. For further information, see the Project Management Guide: http://www.wsdot.wa.gov/Projects/ProjectMgmt/OnlineGuide/ProjectManagementOnlineGuide.htm

project need statement A statement identifying the baseline performance need for the project. For each identified project need, there may be one or more performance metrics, targets, and gaps.

Project Scoping See *scoping phase*.

Project Summary A set of documents consisting of the, Environmental Review Summary (ERS), and Project Definition (PD). The Project Summary is part of the design documentation required to obtain Design Approval and is ultimately part of the design documentation required for Project Development Approval (see Chapter 300).

- ***Environmental Review Summary (ERS)*** A document that records the environmental classification (class of action) and considerations (consequences of action) for a specific project.
- ***Project Definition (PD)*** A document that records the purpose and need of the project, along with program level and design constraints.

Projects of Division Interest (PoDIs) A primary set of projects for which FHWA determines the need to exercise oversight and approval authority, as described in Chapter 300.

proposal The combination of projects/actions selected through the study process to meet a specific transportation system need.

public art An enhancement to a functional element, feature, or place within a transportation facility to provide visual interest. The enhancement could be an addition to a functional element, integrated into a design, or for purely aesthetic purposes. An element is considered “public art” if it is beyond WSDOT standard practice for architectural treatment.

public involvement plan A plan to collaboratively involve the public in decision making, tailored to the specific needs and conditions of a project and the people and communities it serves. It is often part of a broader communications plan.

public transportation Passenger transportation services available to the public, including buses, ferries, rideshare, and rail transit.

purpose General project goals such as improve safety, enhance mobility, or enhance economic development.

Q

Quality of Service (QOS) Defined by the *Highway Capacity Manual* or by agreement. Intended to describe how well a facility or service operates or functions from the perspective of the user.

quantitative safety analysis An analysis that relies on science-based modeling associated with safety, and utilizes quantitative tools.

quantitative tools Tools used to measure performance. Examples of tools currently being used by WSDOT are:

- *Highway Safety Manual* methodology (for safety performance)
    - Safety Analyst Toolset
    - ISATe
    - IHSDM
    - HSM Enhanced Spread Sheets
    - See also http://wwwi.wsdot.wa.gov/RiskManagement/SHS/SafetyTools.htm
- *Highway Capacity Manual* (for mobility performance)

queue cutter traffic signal A traffic signal used at highway-rail grade crossings where the queue from a downstream traffic signal is expected to extend within the Minimum Track Clearance Distance. It is used to keep vehicles from an adjacent signalized intersection from queuing on the railroad tracks.

R

ramp connection The pavement at the end of a ramp, connecting to a main lane of a roadway.

ramp (in relation to a *roadway*) A short roadway connecting a main lane of a highway with another facility, such as a road, parking lot, or transit stop, for vehicular use.

ramp meter A traffic signal at a freeway entrance ramp that allows a measured or regulated amount of traffic to enter the freeway.

ramp terminal An intersection at the end of a ramp.

Record of Decision (ROD) Under the National Environmental Policy Act, the Record of Decision accompanies the Final Environmental Impact Statement; explains the reasons for the project decision; discusses alternatives and values considered in selection of the preferred alternative; and summarizes mitigation measures and commitments that will be incorporated in the project.

recoverable slope A slope on which the driver of an errant vehicle can regain control of the vehicle. Slopes of 4H:1V or flatter are considered recoverable.

recovery area The minimum target value used in highway design when a fill slope between 4H:1V and 3H:1V starts within the Design Clear Zone.

Recreational Vehicle Account In 1980 the RV account was established for use by the department of transportation for the construction, maintenance, and operation of recreational vehicle sanitary disposal systems at safety rest areas (RCW 46.68.170). A recreational vehicle sanitary disposal fee is required for registration of a recreational vehicle (RCW 46.17.375). Adjustments to the recreational vehicle fee by the department of transportation may be implemented after consultation with the citizens' representatives of the recreational vehicle user community (RCW 47.01.460).

Regional Transportation Planning Organization (RTPO) A planning organization authorized by the Legislature in 1990 as part of the Growth Management Act. The RTPO is a voluntary organization with representatives from state and local governments that are responsible for coordinating transportation planning activities within a region.

relocation assistance program A program that establishes uniform procedures for relocation assistance that will ensure legal entitlements and provide fair, equitable, and consistent treatment to persons displaced by WSDOT-administered projects, as defined in the *Right of Way Manual*.

Request for Proposal (RFP) The document package issued by WSDOT requesting submittal of proposals for the project and providing information relevant to the preparation and submittal of proposals, including the instructions to proposers, contract documents, bidding procedures, and reference documents.

rest area An area to the side of a path.

résumé An official notification of action taken by WSDOT following adoption of a findings and order (see Chapter 210).

retroreflection The phenomenon of light rays striking a surface and being returned directly back to the source of light.

Retroreflection, coefficient of (R_L) A measure of retroreflection.

retroreflectometer An instrument used to measure retroreflectivity.

right-hook Potential intersection conflicts between motor vehicles making a right turn and the bicycle through movement.

right of way (R/W) A general term denoting land or interest therein, acquired for or designated for transportation purposes. More specifically, lands that have been dedicated for public transportation purposes or land in which WSDOT, a county, or a municipality owns the fee simple title, has an easement devoted to or required for use as a public road/street and appurtenant facilities, or has established ownership by prescriptive right.

right of way and limited access plan (R/W and L/A plan) A right of way plan that also shows limited access control details.

road approach An access point, other than a public road/street, that allows access to or from a limited access highway on the state highway system.

roadside park A roadside user facility for safe vehicular parking off the traveled way and separated from the highway by some form of buffer. These sites might be equipped with features or elements such as points of interest, picnic tables, and/or vault toilet buildings. Unlike a safety rest area, a roadside park does not always provide a permanent restroom building.

roadway The portion of a highway, including shoulders.

roadway luminance The light projected from a luminaire that travels toward a given area, represented by a point on the pavement surface, and then back toward the observer, opposite to the direction of travel. The units of roadway luminance are footcandles.

roundabout A circular intersection at grade with yield control of all entering traffic, channelized approaches with raised splitter islands, counter-clockwise circulation, and appropriate geometric curvature to force travel speeds on the circulating roadway generally to less than 25 mph.

rumble strips Rumble strips are grooves or rows of raised pavement markers placed perpendicular to the direction of travel to alert inattentive drivers.

S

Safety Analyst A program developed to implement the *Highway Safety Manual* methodology

safety rest area (SRA) A roadside facility equipped with permanent restroom building(s), a parking area, picnic tables, refuse receptacles, illumination, and other ancillary services. SRAs typically include potable water and might include traveler information and telephones.

Safety Rest Area Strategic Plan Developed in 2008 under a stakeholder-coordinated effort of executive and advisory team members, this plan provides guidance for current and future management of the SRA program.

sawtooth berth A series of bays that are offset from one another by connecting curb lines, constructed at an angle from the bus bays. This configuration minimizes the amount of space needed for vehicle pull in and pull out.

scoping phase An initial phase of project development for a specific project. The scoping phase precedes the design and/or preliminary engineering phase and is intended to support priority programing and budget building scenarios. The *Project Summary* is the documentation developed during this phase.

security lighting A minimal amount of lighting used to illuminate areas for public safety or theft reduction. Security lighting for walkways is the lighting of areas where shadows and horizontal and vertical geometry obstruct a pedestrian’s view.

“select zone” analysis A traffic model run, where the related project trips are distributed and assigned along a populated highway network. This analysis isolates the anticipated impact on the state highway network created by the project.

separated HOV facility An HOV roadway that is physically separated from adjacent general-purpose lanes by a barrier or median, or is on a separate right of way.

shared roadway A roadway that is open to both bicycle and motor vehicle travel. This may be a new or existing roadway/highway, a street with wide curb lanes, or a road with paved shoulders.

shared-use landing A level (0 to 2% grade cross slope and running slope) paved area within the shared-use path, designed to provide turning and maneuvering space for wheelchair users and as a resting place for pedestrians.

shared-use path A facility physically separated from motorized vehicular traffic within the highway right of way or on an exclusive right of way with minimal crossflow by motor vehicles. Shared-use paths are primarily used by bicyclists and pedestrians, including joggers, skaters, and pedestrians with disabilities, including those who use nonmotorized or motorized wheeled mobility devices. With appropriate design considerations, equestrians may also be accommodated by a shared-use path facility.

short tunnel A tunnel, lid, or underpass that is shorter than 80' in length and has a length to vertical clearance ratio of 10:1 or less.

shoulder The portion of the roadway contiguous with the traveled way, primarily for accommodation of stopped vehicles, emergency use, lateral support of the traveled way, and where allowed, use by pedestrians and bicycles.

shoulder width The lateral dimension of the shoulder, measured from the edge of traveled way to the edge of roadway or the face of curb.

sight distance The length of highway visible to a driver.

SIgnal Maintenance Management System (SIMMS) A database used for traffic signals, illumination, and Intelligent Transportation Systems (ITS). SIMMS is used to establish an inventory base, enter work reports, print timesheets, and store maintenance records for electrical/electronics systems within WSDOT right of way.

signed shared roadway A shared roadway that has been designated by signing as a route for bicycle use.

single-lane roundabout A roundabout having single-lane entries at all legs and one circulating lane.

single-occupant vehicle (SOV) Any motor vehicle other than a motorcycle carrying one occupant.

site Parcel(s) of land bounded by a property line or a designated portion of a public right of way.

site design Style and configuration of the built environment or parcel(s).

slip base A mechanical base designed to allow the light standard to break away from the fixed foundation when hit by a vehicle traveling at the design speed and traveling at a departure angle less than or equal to the design departure angle.

slip lane A lane that separates heavy right-turn movements from the roundabout circulating traffic (see Chapter 1320).

slip ramp A connection between legs of an intersection that allows right-turning vehicles to bypass the intersection or a connection between an expressway and a parallel frontage road. These are often separated by an island.

slow-moving vehicle turnout A shoulder area widened to provide room for a slow-moving vehicle to pull out of the through traffic, allow vehicles to pass, and then return to the through lane.

speed The operations or target or posted speed of a roadway. There are three classifications of speed established:

- ***Low speed*** is considered 35 mph and below.
- ***Intermediate speed*** is considered 40-45 mph.
- ***High speed*** is considered 50 mph and above.

speed limit sign beacon A beacon installed with a fixed or variable speed limit sign. The preferred display is two flashing yellow indications.

speed management An engineered effort to achieve a targeted speed.

speed transition segment An engineered segment of road intended to lower the operating speed between contexts with different target speeds.

splitter island The raised island at each two-way leg between entering and exiting vehicles, designed primarily to control the entry and exit speeds by providing deflection. They also discourage wrong-way movements, and provide pedestrian refuge.

state highway system All roads, streets, and highways designated as state routes in compliance with RCW 47.17.

Statewide Transportation Improvement Program (STIP) A planning document that includes all federally funded projects and other regionally significant projects for a three-year period.

static scale A scale that requires a vehicle to stop for weighing.

stopping sight distance The distance needed for a driver to stop a vehicle traveling at design speed based on design conditions.

stop sign beacon A beacon installed above a stop sign. The display is a flashing red indication.

streetside The portion of the public right of way dedicated to the pedestrian thoroughfare and supporting the accessibility, activities and functions of the local land use. The streetside is comprised of a frontage zone, pedestrian zone, furnishing zone and parking zone (see Chapter 1238). Note some local agencies may divide the streetside zone.

study area The transportation system area to study in the study process and for an IJR. The study area is a minimum of one interchange upstream and downstream from the proposal. The study area shall also include the intersecting roadway in the area to the extent necessary to ensure its ability to collect and distribute traffic to and from the interchange. The study area should be expanded as necessary to capture operational impacts of adjacent interchanges in the vicinity that are, or will be, bottlenecks or chokepoints that influence the operations of the study interchange.

study plan A term associated with environmental procedures, this plan proposes an outline or "road map" of the environmental process to be followed during the development of a project that requires complex NEPA documentation (see Chapter 210 and the *Environmental Manual*).

subject matter expert A person who is an authority in a particular area or topic, and understands the data and the limitations on the use and application of the data.

superelevation The rotation of the roadway cross section in such a manner as to overcome part of the centrifugal force that acts on a vehicle traversing a curve.

superelevation runoff The length of highway needed to accomplish the change in cross slope from a section with adverse crown removed (level) to a fully superelevated section, or vice versa.

superelevation transition length The length of highway needed to change the cross slope from normal crown or normal pavement slope to full superelevation.

support team An integral part of the IJR process consisting of an assemblage of people from the regions, FHWA (for Interstates), WSDOT HQ Access and Hearings, and other representatives organized to develop and analyze alternatives to meet the need of a proposal, including approval authorities.

Surface Transportation Program (STP) A federal program established by Congress in 1991 that provides a source of federal funding for highway and bridge projects.

T

tangent runout The length of highway needed to change the cross slope from normal crown to a section with adverse crown removed (level).

target speed A proactive approach to establishing a speed consistent with the context characteristics. Target speed is the design operating speed, which aligns design, posted and operating speed as the same value.

team management The direction of a group of individuals that work as a unit. Effective teams are results-oriented and are committed to project objectives, goals and strategies.

temporary traffic signal A conventional traffic signal used during construction to control traffic at an intersection while a permanent signal system is being constructed. A temporary traffic signal is typically an inexpensive span-wire installation using timber strain poles.

Total Project Costs The costs of all phases of a project, including environmental, design, right of way, utilities, and construction.

tradeoffs analysis An analysis method for balancing factors, performance or outcomes, which are not attainable at the same time.

traffic barrier A longitudinal barrier, including bridge rail or an impact attenuator, used to redirect vehicles from fixed features located within an established Design Clear Zone, help mitigate median crossovers, reduce the potential for errant vehicles to travel over the side of a bridge structure, or (occasionally) protect workers, pedestrians, or bicyclists from vehicular traffic.

traffic barrier/longitudinal barrier A device oriented parallel or nearly parallel to the roadway whose primary function is to contain or safely redirect errant vehicles away from fixed features or to (occasionally) protect workers, pedestrians, or bicyclists from vehicular traffic. Beam guardrail, cable barrier, bridge rail, concrete barrier, and impact attenuators are barriers, and they are categorized as rigid, rigid anchored, unrestrained rigid, semirigid, and flexible. They can be installed as roadside or median barriers.

traffic calming treatments Treatments along the roadway that can be used to reduce speeds through a section of roadway (see Chapter 1103).

Traffic Impact Analysis (TIA) (sometimes called *Traffic Impact Study (TIS)*) If a traffic analysis is not an IJR, it is a TIA. TIAs are used for environmental reviews and developer projects (see Chapter 320).

traffic paint A pavement marking material that consists mainly of a binder and a carrier. The carrier is kept in liquid form, which evaporates upon application to the pavement, leaving the binder to form a hard film.

transit A general term applied to passenger rail and bus service used by the public.

transit facility A capital facility that improves the efficiency of public transportation or encourages the use of public transportation.

transit flyer stop A multimodal connection located within the boundaries of a limited access facility.

transition A section of barrier used to produce the gradual stiffening of a flexible or semirigid barrier as it connects to a more rigid barrier or fixed object.

transit lane A lane for the exclusive use of transit vehicles.

transit stop A facility for loading and unloading passengers that is set aside for the use of transit vehicles only.

transit vehicle A bus or other motor vehicle that provides public transportation (usually operated by a public agency).

Transportation Improvement Program (TIP) A three-year transportation improvement strategy required from MPOs by Congress, which includes all federally funded or regionally significant projects.

Transportation Information and Planning Support (TRIPS) A mainframe computer system designed to provide engineering, maintenance, planning, and accounting staff with highway inventory, traffic, and accident data.

Transportation Management Area (TMA) Urbanized areas with populations of 200,000 or greater are federally designated as Transportation Management Areas.

transportation management plan (TMP) A set of traffic control plans, transportation operations plans, and public information strategies for managing the work zone impacts of a project. A TMP is required for all projects to address work zone safety and mobility impacts.

Transportation Planning Studies These studies identify the current functions of a corridor and forecast future demands on the system. Data collection and public involvement are used to forecast future needs that will improve the function of a state route.

travel demand The demand travelers will make on the system based on the number and types of trips they will take and the mode and routes they will use. Local travel demand represents short trips that should be made on the local transportation system, such as intracity roads and streets. Regional travel demand represents long trips that are made on the regional transportation system, such as Interstate, regional, and/or intercity/interregional roads, streets, or highways.

traveled way The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

traveled way zone The portion of the roadway intended for the movement of people and goods, exclusive of shoulders, roadsides, on-street parking, medians and streetside zones.

traveler information Commercial and noncommercial information that informs and orients the traveling public. This includes access information for food, gas, lodging, local attractions, regional tourist attractions, roadway conditions, and construction schedules.

traveling public Motorists, motorcyclists, bicyclists, pedestrians, and pedestrians with disabilities.

trips Short trips are normally local. Long trips are normally interstate, regional, or interregional.

truck apron The optional mountable portion of the central island of a roundabout between the raised nontraversable area of the central island and the circulating roadway (see Chapter 1320).

turning radius The radius that the front wheel of the intersection design vehicle on the outside of the curve travels while making a turn (see Chapter 1320).

turning roadway A curve on an open highway, a ramp, or the connecting portion of the roadway between two intersecting legs of an intersection.

two-way left-turn lane (TWLTL) A lane, located between opposing lanes of traffic, to be used by vehicles making left turns from either direction, from or onto the roadway.

U

undivided multilane A roadway with two or more through lanes in each direction on which left turns are not controlled.

uniformity ratio The ratio of the minimum average light level on the design area to the minimum light level of the same area (see Chapter 1040).

urban area An area designated by the Washington State Department of Transportation (WSDOT) in cooperation with the Transportation Improvement Board (TIB) and Regional Transportation Planning Organizations (RTPO), subject to the approval of the Federal Highway Administration (FHWA).

urbanized area An urban area with a population of 50,000 or more.

usable shoulder The width of the shoulder that can be used by a vehicle for stopping.

V

validation A process to confirm the reasonableness, accuracy and completeness of estimated costs and quantities.

Value Engineering (VE) Analysis A systematic approach to identifying and removing unnecessary costs which do not contribute to a desired result by analyzing cost versus function.

Value Engineering Change Proposal (VECP) A construction contract change proposal submitted by the construction contractor based on a VECP provision in the contract. The intent of these types of proposals is to (1) improve the project's performance, value, and/or quality, (2) lower construction costs, or (3) shorten the delivery time, while considering their impacts on the project's overall life-cycle cost and other applicable factors.

Value Engineering (VE) Job Plan A systematic and structured action plan (see Chapter 310) for conducting and documenting the results of the VE analysis. While each VE analysis shall address each phase in the VE Job Plan, the level of analysis conducted and effort expended for each phase should be scaled to meet the needs of each individual project. The WSDOT VE analysis uses the Seven-Phase Job Plan shown in Exhibit 310-1.

veiling luminance The stray light produced within the eye by light sources produces a veiling luminance that is superimposed on the retinal image of the objects being observed. This stray light alters the apparent brightness of an object within the visual field and the background against which it is viewed, thereby impairing the ability of the driver to perform visual tasks. Conceptually, veiling luminance is the light that travels directly from the luminaire to the observer’s eye.

viewpoint A roadside stopping opportunity with a view of some point of interest or area scenery. This area is not typically separated from the traveled way by some form of highway buffer.

violation rate The total number of violators divided by the total number of vehicles on an HOV facility.

visioning exercises a process of determining the goals for a facility or place.

Visitor Information Center (VIC) A staffed or nonstaffed booth or separate building that displays and dispenses free tourist travel maps and brochures. These are typically located at border-entry SRAs to provide travel information to highway users as they enter the state.

W

warning beacon A beacon that supplements a warning or regulatory sign or marking. The display is a flashing yellow indication. These beacons are not used with STOP, YIELD, or DO NOT ENTER signs or at intersections that control two or more lanes of travel. A warning identification beacon is energized only during those times when the warning or regulation is in effect.

warrant A minimum condition for which an action is authorized. Meeting a warrant does not attest to the existence of a condition that needs attention. Further justification is required.

Washington State Pavement Management System (WSPMS) A computer system that stores data about the pavement condition of all the highways in the state. Information available includes the latest field review and past contracts for every main line mile of state highway. Calculations are used to determine whether a given section of pavement is a past due, due, or future due preservation need.

Washington Transportation Plan (WTP) A WSDOT planning document developed in coordination with local governments, regional agencies, and private transportation providers. The WTP addresses the future of transportation facilities owned and operated by the state as well as those the state does not own but in which it has an interest. It identifies needed transportation investments, which are defined by service objectives and specific desired outcomes for each transportation mode.

weaving section A length of highway over which one-way traffic streams cross by merging and diverging maneuvers.

weigh in motion (WIM) A scale facility capable of weighing a vehicle without the vehicle stopping.

wet film thickness Thickness of a pavement marking at the time of application without beads.

work zone An area of a highway with construction, maintenance, or utility work activities. A work zone is identified by the placement of temporary traffic control devices that may include signs, channelizing devices, barriers, pavement markings, and/or work vehicles with warning lights. It extends from the first warning sign or high-intensity rotating, flashing, oscillating, or strobe lights on a vehicle to the END ROAD WORK sign or the last temporary traffic control device (MUTCD).

work zone impact Highway construction, maintenance, or utility work operations in the traveled way, adjacent to the traveled way, or within the highway's right of way that creates safety and mobility concerns for workers or the traveling public.

work zone traffic control The planning, design, and preparation of contract documents for the modification of traffic patterns due to work zone impacts.

wye (Y) connection An intersecting one-way roadway, intersecting at an angle less than 60°, in the general form of a "Y."

Y

yield-at-entry The requirement that vehicles on all entry lanes yield to vehicles within the circulating roadway.

yield point The point at which entering traffic must yield to circulating traffic before entering the circulating roadway (see Chapter 1320).