Design Policy and Standards Revisions

Design Manual – November 2006 Revisions
The revision starts after page 3 of this document

Revision marks are used throughout the manual to highlight content changes. These consist of sidebars, and underlining. Manual users should periodically check the *Design Manual* Errata web page. They should also report all undocumented errors they believe they have found.

General

- Review and update references, definitions, titles, & acronyms as appropriate.
- The "Documentation" subheadings are revised to direct the reader to the Documentation Checklist on line.

Chapter 100 Manual Description

November 2006 Revision:

- Spot revisions, including emphasis on WSDOT's new Project Management On-Line Guide

Chapter 220 Project Environmental Documentation

November 2006 Revision:

- Spot revisions to statements about Design Approval and Project Development Approval (related to Ch 330 changes)

Chapter 330 Design Documentation, Approval, and Process Review

November 2006 Revision:

- Significant Revision; no revision marks provided
- New and revised Design Milestones / Terminology:
    - Design Concurrence was eliminated and replaced with Design Approval
    - Design Approval changed to Project Development Approval
- Documentation for and Evaluate Upgrade reduced and simplified.

Chapter 340 Minor Operational Enhancements

November 2006 Revision:

- Spot revision about Project Development Approval (related to Ch 330 changes)

Chapter 430 Modified Design Level

November 2006 Revision:

- Spot revisions: Added notes to figures related to shoulder width greater than 4 feet wide, can reduce up to 4 inches. (Relates to changes in Ch 710, regarding larger guardrail blockouts.)

Chapter 440 Full Design Level

November 2006 Revision:

- Spot revisions: Added notes to figures related to shoulder width greater than 4 feet wide, can reduce up to 4 inches. (Relates to changes in Ch 710, regarding larger guardrail blockouts.)

Chapter 640 Geometric Cross Section

November 2006 Revision:

- Spot revisions: Allows a normal crown slopes of 1.5 – 2.5%, with justification.

Chapter 641 Turning Roadways

November 2006 Revision:

- Spot revisions
- Figures 641-1a & 1b revised.
- Figures 641-2b, 3b, and 3c recreated.

Chapter 710 Traffic Barriers

November 2006 Revision:

- Chapter rewritten; no revision marks provided.

A summary of changes to Chapter 710 are outlined below:

- High tension cable barrier systems added
- Cable barrier placement / offset requirements revised
- Beam guardrail height tolerance revised
- 31” guardrail designs added
- 42” concrete barrier design requirements expanded considering FHWA memo HSA-10
- Low profile barrier added
- Barrier placement cases added
- Use of low profile barrier language added
- Existing terminal usage language added considering FHWA memo HSA-10
- Anchored precast concrete barrier usage revised
- Curb and barrier guidance revised
- Errata corrections from last revision addressed
- Existing figures corrected / updated

Chapter 810 Work Zone Safety and Mobility (new title)

November 2006 Revision:

- Chapter rewritten (no revision marks) to implements FHWA's final Rule 23 CFR 630 Subpart J, Work Zone Safety and Mobility.

Chapter 840 Illumination

November 2006 Revision:

- Chapter rewritten (no revision marks) to reflect current highway design standards and requirements of the National Electric code

Chapter 940 Traffic Interchanges

November 2006 Revision:

- Spot revision referencing Chapter 1425 (Interchange Justification Reports)

Chapter 1020 Bicycle Facilities

November 2006 Revision:

- Removed planning information, replaced with reference to *Understanding Flexibility in Transportation Design - Washington*
- Removed signing and striping duplicated in the MUTCD
- Revised the barrier height figure to show heights off of bridges, with a note to contact the bridge office for the design on bridges.
- Where pedestrian design controls on a shared-use path, design criteria replaced with a reference to Chapter 1025.

Chapter 1130 Retaining Walls and Steep Reinforced Slopes

November 2006 Revision:

- Minor spot revision regarding wall approval.

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Instructions:
Page numbers and corresponding sheet-counts are given in the table below to indicate portions of the *Design Manual* that are to be removed and inserted to accomplish this revision.

Chapter	Remove		Insert	
	Page Numbers	Sheets	Page Numbers	Sheets
Letter's List	N/A	1	N/A	1
Contents	1 – 26	13	1 - 25	13
100, "Manual Description"	1 – 7	4	1 – 7	4
140, "Managing Project Delivery" **(Remove Chapter)**	1 – 16	8	N/A	N/A
220, "Project Environmental Documentation"	1 – 2	1	1 – 2	1
330, "Design Documentation, Approval and Process"	1 – 15	8	1 – 16	8
340, "Minor Operational Enhancement Projects"	5 – 6	1	5 – 6	1
430, "Modified Design Level"	9 – 10	1	9 – 10	1
430, "Modified Design Level"	15	1	15	1
440, "Full Design Level"	5 – 18	7	5 – 18	7
640, "Geometric Cross Section"	1 – 21	11	1 - 21	11
641, "Turning Roadways"	1 – 9	5	1 – 9	5
710, "Traffic Barriers"	1 – 28	14	1 – 29	15
810, "Work Zone Safety and Mobility" **(New Title)**	1 – 20	10	1 – 45	23
840, "Illumination"	1 – 16	8	1 – 41	21
940, "Traffic Interchanges"	1 – 2	1	1 – 2	1
1020, "Bicycle Facilities"	1 – 32	16	1 – 27	14
1130, "Retaining Walls and Steep Reinforced Slopes"	11 – 14	2	11 – 14	2
Index	1 – 18	9	1-19	10

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Design Manual Supplements and Instructional Letters

November, 2006

In Effect	Chapter	Date	Type	Subject/Title
Yes Yes	820 850	8/5/2005	DM Supplement	Overhead Sign Illumination (Lighting)
Yes	860	12/30/2005	DM Supplement	Systems Engineering for Intelligent Transportation Systems
Yes	1120	4/24/2006	DM Supplement	Vertical Falsework Clearance for Bridges Over Highways

Notes:

- Changes since the last revision to the *Design Manual* are shown in bold print.
- Items with **No** in the **In Effect** column were superseded by the latest revision and will be dropped from the next printing of this list.
- The listed items marked **Yes** have been posted to the web at the following location:

http://www.wsdot.wa.gov/eesc/design/policy/pdf/DMSupplementLettersList/NOVEMBER2006DMSupplementLettersList.pdf

Contents

Date

Division 1 General Information

Division 2 Hearings, Environmental, and Permits

Division 3 Project Documentation

Division 4 Project Design Criteria

Division 5 Soils and Paving

Division 6 Geometrics

Division 7 Roadside Safety Elements

Division 8 Traffic Safety Elements

Division 9 Interchanges and Intersections

Division 10 Auxiliary Facilities

Division 11 Structures

Division 12 Hydraulics

Division 13 Roadside Development

Division 14 Right of Way and Access Control

Figures

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, it will facilitate the development of a highway system consistent with the needs of the 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*; adherence to the guidance presented, therefore, is not optional for state highway projects.

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

For design questions beyond the scope of the *Design Manual*, contact the Headquarters (HQ) Design Office.

100.02 Presentation and Revisions

The *Design Manual* is available in an up-to-date format on the Internet. It can be accessed through the WSDOT home page, the Design Policy page, or the Engineering Publications Online Library home page. Opening the manual on the Internet can take considerable time. However, it provides the ability to conduct a word search of the whole manual. Opening an individual chapter is faster, but a word search is limited to that chapter.

The *Design Manual* is also available on "Engineering Publications CD Library" (a CD-ROM). The CD is up-to-date as of the date of production. Hard-copy editions are available on a department cost-recovery basis (free to WSDOT employees).

The *Design Manual* is continually revised to reflect changing processes, procedures, regulations, and organizations. Feedback from users is encouraged to improve the manual for everyone. For example, material that is unclear to one user will most likely be unclear to others.

Engineering Publications maintains a list of people interested in receiving e-mail notification when a revision is being distributed. Comments may be submitted by any method that is convenient for the user. There is a Comment Form in the manual, as well as online at the Design Policy Internet page.

A Contents section is provided at the front of the *Design Manual* that lists all chapters, their major headings, and the last revision dates on the pages. There is also a list of all figures, with their page numbers and dates. The dates are provided to aid in determining whether a manual or page is up-to-date. By comparing a printed book or CD file to the manual on the Internet, the date in the footer of the Contents pages will indicate whether the latest revision is in place.

The *Design Manual* is divided into general divisions that contain specialized chapters and an index at the back of the manual.

Each chapter provides a list of the references that are the basis for the information in the chapter, including laws, administrative codes, manuals, and other publications. Each chapter provides definitions for the specialized vocabulary used in the chapter, particularly when a word or phrase has more than one dictionary meaning.

The index lists all significant chapter subheadings, other items selected by the chapters' authors and contributors, and many items suggested by users. Suggestions are helpful because one user's search might help other users later.

100.03 *Design Manual* Applications

The *Design Manual* guidance is provided to encourage uniform application of design details under normal conditions throughout the state. 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) policy and federal and state laws; to develop projects to meet driver expectations; and to balance the benefits and costs of highway construction projects. This manual is designed to allow for flexibility in design for specific and unusual situations. For unusual circumstances, the *Design Manual* provides mechanisms for documenting the reasons for the choices made.

The *Design Manual* supplements engineering analysis and judgment; it is not intended as an engineering textbook. The manual is developed for use on state highways and it may not be suitable for projects on county roads or city streets.

100.04 How the *Design Manual* is to be Used

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 the Revised Code of Washington (RCW) 47.17.

For state highway routes, all projects must be designed using the geometric control criteria (see Chapters 325 and Division Four) in the *Design Manual*. If WSDOT guidance is not used on a project, appropriate documentation and approvals are required. (See Chapters 325 and 330).

When WSDOT designs facilities to 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, this 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.

100.05 The Project Development Process

The *Design Manual* addresses the project development process from programming through the <u>Project Development</u> Approval. The *Design Manual* is a comprehensive guide to the design of transportation projects; however, the full extent of project development is beyond the scope of the *Design Manual*. The following paragraphs provide a brief summary to assist the designer in understanding the relationship between planning, programming, and design at WSDOT.

Project development is a multi-disciplinary effort that develops the needs identified in the *Washington State Highway System Plan* (HSP) and subsequent planning studies in sufficient detail to produce a set of contract documents. This process bridges the gap from project concept to project construction. The project definition documents provide the framework for further development of the project scope, schedule and estimate, and record key decisions made early in the project development process. Final project design decisions are archived in the Design Decision Package (DDP). The contract documents provide sufficient detail to enable contractors to construct the project.

A global understanding of the overall project development process is important in order to eliminate corrective modifications or rework in the later stages of project implementation. Project modifications and rework are not only costly, they also impact delivery commitments made to the Legislature and the public. Integrating planning, program management, and project delivery are vital to efficient and successful delivery of transportation projects. These projects must have information and processes that flow seamlessly between the planning and the implementation phases of a project. A level of analysis guideline (a series of questions addressed to the design engineer) has been developed to address common areas where a lack of information has caused significant changes late in the design process. (See the web site: http://wwwi.wsdot.wa.gov/ppsc/pgmmgt/scoping/LevelAnalysis.pdf)

The HSP is the modal element of the *Washington Transportation Plan* (WTP) that addresses the state's highway system. The HSP, managed by the WSDOT HQ Systems Analysis and Program Development Office, includes a comprehensive assessment of existing and projected 20-year needs on the Washington State highway system. Freight, mobility, safety, bicycle, and pedestrian issues are among the 20-year needs. The HSP also lists potential solutions addressing these needs.

The HSP identifies four major programs that are used to manage the state-owned transportation system. These are:

- Maintenance Program (M)
- Operations Program (Q)
- Preservation Program (P)
- Improvement Program (I)

HQ Systems Analysis and Program Development staff begins programming the Preservation and Improvement programs for the highway construction program by sending out to the WSDOT regions the list of needs for each action strategy identified in the department's *Highway System Plan*. Each region takes the lists of needs and performs an engineering analysis on each need, in order, based on the programming instructions. They must develop a project alternative(s) consistent with the department's design matrices, estimate the cost to accomplish that work, and determine the resulting benefits (what performance change can be achieved).

Based on the resulting benefit to cost ratio (b/c), the projects are prioritized based on the highest to lowest ratio for each system plan strategy. Following this step, HQ Program Development develops different budget scenarios for the available investment dollars for the next 2- to 6-year period.

WSDOT has a responsibility to develop a 6-year highway construction program based on projected revenues (RCW 47.05 - Priority programming for highway development). This effort begins by using the Project Summary process to develop an accurate scope, accurate schedule, and accurate budget. Included in the Project Summary are:

- A project definition
- An Environmental Review Summary/ Environmental Classification Summary
- A cost estimate
- A Design Decision Summary, when required for the project type

In addition, WSDOT develops a 10-year Capital Improvement and Preservation Program (CIPP) that includes a listing, cost estimate, and brief description of every capital improvement project in progress or to be in progress over the next 10-years. The CIPP is adopted by the Transportation Commission and submitted to the Governor and, ultimately, by the Governor to the Legislature. The CIPP is updated each biennium.

Program development staff in the regions work closely with region project development staff to identify projects where preliminary engineering funds are available to develop the contract documents. As these funds become available, the Project Development Engineers are notified, and a Project Engineer is identified to lead the project development process. At this point, the Project Engineer assembles a design team and goes to work on development of the project documents.

Design teams and managers are encouraged to use the WSDOT Project Management On-Line Guide to map out the direction and the expectations for the project. The guide is located at: http:www.wsdot.wa.gov/Projects/ProjectMgmt/Process.htm

The planning study recommendations are used to develop the Project Definition. Following the project definition and required hearings or public involvement, a set of Plans, Specifications and Estimates (PS&E) is completed and used to advertise the project for construction.

The key to maintaining consistency from the planning stage into project construction is to rely on good communication between the planning offices, program management, design engineers, support functions, and the construction office. In general, communication should be thought of as constant and bi-directional. There are always many opportunities throughout the life of a project for these communications to take place.

100.06 How the *Design Manual* is Organized

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

Division One presents general background on the processes that precede project design. These include planning, managing project delivery, project development, and programming.

- Chapter 100–Manual Description: Informs the designer about content and resources within the *Design Manual*.
- Chapter 120–Planning: Informs the designer about resources that can provide critical information relating to the corridor in which the project resides, such as Corridor Studies and Route Development Plans.
- Chapter 141–Project Development Roles and Responsibilities for Projects with Structures: Presents the project development process used by WSDOT to determine the roles and responsibilities for projects with structures during the project development phase of a project.
- Chapter 150–Project Development Sequence: Describes the Project Development sequence from the *Washington Transportation Plan* (WTP) through the contract document, with emphasis on the Project Summary and Change Management process.

Division Two 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: Informs the designer about developing a public involvement plan that meets the specific needs of the project; the ingredients of an effective public involvement plan; and methods for public involvement.
- Chapter 220–Project Environmental Documentation: Provides the designer with elementary background on the environmental documentation process and the many requirements.
- Chapter 240–Environmental Permits and Approvals: Explains permits that may be required for highway and bridge projects.

Division Three provides designers with information on value engineering, design matrices, design documentation, and approvals.

- Chapter 315–Value Engineering: A systematic multi-disciplinary process study early in the project design to provide recommendations to improve scope, functional design, constructability, environmental impacts, or project cost. Value Engineering studies are required by federal law for high-cost, complex projects.
- Chapter 325–Design Matrix Procedures: Includes five figures that provide consistency across projects according to funding type and highway system. Each design matrix sets forth the level of development for a given type of need, which would be automatically approved by the department and FHWA. Deviating from the matrix requires approval. The Design Matrix figures assist the designer to apply the appropriate design level for the majority of improvement and preservation projects.
- Chapter 330–Design Documentation, Approval, and Process Review: Covers building the Project File (PF), and the Design Documentation Package (DDP). The Project File and Design Documentation Package record the recommendations

and decisions that lead to a project by preserving the documents from planning, scoping, programming, and design phases, including permits, approvals, contracts, utility relocation, right of way, advertisement, award, and construction for a project.

- Chapter 340–Minor Operational Enhancement Projects: Provides design matrices for low-cost, quick-fix projects that improve the operation of a state highway facility.

Division Four includes project design criteria for basic design, modified design, and full design that are part of the design matrices in Chapter 325.

- Chapter 410–Basic Design Level: Contains the required basic safety work and minor preservation and safety work included in the preservation of pavement structures and pavement service life, while maintaining safe operation of the highway.
- Chapter 430–Modified Design Level: Provides the design guidance that is unique to the Modified Design Level of preserving and improving existing roadway geometrics, safety and operational elements.
- Chapter 440–Full Design Level: Provides guidance for the highest level of highway design, to improve roadway geometrics, safety and operational elements. Full Design Level is used on new and reconstructed highways.

Division Five presents guidance for investigating soils, rock, and surfacing materials, estimating tables, and guidance and criteria for the use of geosynthetics.

- Chapter 510–Investigation of Soils, Rock, and Surfacing Materials: Describes the requirements for qualifying a materials source, geotechnical investigations, and the documentation to be included in the Project File.
- Chapter 520–Design of Pavement Structures: Provides estimating tables for the design of pavement structures.
- Chapter 530–Geosynthetics: Introduces the types and applications of geosynthetic drainage, earthwork, erosion control, and soil reinforcement materials.

Division Six covers an introduction to highway capacity; geometric plan elements; horizontal alignment; lane configurations and pavement transitions; geometric profile elements; vertical alignment; geometric cross sections; and sight distance.

- Chapter 610–Traffic Analysis: Provides the designer with a basic and limited introduction to highway capacity.
- Chapter 620–Geometric Plan Elements: Provides guidance on the design of horizontal alignment, lane configuration, and pavement transitions.
- Chapter 630–Geometric Profile Elements: Furnishes guidance for the design of vertical alignment.
- Chapter 640–Geometric Cross Section: Introduces the designer to roadway width, superelevation, and slope design.
- Chapter 641–Turning Roadways: Provides guidance for widening curves to make the operating conditions comparable to those on tangent sections.
- Chapter 642–Superelevation: Provides guidance on superelevating curves and ramps so that design speeds can be maintained.
- Chapter 650–Sight Distance: Addresses passing, stopping, and decision sight distance design elements.

Division Seven addresses design considerations for the area outside of the roadway, and includes clear zone, roadside hazards, safety mitigation, traffic barriers, and impact attenuator systems.

- Chapter 700–Roadside Safety: Presents clear zone design, roadside hazards to consider for mitigation, and some roadside safety features.
- Chapter 710–Traffic Barriers: Provides guidance for the design of traffic barriers based on the design levels identified in the Design Matrices.
- Chapter 720–Impact Attenuator Systems: Introduces the designer to permanent and work zone impact attenuator systems.

Division Eight 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 810–Work Zone Safety and Mobility: Addresses the planning, design, and preparation of highway improvement and preservation project plans for modification of traffic patterns during construction.
- Chapter 820–Signing: Presents the use of signing to regulate, warn, and guide motorists.
- Chapter 830–Delineation: Presents the use of pavement markings to designate safe traffic movement.
- Chapter 840–Illumination: Provides guidance on the use of illumination on state highway construction projects.
- Chapter 850–Traffic Control Signals: Offers the designer guidance in the use of power-operated traffic control devices that warn or direct traffic.
- Chapter 860–Intelligent Transportation Systems (ITS): Provides guidance on applying computer and communication technology to optimize the safety and efficiency of the highway system by providing motorists timely traffic condition information.

Division Nine addresses the design considerations of at-grade intersections, roundabouts, road approaches, railroad grade crossings, and traffic interchanges.

- Chapter 910–Intersections At-Grade: Provides guidance for designing intersections at-grade, including at-grade ramp terminals.
- Chapter 915–Roundabouts: Instructs the designer on the design of roundabouts.
- Chapter 920–Road Approaches: Informs the designer about the application and design of road approaches on state highways in unincorporated areas, and in incorporated areas where limited access rights have not been acquired.
- Chapter 930–Railroad Grade Crossings: Addresses the requirements associated with highways crossing railroads.
- Chapter 940–Traffic Interchanges: Provides guidance in the design of interchanges on Interstate highways, freeways, and other multilane divided routes.

Division Ten offers guidance on auxiliary lanes such as climbing lanes and passing lanes; bicycle facilities; pedestrian design considerations; safety rest areas and traveler services; weigh stations; high occupancy vehicle lanes; and transit benefit facilities.

- Chapter 1010–Auxiliary Lanes: Provides guidance on auxiliary facilities such as climbing lanes, passing lanes, slow vehicle turnouts, shoulder driving for slow vehicles, emergency escape ramps, and chain-up areas.
- Chapter 1020–Bicycle Facilities: Serves as a guide for selecting and designing useful and cost-effective bicycle facilities.
- Chapter 1025–Pedestrian Design Considerations: Supplies guidance for designing facilities that encourage safe and efficient pedestrian access.
- Chapter 1030–Safety Rest Areas and Traveler Services: Provides typical layouts for Safety Rest Areas.
- Chapter 1040–Weigh Sites: Provides guidance for the design of permanent, portable, and shoulder-sited weigh sites.
- Chapter 1050–High Occupancy Vehicle Facilities: Presents guidance on evaluating and designing high occupancy vehicle (HOV) facilities.
- Chapter 1060–Transit Benefit Facilities: Provides operational guidance and information for designing transit benefit facilities such as park-and-ride lots; transfer/transit centers; and bus stops and pullouts.

Division Eleven provides guidance for the design of structures for highway projects, including site data for structures, bridges, retaining walls, and noise walls.

- Chapter 1110–Site Data for Structures: Describes the information required by the WSDOT HQ Bridge and Structures Office to provide structural design services.
- Chapter 1120–Bridges: Provides basic design considerations for the development of a preliminary bridge plan and guidelines on basic bridge geometric features.
- Chapter 1130–Retaining Walls and Steep Reinforced Slopes: Provides design principles, requirements, and guidelines for retaining walls and steep reinforced slopes.
- Chapter 1140–Noise Barriers: Addresses the factors that are considered when designing a noise barrier.

Division Twelve 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 1210–Hydraulic Design: Addresses hydraulic considerations for highway projects involving flood plains, stream crossing, channel changes, and ground water.

Division Thirteen provides guidance on the portion of state highways between the traveled way and the right of way boundary.

- Chapter 1300–Roadside Development: Presents guidance on 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 storm water treatment facilities.
- Chapter 1310–Contour Grading: Provides guidance for contour grading, which is an important element in achieving operational, environmental, and visual functions.
- Chapter 1320–Vegetation: Provides a discussion of the use of vegetation in the roadside environment and directs the designer to the Landscape Architect.
- Chapter 1330–Irrigation: Presents design considerations for irrigation on highway projects.
- Chapter 1350–Soil Bioengineering: Offers a discussion of bioengineering and design considerations for the use of bioengineering techniques on highway projects.

Division Fourteen provides guidance on right of way considerations; access point decision reports; limited and managed access; surveying and mapping; monumentation; and fencing.

- Chapter 1410–Right of Way Considerations: Explains the right of way and easement acquisition process.
- Chapter 1420–Access Control: Introduces the WSDOT Access Control program.
- Chapter 1425–Interchange Justification Report: Describes the process for access point revisions on state highways and explains the steps for producing an Interchange Justification Report.
- Chapter 1430–Limited Access: Provides clarification on limited, full, and modified access control.
- Chapter 1435–Managed Access: Explains the classes of managed access and the permitting process, and provides design considerations.
- Chapter 1440–Surveying and Mapping: Introduces the procedures within WSDOT for project surveying.
- Chapter 1450 Monumentation: Introduces monumentation requirements and procedures.
- Chapter 1460 Fencing: Introduces fencing, the purpose of fencing, the types of fencing, and fencing design criteria.

Chapter 220 Project Environmental Documentation

220.01 Introduction

The term "environmental documentation" refers to the documents produced for a project to satisfy the requirements contained in the National Environmental Policy Act (NEPA) and the State Environmental Policy Act (SEPA). The *Environmental Procedures Manual,* M 31-11 provides detailed instructions on how to determine what level of documentation is required and how to prepare the documents. This section provides a summary of the relevant provisions in the *Environmental Procedures Manual*.

The purpose of the environmental document is to provide decision-makers, agencies, and the public with information on a project's environmental impacts, alternatives to the proposed action, and mitigation measures to reduce unavoidable impacts. Final environmental documents identify and evaluate the project to be constructed. Because projects vary in their level of environmental impacts, the rules on environmental documentation allow for different levels of documentation. As a project's impacts increase, so does the level of documentation.

The environmental office in each region and the Environmental Documentation Section of the WSDOT Headquarters (HQ) Environmental Services Office routinely provide environmental documentation assistance to designers and project engineers.

220.02 References

United States Code (USC) 42 USC Chapter 55 National Environmental Policy Act of 1969 (NEPA)

Code of Federal Regulation (CFR) 23 CFR 771 Environmental Impact and Related Procedures

23 CFR 771.135 Section 4(f) (49 U.S.C. 303). Policy on Lands, Wildlife and Waterfowl Refuges, and Historic Sites

36 CFR 800: PART 800-Protection of Historic and Cultural Properties

40 CFR Parts 1500 – 1508 Council for Environmental Quality Regulations for Implementing NEPA

Revised Code of Washington (RCW) 43.21C State Environmental Policy Act (SEPA)

Washington Administrative Code (WAC) 197-11 SEPA Rules

Washington Administrative Code (WAC) 468-12 WSDOT SEPA Rules

Environmental Procedures Manual, M 31-11, WSDOT

220.03 Definitions / Acronyms

Categorical Exclusion (CE) (NEPA) or Categorical Exemption (CE) (SEPA) Actions that do not individually or cumulatively have a significant effect on the environment.

DCE Documented Categorical Exclusion (NEPA)

Determination of Non-significance (DNS) (SEPA) The written decision by the Region 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 Region Administrator that a proposal could have a significant adverse impact and that an EIS is required.

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 if an EIS or a FONSI should be prepared.

Environmental Classification Summary (ECS) A form used to evaluate and classify projects for the construction program. The ECS supports a decision of a documented CE.

Environmental Impact Statement (EIS) A detailed written statement of a proposed course of action, project alternatives and the possible impacts of the proposal.

Environmental Review Summary (ERS) Part of the project summary document, it identifies environmental permits and approvals. The ERS is prepared in the region and is required for Design Approval.

Finding Of No Significant Impact (FONSI) (NEPA) A federal document indicating that a proposal will not significantly affect the environment and that an EIS is not required.

NEPA National Environmental Policy Act

ROD Record Of Decision

SEPA State Environmental Policy Act

220.04 Determining the Environmental Document

The Environmental Review Summary (ERS) provides the first indication of what form the environmental documentation will take. The ERS is prepared as part of the Project Summary. Project Summaries are prepared during the scoping phase of all projects in the construction program. The Project Summary includes three components:

- Project Definition
- Design Decisions Summary
- Environmental Review Summary

The ERS form is found in the Project Summary database in each regional office. The *Environmental Procedures Manual* has detailed instructions on how to prepare the ERS. The process for classifying projects and determining the environmental document is similar for NEPA and SEPA and generally is as follows:

- Once the project has been sufficiently developed to assess any environmental impacts, the region completes the ERS based on the best information available at the scoping phase of development.
- The Regional Environmental Manager then concurs with the classification by signing the ERS and returns the completed form to the region Design Office for inclusion in the Project Summary package.
- For NEPA, if a project has been determined to be a Categorical Exclusion (CE) the NEPA environmental review process is considered complete. If it is determined that a Documented Categorical Exclusion (DCE), Environmental Assessment (EA), or Environmental Impact Statement (EIS) is required, the region evaluates the project schedule and arranges for preparation of the appropriate document.
- For SEPA, the signing and submittal of the ERS completes the environmental classification process. On projects that are categorized as exempt from SEPA, the environmental process is complete, unless the project requires consultation under the Endangered Species Act. On projects that do not meet the criteria for a SEPA Categorical Exemption (WAC 197-11-800 and WAC 468-12) and require a SEPA checklist (WAC 197-11-960) or an EIS, those documents are prepared as necessary prior to Project Development Approval.

The ERS allows environmental staff to consider at this early stage potential impacts and mitigations, and required permits. For many projects, the WSDOT Environmental GIS Workbench coupled with a site visit provide sufficient information to fill out the ERS. (See the *Environmental Procedures Manual.*)

Chapter 330 Design Documentation, Approval, and Process Review

330.01 General

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. Portions of the Project File that are not designated as components of the Design Documentation Package (DDP) may be purged when retention of the construction records is no longer necessary.

The Design Documentation Package is a part of the Project File. It documents and justifies design decisions and the design process that was followed. The Design Documentation Package is retained in a permanent, retrievable file for a period of 75 years, in accordance with Washington State Department of Transportation (WSDOT) records retention policy.

For operational changes and developer projects, design documentation is required and is retained by the region office responsible for the project, in accordance with WSDOT records retention policy. All participants in the design process must provide the appropriate documentation for their decisions.

330.02 References

Federal/State Laws and Codes

Code of Federal Regulations (CFR) 23 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, as implemented in the design matrices (Chapter 325)

Design Guidance

Advertisement and Award Manual, M 27-02, WSDOT

Directional Documents Index, WSDOT, at: http://wwwi.wsdot.wa.gov/docs/

Executive Order E 1010.00, "Certification of Documents by Licensed Professionals," WSDOT

Hydraulics Manual, M 23-03, WSDOT

Master Plan for Limited Access Highways, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Roadside Classification Plan, M 25-31, WSDOT

Route Development Plan, WSDOT

Washington State Highway System Plan, WSDOT

Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

330.03 Definitions

Design Approval Documented approval of the design criteria, which becomes part of the Design Documentation Package. This approval is an endorsement of the design criteria by the designated representative of the approving organization, as shown in Figures 330-2a and 2b.

design exception (DE) Preauthorization to omit correction of an existing design element for various types of projects, as designated in the design matrices. (See Chapter 325.) A DE designation indicates that the design element is normally outside the scope of the project type. (See Figure 330-1.)

design variance A recorded decision to differ from the design level specified in the *Design Manual*, such as an Evaluate Upgrade (EU) not upgraded, a DE, or a deviation. EUs leading to an upgrade are documented but are not considered to be variances. A project or corridor analysis may also constitute a design variance if that analysis leads to a decision to use a design level or design classification that differs from what the *Design Manual* specifies for the project type.

Design Variance Inventory (DVI) A list of design elements that will not be improved in accordance with the *Design Manual* criteria designated for the project.

Design Variance Inventory System (DVIS) A database application developed to generate the DVI form. The DVIS also provides query functions, giving designers an opportunity to search for previously granted variances. The DVIS application can be accessed at: http://www.wsdot.wa.gov/eesc/design/projectdev/

deviation A documented decision granting approval at project-specific locations to differ from the design level specified in the *Design Manual*. (See Figures 325-3 through 7 and Figure 330-1.)

environmental documents:

- ***NEPA*** National Environmental Policy Act
- ***SEPA*** [Washington] State Environmental Policy Act
- ***CE*** NEPA: Categorical Exclusion
- ***CE*** SEPA: Categorical Exception
- ***EA*** Environmental Assessment
- ***ECS*** Environmental Classification Summary
- ***EIS*** Environmental Impact Statement
- ***ERS*** Environmental Review Summary
- ***FONSI*** Finding Of No Significant Impact
- ***ROD*** Record of Decision

evaluate upgrade (EU) A decision-making process to determine whether or not to correct an existing design element as designated in the design matrices. Documentation is required. (See Figure 330-1.)

FHWA Federal Highway Administration.

HQ The Washington State Department of Transportation Headquarters organization.

Project Control Form A form used to document and approve revisions to project scope, schedule, or budget, from a previously approved 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 Figures 330-2a and 2b.)

Project File (PF) A file containing all documentation and data for all activities related to a project. (See 330.01 and 330.04.)

- ***Design Documentation Package (DDP)*** The portion of the Project File, including 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 this chapter. Common components are listed in Figure 330-5. Technical reports and calculations are part of the Project File, but are not designated as components of the DDP. Include estimates and justifications for decisions made in the DDP. (See 330.04(2).) The DDP explains how and why the design was chosen, and documents approvals. (See 330.01.)

Project Summary A set of electronic documents consisting of the Design Decisions Summary (DDS), the Environmental Review Summary (ERS), and the 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 330.06.)

- ***Design Decisions Summary (DDS)*** An electronic document that records major design decisions regarding roadway geometrics, roadway and roadside features, and other issues that influence the project scope and budget.
- ***Environmental Review Summary (ERS)*** An electronic document that records the environmental requirements and considerations for a specific project.
- ***Project Definition (PD)*** An electronic document that records the purpose and need of the project, along with program level and design constraints.

scoping phase The first phase of project development for a specific project. It follows identification of the need for a project and precedes detailed project design. It is the process of identifying the work to be done and developing a cost estimate for completing the design and construction. The Project Summary, engineering and construction estimates, and several technical reports (geotechnical, surfacing, bridge condition, etc.) are developed during this phase.

330.04 Design Documentation

(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.

The DDP identifies the purpose and need of the project and documents how the project addresses the purpose and need. The "Project Design Documentation Check List" has been developed as a tool to assist in generating the contents of the DDP and the PF. The use of this tool is optional and can be found at:
http://www.wsdot.wa.gov/eesc/design/projectdev/

(2) Design Documents

The DDP portion of the PF preserves the decision documents generated during the design process. In each package, a summary (list) of the documents is recommended.

The design documents commonly included in the PF and DDP for all but the simplest projects are listed in Figure 330-5.

Documentation is not required for components not related to the project.

The DVI is *required* for all projects on the National Highway System (NHS) having design variances; it is recommended for all projects having design variances. The DVI lists all EU not upgraded to the applicable design level, DE, and deviations as indicated by the design matrices. Record variances resulting from a project or corridor analysis in the DVI. Use the DVIS database application to record and manage design variances. The DVIS is available at:
http://www.wsdot.wa.gov/eesc/design/projectdev/

The ERS and the PD are required for most projects. Exceptions will be identified by the Project Control and Reporting Office.

The DDS is not required for the following project types unless they involve reconstructing the lanes, shoulders, or fill slopes. Since these and some other project types are not included in the design matrices, evaluate them with respect to modified design level (M) for non-NHS routes and full design level (F) for NHS routes. Include in the evaluation only those design elements specifically impacted by the project. Although the following list illustrates some of the project types that do not require a DDS, the list is not intended to be a complete accounting of all such projects. Consult with the HQ Project Control and Reporting Office for projects not included in the list.

- Bridge painting
- Crushing and stockpiling
- Pit site reclamation
- Lane marker replacement
- Guidepost replacement
- Signal rephasing
- Signal upgrade
- Seismic retrofit
- Bridge joint repair
- Navigation light replacement
- Signing upgrade
- Illumination upgrade
- Rumble strips
- Electrical upgrades
- Major drainage
- Bridge scour
- Fish passage
- Other projects as approved by the HQ Design Office

(3) Certification of Documents by Licensed Professionals

All original technical documents must bear the certification of the responsible licensee. (See Executive Order E 1010.00.)

(4) Design Exception (DE), Evaluate Upgrade (EU), and Deviation Documentation

In special cases, projects may need to address design elements, which are shown as blank cells in a design matrix. (See Figure 330-1.) These special cases must be coordinated with the appropriate Assistant State Design Engineer (ASDE) and the HQ Project Control and Reporting Office. When this is necessary, document the reasons for inclusion of that work in your project.

When the design matrices specify a DE for a design element, the DE documentation must specify the matrix and row, the design element, and the limits of the exception. When a DVI is required for the project, the DE locations must be recorded in the inventory.

The EU process determines if an item of work will or will not be done, through analysis of factors such as benefit/cost, route continuity, accident reduction potential, environmental impact, and economic development. Document all EU decisions to the DDP using the list in Figure 330-6 as a guide for the content. The cost of the improvement must always be considered when making EU decisions. EU examples on the Internet can serve as models for development of EU documentation. The appropriate approval authority for EUs is designated in Figures 330-2a and 2b.

Deviation requests are stand-alone documents requiring enough information and project description for an approving authority to make an informed decision of approval or denial. Documentation of a deviation must contain justification and must be approved at the appropriate administrative level, as shown in Figures 330-2a and 2b. Submit the request as early as possible because known deviations are to be approved prior to Project Development Approval or Intersection/Interchange Plan approval.

When applying for deviation approval, it is necessary to provide two explanations. The first identifies the design element and explains why the design level specified in the design matrices was not or cannot be used. The second provides the justification for the design that is proposed. Justification for a deviation must be supported by at least two of the following:

- Accident history and accident analysis
- Benefit/cost analysis
- Engineering judgment
- Environmental issues
- Route continuity

Engineering judgment includes a reference to another publication, with an explanation of why that reference is applicable to the situation encountered on the project.

If the element meets current AASHTO guidance adopted by FHWA, such as *A Policy on Geometric Design of Highways and Streets*, but not the *Design Manual* criteria, it is a deviation from the *Design Manual* that does not require

Matrix Cell Content	Project corrects design elements that do not conform to specified design level	Document to file[1]	Record in DVIS[2]
Blank cell in design matrix		No[3]	No
Cell Entry			
Full (F), Modified (M), or Basic (B) (with no DE or EU qualifiers)	Yes	No	No
	No[4]	Yes[5]	Yes
Design Exception (DE)	Yes[3]	DDP	No
	No	DDP	Yes
Evaluate Upgrade (EU)[5]	Yes	DDP	No
	No	DDP	Yes

DDP = Document to Design Documentation Package

Notes:
[1] See 330.04(3).
[2] See 330.04(2).
[3] Document to the DDP if the element is included in the project as identified in the Project Summary or Project Control Form.
[4] Nonconformance with specified design level (see Chapter 325) requires an approved deviation.
[5] Requires supporting justification. See 330.04(4).

Design Matrix Documentation Requirements
Figure 330-1

approval by FHWA or the HQ Design Office. However, it only requires documentation and justification in the DDP to support the use of the AASHTO guidance. The following documentation is required:

- Identify the design element
- Explain why the design level specified in the design matrices was not used
- Explain which AASHTO guidance was used (including the title of the AASHTO guidance, the publication date, and the chapter and page number of the guidance)

Deviation approval is at the appropriate administrative level, as shown in Figures 330-2a and 2b.

Reference a corridor or project analysis as supporting justification for design deviations dealing with route continuity issues. (See Chapter 325.)

Once a deviation is approved, it applies to that project only. When a new project is programmed at the same location, the subject design element must be reevaluated and either (1) the subject design element is rebuilt to conform with the applicable design level, or (2) a new deviation is developed, approved, and preserved in the DDP for the new project. Check the DVIS for help in identifying previously granted deviations.

A change in a design level resulting from an approved *Route Development Plan* or a corridor or project analysis, as specified in design matrix notes, is documented similar to a deviation. Design elements that do not comply with the design level specified in an approved corridor or project analysis are documented as deviations.

To prepare a deviation request, use the list in Figure 330-7 as a general guide for the sequence of the content. The list is not all-inclusive of potential content and it might include suggested topics that do not apply to a particular project. Design deviation examples can be found at: http://www.wsdot.wa.gov/eesc/design/projectdev/

330.05 Project Development

In general, the region initiates the development of a specific project by preparing the Project Summary. Some project types may be initiated by other WSDOT groups such as the HQ Bridge and Structures Office or the HQ Traffic Office, rather than the region. The project coordination with other disciplines (such as Real Estate Services, Roadside and Site Development, Utilities, and Environmental) is started in the project scoping phase and continues throughout the project's development. The region coordinates with state and federal resource agencies and local governments to provide and obtain information to assist in developing the project.

The project is developed in accordance with all applicable Directives, Instructional Letters, Supplements, and manuals; the *Master Plan for Limited Access Highways*; the *Washington State Highway System Plan*; the *Route Development Plan*; the Washington Federal-Aid Stewardship Agreement, as implemented in the design matrices (see Chapter 325); and the Project Summary.

The region develops and maintains documentation for each project. The Project File includes documentation of project work including planning; scoping; public involvement; environmental action; design decisions; right of way acquisition; Plans, Specifications, and Estimates (PS&E) development; project advertisement; and construction. Refer to the *Plans Preparation Manual* for PS&E documentation.

All projects involving FHWA action require NEPA clearance. Environmental action is determined through the ECS form. The environmental approval levels are shown in Figures 330-3a and 3b.

Upon receipt of the ECS 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.)

Design approval and approval of Right of Way Plans are required prior to acquiring property. If federal funds are used to purchase the property, then NEPA clearance is also required.

The ASDEs work with the regions on project development and conduct process reviews on projects as described in 330.10.

330.06 Scoping Phase

Development of the project scope is the initial phase of project development. This effort is prompted by the *Washington State Highway System Plan*. The project scoping phase consists of determining a project description, schedule, and cost estimate. The intent is to make design decisions early in the project development process that focus the scope of the project. During the project scoping phase, the Project Summary documents are produced.

(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 consists of ERS, DDS, and PD documents, which are electronic forms. Specific online instructions for filling them out are contained in the Project Summary database.

(a) **Environmental Review Summary (ERS).** Lists the environmental permits and approvals that will be required, environmental classifications, and environmental considerations. This form lists requirements by environmental and permitting agencies. If there is a change in the PD or DDS, the information in the ERS must be reviewed and revised to match the rest of the Project Summary. The ERS is prepared during the scoping phase and is approved by the region. During final design and permitting, revisions may need to be made to the ERS and be reapproved by the region.

(b) **Design Decisions Summary (DDS).** Provides the design matrix used to develop the project, and the roadway geometrics, design deviations, EUs, other roadway features, roadside restoration, and any design decisions made during the scoping of a project. The information contained in this form is compiled from various databases of departmental information, field data collection, and evaluations made in development of the PD and the ERS. Design decisions may be revised throughout the project development process based on continuing evaluations.

The DDS is approved by the appropriate ASDE for new construction and reconstruction projects on the Interstate System before submittal to FHWA. (See 330.07.) The regional design authority approves the DDS for all other types of projects. To approve the Design Decisions Summary, the region must be confident that there will be no significant change in the PD or estimated cost. However, if there is a change to the PD or a significant change in the cost estimate, the DDS is to be revised or supplemented and reapproved. Significant cost changes require a Project Control Form to be submitted and approved by the appropriate designee.

(c) **Project Definition (PD).** Identifies the various disciplines and design elements that will be encountered in project development. The PD states the purpose and need for the project, the program categories, and the recommendations for project phasing. This information determines the level of documentation and evaluation that is needed for Project Development Approval. The PD is completed early in the scoping phase to provide a basis for full development of the ERS, DDS, schedule, and estimate. If circumstances necessitate a change to an approved PD, process a Project Control Form for approval by the appropriate designee, revise the original PD form, and obtain approval of the revisions.

330.07 FHWA Approval

For all NHS projects, the level of FHWA oversight varies according to the type of project, the agency doing the work, and the funding source as shown in Figures 330-2a and 2b. Oversight and funding do not affect the level of design documentation required for a project.

An FHWA determination of engineering and operational acceptance is 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. (See Chapter 1425.)

Documents for projects requiring FHWA review, Design Approval, and Project Development Approval are submitted through the HQ Design Office. Include applicable project documents as specified in Figure 330-5.

330.08 Design Approval

When the Project Summary documents are complete, and the region is confident that the proposed design adequately addresses the purpose and need for the project, a Design Approval may be entered into the PF. Approval levels for design and PS&E documents are presented in Figures 330-2a through 330-4.

The following items must be provided for Design Approval:

- A one- or two-page reader-friendly memo that describes the project
- Project Summary documents
- Corridor or project analysis
- Design Criteria worksheets at: http://www.wsdot.wa.gov/EESC/Design/projectdev/default.htm
- Design Variances Inventory (for known variances)
- 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 confidence level

330.09 Project Development Approval

When all project development documents are complete and approved, Project Development Approval is granted by the approval authority designated in Figures 330-2a and 2b. The Project Development Approval becomes part of the DDP. (See 330.04 and Figure 330-5 for design documents that may lead to Project Development Approval.) Figures 330-2a through 330-4 provide approval levels for project design and PS&E documents.

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

- Required environmental documents
- Design Approval documents (and any supplements)
- Design Variance Inventory (as required)
- Cost estimate
- Stamped cover sheet (project description)

Review new design policy for projects to be advertised more than three years after Project Development Approval, redesign as appropriate, and update the DDP and the Project Development Approval to reflect the revisions. For an overview of design policy changes, consult the Detailed Chronology of Design Policy Changes Affecting Shelved Projects at:
http://www.wsdot.wa.gov/eesc/design/policy/designpolicy.htm

330.10 Process Review

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 in each region at least once each year by the HQ Project Development Branch. The documents used in the review process are (1) the Design Documentation Checklist, (2) the PS&E Review Checklist, and (3) 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, Project Development Branch, maintains current copies at:
http://www.wsdot.wa.gov/eesc/design/projectdev/

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 Maintenance and Operations Programs' Traffic Operations personnel are involved in the review. The WSDOT process reviews may be held in conjunction with FHWA process reviews.

The HQ Project Development Branch schedules the process review and coordinates it with the region and FHWA.

A process review follows this general agenda:

1. Review team meets with regional personnel to discuss the object of the review.
2. Review team reviews the design and PS&E documents, and the construction documents and change orders (if available) using the checklists.
3. Review team meets with regional personnel to ask questions and clarify issues of concern.
4. Review team meets with regional 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's design authority is asked to report the steps that will be taken to correct the deficiency.
7. The process review summary forms are completed.
8. The summary forms and checklists are evaluated by the State Design Engineer.
9. The findings and recommendations of the State Design Engineer are forwarded to the regional design authority for action and/or information within 30 days of the review.

Project Design	FHWA Oversight Level	Deviation and Corridor/Project Approval(a)(b)	EU Approval(b)	Design Approval and Project Development Approval
Interstate				
New/Reconstruction(c) • Federal funds • No federal funds	(d) (e)	FHWA	Region	FHWA*
Intelligent Transportation Systems (ITS) over $1 million	(f)	HQ Design	Region	HQ Design
All Other(g) • Federal funds • State funds • Local agency funds	(f) (f) (e)	HQ Design	Region	Region
National Highway System (NHS)				
Managed access highway outside incorporated cities and towns or inside unincorporated cities and towns, or limited access highway	(f)	HQ Design	Region	Region
Managed access highway within incorporated cities and towns(h) • Inside curb or EPS(i) • Outside curb or EPS	(f) (f)	HQ Design HQ H&LP	Region N/A	Region City/Town

FHWA = Federal Highway Administration
HQ = WSDOT Headquarters
H&LP = WSDOT Highways and Local Programs Office
EPS = Edge of paved shoulder where curbs do not exist

Notes:

(a) These approval levels also apply to deviation processing for local agency work on a state highway.
(b) See 330.04(4).
(c) For definition, see Chapter 325.
(d) Requires FHWA review and approval (full oversight) of design and PS&E submitted by HQ Design Office.
(e) To determine the appropriate oversight level, FHWA reviews the Project Summary (or other programming document) submitted by HQ Design Office, or by WSDOT Highways and Local Programs through the HQ Design Office.
(f) FHWA oversight is accomplished by process review. (See 330.10.)
(g) Reduction of through lane or shoulder widths (regardless of funding) requires FHWA review and approval of the proposal.
(h) Applies to the area within the incorporated limits of cities and towns.
(i) Includes raised medians.
* FHWA will accept design criteria prior to NEPA approval, but will not approve the design until NEPA is complete.

Design Approval Level
Figure 330-2a

Project Design	FHWA Oversight Level	Deviation and Corridor/Project Approval[(a)(b)]	EU Approval[(b)]	Design Approval and Project Development Approval
Non-National Highway System (Non-NHS)				
Improvement project on managed access highway outside incorporated cities and towns or within unincorporated cities and towns, or on limited access highway (Matrix lines 5-8 through 5-26)	N/A	HQ Design	Region	Region
Improvement project on managed access highway within incorporated cities and towns[(h)] • Inside curb or EPS[(i)] • Outside curb or EPS (Matrix lines 5-8 through 5-26)	N/A N/A	HQ Design HQ H&LP	Region N/A	Region City/Town
Preservation project on managed access highway outside incorporated cities and towns or within unincorporated cities and towns, or on limited access highway[(j)] (Matrix lines 5-1 through 5-7)	N/A	Region[(k)]	Region	Region
Preservation project on managed access highway within incorporated cities and towns[(h)(j)] • Inside curb or EPS[(i)] • Outside curb or EPS (Matrix lines 5-1 through 5-7)	N/A N/A	Region HQ H&LP	Region N/A	Region City/Town

FHWA = Federal Highway Administration
HQ = WSDOT Headquarters
H&LP = WSDOT Highways and Local Programs Office
EPS = Edge of paved shoulder where curbs do not exist

Notes:
(a) These approval levels also apply to deviation processing for local agency work on a state highway.
(b) See 330.04(4).
(h) Applies to the area within the incorporated limits of cities and towns.
(i) Includes raised medians.
(j) For Bridge Replacement projects in the preservation program, follow the approval level specified for improvement projects.
(k) For guidance on access deviations, see Chapters 1430 & 1435.

Design Approval Level
Figure 330-2b

Item	Approval Authority		
	Region	HQ	FHWA
Program Development			
Work Order Authorization		X	X[1]
Public Hearings			
Corridor Hearing Summary		X[2]	
Design Summary		X[3]	
Access Hearing Plan		X[4]	
Access Findings and Order		X[5]	
Environmental by Classification			
Summary (ECS) NEPA			X
Class I NEPA (EIS)		[7]	X
Class I SEPA (EIS)		X	
Class II NEPA – Programmatic Categorical Exclusion (CE)*	X		
Class II NEPA – Documented Categorical Exclusion (CE)	[6]		X
Class II SEPA – Categorical Exemption (CE)	X		
Class III NEPA – Environmental Assessment (EA)		[7]	X
SEPA Check List	X		
Design			
Design Deviations	[8]	[8]	[8]
Experimental Features		X	X[9]
Environmental Review Summary	X		
Final Design Decisions Summary	X	X[3]	
Final Project Definition		X[10]	
Interchange Justification Report		[7]	X
Non-Interstate Interchange Justification Report		X	
Interchange Plans	X[11]	X[9][11]	
Intersection Plans	X[11]	X[9][11]	
Right of Way Plans	[12]	X	
Monumentation Map	X		
Materials Source Report		X[13]	
Pavement Determination Report		X[13]	
Roundabout Geometric Design	X[11]	X[11]	
Design Approval	[8]	[8]	[8]
Project Development Approval	[8]	[8]	[8]

Approvals
Figure 330-3a

Item	Approval Authority		
	Region	HQ	FHWA
Design			
Resurfacing Report		X[13]	
Signal Permits	X[14]		
Geotechnical Report		X[13]	
Tied Bids	X[15]		X[9][15]
Bridge Design Plans (Bridge Layout)	X	X	
Hydraulic Report	X[16][17]	X[16][17]	
Preliminary Signalization Plans		X[6]	
Rest Area Plans		X	
Roadside Restoration Plans	X[18]	X[19]	
Structures Requiring TS&L's		X	X
Planting Plans	X[18]	X[19]	
Grading Plans	X[18]	X[19]	
Continuous Illumination – Main Line		X[20]	
Project Control Form	X[21]	X[21]	
Work Zone Transportation Management Plan/Traffic Control Plan	X[22]		

X Normal procedure * If on the preapproved list

Notes:

[1] Federal-aid projects only.
[2] Environmental and Engineering Programs Director approval.
[3] State Design Engineer approval.
[4] Right of Way Plans Engineer approval.
[5] Refer to Chapter 210 for approval requirements.
[6] Final review & concurrence required at the region prior to submittal to approving authority.
[7] Final review & concurrence required at HQ prior to submittal to approving authority.
[8] Refer to Figures 330-2a & 2b for Design Approval and Project Development Approval levels.
[9] Applies to new/reconstruction projects on Interstate routes.
[10] HQ Project Control & Reporting approval.
[11] Include channelization details.
[12] Certified by the responsible professional licensee.
[13] Submit to HQ Materials Laboratory for review and approval.
[14] Approved by region's Administrator or Designee.
[15] See 23 CFR 635.111.
[16] For additional guidance, see the *Hydraulics Manual*, M 23-03.
[17] Region to submit Hydraulic Report. Refer to *Hydraulics Manual*.
[18] Applies only to regions with a Landscape Architect.
[19] Applies only to regions without a Landscape Architect.
[20] Approved by State Traffic Engineer.
[21] Consult HQ Project Control & Reporting for clarification on approval authority.
[22] Region Traffic Engineer.

Approvals
Figure 330-3b

Item	New/ Reconstruction (Interstate only)	NHS and Non-NHS
DBE/training goals* **	(a)	(a)
Right of way certification for federal-aid projects	FHWA(b)	FHWA(b)
Right of way certification for state-funded projects	Region(b)	Region(b)
Railroad agreements	(c)	(c)
Work performed for public or private entities*	[1][2]	Region[1][2]
State force work*	FHWA[3](d)	Region[3](d)
Use of state-furnished stockpiled materials*	FHWA[4]	Region[4]
Stockpiling materials for future projects*	FHWA[4]	Region[4]
Work order authorization	[5](d)	[5](d)
Ultimate reclamation plan approval through DNR	Region	Region
Proprietary item use*	FHWA[4]	[4](c)
Mandatory material sources and/or waste sites*	FHWA[4]	Region[4]
Nonstandard bid item use*	Region	Region
Incentive provisions	FHWA	(e)
Nonstandard time for completion liquidated damages*	FHWA(e)	(e)
Interim liquidated damages*	(f)	(f)

Notes:

[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.
[4] Applies only to federal-aid projects; however, document for all projects.
[5] Prior FHWA funding approval required for federal-aid projects.

Regional or Headquarters approval authority:

(a) Office of Equal Opportunity
(b) Real Estate Services Office
(c) Design Office
(d) Project Control & Reporting Office
(e) Construction Office
(f) Transportation Data Office

References:

**Plans Preparation Manual*
***Advertisement and Award Manual*

PS&E Process Approvals

Figure 330-4

Document[1]	Required for FHWA Oversight
Project Definition	**X**
Design Decisions Summary	**X**
Environmental Review Summary	**X**
Design Variance Inventory (and supporting information for DEs, EUs not upgraded, and deviations)[2]	**X**
Cost Estimate	**X**
SEPA & NEPA documentation	**X**
Design Clear Zone Inventory (see Chapter 700)	**X**
Interchange plans, profiles, roadway sections	**X**
Interchange Justification Report (if requesting new or revised access points)	**X**
Corridor or project analysis (see Chapter 325)	**X**
Traffic projections and analysis	
Accident analysis	
Right of way plans	
Work zone traffic control strategy	
Record of Survey or Monumentation Map	
Documentation of decisions to differ from WSDOT design guidance	
Documentation of decisions for project components for which there is no WSDOT design guidance	
Paths and Trails Calculations[3]	

Notes:
(1) See Design Documentation Checklist for a complete list.
(2) Required for NHS highways; recommended for all highways.
(3) See *Plans Preparation Manual*.

Common Components of Design Documentation Package
Figure 330-5

1. **Design element upgraded to the level indicated in the matrix**

   (a) Design element information

   - Design element
   - Location
   - Matrix number and row

   (b) Cost estimate(1)

   (c) B/C ratio(2)

   (d) Summary of the justification for the upgrade(3)

2. **Design element not upgraded to the level indicated in the matrix**

   (a) Design element information

   - Design element
   - Location
   - Matrix number and row

   (b) Existing Conditions

   - Description
   - Accident Summary
   - Advantages and disadvantages of leaving the existing condition unchanged

   (c) Design Using the *Design Manual* criteria

   - Description
   - Cost estimate(1)
   - B/C ratio(2)
   - Advantages and disadvantages of upgrading to the level indicated in the matrix

   (d) Selected Design, if different from existing but less than the level indicated in the matrix

   - Description
   - Cost estimate(1)
   - B/C ratio(2)
   - Advantages and disadvantages of the selected design

   (e) Summary of the justification for the selected design(3)

Notes:

(1) An estimate of the approximate total additional cost for the proposed design. Estimate may be based on experience and engineering judgment.

(2) Include only when B/C is part of the justification. An approximate value based on engineering judgment may be used.

(3) A brief (one or two sentence) explanation of why the proposed design was selected.

Evaluate Upgrade (EU) Documentation Content List

Figure 330-6

1. **Overview**
    (a) The safety or improvement need that the project is to meet
    (b) Description of the project as a whole
    (c) Highway classification and applicable design matrix number and row
    (d) Funding sources
    (e) Evidence of deviations approved for previous projects (same location)
2. **Design Alternatives in Question**
    (a) Existing Conditions and Design Data
        - Location in question
        - Rural, urban, or developing
        - Route development plan
        - Environmental issues
        - Right of way issues
        - Number of lanes and existing geometrics
        - Present and 20-year projected ADT
        - Design speed, posted speed, and operating speed
        - Percentage of trucks
        - Terrain Designation
        - Managed Access or Limited Access
    (b) Accident Summary and Analysis
    (c) Design Using the *Design Manual* Criteria
        - Description
        - Cost estimate
        - B/C ratio
        - Advantages and disadvantages
        - Reasons for considering other designs
    (d) Other Alternatives (may include “No-build” alternative)
        - Description
        - Cost estimate
        - B/C ratio
        - Advantages and disadvantages
        - Reasons for rejection
    (e) Selected Design Requiring Justification or Documentation to File
        - Description
        - Cost estimate
        - B/C ratio
        - Advantages and disadvantages
3. **Concurrences, Approvals, and Professional Seals**

Deviation Request Content List
Figure 330-7

Unlike the design matrices described in Chapter 325, designers using a minor operational enhancement matrix are not required to inventory deficiencies for elements not improved by the minor enhancement project. Similarly, they are not required to justify existing deficiencies not addressed by minor enhancement projects. In the case where improvements to existing features surpass the existing condition but do not meet the design guidelines, Basic Documentation plus Supplemental Coordination (BD+) is required. See 340.09(1).

A **blank cell** on a minor operational enhancement matrix signifies that the design element is beyond the scope of the project and need not be addressed.

For work on ramps on Interstate or NHS freeway routes, there is a requirement to provide assurance of no adverse effect to main line flow. Provide FHWA a copy of the documentation providing assurance or process a deviation through FHWA if there is an adverse effect.

(1) Design Level

The minor operational enhancement matrices specify the appropriate design level for the various project elements. The design levels specified are Full and Modified.

Full design level (F) improves roadway geometrics, safety, and operational elements. See Chapter 440 and other applicable chapters for design guidance. Use the current traffic volume with Chapter 440 to evaluate design class for Q Program projects.

Modified design level (M) preserves and improves existing roadway geometrics, safety, and operational elements. See Chapter 430.

Design levels specified in a matrix cell are supplemented with notations for design variances.

(2) Design Variances

Design variances are information packages that justify the introduction of features that are not in accordance with design guidelines. Variances specified in minor operational enhancement project cells include: Design Justification, Level 2, Level 3, or Level 4. See 340.09 for details on documentation requirements.

340.08 Project Approval

Project approval for minor operational enhancement projects authorizes expenditures for the project. The State and/or Region's Traffic Engineer have the responsibility and authority to authorize all expenditures for Q2 Low Cost Enhancements. Delegation of design and/or expenditure approval authority for Q Program funded projects must be identified in writing from the appropriate Traffic Engineer to the person receiving the delegated authority. Such written delegation must identify the specific conditions for which approval authority has been delegated. <u>Project Development Approval</u> authority for PS&E contracts cannot be delegated.

Mechanisms for project expenditure approval vary with the types of projects and the costs involved.

- **Minor-cost projects** are projects normally implemented by state forces directed through maintenance task orders, within the monetary limits established in RCW 47.28.030. Expenditure authority is granted by initialing the work order.
- **Mid-range projects** include: all contract change orders, local agency agreements, or Q Program bid items included in an Improvement or Preservation project, regardless of cost. Maintenance task orders exceeding the monetary limits established in RCW 47.28.030 are included in this category. Expenditure authority is granted by initialing the task order, change order, or agreement memo.
- **PS&E contracts** are stand-alone contracts funded through the Q Program for minor operational enhancement projects. A Design Summary/Approval memorandum must be prepared and signed by the region's Traffic Engineer to approve a project in this category. Figures 340-5a and 340-5b provide a template for the approval memo.

Project development decisions and approvals for "Regulatory" and for "Driver Guidance" projects reside within region or Headquarters Traffic Offices. Projects impacting roadway geometric features in the "Pavement Widening," "Rechannelizing Existing Pavement," "Non-motorized Facilities" or "Roadside" categories are developed jointly by the region's Traffic Office and the region's Project Development Office. Depending on the route type, the approval authority may involve the Assistant State Design Engineer and the FHWA.

340.09 Documentation

The minor operational enhancement matrices include a column that specifies the documentation levels for each project type listed. The documentation levels are categorized as Basic Documentation (BD) and Basic Documentation plus Supplemental Coordination (BD+).

In all cases, the documentation must outline the rationale for the project and include backup information sufficient to support the design decisions. Document the roadway configuration prior to implementation of a minor operational enhancement project. Documentation is to be retained in a permanent retrievable file at a central location in each region.

(1) Projects

Basic Documentation (BD) level applies to regulatory or driver guidance projects. Documentation consists of an unstructured compilation of materials sufficient to validate the designer's decisions. Materials may include: meeting notes, printed e-mails, record of phone conversations, copies of memos, correspondence, and backup data such as level of service modeling, accident data, and design drawings.

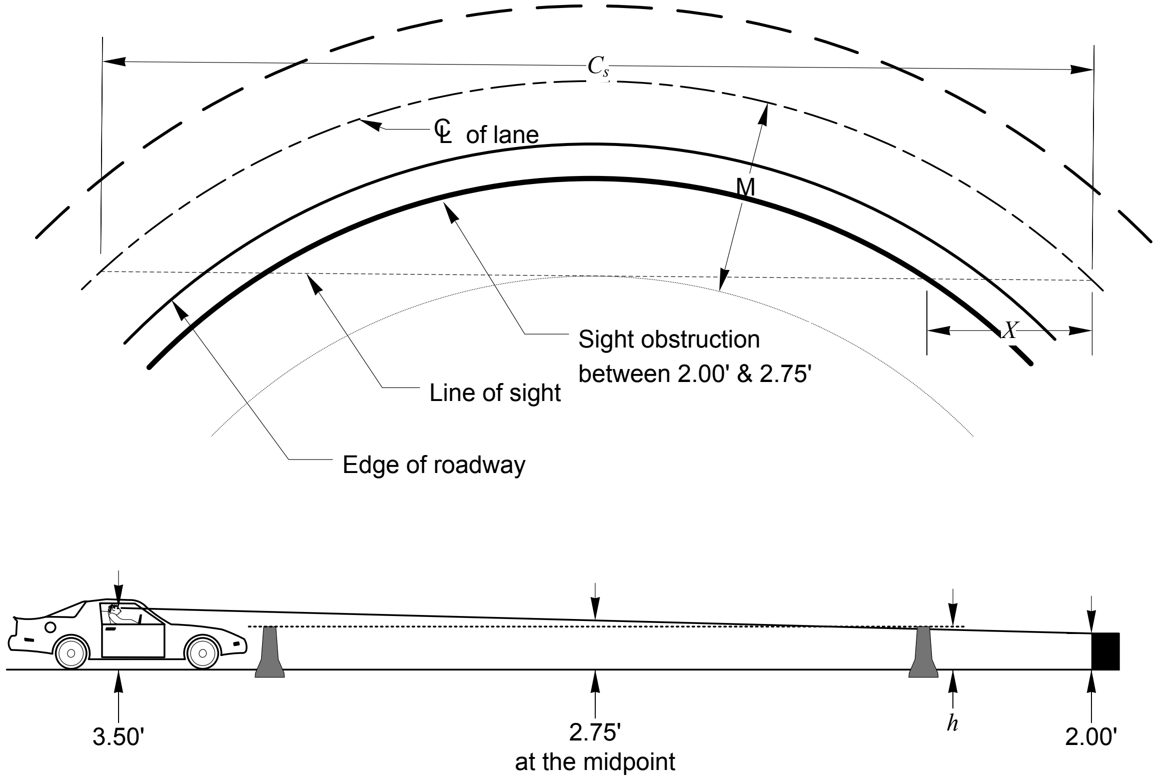
A single narrative outlining the decision-making process from start to finish is not required, provided that the materials retained in the file can be traced to a decision consistent with the project design. This level of documentation includes a requirement for inputting the project information into the TRaffic ACtion Tracking System (TRACTS) database at the conclusion of the project.

Basic Documentation plus Supplemental Coordination (BD+) level applies to all projects except regulatory or driver guidance projects. A more comprehensive evaluation of options and constraints is required for this documentation level. Documentation includes basic documentation with additional information describing coordination efforts with other WSDOT groups having a stake in the project. Document the coordination efforts with the following disciplines: Environmental, Hydraulics, Local Agencies and WSDOT Local Programs, Maintenance, Materials, Program Management, Real Estate Services, Urban Corridors, Utilities, and the general public. This level of documentation also includes a requirement for inputting the project information into the TRACTS database at the conclusion of the project.

(2) Design Deviations

Design Justification (DJ) is a written narrative summarizing the rationale for introduction of a feature that varies from the applicable *Design Manual* guidelines. Include in the narrative sufficient information to describe the problem, the constraints, and the trade-offs at a level of detail that provides a defendable professional judgment. DJs are not intended to have the same level of formality as the Level 2, 3, and 4 deviations. DJs may use written memos, e-mails, or documented discussions with the approving traffic authority. The region's Traffic Engineer has responsibility for approving Design Justifications. The DJ documentation must include the name and date of the approving authority. At the time the work order is approved, the region's Project Development Engineer and the Assistant State Design Engineer are to be sent informational copies of the Design Justification, to provide them an opportunity to communicate their concerns. Comment on the informational copy is not mandatory and progress toward project implementation does not wait on a response.

Level 2 documentation serves to justify a deviation to the specified design guidance. Within the document, summarize the project, the design guidelines, the proposed elements that vary from design guidelines, alternatives analyzed, constraints and impacts of each alternative, and the recommended alternative. Level 2 documentation requires joint approval of the region's Traffic Engineer and region's Project



When $h \leq \left(2 + \frac{1.5X}{C_s}\right)$ modified design criteria is met.

Where:

- M = Lateral clearance for sight distance (ft) See Figure 430-9a
- C_S = Stopping sight distance chord (ft)
- X = Distance from the sight obstruction to the end of the sight distance chord (ft)
- h = Height of sight obstruction above the inside lane.

Evaluation for Stopping Sight Distance Obstruction for Horizontal Curves, Modified Design Level

Figure 430-9b

	Multilane Divided				Multilane Undivided			
	Trucks Under 10%		Trucks 10% and Over		Trucks Under 10%		Trucks 10% and Over	
Design Class	MDL-1	MDL-2	MDL-3	MDL-4	MDL-5	MDL-6	MDL-7	MDL-8
Current ADT (1)	Under 4000	Over 4000	Under 4000	Over 4000	Under 4000	Over 4000	Under 4000	Over 4000
Design Speed	See Figure 430-1							
Traffic Lanes Number Width	 4 or more 11 ft	 4 or more 11 ft	 4 or more 11 ft	 4 or more 12 ft	 4 or more 11 ft	 4 or more 11 ft	 4 or more 11 ft	 4 or more 12 ft
Parking Lanes Urban	None	None	None	None	8 ft	8 ft (2)	8 ft	8 ft (2)
Median Width Rural Urban	 Existing Existing	 Existing Existing	 Existing Existing	 Existing Existing	 2 ft 2 ft	 4 ft 2 ft	 4 ft 2 ft	 4 ft 2 ft
Shoulder Width (15) Right (3) Left (4)	 4 ft 2 ft	 6 ft 2 ft	 4 ft 2 ft	 6 ft 2 ft	 4 ft	 6 ft (5)	 4 ft	 6 ft (5)
Minimum Width for Bridges to Remain in Place (6) (7) (8)	24 ft (9)	26 ft (9)	24 ft (9)	26 ft (10)	48 ft (9)	50 ft (9) (11)	50 ft (9) (11)	54 ft (10) (11)
Minimum Width for Rehabilitation of Bridges to Remain in Place (6) (8) (12)	28 ft (9)	30 ft (9)	28 ft (9)	32 ft (10)	54 ft (9)	60 ft (9) (11) (13)	56 ft (9) (11)	64 ft (10) (11) (13)
Minimum Width for Replacement Bridges	Full Design Level Applies (14)							
Access Control	See Chapters 1430 and 1435 and the Master Plan for Limited Access Highways, or WAC 468-52 and the region's Highway Access Management Classification Report							

Notes:

(1) If current ADT is approaching a borderline condition, consider designing for the higher classification.

(2) Parking restricted when ADT is over 15,000.

(3) When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 feet. In urban areas, see Chapter 440. On a route identified as a local, state, or regional significant bicycle route the minimum shoulder width is 4 feet (See Chapter 1020).

(4) When a curb section is used, the minimum shoulder width from the edge of traveled way to the face of the curb is 1 foot on the left.

(5) May be reduced by 2 feet under urban conditions.

(6) Width is the clear distance between curbs or rails, whichever is less.

(7) Use these widths when a bridge within the project limits requires deck treatment or thrie beam retrofit only.

(8) For median widths 25 feet or less, see Chapter 1120.

(9) Add 11 feet for each additional lane.

(10) Add 12 feet for each additional lane.

(11) Includes a 4-foot median, which may be reduced by 2 feet under urban conditions.

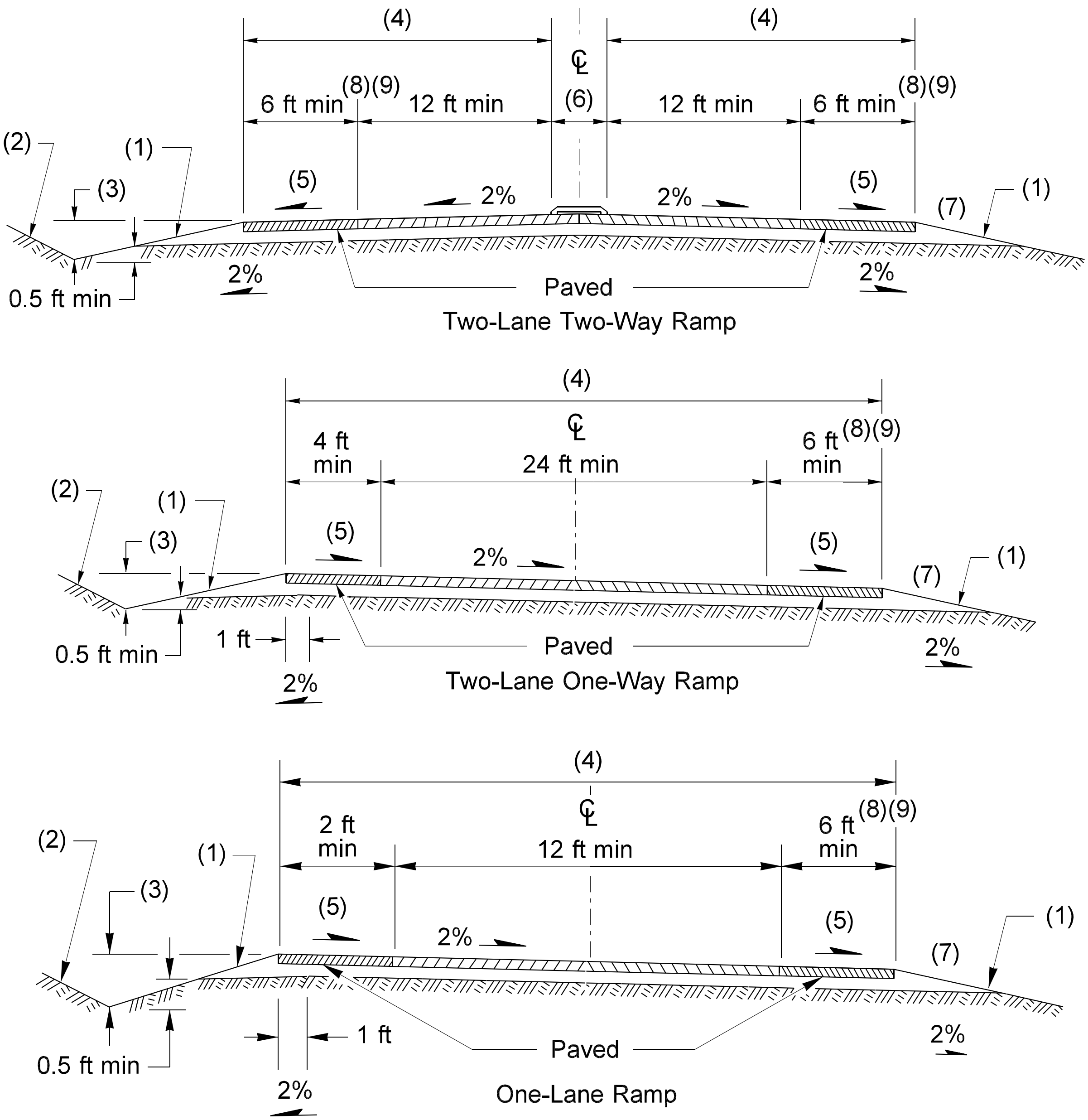
(12) Use these widths when a bridge within the project limits requires any work beyond the treatment of the deck such as bridge rail replacement, deck replacement, or widening.

(13) Includes 6-foot shoulders — may be reduced by 2 feet on each side under urban conditions.

(14) Modified design level lane and shoulder widths may be used when justified with a corridor or project analysis.

(15) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced by up to 4 inches.

Multilane Highways and Bridges,
Modified Design Level
Figure 430-10



Notes:

(1) See Fill and Ditch Slope Selection Table on Figure 430-13.
(2) See Cut Slope Selection Table on Figure 430-13
(3) Minimum ditch depth is 2 feet for design speeds over 40 mph and 1.5 feet for design speeds at and under 40 mph.
(4) See 430.04(2)(b) and Figure 430-6 for minimum ramp width.
(5) See Chapter 640 for shoulder slope requirements.
(6) The median width of a two-lane two-way ramp shall not be less than that required for traffic control devices and their required shy distances.
(7) Widen and round embankments steeper than 4H:1V.
(8) Existing 6 feet may remain. When the roadway is to be widened, 8 feet is preferred.
(9) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced by up to 4 inches.

Ramp Roadway Sections,
Modified Design Level
Figure 430-14

Route Type	Posted speed	Desirable Design Speed
Freeways	All	10 mph over the posted speed
non-Freeways	45 mph or less	Not less than the posted speed.
	Over 45 mph	5 mph over the posted speed

Desirable Design Speed
Figure 440-1

On urban highways, that have obvious "street-like" characteristics, operationally and physically, the design speed is less critical to the operation of the facility. Closely spaced intersections and other operational constraints usually limit vehicular speeds more than the design speed.

For managed access facilities in urban areas, select a design speed based on Figure 440-1. In cases where the 440-1 design speed does not fit the conditions, use a corridor analysis to select a design speed. Select a design speed not less than the posted speed and logical with respect to topography, operating speed (or anticipated operating speed for new alignment), adjacent land use, design traffic volume, accident history, access control, and the functional classification. Consider both year of construction and design year. Maintain continuity throughout the corridor, with changes at logical points, such as a change in roadside development.

440.08 Traffic Lanes

Lane width and condition have a great influence on safety and comfort. The minimum lane width is based on the highway design class, terrain type, and whether it is in a rural or urban area. Lanes 12 ft wide provide desirable clearance between large vehicles where traffic volumes are high and a high number of large vehicles are expected. The added cost for lanes 12 ft wide is offset, to some extent, by the reduction in shoulder maintenance cost due to the lessening of wheel load concentrations at the edge of the lane.

Highway capacity is also affected by the width of the lanes. With narrow lanes, drivers must operate their vehicles closer (laterally) to each other than they normally desire. To compensate for this, drivers increase the headway, resulting in reduced capacity.

Figures 440-4 through 440-7a give the minimum lane width for the various design classes for use on all rural highways and urban limited access highways. Figure 440-8 gives the minimum lane widths for urban managed access highways.

The roadway on a curve may need to be widened to make the operating conditions comparable to those on tangents. See Chapter 641 for guidance on width requirements on turning roadways.

440.09 Shoulders

The shoulder width is controlled by the functional classification of the roadway, the traffic volume, and the function the shoulder is to serve.

The more important shoulder functions and the associated minimum widths are given in Figure 440-2.

Shoulder Function	Minimum Shoulder Width
Stopping out of the traffic lanes	8 ft
Minimum lateral clearance	2 ft (1)
Pedestrian or bicycle use	4 ft (2)
Large vehicle off tracking on curves.	See Chapters 641 & 910
Maintenance operations.	Varies (3)
Law enforcement	8 ft (4)
Bus stops.	See Chapter 1060.
Slow vehicles turnouts and shoulder driving.	See Chapter 1010
Ferry holding	8 ft (5)
For use as a lane during reconstruction of the through lanes.	8 ft
Structural support	2 ft
Improve sight distance in cut sections.	See Chapter 650
Improve capacity.	See Chapter 610

(1) See Chapters 700 and 710.
(2) Minimum usable shoulder width for bicycles. For additional information, see Chapter 1020 for bicycle and Chapter 1025 for pedestrians.
(3) 10 ft usable width to park a maintenance truck out of the through lane; 12 ft, 14 ft clearance is preferred, for equipment with outriggers to work out of traffic.
(4) See Chapters 1040 and 1050 for additional information.
(5) Minimum usable shoulder width, 10 ft preferred.

Minimum Shoulder Width
Figure 440-2

Contact the region maintenance office to determine the shoulder width for maintenance operations. When shoulder widths wider than called for in Figures 440-4 through 8 are requested, compare the added cost of the wider shoulders to the added benefits to maintenance operations and other benefits that may be derived. When the maintenance office requests a shoulder width different than for the design class, justify the width selected.

Shoulders also:

- Provide space to escape potential accidents or to reduce their severity.
- Provide a sense of openness, contributing to driver ease and freedom from strain.
- Reduce seepage adjacent to the traveled way by discharging storm water farther away.

Minimum shoulder widths for use on all rural highways and urban limited access highways are based on functional classification and traffic volume, see Figures 440-4 through 7b. Figure 440-8 gives the minimum shoulder widths for urban managed access highways without curb.

When curbing with a height less than 24 inches is present on urban managed access highways, provide the minimum shoulder widths shown in Figure 440-3. (See 440.11 for information on curb.)

Lane Width	Posted Speed			
	>45 mph	≤45 mph	>45 mph	≤45 mph
	On Left		On Right (3)	
12 ft or wider	4 ft	(1)(2)	4 ft	2 ft
11 ft	4 ft	(1)(2)	4 ft	3 ft (4)

Notes:

(1) When mountable curb is used on routes with a posted speed of 35 mph or less, shoulder width is desirable but, with justification, curb may be placed at the edge of traveled way.

(2) 1 ft for curbs with a height of 8 in or less.
2 ft for curbs or barriers with a height between 8 in and 24 in.

(3) When the route has been identified as a local, state, or regional significant bike route, the minimum shoulder width is 4 ft or as indicated in Chapter 1020 for signed bike lanes.

(4) When bikes are not a consideration, may be reduced to 2 ft with justification.

(5) Measured from the edge of traveled way to the face of the curb.

Shoulder Width for Curbed Sections (5)
Figure 440-3

When traffic barrier with a height of 2 ft or greater is used adjacent to the roadway, the minimum shoulder width from the edge of traveled way to the face of the traffic barrier is 4 ft. Additional width for traffic barrier is not normally required on urban managed access highways.

Where there are no sidewalks the minimum shoulder width is 4 ft. Shoulder widths less than 4 ft will require wheelchairs using the roadway to encroach on the through lane. See Chapter 1025 for additional information and requirements on pedestrians and accessible routes.

The 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. See Chapter 710 for the required widening.

Shoulders on the left between 4 ft and 8 ft are undesirable. Shoulders in this width range might appear to a driver to be wide enough to stop out of the through traffic, when it is not. To prevent the problems that can arise from this, when the shoulder width and any added clearance result in a width in this range, consider increasing the width to 8 ft.

Provide a minimum clearance to roadside objects so that the shoulders do not require narrowing. At existing bridge piers and abutments, shoulders less than full width to a minimum of 2 ft may be used with design exception documentation. See Chapter 700 for design clear zone and safety treatment requirements.

For routes identified as local, state, or regional significant bicycle routes, provide a minimum 4 ft shoulder. Maintain system continuity for the bicycle route, regardless of jurisdiction and functional class. See Chapter 1020 for additional information on bicycle facilities.

Shoulder widths greater than 10 ft may encourage use as a travel lane. Therefore, use shoulders wider than this only where required to meet one of the listed functions.

440.10 Medians

Medians are either restrictive or nonrestrictive. Restrictive medians limit left-turns, physically or legally, to defined locations. Nonrestrictive medians allow left-turns at any point along the route. Consider restrictive medians on multilane limited access highways and multilane managed access highways when the DHV is over 2000.

The primary functions of a median are to:

- Separate opposing traffic.
- Provide for recovery of out-of-control vehicles.
- Reduce head-on accidents.

- Provide an area for emergency parking.
- Allow space for left turn lanes.
- Minimize headlight glare.
- Allow for future widening.
- Control access.

For maximum efficiency, make medians highly visible both night and day. Medians may be depressed, raised, or flush with the through lanes.

The width of a median is measured from edge of traveled way to edge of traveled way and includes the shoulders. The minimum median width for each design class is given in Figures 440-4 through 440-8. When selecting a median width, consider future needs such as wider left shoulders when widening from four to six lanes.

A two-way left-turn lane (TWLTL) may be used as a nonrestrictive median for an undivided managed access highway. (See Figure 440-8.) The desirable width of a TWLTL is 13 ft with a minimum width of 11 ft. For more information on traffic volume limits for TWLTLs on managed access highways, see Chapter 1435. See Chapter 910 for additional information on TWLTL design.

A common form of restrictive median on managed access highways in urban areas is the raised median. 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. For more information on traffic volume limits for restrictive medians on managed access highways, see Chapter 1435.

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 vehicles making the u-turn. See Chapter 910 for information on u-turn locations.

When the median is to be landscaped or where rigid objects are to be placed in the median, see Chapter 700 for traffic barrier and clear zone requirements. When the median will include a turn-lane lane, see Chapter 910 for left-turn lane design.

440.11 Curbs

(1) General

Curbs are divided into vertical curbs and sloped curbs. Vertical curbs have a face batter 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 in or less, preferably 4 in or less. When the face slope is steeper than 1H:1V, the height of a mountable curb is limited to 4 in or less.

Where curbing is to be provided, ensure that surface water that collects at the curb will drain and not pond or flow across the roadway.

When an overlay will reduce the height of a vertical curb, evaluate grinding to maintain curb height, or replacing the curb, versus the need to maintain the height of the curb.

Curbs can hamper snow removal operations. The area Maintenance Superintendent's review and approval is required for the use of curbing in areas of heavy snowfall.

For curbs at traffic islands, see Chapter 910.

(2) Curb Usage

Curbing is used for the following purposes:

- control drainage
- delineate the roadway edge
- delineate pedestrian walkways
- delineate islands
- reduce right of way
- assist in access control
- inhibit mid-block left turns

Avoid using curbs if the same objective can be attained with pavement markings.

In general, curbs are not used on facilities with a posted speed greater than 40 mph. The exceptions are for predominantly urban or rapidly developing areas where sidewalks are provided or where traffic movements are to be restricted. Justify the use of curb when the posted speed is greater than 40 mph.

(a) Vertical curbs with a height of 6 inches or more are required for:

- inhibiting or at least discouraging vehicles from leaving the roadway.
- walkway and pedestrian refuge separations.
- raised islands on which a traffic signal, or traffic signal hardware, is located.

When an overlay is planned, do not reduce the height of the curb to less than 4 inches.

(b) Consider vertical curbs with a height of 6 inches or more:

- to inhibit mid-block left turns.
- for divisional and channelizing islands.
- for landscaped islands.

(c) Provide mountable curbs where a curb is needed but higher vertical curb is not justified.

440.12 Parking

In urban areas and rural communities, land use might require parking along the highway. In general, on-street parking decreases capacity, increases accidents, and impedes traffic flow. Therefore, it is desirable to prohibit parking.

Although design data for parking lanes are included on Figures 440-5a through 8, consider them only in cooperation with the municipality involved. The lane widths given are the minimum for parking, provide wider widths when practical.

Angle parking is not permitted on any state route without approval by WSDOT (RCW 46.61.575). This approval is delegated to the State Traffic Engineer. Angle parking approval is to be requested through the HQ Design Office. Provide an engineering study, approved by the region's Traffic Engineer, with the request that shows the parking will not unduly reduce safety and that the roadway is of sufficient width that the parking will not interfere with the normal movement of traffic.

440.13 Pavement Type

The pavement types given in Figures 440-4 through 7a are the recommended for each design class. (See Chapter 520 for information on pavement type selection). When a roadway is to be widened and the existing pavement will remain, the new pavement type may be the same as the existing without a pavement type determination.

440.14 Structure Width

Provide a clear width between curbs on a structure not less than the approach roadway width (lanes plus shoulders). The structure widths given in Figures 440-4 through 8 are the minimum structure width for each design class.

Additional width for barriers is not normally added to the roadway width on structures. When a structure is in a run of roadside barrier with the added width, consider adding the width on shorter structures to prevent narrowing the roadway.

440.15 Right of Way Width

Right of way width must be sufficient to accommodate all roadway elements and required appurtenances necessary for the current design and known future improvements. To allow for construction and maintenance activities, provide 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut. See Chapter 640 and the Standard Plans for slope treatment information.

The right of way widths given in Figures 440-4 through 7b, are desirable minimums for new alignment requiring purchase of new right of way. See Chapter 1410 for additional information and consideration on right of way acquisition.

440.16 Grades

Grades can have a pronounced effect on the operating characteristics of the vehicles negotiating them. Generally, passenger cars can readily negotiate grades as steep as 5% without appreciable loss of speed from that maintained on level highways. Trucks, however, travel at the average speed of passenger cars on the level but display up to a 5% increase in speed on downgrades and a 7% or more decrease in speed on upgrades (depending on length and steepness of the grade as well as weight to horsepower ratio).

The maximum grades for the various functional classes and terrain conditions are shown in Figures 440-4 through 7a. For the effects of these grades on the design of a roadway see Chapters 630 and 1010.

440.17 Documentation

A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

	Divided Multilane	
Design Class	I-1	
Design Year	(1)	
Access Control (2)	Full	
Separate Cross Traffic		
Highways	All	
Railroads	All	
Design Speed (mph)		
Rural	80 (3)	
Urbanized	70 (4)	
Traffic Lanes		
Number	4 or more divided	
Width (ft)	12	
Median Width (ft)	4 lane	6 lanes or more
Rural — Minimum (5)	40	50
Urban — Minimum	16	22
Shoulder Width (ft)(14)		
Right of Traffic	10 (6)	10 (6)
Left of Traffic	4	10 (6)(7)
Pavement Type (8)	High	
Right of Way (9)		
Rural — Width (ft)	63 from edge of traveled way	
Urban — Width (ft)	As required (10)	
Structures Width (ft) (11)	Full roadway width each direction (12)	

Type of Terrain	Design Speed (mph) 50	55	60	65	70	75	80
Level	4	4	3	3	3	3	3
Rolling	5	5	4	4	4	4	4
Mountainous	6	6	6	5	5	5	5
Grades (%) (13)							

Interstate Notes:

(1) The design year is 20 years after the year the construction is scheduled to begin.
(2) See Chapter 1430 for access control requirements.
(3) 80 mph is the desirable design speed; with a corridor analysis, the design speed may be reduced to 60 mph in mountainous terrain and 70 mph in rolling terrain. Do not select a design speed that is less than the posted speed.
(4) 70 mph is the desirable design speed, with a corridor analysis the design speed may be reduced to 50 mph. Do not select a design speed that is less than the posted speed.
(5) Independent alignment and grade is desirable in all rural areas and where terrain and development permits in urban areas.
(6) 12 ft shoulders are desirable when the truck DDHV is 250 or greater.
(7) For existing 6-lane roadways, existing 6 ft left shoulders may remain with design exception documentation, when they are not being reconstructed, and no other widening is required.
(8) See Chapter 520 for Pavement Type Determination.
(9) Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut. See 440.15.
(10) In urban areas, make right of way widths not less than those required for necessary cross section elements.
(11) See Chapter 1120 for minimum vertical clearance.
(12) For median widths 26 ft or less, address bridge(s) in accordance with Chapter 1120.
(13) Grades 1% steeper may be provided in urban areas and mountainous terrain with critical right of way controls.
(14) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced up to 4 inches.

Geometric Design Data, Interstate
Figure 440-4

Design Class	Divided Multilane				Two-Lane						Undivided Multilane	
	P-1		P-2		P-3		P-4		P-5		P-6 (1)	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
DHV in Design Year (2) NHS	Over 1,500		Over 700		Over 201 (3)		61-200 (4)		60 and under		Over 700	
Non NHS					Over 301		101-300		100 and Under			
Access Control	Full (5)		Partial (5)		(5)		(5)		(5)		(5)	
Separate Cross Traffic												
Highways	All		Where Justified		Where Justified		Where Justified		Where Justified		Where Justified	
Railroads (6)	All		All		All (7)		Where Justified (8)		Where Justified (8)		Where Justified (8)	
Design Speed (mph) (9)	80		70		70	60	70	60	60	60	70	60
Minimum (10)	60 (11)		50 (12)		50	40 (12)	50	40 (12)	40	30 (12)	40	30 (12)
Traffic Lanes												
Number	4 or more divided		4 or 6 divided		2		2		2		4	4 or 6
Width (ft)	12		12		12		12		12		12	11 (13)
Shoulder Width (ft) (30)												
Right of Traffic	10 (14)		10		8		6		4		8	8(17)
Left of Traffic	Variable (15)(16)		Variable (15)(16)									
Median Width (ft)												
4 lane	40 (18)	16	60	16							4	2 (19)
6 or more lanes	48 (18)	22	60	22							4	2 (19)
Parking Lanes Width (ft) — Minimum	None		None		None		None	10	None	10	None	10 (20)
Pavement Type (21)	High				High or intermediate							
Right of Way (22) —Width (ft)	(23)	(24)	(23)	(24)	120	80	120	80	100	80	150	80
Structures Width (ft) (25)	Full roadway width (26)				40		40		32		Full roadway width	
Other Design Considerations-Urban					(27)		(27)		(27)		(27)	

Type of Terrain	Rural — Design Speed (mph)									Urban — Design Speed (mph)						
	40	45	50	55	60	65	70	75	80	30	35	40	45	50	55	60 (28)
Level	5	5	4	4	3	3	3	3	3	8	7	7	6	6	5	5
Rolling	6	6	5	5	4	4	4	4	4	9	8	8	7	7	6	6
Mountainous	8	7	7	6	6	5	5	5	5	11	10	10	9	9	8	8
Grades (%) (29)																

Geometric Design Data, Principal Arterial
Figure 440-5a

Principal Arterial Notes:

(1) Justify the selection of a P-6 design class on limited access highways.

(2) The design year is 20 years after the year the construction is scheduled to begin.

(3) Where DHV exceeds 700, consider four lanes. When the volume/capacity ratio is equal to or exceeds 0.75, consider the needs for a future four-lane facility. When considering truck climbing lanes on a P-3 design class highway, perform an investigation to determine if a P-2 design class highway is justified.

(4) When considering a multilane highway, perform an investigation to determine if a truck climbing lane or passing lane will satisfy the need. See Chapter 1010.

(5) See Chapters 1430 and 1435 and the Master Plan for Limited Access Highways for access control requirements. Contact the HQ Design Office Access & Hearings Unit for additional information.

(6) Contact the Rail Office of the Public Transportation and Rail Division for input on the needs for the railroad.

(7) All main line and major-spur railroad tracks will be separated. Consider allowing at-grade crossings at minor-spur railroad tracks.

(8) Criteria for railroad grade separations are not clearly definable. Evaluate each site regarding the hazard potential. Provide justification for railroad grade separations.

(9) These are the design speeds for level and rolling terrain in rural areas. They are the preferred design speeds for mountainous terrain and urban areas. Higher design speeds may be selected, with justification.

(10) These design speeds may be selected in mountainous terrain, with a corridor analysis. Do not select a design speed that is less than the posted speed.

(11) In urbanized areas, with a corridor analysis, 50 mph may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

(12) In urban areas, with a corridor analysis these values may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

(13) 12 ft lanes are required when the truck DDHV is 150 or greater.

(14) 12 ft shoulders are desirable when the truck DDHV is 250 or greater.

(15) Minimum left shoulder width is to be as follows: four lanes — 4 ft: six or more lanes — 10 ft. Consider 12 ft shoulders on facilities with 6 or more lanes and a truck DDHV of 250 or greater.

(16) For existing 6-lane roadways, existing 6 ft left shoulders may remain with design exception documentation, when they are not being reconstructed, and no other widening is required.

(17) When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 ft.

(18) On freeways or expressways requiring less than eight lanes within the 20-year design period, provide sufficient median or lateral clearance and right of way to permit addition of a lane in each direction if required by traffic increase after the 20-year period.

(19) When signing is required in the median of a six-lane section, the minimum width is 6 ft. If barrier is to be installed at a future date, an 8 ft minimum median is required.

(20) Restrict parking when DHV is over 1500.

(21) <u>See Chapter 520 for</u> Pavement Type Determination.

(22) Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut. See 440.15.

(23) 63 ft from edge of traveled way.

(24) Make right of way widths not less than those required for necessary cross section elements.

(25) See Chapter 1120 for the minimum vertical clearance.

(26) For median widths 26 ft or less, address bridges in accordance with Chapter 1120.

(27) For bicycle requirements, see Chapter 1020. For pedestrian and sidewalk requirements, see Chapter 1025. Curb requirements are in 440.11. Lateral clearances from the face of curb to obstruction are in Chapter 700.

(28) For grades at design speeds greater than 60 mph in urban areas, use rural criteria.

(29) Grades 1% steeper may be used in urban areas and mountainous terrain with critical right of way controls.

(30) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced up to 4 inches.

Geometric Design Data, Principal Arterial

Figure 440-5b

Design Class	Divided Multilane		Two-Lane						Undivided Multilane	
	M-1		M-2		M-3		M-4		M-5 (1)	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
DHV in Design Year (2) NHS Non NHS	Over 700		Over 201 (3) Over 401		61-200 (4) 201-400		60 and Under 200 and Under		Over 700	
Access Control	Partial (5)		(5)		(5)		(5)		(5)	
Separate Cross Traffic Highways Railroads (6)	Where Justified All		Where Justified All (7)		Where Justified Where Justified (8)		Where Justified Where Justified (8)		Where Justified Where Justified (8)	
Design Speed (mph) (9) Minimum (10)(11)	70 50		70 50	60 40	70 50	60 40	60 40	60 30	70 40	60 30
Traffic Lanes Number Width (ft)	4 or 6 divided 12		2 12		2 12		2 12		4 12	4 or 6 11 (12)
Shoulder Width (ft) (27) Right of Traffic Left of Traffic	10 Variable (13)(14)		8		6		4		8	8 (15)
Median Width (ft) 4 lane 6 lane	60 60	16 22							4	2 (16)
Parking Lanes Width (ft) — Minimum	None		None		None	10	None	10	None	10 (17)
Pavement Type (18)	High		As required						High or Intermediate	
Right of Way (19) —Width (ft)	(20)	(21)	120	80	120	80	100	80	150	80
Structures (ft) (22)	Full Roadway Width (23)		40		40		32		Full Roadway Width	
Other Design Considerations-Urban			(24)		(24)		(24)		(24)	

Type of Terrain	**Rural — Design Speed** (mph)									**Urban — Design Speed** (mph)						
	40	45	50	55	60	65	70	75	80	30	35	40	45	50	55	60 (25)
Level	5	5	4	4	3	3	3	3	3	8	7	7	6	6	5	5
Rolling	6	6	5	5	4	4	4	4	4	9	8	8	7	7	6	6
Mountainous	8	7	7	6	6	5	5	5	5	11	10	10	9	9	8	8
	Grades (%)(26)															

Geometric Design Data, Minor Arterial
Figure 440-6a

Minor Arterial Notes:

(1) Justify the selection of an M-5 design class on limited access highways.

(2) The design year is 20 years after the year the construction is scheduled to begin.

(3) Where DHV exceeds 700, consider four lanes. When the volume/capacity ratio is equal to or exceeds 0.75, consider the needs for a future four-lane facility. When considering truck climbing lanes on an M-2 design class highway, perform an investigation to determine if an M-1 design class highway is justified.

(4) When considering a multilane highway, perform an investigation to determine if a truck climbing lane or passing lane will satisfy the need. See Chapter 1010.

(5) See Chapters 1430 and 1435 and the Master Plan for Limited Access Highways for access control requirements. Contact the HQ Design Office Access & Hearings Unit for additional information.

(6) Contact the Rail Office of the Public Transportation and Rail Division for input on the needs for the railroad.

(7) All main line and major-spur railroad tracks will be separated. Consider allowing at-grade crossings at minor-spur railroad tracks.

(8) Criteria for railroad grade separations are not clearly definable. Evaluate each site regarding the hazard potential. Provide justification for railroad grade separations.

(9) These are the design speeds for level and rolling terrain in rural areas. They are the preferred design speeds for mountainous terrain and urban areas. Higher design speeds may be selected, with justification.

(10) In urban areas, with a corridor analysis these values may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

(11) These design speeds may be selected in mountainous terrain, with a corridor analysis. Do not select a design speed that is less than the posted speed.

(12) When the truck DDHV is 150 or greater, consider 12 ft lanes.

(13) The minimum left shoulder width is 4 ft for four lanes and 10 ft for six or more lanes.

(14) For existing 6-lane roadways, existing 6 ft left shoulders may remain with design exception documentation, when they are not being reconstructed,and no other widening is required.

(15) When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 ft.

(16) When signing is required in the median of a six-lane section, the minimum width is 6 ft. If barrier is to be installed at a future date, an 8 ft minimum median is required.

(17) Restrict parking when DHV is over 1500.

(18) <u>See Chapter 520 for</u> Pavement Type Determination.

(19) Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut. See 440.15.

(20) 63 ft from edge of traveled way

(21) Make right of way widths not less than those required for necessary cross section elements.

(22) See Chapter 1120 for the minimum vertical clearance.

(23) For median widths 26 ft or less, address bridges in accordance with Chapter 1120.

(24) For bicycle requirements, see Chapter 1020. For pedestrian and sidewalk requirements see Chapter 1025. Curb requirements are in 440.11. Lateral clearances from the face of curb to obstruction are in Chapter 700.

(25) For grades at design speeds greater than 60 mph in urban areas, use rural criteria.

(26) Grades 1% steeper may be used in urban areas and mountainous terrain with critical right of way controls.

(27) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced up to 4 inches.

Geometric Design Data, Minor Arterial
Figure 440-6b

Design Class	Undivided Multilane		Two-Lane					
	C-1		C-2		C-3		C-4	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
DHV in Design Year (1) NHS Non NHS	Over 900		Over 301 (2) Over 501		201-300 (3) 301-500		200 and under 300 and Under	
Access Control	(4)		(4)		(4)		(4)	
Separate Cross Traffic Highways Railroads (5)	Where Justified Where Justified (6)		Where Justified All (6)		Where Justified Where Justified (6)		Where Justified Where Justified (6)	
Design Speed (mph) (7) Minimum (8)(9)	70 40	60 30	70 50	60 40	70 50	60 40	60 40	60 30
Traffic Lanes Number Width (ft)	4 12	4 or 6 11 (10)	2 12		2 12		2 12	
Shoulder Width (ft) (19)	8	8 (11)	8		6		4	
Median Width — Minimum (ft)	4	2 (12)						
Parking Lanes Width (ft) — Minimum	None	10	None		None	10	None	10
Pavement Type (13)	High or Intermediate		As required					
Right of Way (ft) (14)	150	80	120	80	120	80	100	80
Structures Width (ft) (15)	Full Roadway Width		40		40		32	
Other Design Considerations — Urban	(16)		(16)		(16)		(16)	

	Rural — Design Speed (mph)										**Urban — Design Speed** (mph)								
Type of Terrain	25	30	35	40	45	50	55	60	65	70	20	25	30	35	40	45	50	55	60(17)
Level	7	7	7	7	7	6	6	5	5	4	9	9	9	9	9	8	7	7	6
Rolling	10	9	9	8	8	7	7	6	6	5	12	12	11	10	10	9	8	8	7
Mountainous	11	10	10	10	10	9	9	8	8	6	14	13	12	12	12	11	10	10	9
Grades (%) (18)																			

Geometric Design Data, Collector

Figure 440-7a

Collector Notes:

(1) The design year is 20 years after the year the construction is scheduled to begin.

(2) Where DHV exceeds 900, consider four lanes. When the volume/capacity ratio is equal to or exceeds 0.85, consider the needs for a future four-lane facility. When considering truck climbing lanes on a C-2 design class highway, perform an investigation to determine if a C-1 design class highway is justified.

(3) When considering a multilane highway, perform an investigation to determine if a truck climbing lane or passing lane will satisfy the need. See Chapter 1010.

(4) See Chapters 1430 and 1435 and the Master Plan for Limited Access Highways for access control requirements. Contact the HQ Design Office Access & Hearings Unit for additional information.

(5) Contact the Rail Office of the Public Transportation and Rail Division for input on the needs for the railroad.

(6) Criteria for railroad grade separations are not clearly definable. Evaluate each site regarding the hazard potential. Provide justification for railroad grade separations.

(7) These are the design speeds for level and rolling terrain in rural areas. They are the preferred design speeds for mountainous terrain and urban areas. Higher design speeds may be selected, with justification. Do not select a design speed that is less than the posted speed.

(8) In urban areas, with a corridor analysis these values may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

(9) These design speeds may be selected in mountainous terrain, with a corridor analysis. Do not select a design speed that is less than the posted speed.

(10) Consider 12 ft lanes when the truck DHV is 200 or greater.

(11) When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 ft.

(12) When signing is required in the median of a six-lane section, the minimum width is 6 ft median. If barrier is to be installed at a future date, an 8 ft minimum median is required.

(13) <u>See Chapter 520 for</u> Pavement Type Determination.

(14) Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut. See 440.15.

(15) See Chapter 1120 for the minimum vertical clearance.

(16) For bicycle requirements, see Chapter 1020. For pedestrian and sidewalk requirements see Chapter 1025. Curb requirements are in 440.11. Lateral clearances from the face of curb to obstruction are in with Chapter 700.

(17) For grades at design speeds greater than 60 mph in urban areas, use rural criteria.

(18) Grades 1% steeper may be used in urban areas and mountainous terrain with critical right of way controls.

(19) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced up to 4 inches.

Geometric Design Data, Collector
Figure 440-7b

Design Class	Divided Multilane		Undivided Multilane		Two-Lane	
	UM/A-1	UM/A-2	UM/A-3	UM/A-4	UM/A-5	UM/A-6
DHV in Design Year (1)	Over 700	Over 700	700 – 2,500	Over 700	All	All
Design Speed (mph)	Greater than 45	45 or less	35 to 45	30 or less	Greater than 45	45 or less
Access	(2)	(2)	(2)	(2)	(2)	(2)
Traffic Lanes						
Number	4 or more	4 or more	4 or more	4 or more	2	2
Width (ft) NHS	12 (3)(4)	12 (3)	12 (3)	12 (3)	12 (3)(6)	12 (3)
Non NHS	11 (4)	11 (5)	11 (5)	11 (5)	11 (6)	11 (7)
Shoulder Width (ft) (8)						
Right of Traffic (19)	10	10	8	8	8 (9)	4
Left of Traffic	4	4				
Median Width (ft)	10 (10)	3 (10)(11)	(12)	(12)		
Parking Lane Width (ft)	None	10 (13)	10 (13)	8 (14)	10 (15)	8 (14)
Structures Width (ft) (16)	Full roadway width (17)		Full roadway width		32	30
Other Design Considerations	(18)	(18)	(18)	(18)	(18)	(18)

Urban Managed Access Highways Notes:

(1) The design year is 20 years after the year the construction is scheduled to begin.
(2) The urban managed access highway design is only used on managed access highways. See Chapter 1435.
(3) May be reduced to 11 ft with justification.
(4) Provide 12 ft lanes when truck DDHV is 200 or greater.
(5) Consider 12 ft lanes when truck DDHV is 200 or greater.
(6) Provide 12 ft lanes when truck DHV is 100 or greater.
(7) Consider 12 ft lanes when truck DHV is 100 or greater.
(8) See Figure 440-3 when curb section is used.
(9) When DHV is 200 or less, may be reduced to 4 ft.
(10) 12 ft desirable. At left-turn lanes, the minimum median width is 12 ft to accommodate the turn lane.
(11) The minimum median width is 10 ft when median barrier is used.
(12) 2 ft is desirable. When a TWLTL is present 13 ft is desirable, 11 ft is minimum.
(13) Prohibit parking when DHV is over 1500.
(14) 10 ft desirable.
(15) Prohibit parking when DHV is over 500.
(16) See Chapter 1120 for minimum vertical clearance.
(17) See Chapter 1120 for median requirements.
(18) For bicycle requirements, see Chapter 1020. For pedestrian and sidewalk requirements, see Chapter 1025. Lateral clearances from the face of curb to obstruction are in with Chapter 700. For railroad and other roadway grade separation, maximum grade, and pavement type for the functional class, see Figures 440-5a through 7b. Make right of way widths not less than required for necessary cross section elements.
(19) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced up to 4 inches.

Geometric Design Data, Urban Managed Access Highways
Figure 440-8

Chapter 640 Geometric Cross Section

640.01 General

Geometric cross sections for state highways are governed by functional classification criteria, traffic volume, and whether the highway is in a rural or an urban area. (See Chapter 440 for information on functional class.)

High Occupancy Vehicle (HOV) lanes must be considered when continuous through lanes are to be added within the limits of an urban area with a population over 200,000. (See Chapter 1050.)

When a state highway within an incorporated city or town is a portion of a city street, the design features must be developed in cooperation with the local agency. (See Chapter 440 for guidance on geometric design data when a state highway within an incorporated city or town is a portion of a city street.)

For additional information, see the following chapters:

Chapter	Subject
430	Roadway widths and cross slopes for modified design level
440	Minimum lane and shoulder widths for full design level
440	Shoulder widths at curbs
510	Geotechnical investigation
520	Pavement type
641	Turning roadway width
642	Superelevation
910	Requirements for islands
940	Lane and shoulder widths for ramps
960	Median crossovers

640.02 References

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 (Standard Plans), M 21-01, WSDOT

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

Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

640.03 Definitions

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.

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.

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.

high pavement type Portland cement concrete pavement or hot mix asphalt (HMA) pavement on a treated base.

intermediate pavement type Hot mix asphalt pavement on an untreated base.

lane A strip of roadway used for a single line of vehicles.

lane width The lateral design width for a single lane, striped as shown in the Standard Plans and the Standard Specifications.

low pavement type Bituminous surface treatment (BST).

median The portion of a highway separating the traveled ways for traffic in opposite directions.

outer separation The area between the outside edge of the traveled way for through traffic and the nearest edge of the traveled way of a frontage road or a collector-distributor road.

roadway The portion of a highway, including shoulders, for vehicular use.

rural design area An area that meets none of the conditions to be an urban design area.

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 use by pedestrians.

shoulder width The lateral width of the shoulder, measured from the outside edge of the outside lane to the edge of the roadway.

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.

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.

turning roadway A curve on an open highway, a ramp, or the connecting portion of the roadway between two intersecting legs of an intersection.

undivided multilane A roadway with two or more through lanes in each direction on which left turns are not controlled.

urban area An area designated by the Washington State Department of Transportation (WSDOT) in cooperation with the Transportation Improvement Board and regional transportation planning organizations, subject to the approval of the FHWA.

urban design area An area where urban design criteria is appropriate, that is defined by one or more of the following:

- An urban area.
- An area within the limits of an incorporated city or town.
- An area characterized by intensive use of the land for the location of structures, that receives such urban services as sewer, water, and other public utilities, as well as services normally associated with an incorporated city or town. This may include an urban growth area defined under the Growth Management Act (see Chapter 36.70A RCW, Growth management – planning by selected counties and cities), but outside the city limits.
- An area with not more than 25% undeveloped land.

640.04 Roadways

The cross sections shown in Figures 640-1, 2, 3, 4a, and 4b represent minimum values for full design level. (See Chapter 440 for additional design information for full design level and Chapter 430 for cross sections and design information for modified design level.)

(1) Traveled Way Cross Slope

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 two contradicting controls. Reasonably steep cross slopes are desirable to aid in water runoff and to minimize ponding as a result of pavement imperfections and unequal settlement. However, steep cross slopes are undesirable on tangents because of the tendency for vehicles to drift to the low side of the roadway. Steeper cross slopes are noticeable in steering, and they increase susceptibility to sliding 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. With justification and a hydraulic analysis, cross slopes between 1.5% and 2.5% are acceptable. Do not design cross slopes flatter than 1.5%.

On low pavement types, the cross slope may be increased to 3% to allow for reduced construction control and greater settlement.

Superelevation on curves is a function of the design speed and the radius of the curve. (See Chapter 642 for guidance on superelevation design.)

(2) Turning Roadways

The roadway on a curve may need to be widened to make the operating conditions comparable to those on tangents. There are two main reasons to do this. One is the offtracking of vehicles, such as trucks and buses. The other is the increased difficulty drivers have in keeping their vehicles in the center of the lane. (See Chapter 641 for width requirements on turning roadways.)

To maintain the desired design speed, highway and ramp curves are usually superelevated to overcome part of the centrifugal force that acts on a vehicle. (See Chapter 642 for superelevation requirements.)

(3) Shoulders

Pave the shoulders of all highways where high or intermediate pavement types are used. Where low pavement type is used, treat the roadway full width.

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%. Examples of 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.

When extruded curb is used, see the Standard Plans for required widening. Widening is normally required when traffic barrier is installed. (See Chapter 710.)

It is preferred that curb not be used on high-speed facilities (design speed above 45 miles per hour). In some areas, curb may be needed to control runoff water until ground cover is attained to prevent erosion. Plan for the removal of the curb when the ground cover becomes adequate. Arrange for curb removal with regional maintenance as part of the future maintenance plans. When curb is used in conjunction with guardrail, see Chapter 710 for guidance.

Figures 640-5a and 5b represent shoulder details and requirements.

640.05 Medians and Outer Separations

(1) Purpose

The main function of a median is to separate opposing traffic lanes. The main function of an outer separation is to separate the main roadway from a frontage road. Medians and outer separations also provide space for:

- Drainage facilities.
- Undercrossing bridge piers.
- Vehicle storage space for crossing and left-turn movements at intersections.
- Headlight glare screens, including planted or natural foliage.
- Visual separation of opposing traffic.
- Safety refuge areas for errant or disabled vehicles.
- Storage space for snow and water from traffic lanes.
- Increased safety, comfort, and ease of operations.
- Access control.
- Enforcement.

(2) Design

Figures 640-6a through 6c give minimum design requirements for medians. (See Chapters 430 and 440 for minimum median widths.) Median widths in excess of the minimums are highly desirable. 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 Figure 640-1. Independent horizontal and vertical alignment, rather than parallel alignment, is desirable.

No attempt has been made to cover all the various grading techniques that are possible on wide, variable-width medians. Considerable latitude in treatment is intended, provided the requirements of minimum geometrics, safety, and aesthetics are met or exceeded. Unnecessary clearing, grubbing, and grading are undesirable within wide medians. Give preference to selective thinning and limited reshaping of the natural ground. For median clear zone requirements, see Chapter 700, and for slopes into the face of traffic barriers, see Chapter 710.

In areas where land is expensive, make an economic comparison of wide medians to narrow medians with their barrier requirements. Consider right of way, construction, maintenance, and accident costs. The widths of medians need not be uniform. Make the transition between median widths as long as feasible. (See Chapter 620 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.

640.06 Roadsides

(1) Side Slopes

When designing side slopes, 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. Slopes flatter than recommended are desirable, especially within the Design Clear Zone. 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. Where mowing is contemplated, slopes must not be steeper than 3H:1V. If there will be continuous traffic barrier on a fill slope, and mowing is not contemplated, the slope may be steeper than 3H:1V.

Where unusual geological features or soil conditions exist, treatment of the slopes will depend upon results of a review of the location by the region's Materials Engineer.

With justification, fill slopes steeper than shown in the Fill and Ditch Slope Selection tables in Figures 640-1, 2, 3, and 4b may be used when traffic barrier is installed. Do not install traffic barrier unless a hazard requiring mitigation is present. The steepest slope is determined by the soil conditions. Where favorable soil conditions exist, higher fill slopes may be as steep as 1½H:1V. (See Chapter 700 for clear zone and barrier requirements.)

The Cut Slope Selection tables in Figures 640-1, 2, 3, and 4b are for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable cut slopes just to meet the slopes given in the Cut Slope Selection tables. When an existing slope is to be revised, document the reason for the change.

If borrow is required, consider obtaining it by flattening cut slopes uniformly on one or both sides of the highway. Where considering wasting excess material on an existing embankment slope, consult the region's Materials Engineer to verify that the foundation soil will support the additional material.

In all cases, provide for adequate drainage from the roadway surface and adequate drainage in ditches. (See 640.06(4) for drainage ditches in embankment areas details.)

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 all nonpaved 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's Landscape Architect to determine the appropriate configuration of the roadway cross section and soil and plant specifications.

Slope treatment, as shown in the Standard Plans, is required at the top of all 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.

(2) Roadway Sections in Rock Cuts

Typical sections for rock cuts, illustrated in Figures 640-7a and 7b, are guides for the design and construction of roadways through rock cuts. 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's Materials Engineer and Landscape Architect. Headquarters (HQ) Materials Lab concurrence is required.

There are two basic design treatments applicable to rock excavation (see Figures 640-7a and 7b). Design A applies to most rock cuts. Design B is a talus slope treatment.

(a) **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 Figure 640-7a:

- 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 only when extreme rockfall conditions exist.

  Show Stage 3 as the ultimate stage for future construction on the Plans, Specifications, and Estimates (PS&E) if there is any possibility that it will be needed.

The use of Stage 2 or 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. Appropriate terminal treatment is required. (See Chapter 710.)

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. The cut slope selected for a project must be that required to effect stability of the existing material.

Benches may be used to increase slope stability; however, the use of benches may alter the design requirements for the sections given in Figure 640-7a.

The necessity for benches, as well as their width and vertical spacing, is established only 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.

(b) **Design B**. A talus slope treatment is shown in Figure 640-7b. 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. The exact placement of the rock protection fence in talus slope areas requires considerable judgment and should be determined only after consultation with the region's Materials Engineer.

- **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. However, gabion treatment is considered similar to a wall and therefore requires appropriate face and end protection for safety. (See Chapters 710 and 1130.)

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.

Rock protection treatments other than those described above may be required for cut slopes that have relatively uniform spalling surfaces (consult with the region's Materials Engineer).

(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 only on the recommendation of the region's Materials Engineer. (See Chapter 510.) Consult the region's landscape personnel for appropriate design and vegetative materials to be used. (See Figure 640-8 for stepped slope design details.)

(4) Drainage Ditches in Embankment Areas

Where it is necessary to locate a drainage ditch adjacent to the toe of a roadway embankment, consider the stability of the embankment. A drainage ditch placed immediately adjacent to the toe of an embankment slope has the effect of increasing the height of the embankment by the depth of the ditch. In cases where the foundation soil is weak, the extra height could result in an embankment failure. As a general rule, the weaker the foundation and the higher the embankment, the farther the ditch should be from the embankment. Consult the region's Materials Engineer for the proper ditch location.

When topographic restrictions exist, consider an enclosed drainage system with appropriate inlets and outlets. Do not steepen slopes to provide lateral clearance from toe of slope to ditch location, thereby necessitating traffic barriers or other protective devices.

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.

Provide for disposition of the drainage collected by ditches in regard to siltation of adjacent property, embankment erosion, and other undesirable effects. This may also apply to top of cut slope ditches.

(5) Bridge End Slopes

Bridge end slopes are determined by several factors, including location, fill height, depth of cut, soil stability, and horizontal and vertical alignment. Close coordination between the HQ Bridge and Structures Office and the region is necessary to ensure proper slope treatment. (See Chapter 1120.)

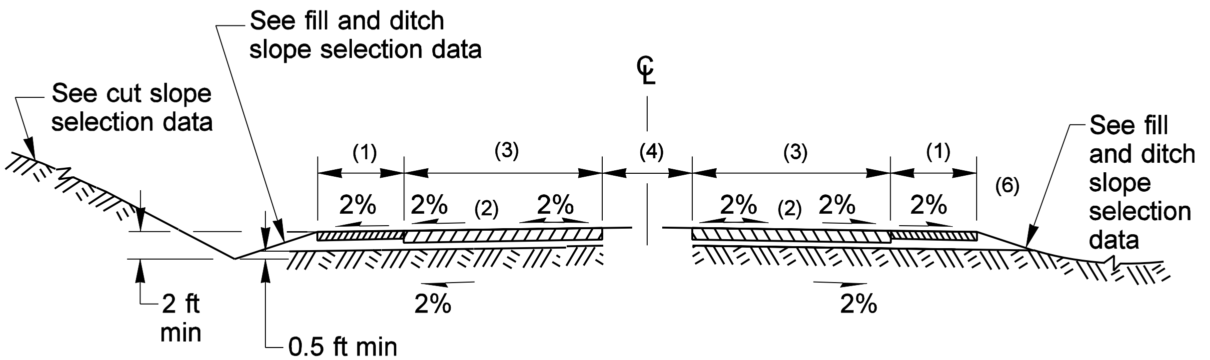
Early in the bridge plan development, determine preliminary bridge geometrics, end slope rates, and toe of slope treatments. Figure 640-9a provides guidelines for use of slope rates and toe of slope treatments for overcrossings. Figure 640-9b shows toe of slope treatments to be used on the various toe conditions.

640.07 Roadway Sections

Provide a typical roadway section for inclusion in the PS&E for each general type used on the main roadway, ramps, detours, and frontage or other roads. (See the *Plans Preparation Manual* for requirements.)

640.08 Documentation

A list of the documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/



Design Class I-1, P-1, P-2, M-1, $U_{M/A}$-1, $U_{M/A}$-2

Height of fill/depth of ditch (ft)	Slope not steeper than (5)
10	6H:1V
10 – 20	4H:1V
20 – 30	3H:1V (6)
over 30	2H:1V (6)(8)

Fill and Ditch Slope Selection

Height of cut (ft)*	Slope not steeper than
0 – 5	6H:1V
5 – 20	3H:1V
over 20	2H:1V (7)
* From bottom of ditch	

Cut Slope Selection (9)

Notes:

(1) For shoulder details, see Figures 640-5a and 5b. For minimum shoulder width, see Chapters 430 and 440.

(2) Generally, the crown slope will be as follows:
- Four-lane highway – Slope all lanes away from the median (plane section).
- Six-lane highway – Slope all lanes away from the median unless high rainfall intensities would indicate otherwise.
- Eight-lane highway – Slope two of the four directional lanes to the right and two to the left unless low rainfall intensities indicate that all four lanes could be sloped away from the median.

(3) For minimum number and width of lanes, see Chapters 430 and 440. For turning roadway width, see Chapter 641.

(4) For median details, see Figures 640-6a through 6c. For minimum median width, see Chapters 430 and 440.

(5) Where practicable, consider flatter slopes for the greater fill heights and ditch depths.

(6) Widen and round foreslopes steeper than 4H:1V, as shown in Figure 640-5b.

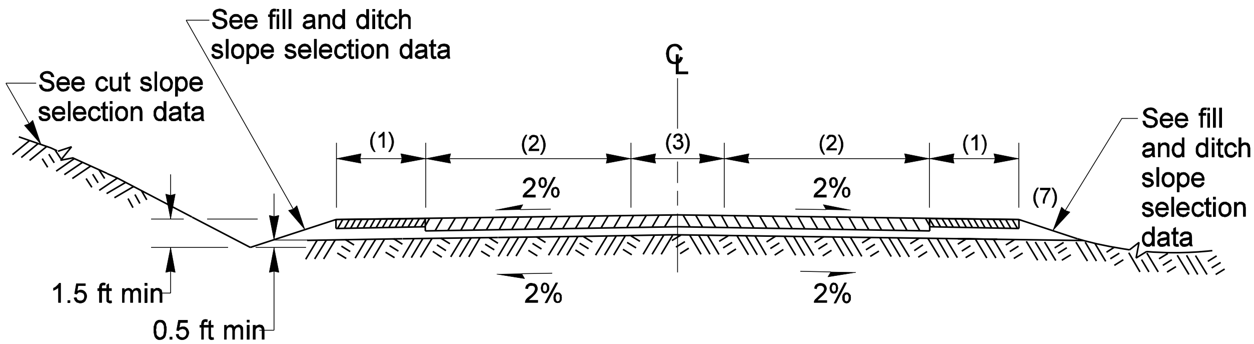
(7) Cut slopes steeper than 2H:1V may be used where favorable soil conditions exist or stepped construction is used. (See Chapter 700 for clear zone and barrier requirements.)

(8) Fill slopes as steep as 1½H:1V may be used where favorable soil conditions exist. (See Chapter 700 for clear zone and barrier requirements.)

(9) The Cut Slope Selection table is for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable slopes just to meet the slopes given in this table.

Divided Highway Roadway Sections

Figure 640-1



Design Class P-6, M-5, C-1, $U_{M/A}$-3, $U_{M/A}$-4

Height of fill/depth of ditch (ft)	Slope not steeper than (4)
0 – 5	6H:1V
5 – 20	4H:1V
20 – 30	3H:1V (7)
over 30	2H:1V (6)(7)

Fill and Ditch Slope Selection

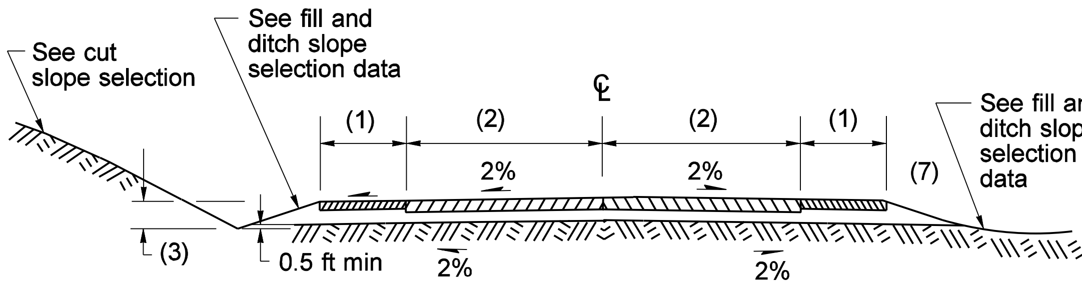
Height of cut (ft)*	Slope not steeper than
0 – 5	4H:1V
over 5	2H:1V (5)
* From bottom of ditch	

Cut Slope Selection (8)

Notes:

(1) For shoulder details, see Figures 640-5a and 5b. For minimum shoulder width, see Chapters 430 and 440.
(2) For minimum number and width of lanes, see Chapters 430 and 440. For turning roadway width, see Chapter 641.
(3) For minimum median width, see Chapters 430 and 440. For width when median is a two-way left-turn lane, see Chapter 910.
(4) Where practicable, consider flatter slopes for the greater fill heights and ditch depths.
(5) Cut slopes steeper than 2H:1V may be used where favorable soil conditions exist or stepped construction is used. (See Chapter 700 for clear zone and barrier requirements.)
(6) Fill slopes up to 1½H:1V may be used where favorable soil conditions exist. (See Chapter 700 for clear zone and barrier requirements.)
(7) Widen and round foreslopes steeper than 4H:1V, as shown in Figure 640-5b.
(8) The Cut Slope Selection table is for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable slopes just to meet the slopes given in this table.

Undivided Multilane Highway Roadway Sections
Figure 640-2



Design Class P-3, P-4, P-5. M-2, M-3, M-4, C-2, C-3, C-4, $U_{M/A}$-^{5}, $U_{M/A}$-^{6}

Design Class of highway	**P-3, P-4, M-2, C-2, $U_{M/A}{}^{5}$**	**P-5, M-3, M-4, C-3, C-4, $U_{M/A}{}^{6}$**
Height of fill/ depth of ditch (ft)	**Slope not steeper than (4)**	
0 – 10	6H:1V	4H:1V
10 – 20	4H:1V	4H:1V
20 – 30	3H:1V (7)	3H:1V (7)
over 30	2H:1V (5)(7)	2H:1V (5)(7)

Fill and Ditch Slope Selection

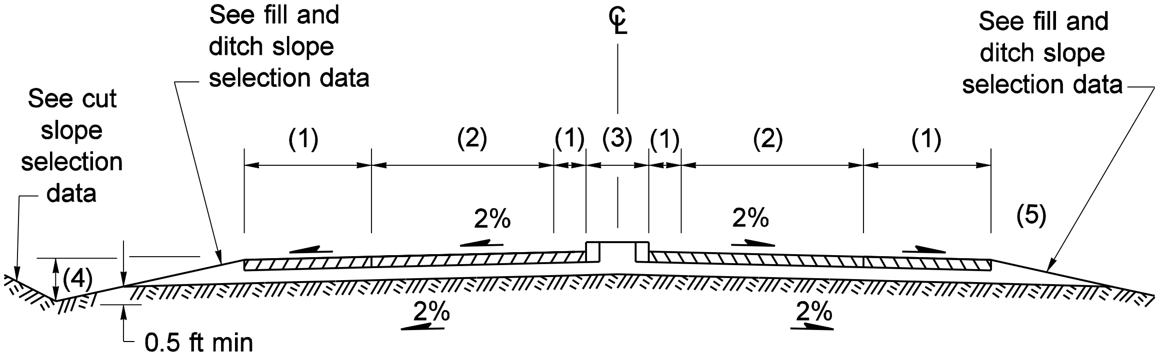
Design Class of highway	**P-3, P-4, M-2, C-2, $U_{M/A}{}^{5}$**	**P-5, M-3, M-4, C-3, C-4, $U_{M/A}{}^{6}$**
Height of cut (ft)*	**Slope not steeper than**	
0 – 5	6H:1V	4H:1V
5 – 20	3H:1V	2H:1V (6)
over 20	2H:1V (6)	2H:1V (6)
* From bottom of ditch		

Cut Slope Selection (8)

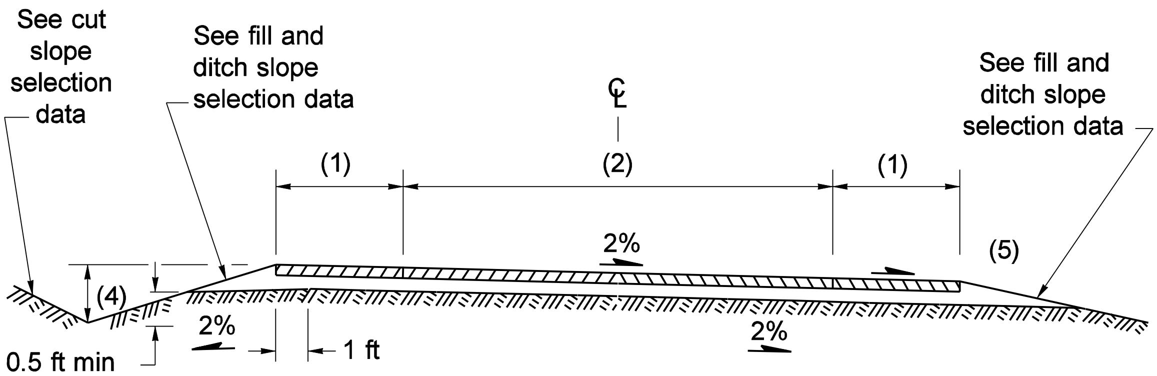
Notes:

(1) For shoulder details, see Figures 640-5a and 5b. For minimum shoulder width, see Chapters 430 and 440.
(2) For minimum width of lanes, see Chapters 430 and 440. For turning roadway width, see Chapter 641.
(3) The minimum ditch depth is 2 feet for Design Class P3 and 1.5 feet for Design Classes P-4, P-5, M-2, M-3, M-4, C-2, C-3, C-4, UM/A-5, and UM/A-6.
(4) Where practicable, consider flatter slopes for the greater fill heights.
(5) Fill slopes up to 1½H:1V may be used where favorable soil conditions exist. (See Chapter 700 for clear zone and barrier requirements.)
(6) Cut slopes steeper than 2H:1V may be used where favorable soil conditions exist or stepped construction is used. (See Chapter 700 for clear zone and barrier requirements.)
(7) Widen and round foreslopes steeper than 4H:1V, as shown in Figure 640-5b.
(8) The Cut Slope Selection table is for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable slopes just to meet the slopes given in this table.

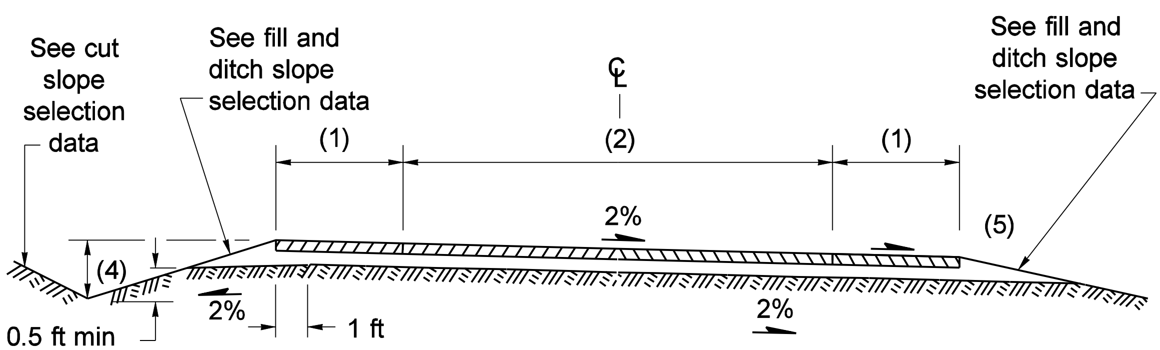
Two-Lane Highway Roadway Sections
Figure 640-3



Two-Lane Two-Way Ramp



Two-Lane One-Way Ramp



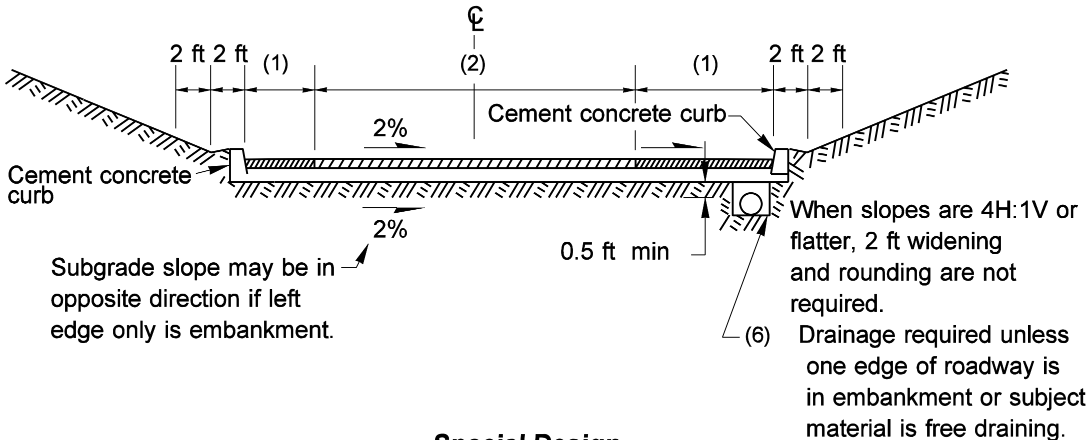
One-Lane Ramp

Note:

For notes, dimensions, and slope selection tables, see Figure 640-4b.

Ramp Roadway Sections

Figure 640-4a



Special Design

This special design section is to be used only when restrictions (high right of way costs or physical features that are difficult or costly to correct) require its consideration.

Height of fill/depth of ditch (ft)	Slope not steeper than (7)
0 – 10	6H:1V
10 – 20	4H:1V
20 – 30	3H:1V (5)
over 30	2H:1V (5) (9)

Fill and Ditch Slope Selection

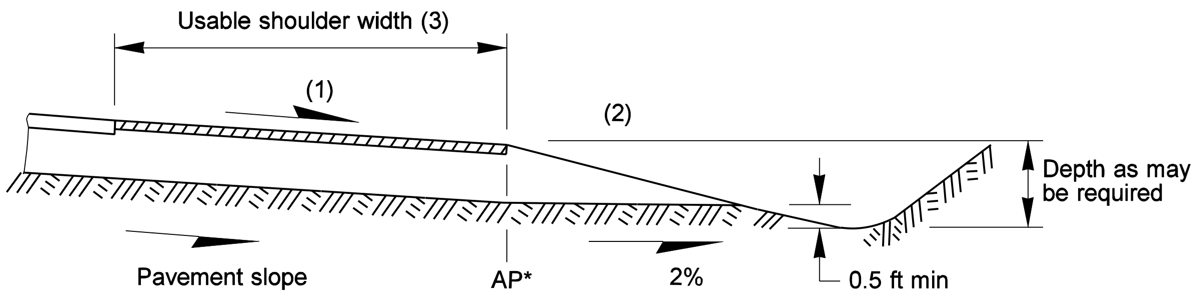
Height of cut (ft)*	Slope not steeper than
0 – 5	6H:1V
5 – 20	3H:1V
over 20	2H:1V (8)
* From bottom of ditch	

Cut Slope Selection (10)

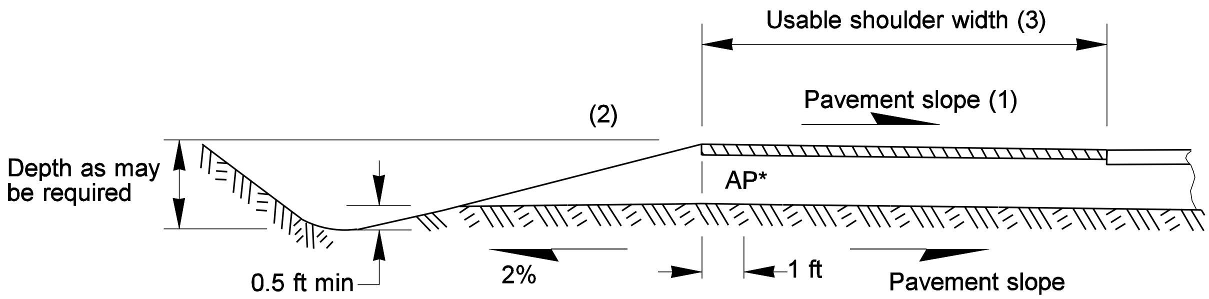
Notes:

(1) For shoulder details, see Figures 640-5a and 5b. For minimum shoulder widths, see Chapter 940.
(2) For minimum ramp lane widths, see Chapter 940. For turning roadway width, see Chapter 641. For two-way ramps, treat each direction as a separate one-way roadway.
(3) The minimum median width of a two-lane two-way ramp is not less than that required for traffic control devices and their respective clearances.
(4) Minimum ditch depth is 2 feet for design speeds over 40 mph and 1.5 feet for design speeds of 40 mph or less. Rounding may be varied to fit drainage requirements when minimum ditch depth is 2 feet.
(5) Widen and round foreslopes steeper than 4H:1V, as shown in Figure 640-5b.
(6) Method of drainage pickup to be determined by the designer.
(7) Where practicable, consider flatter slopes for the greater fill heights and ditch depths.
(8) Cut slopes steeper than 2H:1V may be used where favorable soil conditions exist or stepped construction is used. (See Chapter 700 for clear zone and barrier requirements.)
(9) Fill slopes as steep as 1½H:1V may be used where favorable soil conditions exist. (See Chapter 700 for clear zone and barrier requirements.)
(10) The Cut Slope Selection table is for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable slopes just to meet the slopes given in this table.

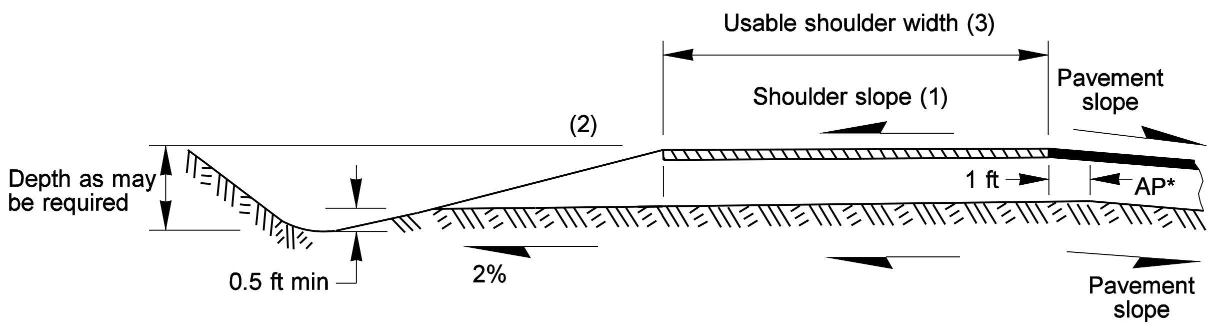
Ramp Roadway Sections
Figure 640-4b



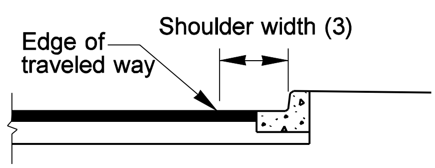
Shoulder Design on the Low Side of the Roadway for Cross Slopes Greater Than 2%.



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 (5)(6).

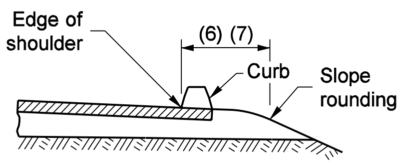
*AP = angle point in the subgrade.

Note:

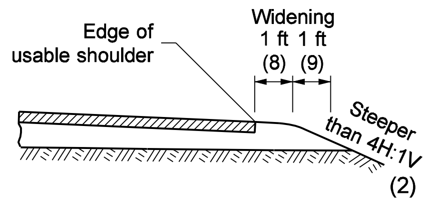
For notes, see Figure 640-5b.

Shoulder Details

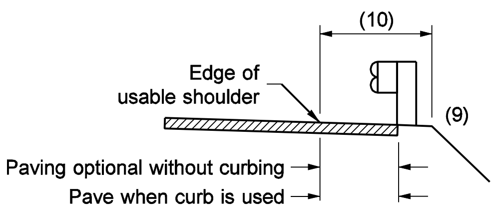
Figure 640-5a



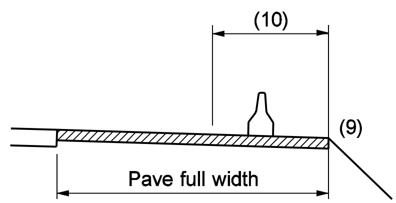
Extruded Curb Placement



Slope Rounding



Shoulder Widening for Guardrail

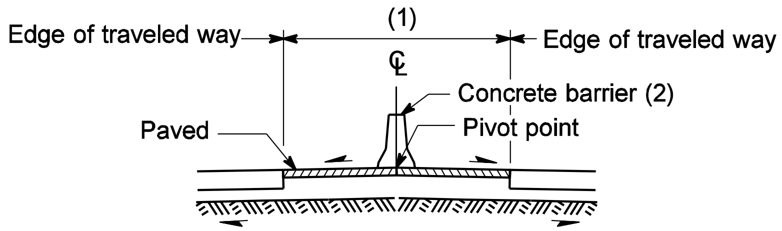


Shoulder Widening for Barrier

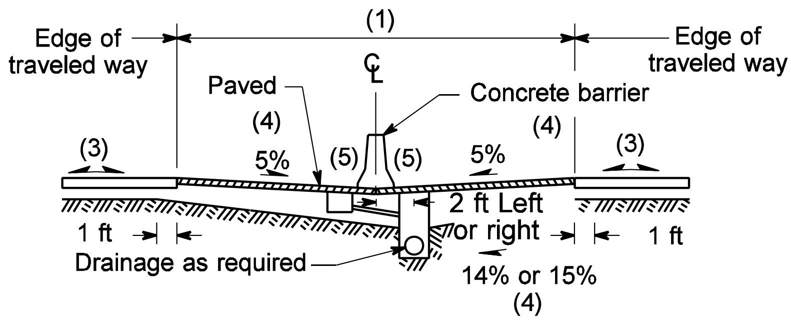
Notes:

(1) Shoulder cross slopes are normally the same as the cross slopes for adjacent lanes. (See 640.04(3) in the text for examples, additional information, and requirements of locations where it may be desirable to have a shoulder cross slope different than the adjacent lane.)
(2) Widening and slope rounding outside the usable shoulder is required when foreslope is steeper than 4H:1V.
(3) For minimum shoulder width, see Chapters 430, 440, and 940.
(4) On divided multilane highways, see Figures 640-6a through 6c for additional details and requirements for median shoulders.
(5) For additional requirements for sidewalks, see Chapter 1025.
(6) It is preferred that curb not be used on high-speed facilities (posted speed >40 mph).
(7) Paved shoulders are required wherever extruded curb is placed. Use curb only where necessary to control drainage from roadway runoff. (See the Standard Plans for additional details and dimensions.)
(8) When rounding is required, use it uniformly 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.
(9) When widening beyond the edge of usable shoulder is required for curb, barrier, or other purposes, additional widening for slope rounding is not required.
(10) For required widening for guardrail and concrete barrier, see Chapter 710.

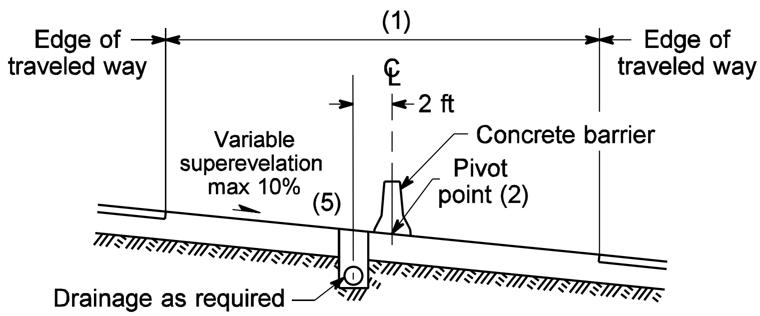
Shoulder Details
Figure 640-5b



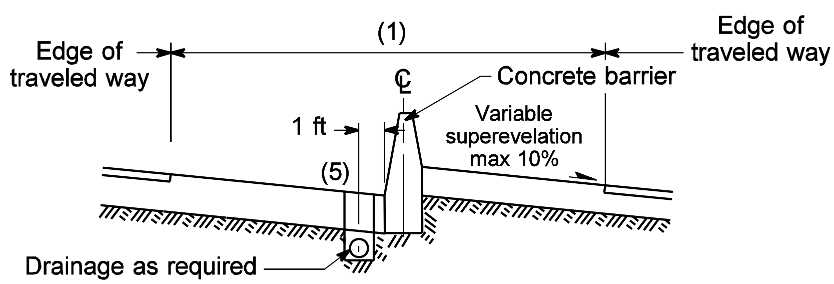
Design A Crowned Median



Design B Depressed Median



Alternate Design 1 Treatment on Curves

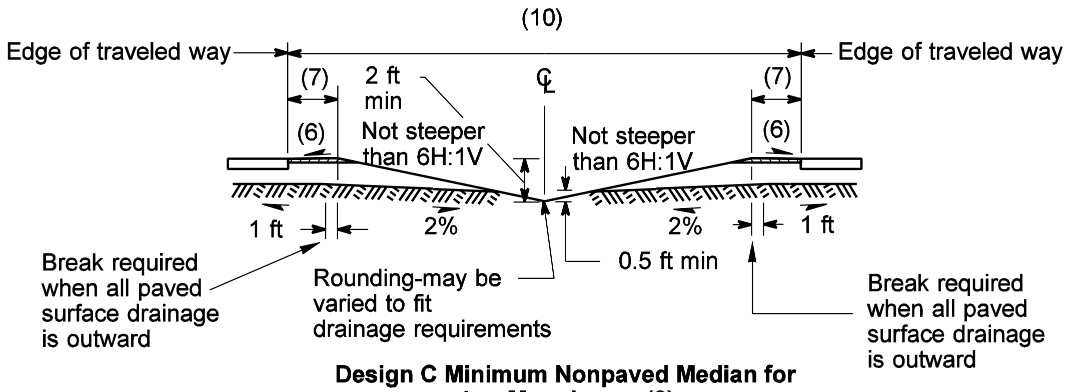


Alternate Design 2 No Fixed Pivot Point (2)

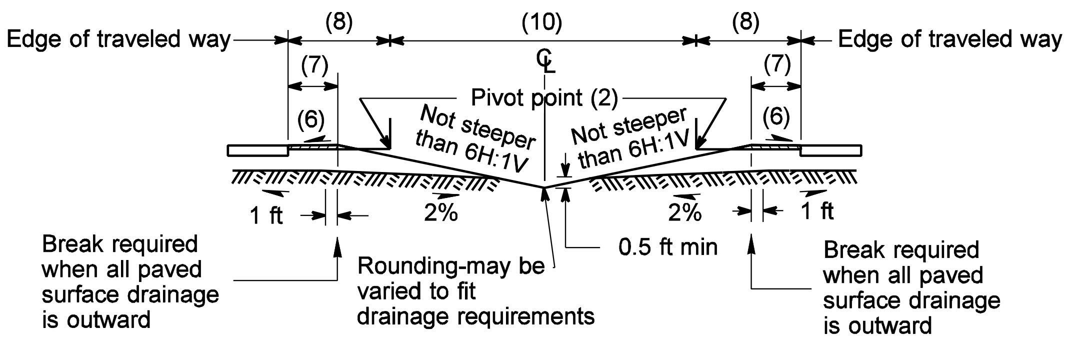
Note:

For notes, see Figure 640-6c.

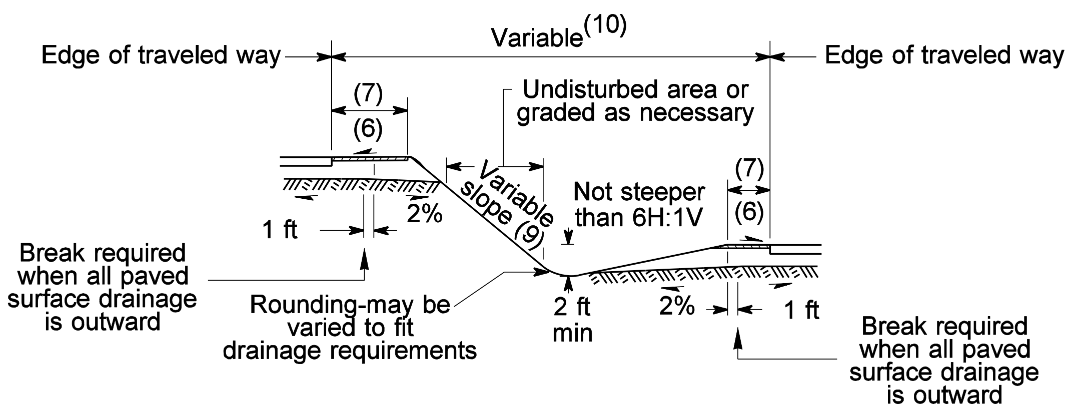
Divided Highway Median Sections
Figure 640-6a



Design C Minimum Nonpaved Median for 4 or More Lanes (2)



Design D Minimum for 4 or More Lanes with Future Lanes in Median



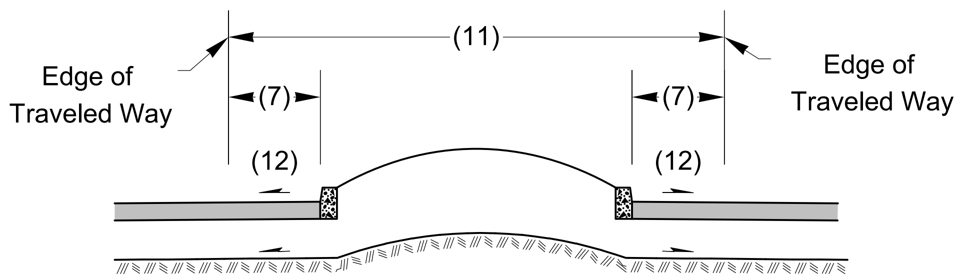
Design E Minimum for 4 or More Lanes with Independent Alignment

Note:

For notes, see Figure 640-6c.

Divided Highway Median Sections

Figure 640-6b

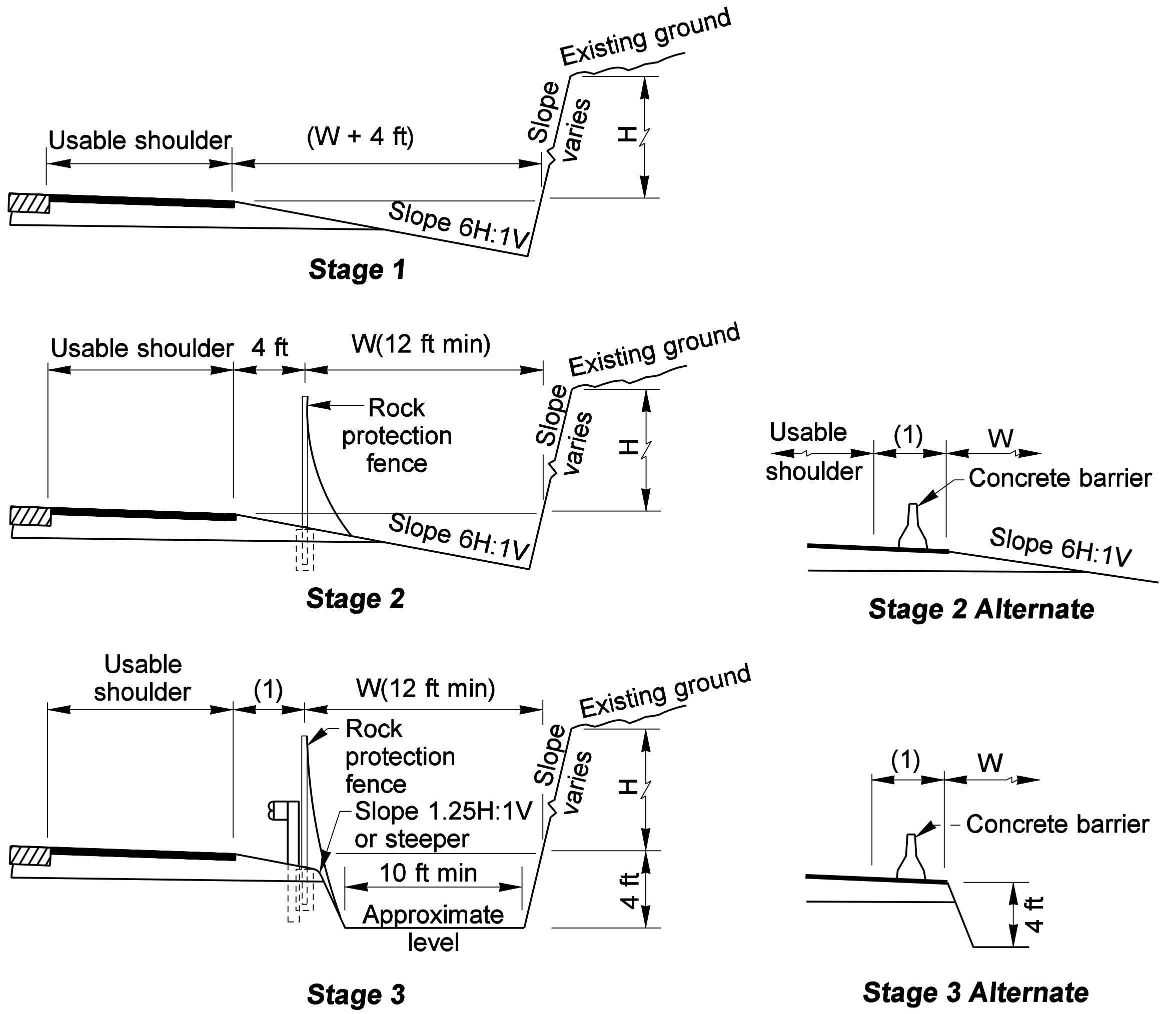


Design F Raised Median (13)

Notes:

(1) For minimum median width, see Chapters 430 and 440.
(2) Locate the pivot point to best suit the requirements of vertical clearances, drainage, and aesthetics.
(3) Pavement slopes generally shall be in a direction away from the median. A crowned roadway section may be used in conjunction with the depressed median where conditions justify. (See Figure 640 1 for additional crown information.)
(4) Design B may be used uniformly on both tangents and horizontal curves. Use alternate designs 1 or 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 640.04(3) for examples, additional information, and requirements of locations where it may be desirable to have a shoulder cross slope different than the adjacent lane.)
(7) For minimum shoulder width, see Chapters 430 and 440.
(8) Future lane (see Chapter 440 for minimum width).
(9) Widen and round foreslopes steeper than 4H:1V, as shown in Figure 640 5b.
(10) Designs C, D, and E are rural median designs. (See Chapter 440 for minimum rural median widths.) Rural median designs may be used in urban areas when minimum rural median widths can be achieved.
(11) For minimum median width, see Chapter 440. Raised medians may be paved or landscaped. For clear zone and barrier requirements when fixed objects or trees are in the median, see Chapter 700.
(12) Lane and shoulders normally slope away from raised medians. When they slope toward the median, provide for drainage.
(13) The desirable maximum design speed for a raised median is 45 mph. When the design speed is above 45 mph, Design A or Design B is preferred.

Divided Highway Median Sections
Figure 640-6c



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:

Cut heights less than 20 feet shall be treated as a normal roadway, unless otherwise determined by the region's Materials Engineer.

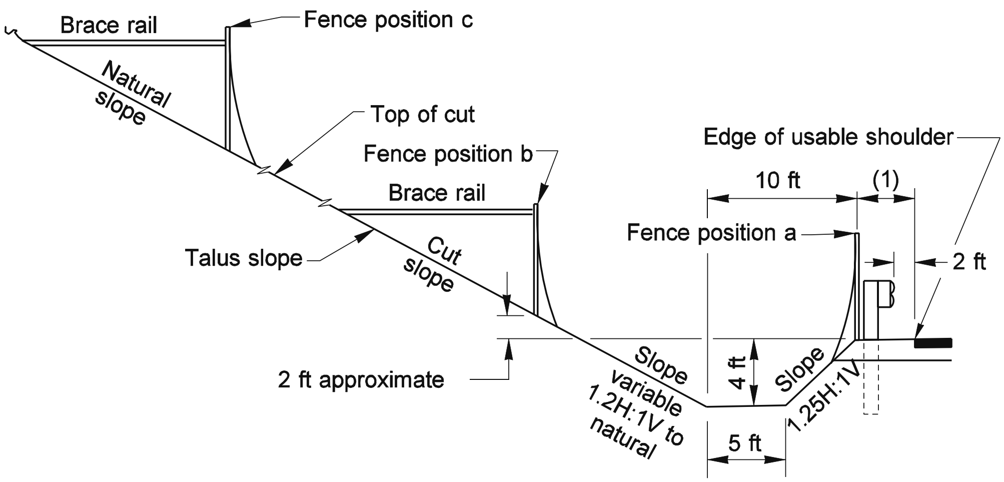
Stage 2 and 3 Alternates may be used when site conditions dictate.

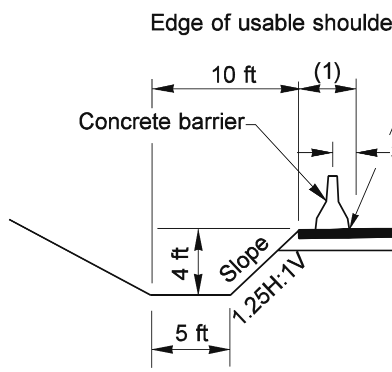
Fence may be used in conjunction with the Stage 3 Alternate. (See Chapter 700 for clear zone requirements.)

(1) For required widening for guardrail and concrete barrier, see Chapter 710.

Roadway Sections in Rock Cuts, Design A

Figure 640-7a





Shoulder Barrier Alternate

Notes:

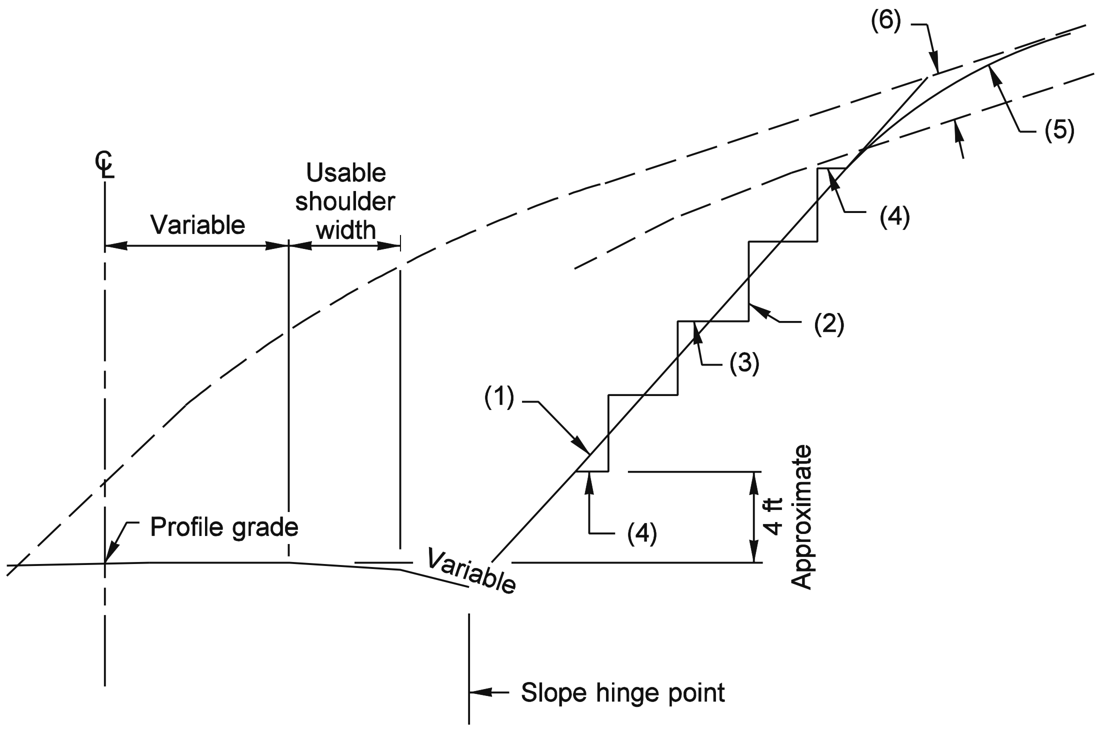
Ordinarily, place fence within a zone of 100 feet to 200 feet maximum from base of cliff, measured along the slope.

Rock protection fence may be used in conjunction with the Shoulder Barrier Alternate when site conditions dictate.

(1) For required widening for guardrail and concrete barrier, see Chapter 710.

Roadway Sections in Rock Cuts, Design B

Figure 640-7b



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.

Roadway Sections With Stepped Slopes

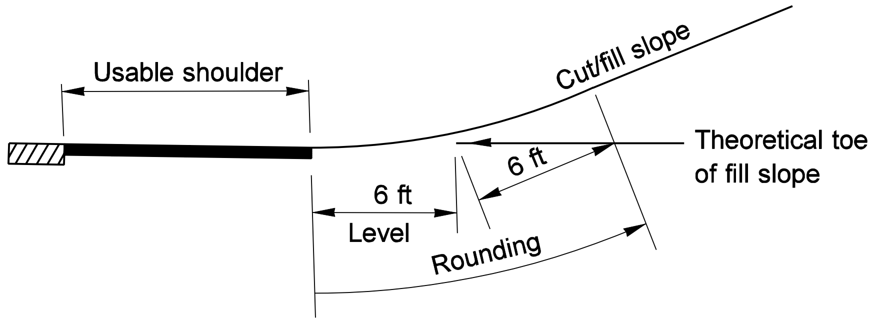
Figure 640-8

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)

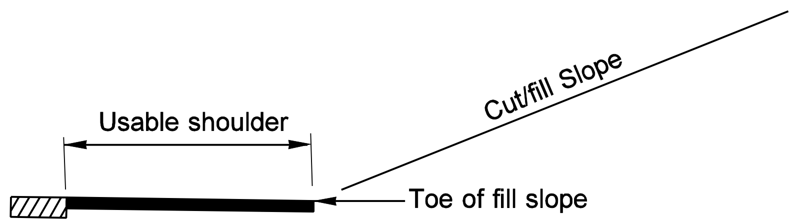
Notes:

(1) See Figure 640-9b.
(2) Slope may be 1¾H:1V in special cases.
(3) In interchange areas, continuity may require variations.
(4) See 640.06.

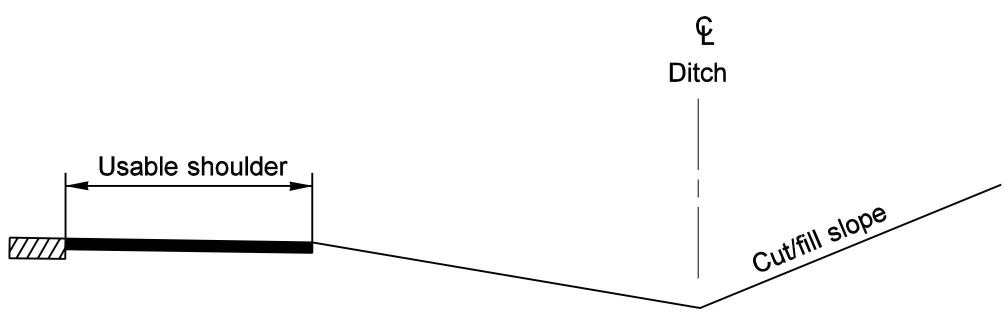
Bridge End Slopes
Figure 640-9a



Rounding



No Rounding



Toe at ℄ of Roadway Ditch

Bridge End Slopes
Figure 640-9b

Chapter 641 Turning Roadways

641.01 General

The roadway on a curve may need to be widened to make the operating conditions comparable to those on tangents. There are two main reasons to do this. One is the offtracking of vehicles, such as trucks and buses. The other is the increased difficulty drivers have in keeping their vehicles in the center of the lane.

For additional information, see the following chapters:

Chapter	Subject
430	Roadway widths and cross slopes for modified design level
440	Minimum lane and shoulder widths for full design level
642	Superelevation
940	Lane and shoulder widths for ramps

641.02 References

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

Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

641.03 Definitions

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.

lane A strip of roadway used for a single line of vehicles.

lane width The lateral design width for a single lane, striped as shown in the Standard Plans and the Standard Specifications.

roadway The portion of a highway, including shoulders, for vehicular use.

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 use by pedestrians.

shoulder width The lateral width of the shoulder, measured from the outside edge of the outside lane to the edge of the roadway.

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.

turning roadway A curve on an open highway, a ramp, or the connecting portion of the roadway between two intersecting legs of an intersection.

undivided multilane A roadway with two or more through lanes in each direction on which left turns are not controlled.

641.04 Turning Roadway Widths

(1) Two-Lane Two-Way Roadways

Figure 641-1a shows the traveled way width W for two-lane two-way roadways. For values of R between those given, interpolate W and round up to the next foot.

Minimum traveled way width W based on the delta angle of the curve, shown in Figure 641-1b, may be used. Document the reasons for using the minimum width. Round W to the nearest foot.

Widths given in Figures 641-1a and 1b are for facilities with 12-foot lanes. When 11-foot lanes are called for, width W may be reduced by 2 feet.

(2) Two-Lane One-Way Roadways

Figure 641-2a shows the traveled way width W for two-lane one-way turning roadways, including two lane ramps and four-lane highways. For values of R between those given, interpolate W and round up to the next foot. Treat each direction of travel on four-lane facilities as a one-way roadway.

Minimum traveled way width W based on the delta angle of the curve, shown in Figure 641-2b, may be used. Document the reasons for using the minimum width. Round W to the nearest foot.

Widths given in Figures 641-2a and 2b are for facilities with 12-foot lanes. When 11-foot lanes are called for, width W may be reduced by 2 feet.

To keep widths to a minimum, traveled way widths for Figures 641-2a and 2b were calculated using the WB-40 design vehicle. When volumes are high for trucks larger than the WB-40 and other traffic, consider using the widths from Figures 641-1a and 1b.

(3) One-Lane Roadways

Figure 641-3a shows the traveled way width W for one-lane turning roadways, including one-lane ramps. For values of R between those given, interpolate W and round up to the next foot.

Minimum width W, based on the delta angle of the curve for one-lane roadways shown in Figure 641-3b using the radius to the outer edge of the traveled way and Figure 641-3c using the radius on the inner edge of the traveled way, may be used. Document the reasons for using the minimum width. Round W to the nearest foot.

Build shoulder pavements at full depth for one-lane roadways. To keep widths to a minimum, traveled way widths were calculated using the WB-40 design vehicle, which may force larger vehicles to encroach on the shoulders. This also helps to maintain the integrity of the roadway structure during partial roadway closures.

(4) Other Roadways

For roadways where the traveled way is more than two lanes in any direction, for each lane in addition to two, add the lane width for the highway functional class from Chapter 440 to the width from 641.04(2).

For three-lane ramps with HOV lanes, see Chapter 1050.

(5) Total Roadway Width

Full design shoulder widths for the highway functional class or ramp are added to the traveled way width to determine the total roadway width.

Small amounts of widening will add cost with little benefit. When the required traveled way widening is less than 0.5 feet per lane, it may be disregarded. If the total roadway width deficiency is less than 2 feet on existing roadways that are to remain in place, correction is not normally required.

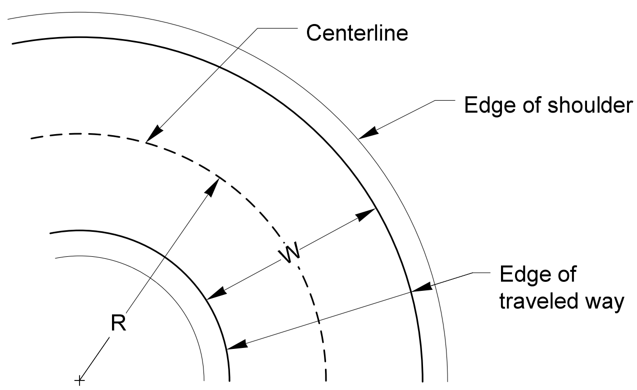
When widening the traveled way:

- Widening may be constructed on the inside of the traveled way or divided equally between the inside and outside. Do not construct widening only on the outside of a curve.
- Place final marked lane lines, and any longitudinal joints, at equal spacing between the edges of the widened traveled way.
- Provide widening throughout the curve length.
- For widening on the inside, make transitions on a tangent where possible.
- For widening on the outside, develop the widening by extending the tangent. This avoids the appearance of a reverse curve that a taper would create.
- For widening of 6 feet or less, use a 1:25 taper. For widths greater than 6 feet, use a 1:15 taper.

641.05 Documentation

A list of the documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

Radius on Centerline of Traveled Way (ft)	Design Traveled Way Width (W)(ft)[(1)]
3000 to tangent	24
2999	25
2000	26
1000	27
800	28
600	29
500	30
400	31
350	32
300	33
250	35
200	37
150	41

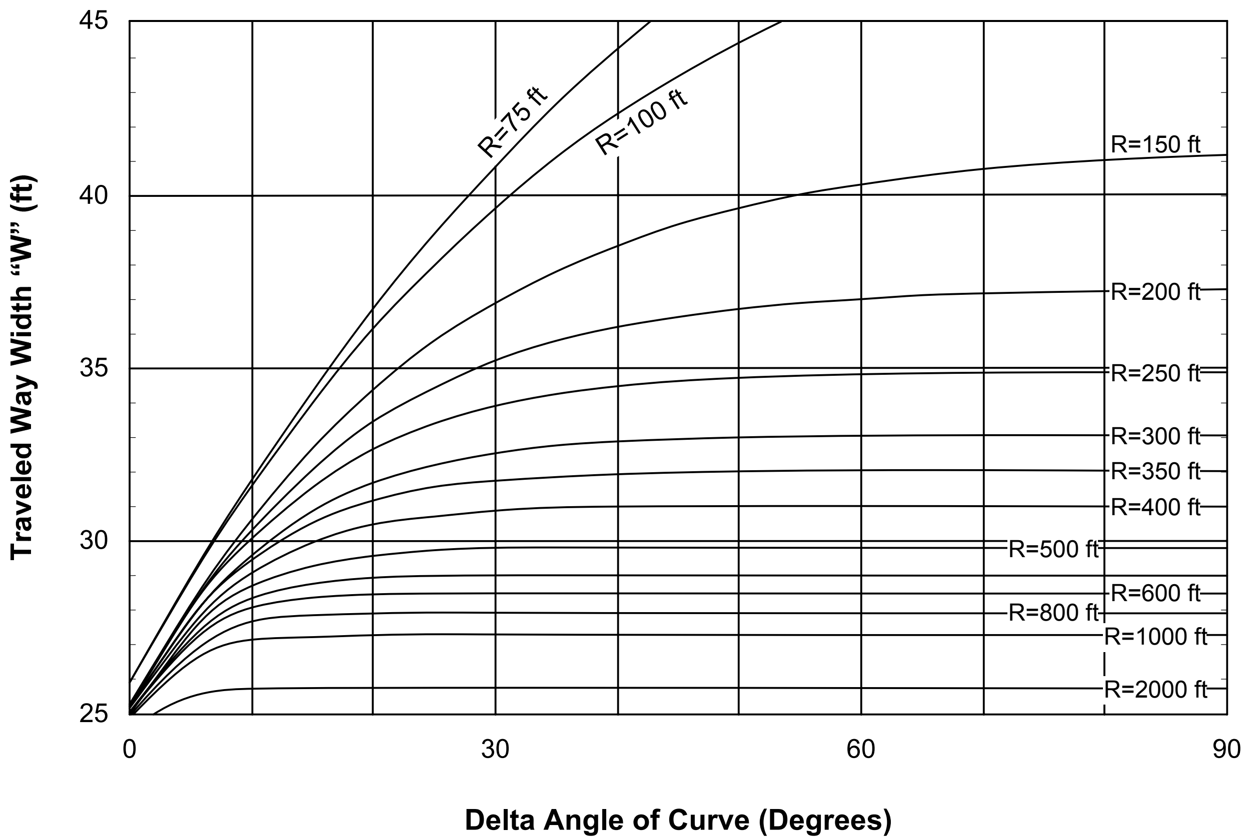


Note:

(1) Width (W) is for facilities with 12-foot lanes. When 11-foot lanes are called for, width may be reduced by 2 feet.

Traveled Way Width for Two-Lane Two-Way Turning Roadways

Figure 641-1a



Note:

Width (W) is for facilities with 12-foot lanes. When 11-foot lanes are called for, width may be reduced by 2 feet.

Traveled Way Width for Two-Lane Two-Way Turning Roadways

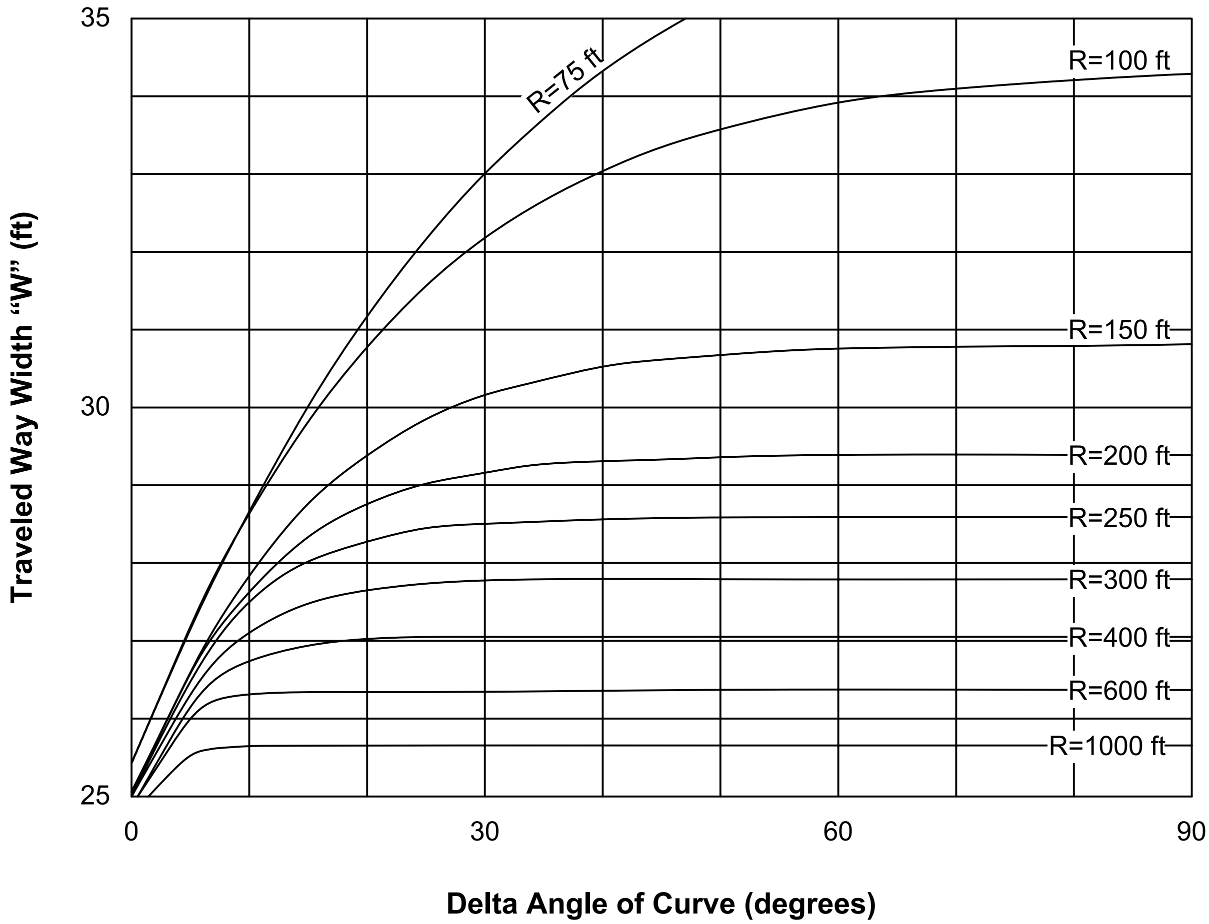
Figure 641-1b

Radius on Centerline of Traveled Way (ft)	Design Traveled Way Width (W) (ft)(1)
3000 to tangent	24
1000 to 2999	25
999	26
600	26
500	27
400	27
300	28
250	29
200	29
150	31
100	34

Note:

(1) Width (W) is for facilities with 12-foot lanes. When 11-foot lanes are called for, width may be reduced by 2 feet.

Traveled Way Width for Two-Lane One-Way Turning Roadways
Figure 641-2a



Note:

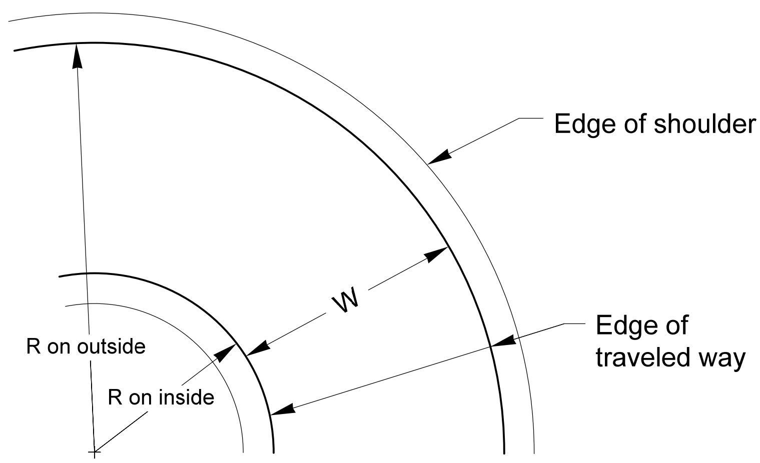
(1) Width (W) is for facilities with 12-foot lanes. When 11-foot lanes are called for, width may be reduced by 2 feet.

Traveled Way Width for Two-Lane One-Way Turning Roadways

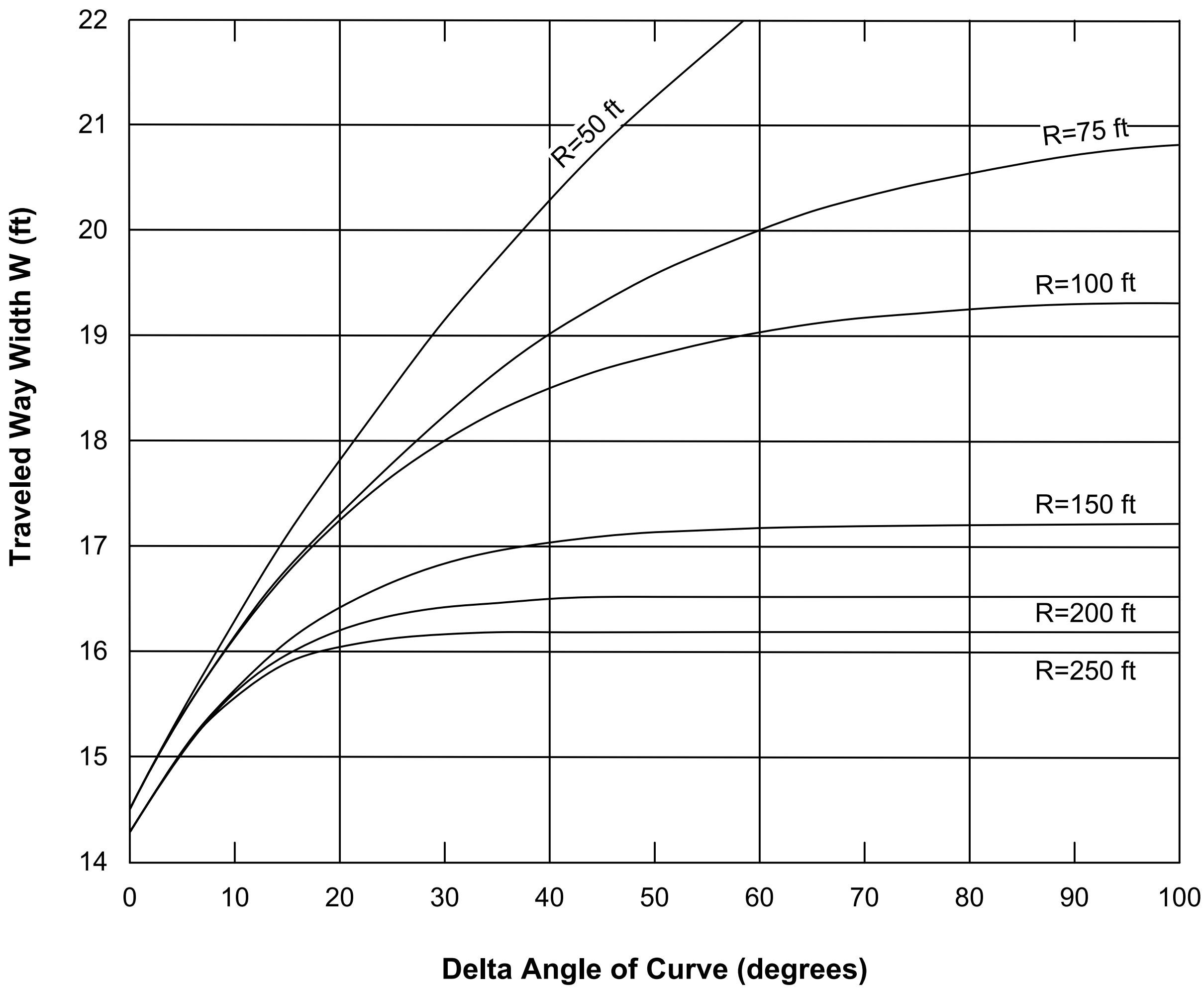
Figure 641-2b

Radius (ft)	Design Traveled Way Width (W) (ft)	
	Radius on outside edge of traveled way	Radius on inside edge of traveled way
7500 to tangent	13[1]	13[1]
1600	14	14
300	15	15
250	16	16
200	17	17
150	17	17
100	19	18
75	21	19
50	26	22

Note:
(1) On tangents, the minimum lane width may be reduced to 12 feet.

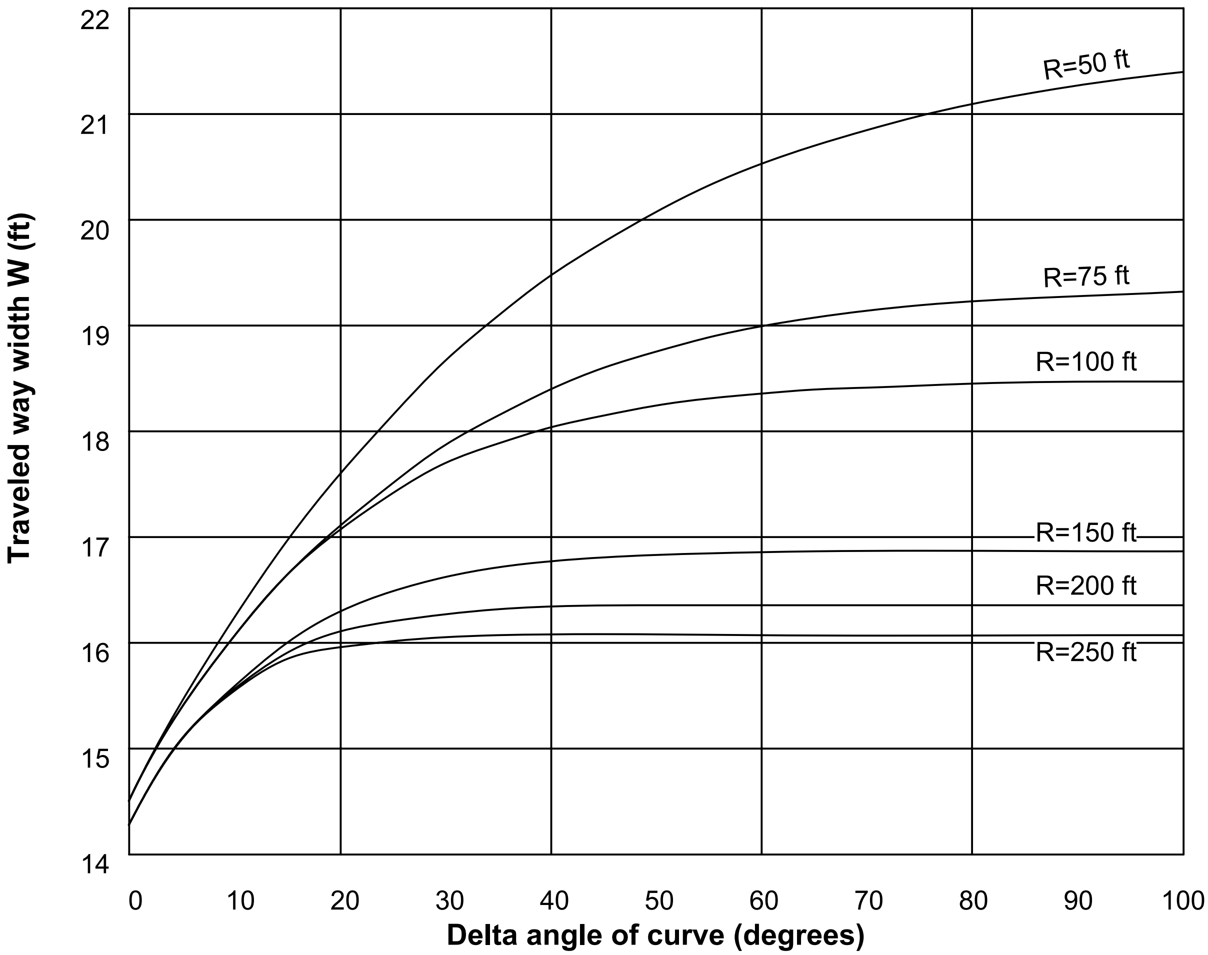


Traveled Way Width for One-Lane Turning Roadways
Figure 641-3a



Note:
All radii are to the outside edge of traveled way.

Traveled Way Width for One-Lane Turning Roadways
Figure 641-3b



Note:
All radii are to the inside edge of traveled way.

Traveled Way Width for One-Lane Turning Roadways
Figure 641-3c

710.01 General

Traffic barriers are used to reduce the severity of accidents that occur when an errant vehicle leaves the traveled way. However, traffic barriers are obstacles that the vehicle will encounter and they must only be used when justified by accident history or the criteria in Chapter 700.

710.02 References

Design Guidance

Bridge Design Manual, M 23-50, WSDOT

Roadside Design Guide, AASHTO

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

Traffic Manual, M 51-02, WSDOT

710.03 Definitions

barrier terminal A crashworthy 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.

controlled releasing terminal (CRT) post A standard length guardrail post that has two holes drilled through it so that it will break away when struck.

crashworthy A feature that has been proven acceptable for use under specified conditions, either through crash testing or in-service performance.

hazard A side slope, a fixed object, or water that, when struck, can result in unacceptable impact forces on a vehicle's occupants or place the occupants in a hazardous position. A hazard can be either natural or manmade.

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 hazard.

length of need The length of a traffic barrier needed to shield a hazard.

longitudinal barrier Traffic barrier oriented parallel or nearly parallel to the roadway. The purpose is to contain or redirect errant vehicles. Beam guardrail, cable barrier, bridge rail, and concrete barrier are longitudinal barriers, which are categorized as rigid, unrestrained rigid, semirigid, and flexible. They can be installed as roadside or median barriers.

shy distance The distance from the edge of the traveled way beyond which a roadside object will not be perceived as an immediate hazard by the typical driver to the extent that the driver will change the vehicle's placement or speed.

traffic barrier A longitudinal barrier, including bridge rail, or an impact attenuator used to redirect vehicles from hazards located within an established Design Clear Zone, to prevent median crossovers, to prevent errant vehicles from going over the side of a bridge structure, or (occasionally) to protect workers, pedestrians, or bicyclists from vehicular traffic.

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.

710.04 Project Requirements

This section identifies the barrier elements that must be addressed according to the Design Matrices in Chapter 325. Remove any barrier that is not needed (based on the criteria in Chapter 700) or that poses a more severe hazard than the hazard it is shielding.

(1) Barrier Terminals and Transitions

Install, replace, or upgrade transitions as discussed in 710.06(5), Transitions and Connections.

Impact attenuator requirements can be found in Chapter 720, "Impact Attenuator Systems."

When installing new terminals, consider extending the guardrail to meet the length of need criteria in 710.05(4) as a spot safety enhancement.

Concrete barrier terminal requirements can be found in 710.08(3). When the end of a concrete barrier has been terminated with a small mound of earth (a design formerly known as a Concrete Barrier Berm), remove and replace with a crashworthy terminal, except as noted in 710.09.

Redirectional land forms, also referred to as earth berms, were installed to mitigate hazards 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 land forms has been discontinued as a means for mitigating fixed objects. Where redirectional land forms currently exist as mitigation for a fixed object, ensure that the hazard they were intended to mitigate is 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.

Replace guardrail terminals that do not have a crashworthy design with crashworthy guardrail terminals. (See 710.06(4), Terminals and Anchors.) Common features of noncrashworthy designs include the following:

- 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—see the Standard Plans for end section details)
- 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 2 feet

When the height of a standard terminal will be reduced to less than 26 inches from the ground to the top of the rail element, adjust the height to a minimum of 26 inches and a maximum of 28 inches. A rail height of 28 inches is desirable to accommodate future overlays. Terminals are equipped with CRT posts with drilled holes that 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 SRT and a Type 1 anchor. Type 1 anchor posts are wood set in a steel tube or a concrete foundation.

Replace BCTs on Interstate routes. On non-Interstate routes, BCTs that have at least a 3-foot offset 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.) Replace all BCTs that have less than a 3-foot offset.

Existing transitions that do not have a curb, but are otherwise consistent with the designs shown in the Standard Plans, may remain in place.

For preservation projects, terminal and transition work may be programmed under a separate project, as described in Chapter 410.

(2) Standard Run of Barrier

In Chapter 325, the Design Matrices offer guidance on how to address standard barrier runs for different project types. A "Standard Run" of barrier consists of longitudinal barrier that is detailed in the Washington State Department of Transportation (WSDOT) Standard Plans.

(a) **Basic Design Level (B).** When the basic design level (B) is indicated in the Standard Run column of a Design Matrix and the height of W-beam guardrail is or would be reduced to less than 26 inches from the ground to the top of the rail element, adjust the height to a minimum of 26 inches and maximum of 28 inches. A rail height of 28 inches is desirable to accommodate future overlays.

If Type 1 Alternate W-beam guardrail is present, raise the rail element after each overlay. If Type 1 Alternate is not present, raise the existing blockout up to 4 inches higher than the top of the existing post by boring a new hole in the post.

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 required. Allow no more than 1 foot 1 inch from the pavement to the beginning of the top near-vertical face of the safety shape barriers. Allow no less than 2 feet 8 inches from the pavement to the top of the single-slope barrier. Allow no less than 2 feet 3 inches from the ground to the top cable of the Type 1 cable barrier, and no less than 2 feet 6 inches for the Type 2 and Type 3 and high tension cable barriers.

(b) **Full Design Level (F).** When the full design level (F) is indicated, in addition to the requirements for the basic design level, the barrier must meet the requirements found in the following:

Chapter	Subject
700.06	Median considerations
710.05(1)	Shy distance
710.05(2)	Barrier deflections
710.05(3)	Flare rate
710.05(4)	Length of need
710.05(5)	Median barrier selection and placement considerations
710.06	Beam guardrail
710.07	Cable barrier
710.08	Concrete barrier

Examples of barriers that are not acceptable as a "Standard Run" are:

- W-beam guardrail (excluding the Type 31 NB4 proprietary system) with 12-foot-6-inch post spacing and/or no blockouts.
- W-beam guardrail on concrete posts.
- Cable barrier on wood or concrete posts.
- Half-moon or C-shaped rail elements.

(3) Bridge Rail

When the Bridge Rail column of a matrix applies to the project, the bridge rails must meet the following requirements:

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. Consult the Headquarters (HQ) Bridge and Structures Office regarding bridge rail selection and design, and for design of the connection to an existing bridge.

An existing bridge rail on a highway with a posted speed of 30 miles per hour or less 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 miles per hour or less, it may remain in place, regardless of the type of metal rail installed. All other bridge rails must be evaluated for strength and geometrics. (See 710.10 for guidance on retrofit techniques.) 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 (Preservation or Improvement). For longer bridges, the retrofit can be funded by the I-2 subprogram. Contact programming personnel to determine if funding is available.

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 dictate the adequacy of the Type 7 bridge rail, as shown in Figure 710-1. Consult the HQ Bridge and Structures Office for assistance in evaluating other bridge rails.

710.05 Barrier Design

When selecting a barrier, consider the flexibility, cost, and maintainability of the system. It is generally desirable to use the most flexible system possible to minimize damage to the impacting vehicle and injury to the vehicle's occupant(s). However, since nonrigid systems sustain more damage during an impact, the exposure of maintenance crews to traffic might be increased.

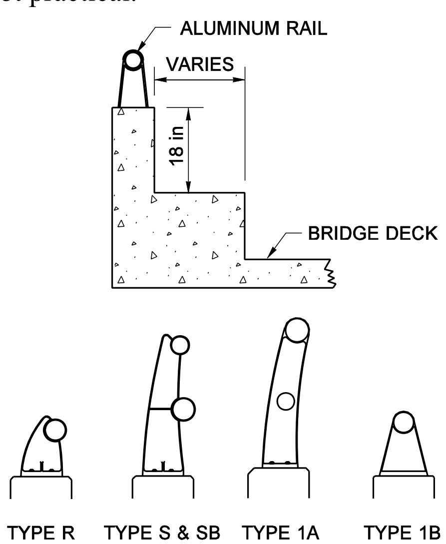
Concrete barrier maintenance costs are lower than for other barrier types. Deterioration due to weather and vehicle impacts is limited. Unanchored precast concrete barrier can usually be realigned or repaired when moved from its alignment. However, heavy equipment may be required to reposition or replace 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.

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. Slope flattening is highly recommended, even at additional cost, to eliminate the need for the barrier. Cable barrier is not an obstruction to drifting snow and can be used if slope flattening is not practical.

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's Landscape Architect or the Scenic Byways Coordinator in the HQ Highways and Local Programs Office to determine whether the project is on such a designated route. Low-cost options, such as using weathering steel beam guardrail (see 710.06) or cable barrier (see 710.07), might be feasible on many projects. Higher-cost options, such as steel-backed timber rail and stone guardwalls (see 710.09), might require 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. (See Chapter 120.)

(1) Shy Distance

Provide 2 feet of additional widening for shy distance when a barrier is to be installed in areas where the roadway is to be widened and the shoulder width will be less than 8 feet. This shy distance is not required when the section of roadway is not being widened or the shoulders are at least 8 feet wide.



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 HQ Bridge and Structures Office	
* When the curb width is greater than 9 inches, the aluminum rail must be able to withstand a 5 kip load.		

Type 7 Bridge Rail Upgrade Criteria
Figure 710-1

(2) Barrier Deflections

All barriers except rigid barriers (concrete bridge rails, for example) will deflect when hit by an errant vehicle. The amount of deflection is primarily dependent on the stiffness of the system. Vehicle speed, angle of impact, and weight also affect the amount of barrier deflection. For flexible and semirigid 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 prevent the barrier from being knocked over the side of a drop-off or steep fill slope (2H:1V or steeper).

In median installations, the deflected system must not become a hazard to oncoming traffic. Use a rigid system where deflection cannot be tolerated, 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, precast concrete barrier can be anchored. However, unless the anchoring system has been designed to function as a rigid barrier, some movement can be expected and repairs may be more expensive. Use of a nonrigid barrier on top of a retaining wall requires approval from the HQ Design Office.

Refer to Figure 710-2 for barrier deflection design values to be used when selecting a longitudinal barrier. The deflection distances for cable and beam guardrail are the minimum measurements from the face of the barrier to the hazard. The deflection distance for unanchored concrete barrier is the minimum measurement from the back edge of the barrier to the drop-off or slope break.

(3) Flare Rate

Flare the ends of longitudinal barriers where possible. There are four functions of the flare:

- To locate the barrier and its terminal as far from the traveled way as is feasible
- To reduce the length of need
- To redirect an errant vehicle
- To minimize a driver's reaction to the introduction of an object near the traveled way

Keeping flare rates as flat as practicable preserves the barrier's redirectional performance and minimizes the angle of impact. However, it has 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 that the driver does not perceive the barrier as a hazard. The flare rates in Figure 710-3 satisfy all four functions listed above. More gradual flares may be used. Flare rates are offset parallel to the edge of the traveled way. Transition sections are not normally flared.

(4) Length of Need

The length of traffic barrier required to shield a hazard (length of need) is dependent on the location and geometrics of the hazard, direction(s) of traffic, posted speed, traffic volume, and type and location of traffic barrier. When designing a barrier for a fill slope as recommended in Chapter 700, the length of need begins at the point where barrier is recommended. For fixed objects and water hazards, Figures 710-11a and 11b show design parameters for determining the necessary length of a barrier for both adjacent and opposing traffic on relatively straight sections of highway.

When the barrier is to be installed on the outside of a horizontal curve, the length of need can be determined graphically, as shown in Figure 710-11c. For installations on the inside of a curve, determine the length of need as though it were straight. Consider the flare rate, barrier deflection, and barrier end treatment to be used when determining the length of need. 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 clear zone of opposing traffic. (See Figure 710-11d.)

Barrier Type	System Type	Deflection
Cable barrier or beam guardrail (Types 20 and 21) on G-2 posts	Flexible	up to 12 ft (face of barrier to object)
Beam guardrail Types 1, 1a, 2, 10, 11, 31, and 31NB	Semirigid	3 ft (face of barrier to object)
Two-sided W-beam guardrail Types 3 and 4	Semirigid	2 ft (face of barrier to object)
Permanent concrete barrier, unanchored	Unrestrained Rigid	3 ft(1) (back of barrier to object)
Temporary concrete barrier, unanchored	Unrestrained Rigid	2 ft(2) (back of barrier to object)
Precast concrete barrier, anchored	Semirigid	6 inches (back of barrier to object)
Rigid concrete barrier	Rigid	no deflection
(1) When placed in front of a 2H:1V or flatter fill slope, the deflection distance can be reduced to 2 feet. (2) When used as temporary bridge rail, anchor all barrier that is within 3 feet of a drop-off.		

Longitudinal Barrier Deflection
Figure 710-2

Posted Speed (mph)	Rigid System	Unrestrained Rigid System	Semirigid System
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

Longitudinal Barrier Flare Rates
Figure 710-3

Before the actual length of need is determined, establish the lateral distance between the proposed barrier installation and the item shielded. Provide a distance that is greater than or equal to the anticipated deflection of the longitudinal barrier. (See Figure 710-2 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 710.06(4)(a).) Avoid gaps of 300 feet or less. Short gaps are acceptable when the barriers are 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 when determining whether to connect barriers.

(5) Median Barrier Selection and Placement Considerations

As with all barriers, the most desirable installation uses a system that is the most flexible system appropriate for the location and that is placed as far from the traveled way as practicable. With median barriers, the deflection characteristics and placement of the barrier for a traveled way in one direction can have an impact on the traveled way in the opposing direction. In addition, the median slopes and environmental issues might influence the type of barrier that is appropriate.

In narrow medians, avoid placement where the design deflection extends into oncoming traffic. In addition, narrow medians provide little space for maintenance crews to repair or reposition the barrier. Avoid installing deflecting barriers in medians that provide less than 8 feet from the edge of the traveled way to the face of the barrier. In wider medians, the selection 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 as possible so that the recovery distance can be maximized for both directions. It might be necessary to offset the barrier from the flow line to avoid impacts to the drainage flow. Cable barrier is recommended with medians that are 30 feet or wider. In wide medians where the slopes are steeper than 10H:1V but not steeper than 6H:1V, cable barrier placed near the center of the median is preferred. Placement of beam guardrail requires that the barrier be placed at least 12 feet from the slope break, as is shown in Figure 710-4. Do not use concrete barrier at locations where the foreslope into the face of the barrier is steeper than 10H:1V.

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 necessary along the lower roadway, except where there are fixed objects in the median.

When barrier is placed in a median as a countermeasure for cross median collisions, design the barrier to be struck from either direction of travel. For example, beam guardrail should be double-sided (Type 3 or 4).

710.06 Beam Guardrail

(1) Beam Guardrail Systems

Beam guardrail systems are shown in the Standard Plans.

Strong post W-beam guardrail (Types 1 through 4, 31, and 31NB) and thrie beam guardrail (Types 10 and 11) are semirigid barriers used predominantly on roadsides. They also have limited application as median barrier. Installed incorrectly, strong post 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 crashworthy end treatments, and by blocking the rail away from the strong posts. However, avoid the use of blockouts that extend from the post to the rail element for a distance exceeding 16 inches.

W-beam guardrail has typically been installed with a rail height of 27 inches. However, there are some newer designs that use a 31-inch rail height. One is the 31-inch-high WSDOT Type 31. The other is a proprietary system called the Type 31NB system.

The Type 31 system uses many of the same components as the WSDOT Type 1 system. However, the main differences are that the blockouts extend 12 inches from the posts, the rail height is 31 inches from the ground, and the rail elements are spliced between posts.

The main characteristics of the Type 31NB system are that it incorporates posts designed to bend on impact, and it does not use blockouts, which potentially can offer advantages in applications with narrow shoulder widths. This system is also 31 inches measured from the ground to the top of the rail element, and the rail element is spliced between posts. Currently the Type 31 NB system is not approved for the use of curb with this system.

Although somewhat different, both systems offer tolerances for future HMA overlays. The Type 31 system allows a 4-inch tolerance from 31 inches to 27 inches without adjustment of the rail element. The Type 31NB system offers a tolerance from 31 inches to 29 inches.

(2) W-Beam Barrier Selection and Placement

- Existing runs with rail height at 27 inches are acceptable to leave in place and can be extended if the design height of 27 inches is maintained in the extended section. Where future overlays are anticipated, extend with Type 1 alternate or the 31-inch design.
- For existing runs below 26 inches, adjust or replace the rail to a height of 26 inches minimum to 28 inches maximum or replace the run.
- Use the 31-inch-high guardrail design for new runs.

1. For existing roadways where the shoulder will not be widened and the shoulder is greater than 4 feet, use the Type 31 system. The existing shoulder width may be reduced up to 4 inches to accommodate the 12-inch blockout without processing a deviation.
2. For existing roadways where the shoulder width is 4 feet or less, the Type 31NB system can be used.

For currently available plans for Type 31, refer to the HQ Design Standards (Plan Sheet Library) at the following web site: http://www.wsdot.wa.gov/eesc/design/designstandards/psl/default.htm

Some transitions and connections are currently under development and will be added to this site as soon as they are completed. Plans will be housed at this location until they are transitioned into the Standard Plans.

(3) Additional Guidance

Weak post W-beam guardrail (Type 20) and thrie beam guardrail (Type 21) are flexible barrier systems that can be used where there is adequate deflection distance. These systems use weak steel posts. The primary purpose of these posts is to position the guardrail vertically, and they are designed to bend over when struck. These more flexible systems will result in less damage to the impacting vehicle. Since the weak posts will not result in snagging, blockouts are not necessary.

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 between 6H:1V and 10H:1V, beam guardrail must not be placed within 12 feet of the break point. Do not place beam guardrail on a fill slope steeper than 6H:1V. For additional guidance on beam guardrail slope placement, refer to Figure 710-4.

On the high side of superelevated sections, place beam guardrail at the edge of shoulder prior to the slope break.

For 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 beginning of a fill slope. If the slope is 2H:1V or flatter, this distance can be measured from the face of the guardrail rather than the back of the post. (See Figure 710-12, Case 1.)

On projects where no roadway widening is proposed and the minimum 2-foot shoulder widening behind the barrier is not practicable, long post installations are available as shown in Figure 710-12, Cases 3, 4, 5, and 6. When guardrail is to be installed in areas where the roadway is to be widened, the use of Cases 4, 5, or 6 requires a design deviation.

Rail washers on beam guardrail are not normally used. If rail washers are present, they are not required to be removed. 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 and rail washers in the contract documents. (Snowload post washers are used to prevent the bolts from pulling through the posts, and snowload rail washers are used to 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. Rail washers are never to be used within the limits of a guardrail terminal, except at the end post where they are required for anchorage of the rail.

The use of curb in conjunction with beam guardrail is discouraged. If a curb is necessary, the 3-inch-high curb is preferred. If necessary, the 4-inch-high extruded curb can be used behind the face of rail at any posted speed. The 6-inch-high extruded curb can be used at locations where the posted speed is 50 miles per hour or less. When replacing extruded curb at locations where the posted speed is greater than 50 miles per hour, use 3-inch-high or 4-inch-high curb. (See the Standard Plans for extruded curb designs.)

When curb is used in conjunction with 31-inch-high Type 31 W-beam guardrail, it is acceptable to place a 6-inch-high curb at a 7-inch offset from the face of the rail.

Currently, curb is not approved for use with the Type 31 NB system.

Beam guardrail is usually galvanized and has a silver color. It can also be provided in a weathering steel that has a brown or rust color. Along Scenic Byways, Heritage Tour Routes, state highways through national forests, or other designated areas, consider using weathering steel guardrail, weathering steel terminals, and wooden posts to minimize the barrier's visual impact. (See 710.05.)

(4) 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 crashworthy guardrail terminal is required. (See the Standard Plans.)

The buried terminal (BT) 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.

The BT uses a Type 2 anchor to develop the tensile strength in the guardrail. 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. The backslope required to install a BT must be 3H:1V or steeper and at least 4 feet in height above the roadway. Flare the guardrail into the backslope using a flare rate that meets the criteria in 710.05(3). Provide a 10H:1V or flatter foreslope into the face of the guardrail (and up to 4H:1V in the ditch section of the Type 2 buried terminal), and maintain the full guardrail height to the foreslope/backslope intersection. This might require filling ditches and installing culverts in front of the guardrail face. 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.

If the backslope is flatter than 1H:1V, provide a minimum 75-foot-long clear area on the back side of the barrier prior to the mitigated hazard.

(a) **Flared Terminal.** If a BT cannot be installed as described above, consider a flared terminal. (See Figure 710-13.) There are currently two acceptable sole source proprietary designs: the Slotted Rail Terminal (SRT) and the Flared Energy Absorbing Terminal (FLEAT). Both of these designs include an anchor for developing the tensile strength of the guardrail. The length of need begins at the third post for both flared terminals.

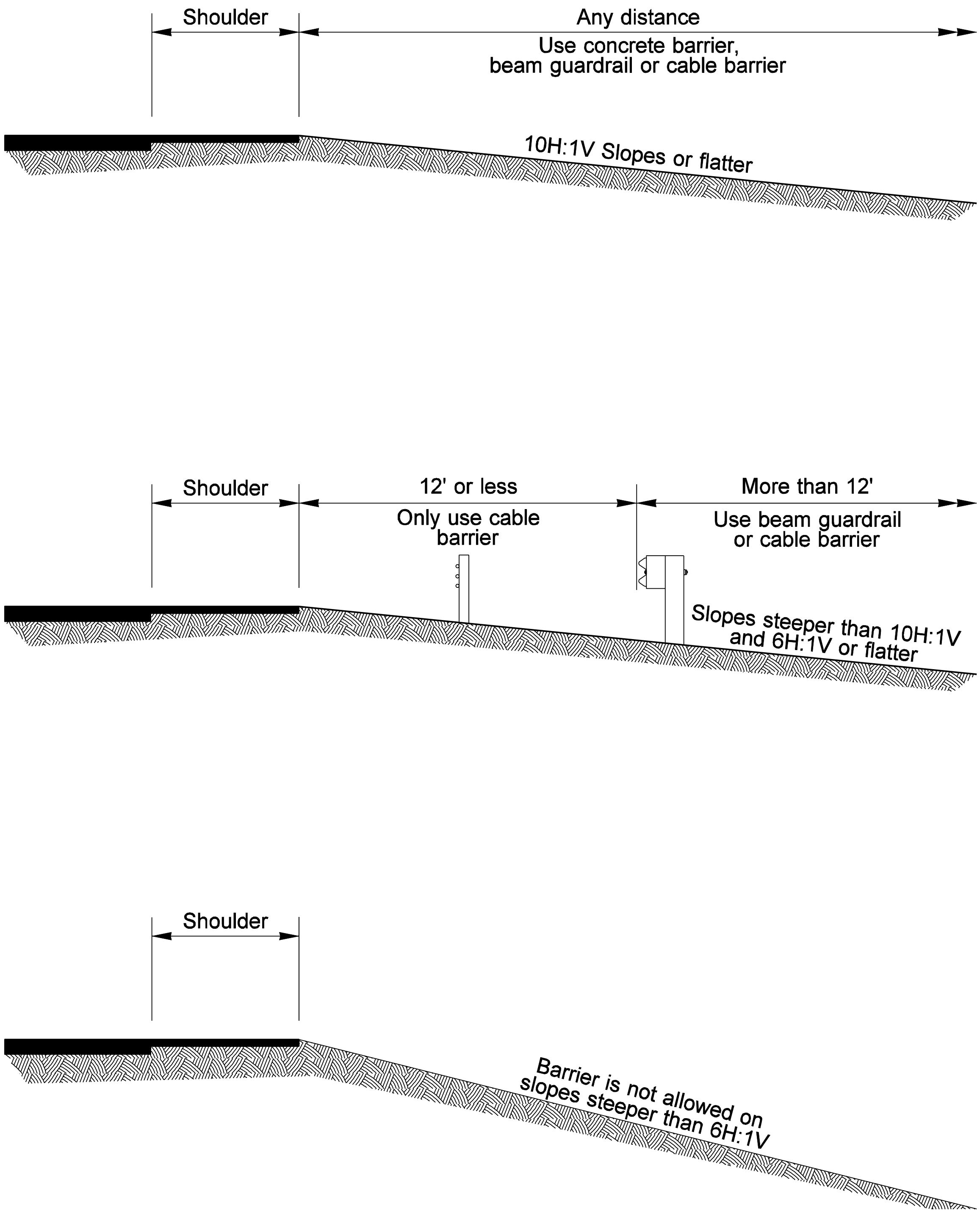
1. The SRT uses W-beam guardrail with slots cut into the corrugations, and wood breakaway and controlled release terminal (CRT) posts that are designed to break away when hit. The end of the SRT is offset from the tangent guardrail run by the use of a parabolic flare. When struck head on, the first two posts are designed to break away, and the parabolic flare gives the rail a natural tendency to buckle, minimizing the possibility of the guardrail end entering the vehicle. The buckling is facilitated by the slots in the rail. The CRT posts provide strength to the system for redirection and deceleration without snagging the vehicle. The SRT has a 4-foot offset of the first post.
2. The FLEAT uses W-beam guardrail with a special end piece that fits over the end of the guardrail and wood breakaway and CRT posts. The end of the FLEAT is offset from the tangent guardrail run by the use of a straight flare. When struck head on, the end piece is forced over the rail, bending the rail and forcing it away from the impacting vehicle.

   The FLEAT is available in two designs based on the posted speed of the highway. For highways with a posted speed of 45 miles per hour or greater, use a FLEAT 350 that has a 4-foot offset at the first post. For lower-speed highways (a posted speed of 40 miles per hour or less), use a FLEAT TL-2 that has a 1-foot-8-inch offset at the first post.

When a flared terminal is specified, it is critical that embankment also be specified so that the area around the terminal can be flattened as shown on the Standard Plans. For every foot of height of the embankment, 13 cubic yards of embankment are required.

No snowload rail washers are allowed within the limits of these terminals.

The FHWA has granted approval to use these sole source proprietary terminals without justification.



Traffic Barrier Locations on Slopes
Figure 710-4

(b) **Nonflared Terminal.** Where widening to provide the offset for a flared terminal is not practicable, consider a nonflared terminal. (See Figure 710-13.) There are currently two acceptable sole source proprietary designs: the ET PLUS and the Sequential Kinking Terminal (SKT). Both of these systems use W-beam guardrail with a special end piece that fits over the end of the guardrail and wood breakaway and CRT posts. When hit head on, the end piece is forced over the rail and either flattens or bends the rail and then forces it away from the impacting vehicle.

Both of these terminals include an anchor for developing the tensile strength of the guardrail. The length of need begins at the third post for both terminals.

Both of these terminals are available in two designs based on the posted speed of the highway. The primary difference in these designs is the length of the terminal. For highways with a posted speed of 45 miles per hour or greater, use the 50-foot-long ET PLUS TL3 or SKT 350. For lower-speed highways (a posted speed of 40 miles per hour or less), use the 25-foot-long ET PLUS TL2 or SKT-TL2.

While these terminals do not require an offset at the end, a flare is recommended so that the end piece does not protrude into the shoulder. These terminals may have a 1-foot offset to the first post. Four feet of widening is required at the end posts to ensure that the system is properly anchored. For every foot of embankment height, 3 cubic yards of embankment are required.

No snowload rail washers are allowed within the limits of these terminals.

The FHWA has granted approval to use these sole source proprietary terminals without justification.

(c) **Terminal Evolution Considerations.** Some 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. All previous designs for these terminals may remain in place. If questions arise concerning the current approval status of a device, contact the HQ Design Office for clarification when replacement is being considered.

(d) **Other Anchor Applications.** Use the Type 1 anchor to develop the tensile strength of the guardrail on the end of guardrail runs where a crashworthy terminal is not required. Use the Type 4 anchor to develop the tensile strength of the guardrail on the trailing end of guardrail runs along one-way highways. Use the Type 5 anchor with the Weak Post Intersection Design. (See 710.06(6), Cases 12 and 13.) Use the Type 7 anchor to develop tensile strength in the middle of a guardrail run when the guardrail curves and weak posts are used. (See 710.06(6), Cases 9, 12, and 13.)

The old Type 3 anchor was primarily used at bridge ends. (See Figure 710-5.) This anchor consisted of a steel pipe mounted vertically in a concrete foundation. Bridge approach guardrail was then mounted on the steel pipe. On one-way highways, these anchors were usually positioned so that neither the anchor nor the bridge rail posed a snagging hazard. In these cases, the anchor may remain in place if a stiffened transition section is provided at the connection to the post. On two-way highways, the anchor may present a snagging hazard. In these cases, install a connection from the anchor to the bridge rail if the offset from the bridge rail to the face of the guardrail is 1 foot 6 inches or less. If the offset is greater than 1 foot 6 inches, remove the anchor and install a new transition and connection.

Locations where crossroads and driveways cause gaps in the guardrail require special consideration. Elimination of the need for the barrier is the preferred solution. Otherwise, a barrier flare might be required to provide sight distance. If the slope is 2H:1V or flatter and there are no hazards on or at the bottom of the slope, a terminal can be used to end the rail. Place the anchor of this installation as close as possible to the road approach radius PC. If there is a hazard at or near the bottom of the slope that cannot be mitigated, then the Weak Post Intersection Design (see 710.06 and the Standard Plans) can be used. This system can also be used at locations where a crossroad or road approach is near the end of a bridge and installing a bridge approach guardrail placement (including guardrail transition and terminal) is not possible.

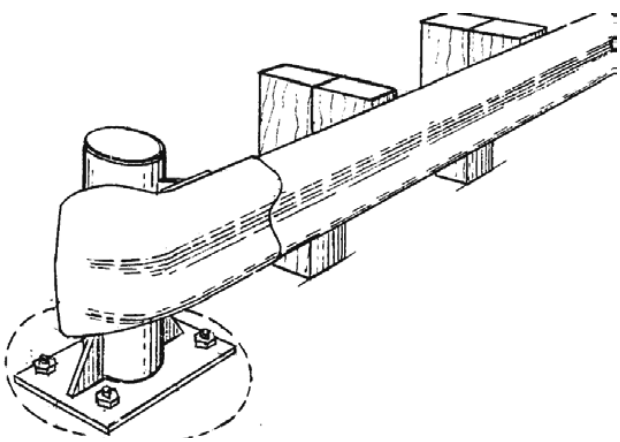
(5) Transitions and Connections

When there is an abrupt change from one barrier type to a more rigid barrier type, a vehicle hitting the more flexible barrier is likely to 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 eliminate the possibility of pocketing.

When connecting beam guardrail to a more rigid barrier or a structure, or when a rigid object is within the deflection distance of the barrier, use the transitions and connections that are shown in Figures 710-6 and 710-10 and detailed in the Standard Plans. The transition pay item includes the connection.

For currently available transitions and connections for Types 31 and 31NB, refer to the HQ Design Standards (Plan Sheet Library) at the following web site: http://www.wsdot.wa.gov/eesc/design/designstandards/psl/default.htm

Some transitions and connections are currently under development and will be added to this site as soon as they are completed. Plans will be housed at this location until they are transitioned into the Standard Plans.



Old Type 3 Anchor
Figure 710-5

Condition	Connection
Unrestrained concrete barrier	A
Rigid 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 or tapered safety shape barrier(1)	D

(1) New 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.

Guardrail Connections
Figure 710-6

(6) Guardrail Placement Cases

The Standard Plans contains placement cases that show all of the beam guardrail elements required for typical situations. Following is a description of each case:

Case 1 is used only where there is one-way traffic. It uses a crashworthy terminal on the approach end and a Type 4 anchor on the trailing end.

Case 2 is used where there is two-way traffic. A crashworthy terminal is used on both ends. When flared terminals are used on both ends, a minimum of 25 feet of guardrail is required between the terminal limits.

Case 3 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. For one-way roadways, a Type 4 anchor is used on the trailing end. On two-way roadways, a Type 1 anchor is used on the trailing end. If there is a history of crossover accidents, consider additional protection, such as an impact attenuator.

Case 4 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 required at the bridge end. A curve in the guardrail is shown to shift it to the bridge rail. However, the length of the curve is not critical and the only requirement is to provide a smooth curve that is not more abrupt than the allowable flare rate. (See Figure 710-3.)

Case 5 is a typical bridge approach where a terminal and a transition are required.

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 clear zone for the opposing traffic.

Cases 7 and 8 are used with beam guardrail median barrier when median hazards such as bridge piers are encountered. A transition is required on the approach end for each direction and the flare rate must not be more abrupt than the allowable flare rate. (See Figure 710-3.)

Case 9 (A, B, and C) is used on bridge approaches where opposing traffic is separated by a median less than 36 feet wide. This design, called a "Bull Nose Terminal," treats both bridge ends and the opening between the bridges. The "nose" is designed to collapse when struck head on, and the ribbon strength of the rail brings the vehicle to a controlled stop. Type 7 anchors are installed on each side of the nose to develop the ribbon strength.

Since an impacting vehicle will penetrate into the system, it is critical that no fixed object be located within the first 30 feet of the system.

Case 10 (A, B, and C) is used at roadside hazards (such as bridge piers) when 3 feet or more are available from the face of the guardrail to the hazard. The approach end is the same for one-way or two-way traffic. Case 10A is used with two-way traffic; therefore, a terminal is required on the trailing end. Case 10B is used for one-way traffic when there is no need to extend guardrail past the bridge pier and a Type 4 anchor is used to end the guardrail. Case 10C is used for one-way traffic when the guardrail will extend for a distance past the bridge pier.

Case 11 (A, B, and C) is used at roadside hazards (such as bridge piers) when the guardrail is to be placed within 3 feet of the hazard. Since there is no room for deflection, the rail in front of the hazard must be considered a rigid system and a transition is necessary. The trailing end cases are the same as described for Case 10.

Cases 12 and 13 are called "Weak Post Intersection Designs." They are used where an intersection requires a gap in the guardrail or there is not adequate space for a bridge approach installation that includes a transition and/or terminal. These placements are designed to collapse when hit at the nose, and the ribbon strength of the rail brings the vehicle to a stop. A Type 7 anchor is used to develop the ribbon strength. These designs include a Type 5 transition for connection with bridge rail and a Type 5 anchor at the other end of the rail. The Type 5 anchor is not a breakaway anchor and, therefore, can only be used on low-speed side roads and driveways.

Since an impacting vehicle will penetrate into the system, it is critical that no fixed object be located within the clear area shown on the Standard Plan. The 25 feet along the side road are critical for the operation of this system.

These designs were developed for intersections that are approximately perpendicular. Evaluate installation on skewed intersections on a case-by-case basis. Use the Case 22 placement if it is not feasible to install this design according to the Standard Plan.

Case 14 shows the approach rail layout for a Service Level 1 bridge rail system. Type 20 guardrail is used on the approach and no transition is required between the Type 20 guardrail and the Service Level 1 bridge rail since they are both weak post systems. A Type 6 transition is used when connecting the Type 20 to a strong post guardrail or a terminal.

Case 15 is used to carry guardrail across a box culvert where there is insufficient depth to install standard posts for more than 17 feet 8 inches. This design uses steel posts anchored to the box culvert to support the rail. Newer designs, Cases 19, 20, and 21, have replaced this design for shorter spans.

Cases 16 and 17 are similar to Cases 1 and 2, except that they flare the rail and terminal as far from the road as possible and reduce the length of need.

Case 18 is used on the trailing end of bridge rail on a one-way roadway. No transition is necessary.

Case 19 (A and B) is used where it is not possible to install a post at the 6-foot-3-inch spacing. This design omits one post (resulting in a span of 11 feet 6 inches, which is consistent with a post spacing of 12 feet 6 inches) and uses nested W-beam to stiffen the rail. The cases differ by the location of the splice. No cutting of the rail or offsetting of the splices is necessary or desirable.

Case 20 is similar to Cases 19A and 19B, except that it allows for two posts to be omitted (which results in a span consistent with a post spacing of 18 feet 9 inches).

Case 21 has a similar intent as Cases 19A, 19B, and 20 in that it allows for the omission of posts to span an obstruction. This design uses CRT posts with additional post blocks for three posts before and after the omitted posts. The design allows for three posts to be omitted (which results in a span consistent with a post spacing of 25 feet).

Case 22 is the "Strong Post Intersection Design" that provides a stiff barrier. This design is only to be used as a last resort at crossroads or road approaches where a barrier is necessary and there isn't a clear area behind the nose or minimum distances for a "Weak Post Intersection Design." (See Cases 12 and 13.)

Case 23 – the placement/connection of generic cable barrier to W-beam flared terminals.

Case 24 – the placement/connection of generic cable barrier to W-beam bull nose applications.

Case 25 – the placement of generic cable barrier at thrie beam bull nose locations.

Case 26 – the generic cable barrier to W-beam shielding at redirectional landform locations.

Case 27 – the placement of generic cable barrier for shielding at redirectional landform locations.

710.07 Cable Barrier

Cable barrier is a flexible barrier system that can be used on a roadside or as a median barrier. The primary advantage of cable barrier is that it provides effective vehicle containment and redirection while imposing the lowest deceleration forces on the vehicle's occupants. It also has advantages in heavy snowfall areas in that it has minimal potential to create snowdrifts. In addition, it does not present a visual barrier, which may make it desirable on Scenic Byways. (See 710.05.)

Maintenance is a consideration because routine maintenance is necessary to keep tension in the cables, and a comparatively long run of cable barrier will have to be repaired after an impact. However, the effort (time and materials) required to maintain and repair cable barrier is much less than the effort required for a W-beam system.

There are currently two main types of cable barrier in use. The first is the generic cable barrier system, which is detailed in the Standard Plans. The second is the proprietary high-tension (H.T.) cable barrier systems (available from several manufacturers).

For new installations, the high-tension cable barriers are the first choice. However, it is acceptable for the generic system to remain in place or to be installed new, if needed.

(1) WSDOT Generic Cable Barrier

The WSDOT Generic System consists of three steel cables mounted to steel posts (weak posts). The maximum spacing for the steel posts is 16 feet on tangent sections and curves with a 700-foot radius or greater. A deflection of 11 feet 6 inches is anticipated with this post spacing. A smaller spacing is required on radii less than 700 feet. For tangent sections and large radius curves, the deflection can be reduced to 7 feet by reducing the post spacing to 4 feet.

At each end of the barrier run, the cable is turned down and anchored to concrete blocks. A coil spring and turnbuckle are required on each cable to maintain tension on the system.

(2) High-Tension Cable Barrier

In addition to the generic cable barrier system described above, proprietary high-tension (H.T.) cable barrier systems are now available from a few different manufacturers. Potentially, these systems offer some advantages over the WSDOT Generic Cable Barrier System. For example, these systems deflect less than the standard WSDOT design. Depending on the system and post spacing, deflection distances range from 6 feet 8 inches to 9 feet 3 inches. In addition, when impacted, the H.T. systems also result in less damage to the barrier. In many cases, the cables remain at the proper height after a collision has damaged several posts, which offers some maintenance benefits. (See Figure 710-14 for placement details.)

(3) Cable Barrier Placement

Cable barrier can be installed up to 1 foot in front of side slopes as steep as 2H:1V. Cable barrier is the only barrier that can be placed on a side slope steeper than 10H:1V within the 12-foot area immediately beyond the breakpoint. Do not place this barrier on a side slope steeper than 6H:1V. Figure 710-14 shows the placement of cable barrier.

Narrow medians provide little space for maintenance crews to repair or reposition the barrier. Whenever sight conditions permit, provide at least 14 feet of clearance from the adjacent lane edge to the cable barrier.

When cable barrier is to be connected to a more rigid barrier, a transition section is required. (See the Standard Plans or contact the HQ Design Office for further details.)

710.08 Concrete Barrier

Concrete barriers are rigid or unrestrained rigid systems. They are also used as shoulder barriers. These systems are stiffer than beam guardrail or cable barrier, and impacts with these barriers will tend to be more severe.

Light standards mounted on top of concrete median barrier must not have breakaway features. (See the Standard Plans for the concrete barrier light standard section.)

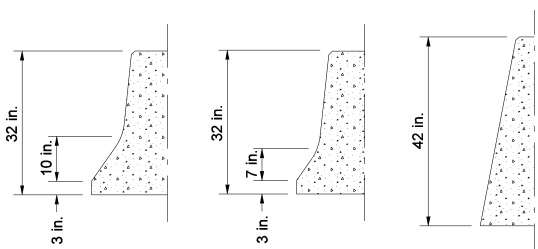
Where drainage might be a problem, contact the HQ Hydraulics Branch for guidance.

(1) Concrete Barrier Shapes

Concrete barriers use a safety shape (New Jersey shape and, on bridges, the F-Shape) or single-sloped face to redirect vehicles while minimizing vehicle vaulting, rolling, and snagging. A comparison of these barrier shapes is shown in Figure 710-7.

The New Jersey shape face is used on precast concrete barrier.

The single-slope barrier face is recommended when separating roadways with different elevations (stepped medians). The single-slope barrier face can be used for bridge rails (median or outside) when it is to be used on any approach to a bridge and an existing bridge rail is to be replaced.



New Jersey Shape (Type 2) | **F-Shape** | **Single-Slope Concrete Barrier**

Concrete Barrier Shapes
Figure 710-7

The F-Shape face is used on all other bridge rails and on cast-in-place barrier where the New Jersey and single-slope face are not appropriate. When the F-Shape face is used and precast barrier is to be used on the approaches, a cast-in-place transition section is required so that no vertical edges of the barriers are exposed to oncoming traffic. For details on the F-Shape barrier or any of the 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.

(a) **New Jersey Shape Barrier.** The New Jersey shape face is primarily used on precast concrete barrier.

Concrete barrier Type 2 (see the Standard Plans) is a precast barrier that has the New Jersey shape on two sides and can be used for both median and shoulder installations. This barrier is 2 feet 8 inches in height, which includes 3 inches for future pavement overlay.

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 requirements 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 require cast-in-place barrier, such as for a light standard section.

Concrete barrier Type 4 is also a precast, single-faced New Jersey shape barrier. These units are not freestanding and must be placed against a rigid structure or anchored to the pavement. If Type 4 barriers are used back to back, consider filling any gap between them to prevent tipping.

Concrete barrier Type 5 is a precast barrier that has a single New Jersey face and is intended for use at bridge ends where the flat side is highly visible. Both Type 2 and Type 5 designs are freestanding, unanchored units connected with steel pins through wire rope loops. For permanent installation, this barrier is placed on a paved surface and a 2-foot-wide paved surface is provided beyond the barrier for its displacement during impact. (See Chapter 640.)

Precast barrier can be anchored where a more rigid barrier is desired. (Anchoring methods are shown in the Standard Plans.) The Type 1 and Type 2 anchors are for temporary installations on a rigid pavement. Type 3 anchors can be used in temporary or permanent installations on an asphalt pavement. Consult the HQ Bridge and Structures Office for details when anchoring permanent precast concrete barrier to a rigid pavement.

Precast barrier used on the approach to bridge rail must be connected to the bridge rail by installing wire rope loops embedded 1 foot 3 inches into the bridge rail with epoxy resin.

Place unrestrained (unanchored) precast concrete barrier, on foundation slopes of 5% or flatter. In difficult situations, a maximum slope of 8% may be used. Keep the slope of the area between the edge of the shoulder and the face of the traffic barrier as flat as possible. The maximum slope is 10H:1V (10%).

(b) **Single-Slope Barrier**. The single-slope concrete barrier can be cast in place, slipformed, or precast. The most common construction technique for this barrier has been slipforming, but some precast single-slope barrier has been installed. The primary benefit of using precast barrier is that it can be used as temporary barrier during construction and then reset into a permanent location.

This barrier is considered a rigid system regardless of the construction method used. For new installations, the minimum height of the barrier above the roadway is 2 feet 10 inches, which allows 2 inches for future overlays. The minimum total height of the barrier section is 3 feet 6 inches, with a minimum of 3 inches embedded in the roadway wearing surface. 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, as shown in the Standard Plans. The barrier must have a depth of embedment equal to or greater than the grade separation. Contact the HQ Bridge and Structures Office for grade separations greater than 10 inches. (See the Standard Plans.)

(c) **Low Profile Barrier.** Low profile barrier designs are available for median applications where the posted speed is 45 miles per hour or less. 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.

(2) High Performance Concrete Barrier

High Performance Concrete Barrier (HP Barrier) is a rigid 42-inch-high barrier designed to function better during heavy-vehicle collisions. This taller barrier may also offer the added benefits of reducing headlight glare and reducing noise in surrounding environments. HP Barrier is generally considered single-slope barrier. However, other shapes are available. (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 accident history suggests a need, or where roadway 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).

Consider the use of HP Barrier at other locations, such as near highly sensitive environmental areas, near densely populated areas, over or near mass transit facilities, or on vertically divided highways.

(3) Concrete Barrier Terminals

Whenever possible, bury the end of the concrete barrier in the backslope. The backslope required to bury the end must be 3H:1V or steeper and at least 4 feet in height above the roadway. Flare the concrete barrier into the backslope using a flare rate that meets the criteria in 710.05(3). Provide a 10H:1V or flatter foreslope into the face of the barrier and maintain the full barrier height to the foreslope/backslope intersection. This might require filling ditches and installing culverts in front of the barrier face.

The 7-foot-long precast concrete terminal end section for Concrete Barrier Type 2 may be used:

- 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 miles per hour or less.

Another available end treatment for Type 2 barriers is a precast or cast-in-place tapered terminal section having a minimum length of 48 feet and a maximum length of 80 feet. It is used infrequently for special applications and can only be used for posted speeds of 35 miles per hour or less. For details, contact the HQ Design Office or refer to the Plan Sheet Library at the following web site: http://www.wsdot.wa.gov/eesc/design/designstandards/psl/default.htm

When the “Barrier Terminals and Transitions” column of a design matrix applies to a project, existing sloped-down concrete terminals that are within the Design Clear Zone must be replaced when they do not meet the criteria above.

When the end of a concrete barrier cannot be buried in a backslope or terminated as described above, terminate the barrier using a guardrail terminal and transition or an impact attenuator. (See Chapter 720.)

(4) Assessing Impacts to Wildlife

The placement of concrete barriers in locations where wildlife frequently cross the highway can influence traffic safety and wildlife mortality. When wildlife encounter physical barriers that are difficult to cross, they often travel parallel to those barriers. With traffic barriers, this means that they often remain on the highway for a longer period, increasing the risk of wildlife/vehicle collisions or vehicle/vehicle collisions as motorists attempt avoidance.

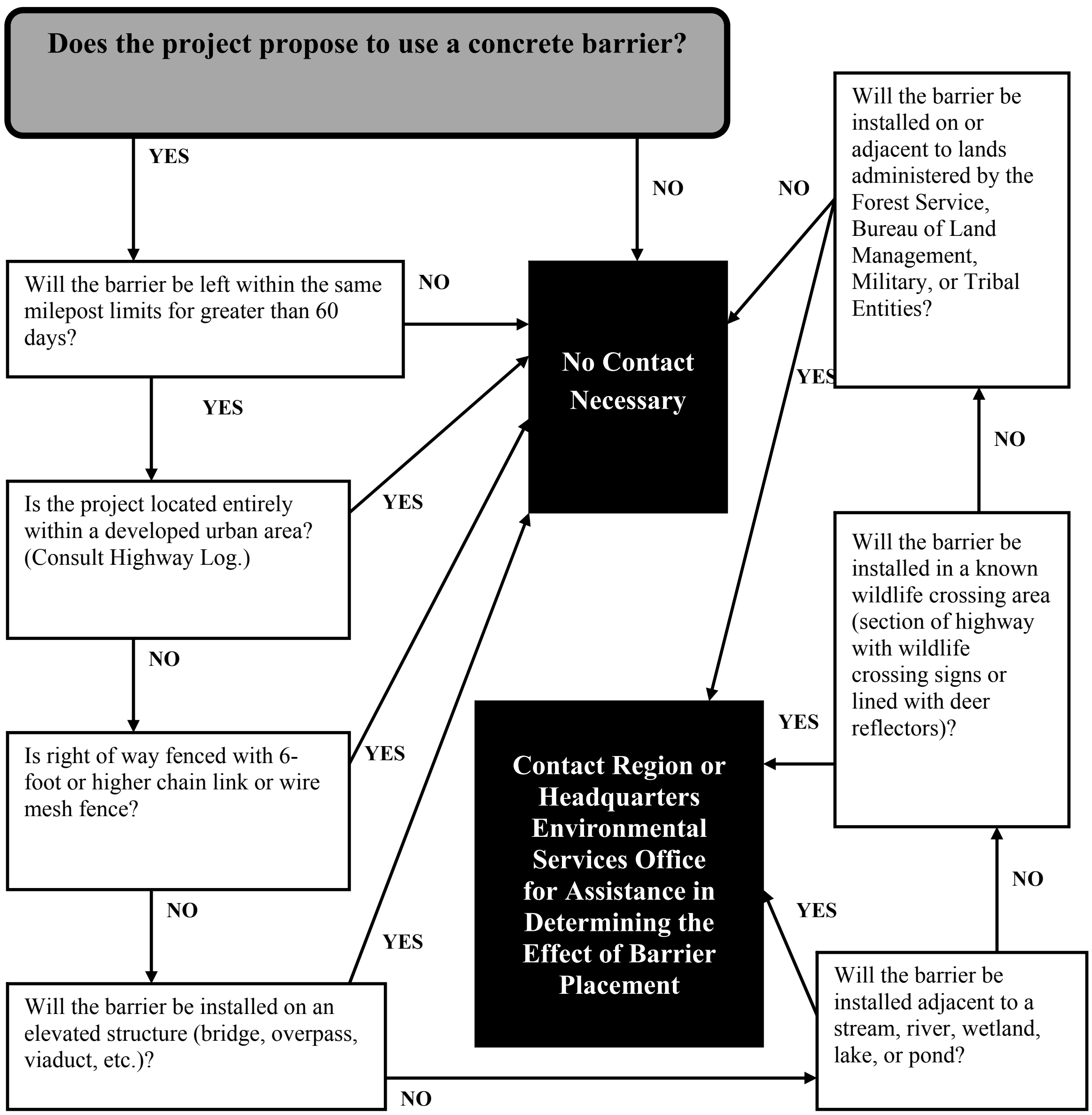
Traffic-related wildlife mortality may play a role in the decline of some species listed under the Endangered Species Act. To address public safety and wildlife concerns, see Figure 710-8 to assess whether concrete barrier placement requires an evaluation by the Environmental Services Office to determine its effect on wildlife. Make this evaluation early in the project development process to allow adequate time for discussion of options.

710.09 Special-Use Barriers

The following barriers may be used on designated Scenic Byway and Heritage Tour routes if funding can be arranged. (See 710.05 and Chapter 120.)

(1) 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 Ironwood guardrail can be allowed as an alternative to the nonproprietary system. However, specifying this system exclusively requires approval by the Assistant State Design Engineer of a public interest finding for the use of a sole source proprietary item.



Concrete Barrier Placement Guidance (Assessing Impacts to Wildlife)
Figure 710-8

The most desirable method of terminating the steel-backed timber guardrail is to bury the end in a backslope as described in 710.06(4). When this type of terminal is not possible, the use of the barrier is limited to highways with a posted speed of 45 miles per hour or less. On these lower-speed highways, the barriers can be flared away from the traveled way and terminated in a berm.

For details on these systems, contact the HQ Design Office.

(2) Stone Guardwalls

Stone guardwalls function like rigid concrete barriers but have an 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 projection of the stones that will not affect 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 710.08(3). When this type of terminal is not possible, the use of the barrier is limited to highways with a posted speed of 45 miles per hour or less. On these lower-speed highways, the barrier can be flared away from the traveled way and terminated in a berm.

For details on these systems, contact the HQ Design Office.

710.10 Bridge Traffic Barriers

Bridge traffic barriers redirect errant vehicles and prevent 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.)

For most new bridge rail installations, use a 2-foot-8-inch-high safety shape (F-Shape) bridge barrier. A transition is available to connect the New Jersey shape (Type 2 Concrete Barrier) and the F-Shape bridge barrier. (See the Standard Plans for further details.) The single-slope bridge barrier that is 2 feet 10 inches high can be used to be consistent with the heights of connecting single-slope barrier. (See 710.08(1)(b).)

Use taller 3-foot-6-inch safety shape or single-slope bridge barriers on Interstate or freeway routes where accident history suggests a need or where roadway 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).

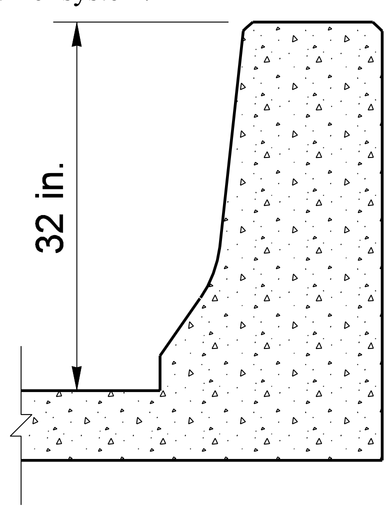
For bridges where high volumes of pedestrian traffic are anticipated, see Chapter 1020 for further guidance.

Approach barriers, transitions, and connections are usually required on all four corners of bridges carrying two-way traffic and on both corners of the approach end for one-way traffic. (See 710.06(5) for guidance on transitions.)

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 required. The modifications can be made using one of the retrofit methods described below.

(1) Concrete Safety Shape

Retrofitting with a new concrete bridge barrier (see Figure 710-9) is costly and requires justification when no widening is proposed. Consult the HQ Bridge and Structures Office for design details and to determine if the existing bridge deck and other superstructure elements are of sufficient strength to accommodate this bridge barrier system.



Safety Shape Concrete Bridge Rail Retrofit
Figure 710-9

(2) Thrie Beam Retrofit

Retrofitting with thrie beam is an economical way to improve the strength and redirectional performance of bridge barriers. 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.

The HQ Bridge and Structures Office is responsible for the design of thrie beam bridge barrier. Figure 710-15 shows typical installation criteria. Contact the HQ Bridge and Structures Office for assistance with thrie beam retrofit design.

Consider the Service Level 1 (SL-1) system on bridges with wooden decks and for bridges with concrete decks that do not have adequate strength to accommodate the thrie beam system. Contact the HQ Bridge and Structures Office for information required for the design of the SL-1 system.

A sidewalk reduction of up to 6 inches as a result of a thrie beam retrofit can be documented as a design exception.

Many bridge rail retrofit projects involve bridges over 250 feet in length. These projects will normally be funded from the I-2 program. Shorter bridges may be funded as a spot safety improvement. Contact the HQ Project Control and Reporting Office for clarification.

710.11 Other Barriers

(1) 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 a minimum of 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 1010)
- T-intersections
- Work zones
- Swing span bridges

For permanent installations, this system can be installed between towers that lower the unit into position when needed and lift it out of the way when it is no longer needed. For work zone applications, it is critical to provide deflection space for stopping the vehicle between the system and the work zone. For additional information on the Dragnet, contact the HQ Design Office.

710.12 Documentation

The list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

Connecting W-Beam Guardrail to: Transitions and Connections			Transition Type*	Connection
Bridge Rail	New		1[1] 4[5]	D
	Existing Concrete	Concrete Parapet > 20 inches	1[1] 4[5]	Figure 710-6
		Concrete Parapet < 20 inches	2 4[5]	Figure 710-6
		Existing W-Beam Transition	2[2][6] 4[5]	[2]
	Thrie Beam at face of curb[4]	Approach end	10	na
		Trailing end (two-way traffic only)	11 12	na
	Thrie Beam at bridge rail (curb exposed)[4]	Approach end	13	na
		Trailing end (two-way traffic only)	14 15	na
	Weak Post Intersection Design (see 710.06(4) Cases 12 & 13)		5	Figure 710-6
Concrete Barrier	Rigid Restrained		1 4[5]	Figure 710-6
	Unrestrained		2 4[5]	A
Weak Post Barrier Systems (Type 20 and 21)			6	na
Rigid Structures such as Bridge Piers	New Installation (see Case 11)		16 17 18	na
	Existing W-Beam Transition		[3]	na
Connecting Thrie Beam Guardrail to:				
Bridge Rail or Concrete Barrier	New installation (example: used with thrie beam bull nose)		1B	Figure 710-6

* Consult Section C of the Standard Plans for detail on transition types.

Notes:

(1) A Type 1A transition can be used where there is a problem placing a post within 2’-5” from the end of the bridge, in which case a B or E connection is required. When the E connection is to be used, a special detail for the end of the bridge is required. Contact the HQ Bridge and Structures Office.

(2) If work requires 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. (See Section 710.06(4)(d) for guidance when Type 3 anchors are encountered.)

(3) For new/reconstruction, use Case 11 (thrie beam). For existing Case 11 with W-beam, add a second W-beam rail element.

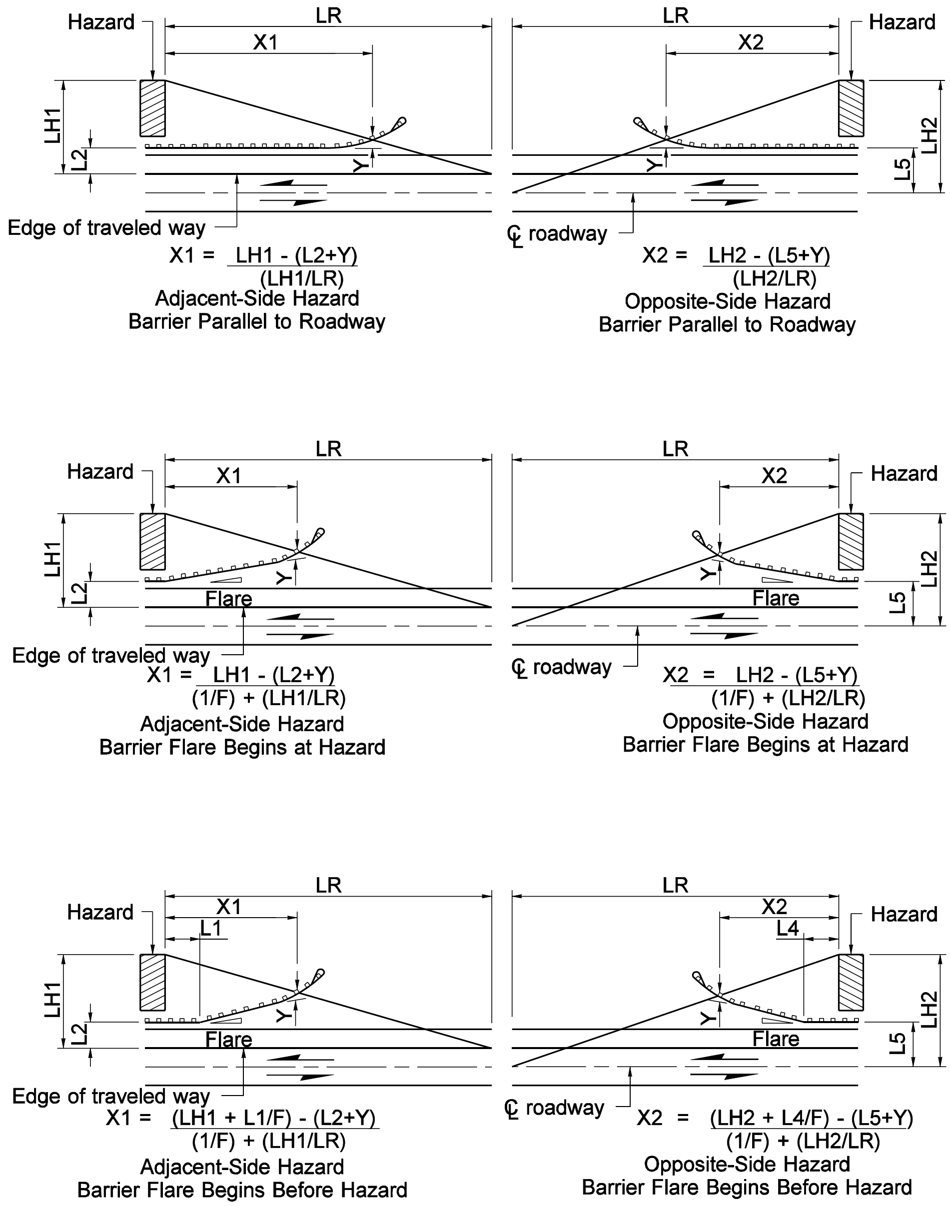
(4) For Service Level 1 bridge rail, see Section 710.06(6), Case 14.

(5) Use on highways with speeds 45 miles per hour or less.

(6) If existing transition has adequate guardrail height—three 10”x10” (nominal) posts and three 6” x 8” (nominal) posts spaced 3’-1.5” apart—it is acceptable to nest existing single W-beam element transitions.

Transitions and Connections

Figure 710-10



Barrier Length of Need on Tangent Sections

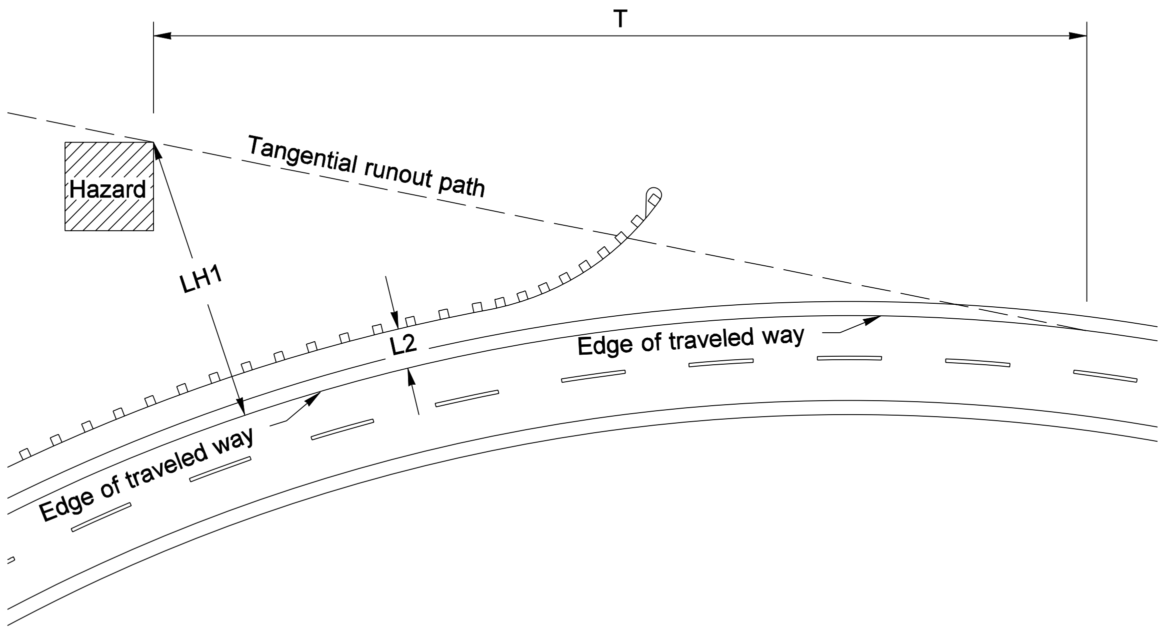
Figure 710-11a

Posted Speed (mph)	Design Parameters						
	ADT				Barrier Type		
	Over 10,000	5,000 to 10,000	1,000 to 4,999	Under 1,000	Rigid Barrier	Unrestrained Barrier	Semirigid Barrier
	LR (ft)	LR (ft)	LR (ft)	LR (ft)	F	F	F
70	460	395	345	295	20	18	15
60	360	295	260	230	18	16	14
55	310	260	230	195	16	14	12
50	260	215	180	165	14	12	11
45	245	195	165	150	12	11	10
40	215	180	150	130	11	10	9
35	185	155	130	115	11	10	9
30	165	135	115	105	11	10	9
25	150	125	105	95	11	10	9

L1 = Length of barrier parallel to roadway from adjacent-side hazard 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 hazard to beginning of barrier flare.
L5 = Distance from centerline of roadway to portion of barrier parallel to roadway. Note: If the hazard is outside the Design Clear Zone when measured from the centerline, it may only be necessary to provide a crashworthy end treatment for the barrier.
LH1 = Distance from outside edge of traveled way to back side of adjacent-side hazard. Note: If a hazard 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 hazard. Note: If a hazard 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 hazard.
X2 = Length of need for barrier to shield an opposite-side hazard.
F = Flare rate value.
Y = Offset distance required at the beginning of the length of need.

Different end treatments require 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 required for the nonflared terminals or impact attenuator systems. Use Y = 0.
Buried terminal end treatments are used with barrier flares and have no offset. Use Y = 0.

Barrier Length of Need
Figure 710-11b



Notes:

This is a graphical method for determining the length of need for barrier on the outside of a curve.

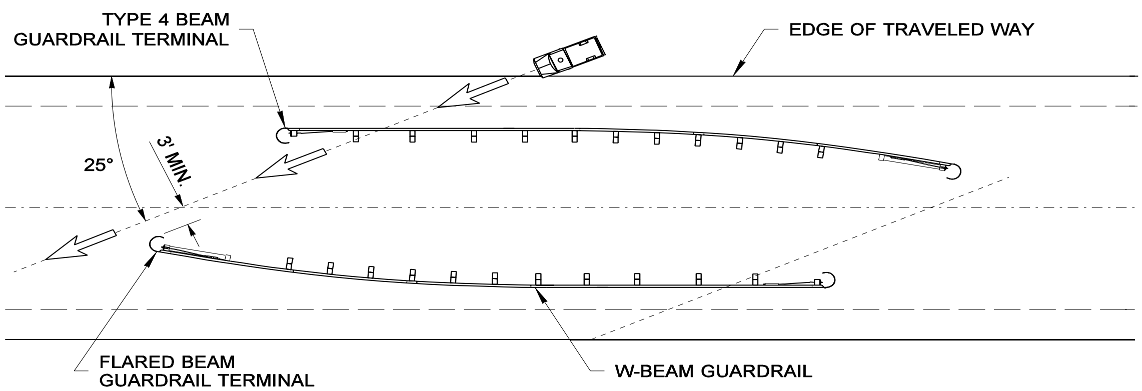
On a scale drawing, draw a tangent from the curve to the back of the hazard. Compare T to LR from Figure 710-11b and use the shorter value.

If using LR, follow Figures 710-11a and 11b.

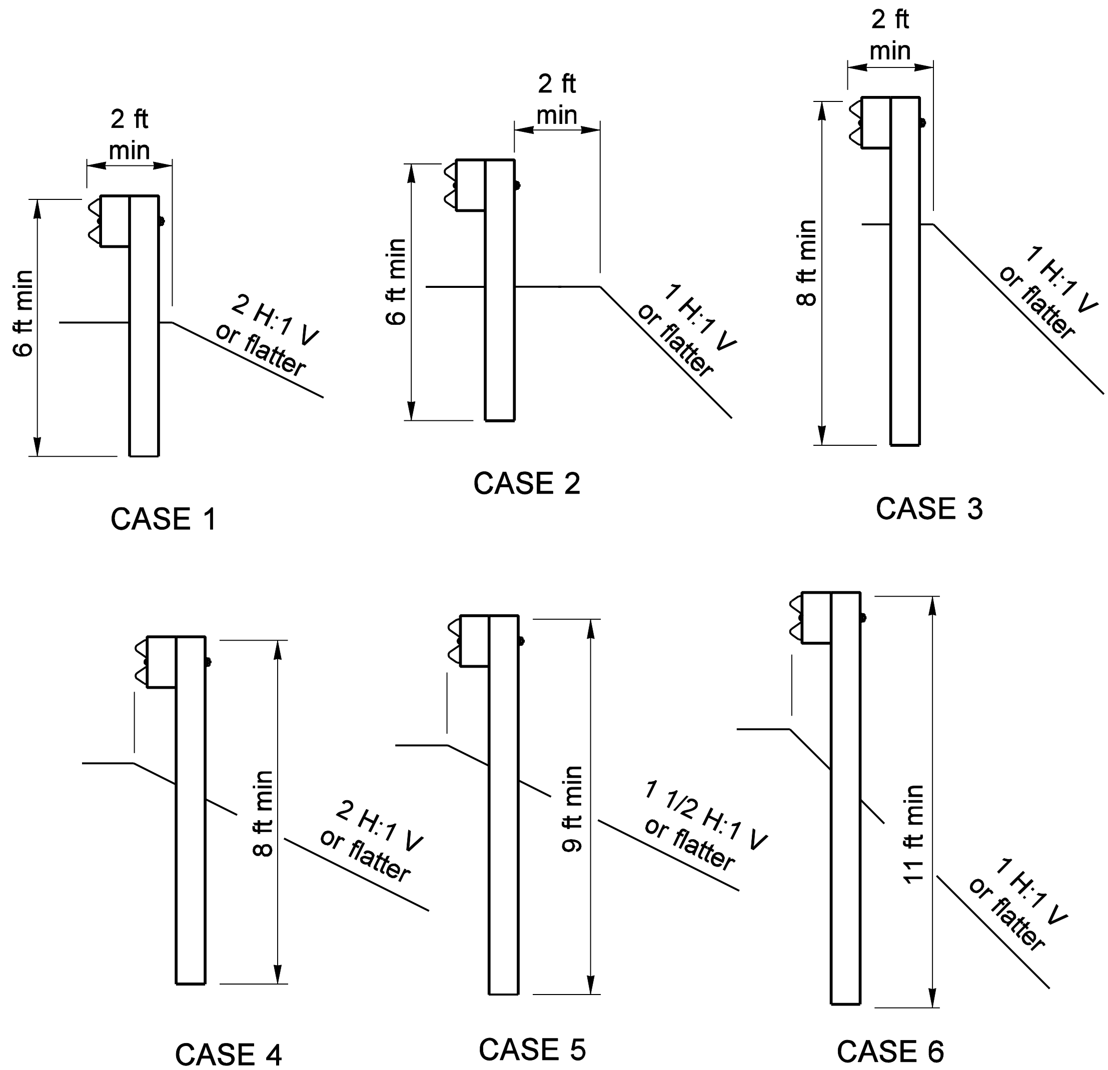
If using T, draw the intersecting barrier run to scale and measure the length of need.

Barrier Length of Need on Curves

Figure 710-11c



W-Beam Guardrail Trailing End Placement for Divided Highways
Figure 710-11d



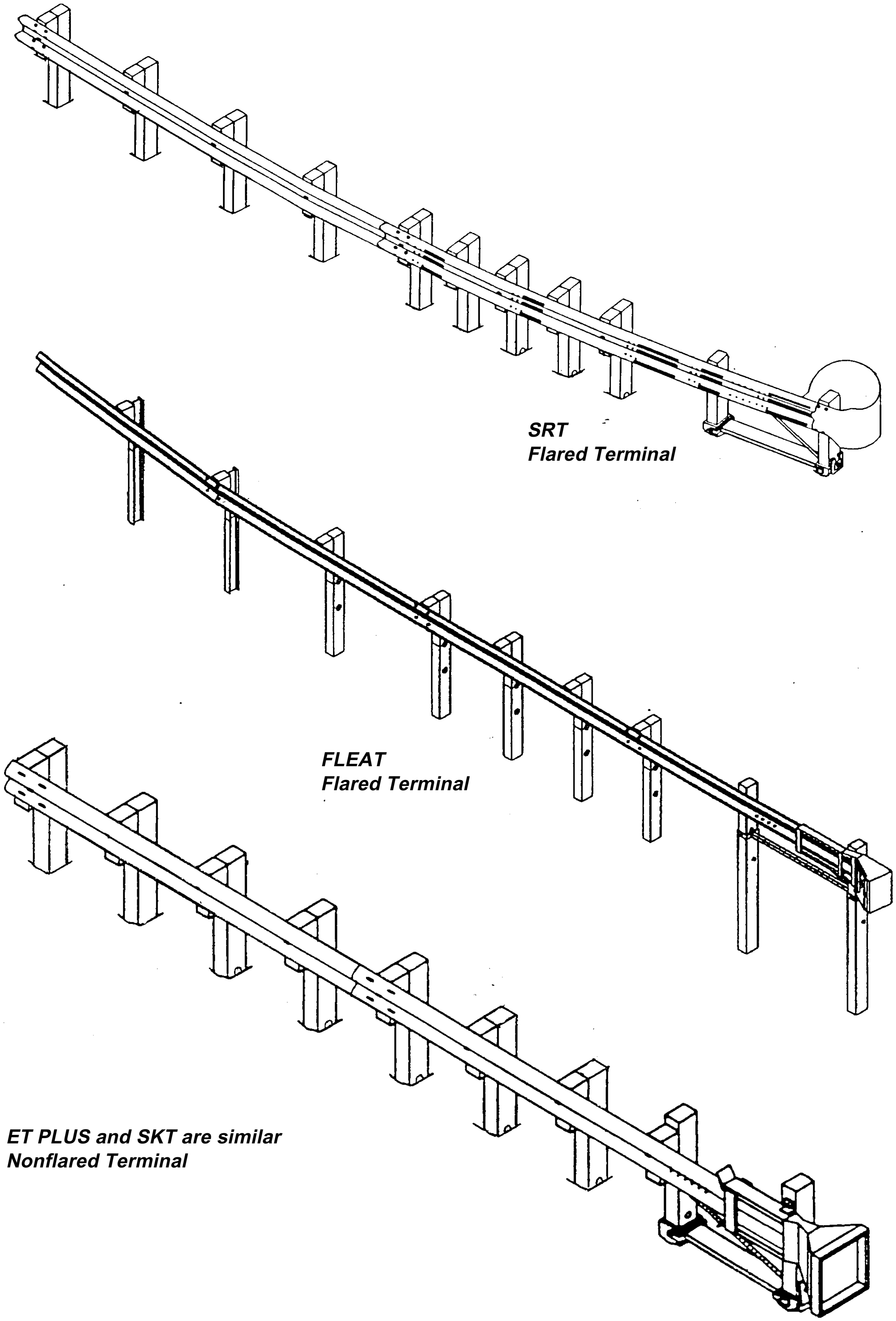
Notes:

Use Cases 1, 2, and 3 when there is a 2-foot or greater shoulder widening from face of guardrail to the breakpoint.

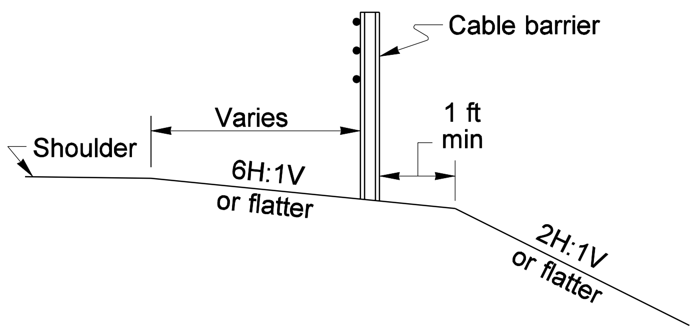
Use Cases 4, 5, and 6 when there is less than a 2-foot shoulder widening from face of guardrail to the breakpoint.

Beam Guardrail Post Installation

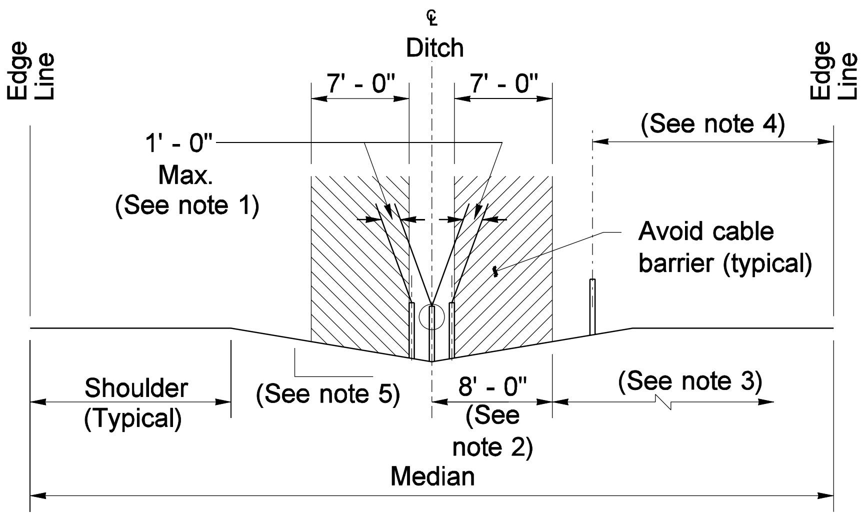
Figure 710-12



Beam Guardrail Terminals
Figure 710-13



Shoulder Installation



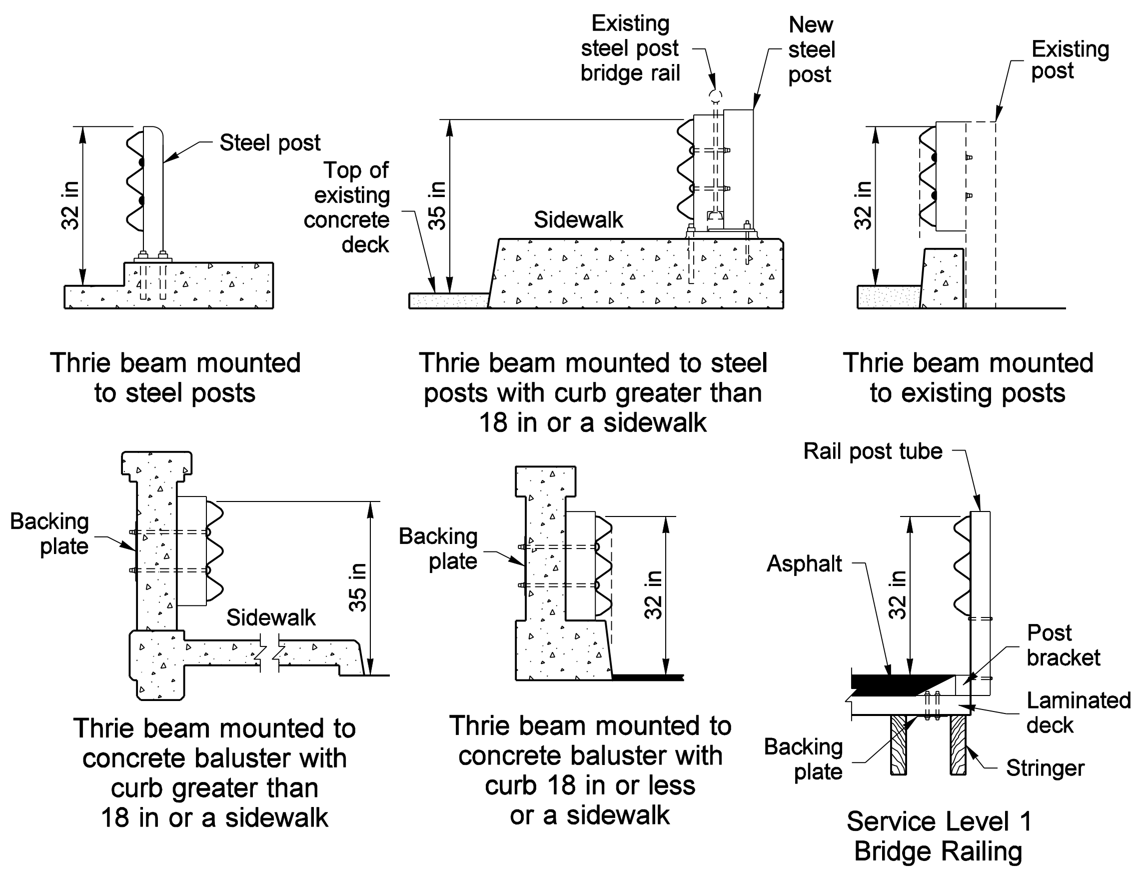
Notes:

(1) Cable barrier may be installed in the center of the ditch. The cable barrier may be offset from the ditch centerline a maximum of 1 foot in either direction.
(2) Avoid installing cable barrier within a 1 foot to 8 foot offset from the ditch centerline.
(3) Cable barrier may be installed a distance of 8 feet or greater from the ditch centerline.
(4) Depending on the system used and post spacing, this distance varies from 6 feet 8 inches to 12 feet.
(5) Applies to slopes between 6H:1V to 10H:1V.

Cable Barrier Locations on Slopes
Figure 710-14

		Concrete Bridge Deck		Wood Bridge Deck or Low- Strength Concrete Deck
Curb Width	**Bridge Width**	**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]
>18 inches	**> 28 feet (curb to curb)**	Thrie beam mounted to steel posts[2] at the face of curb.[1] Height = 32 inches		Height = 32 inches
>18 inches	**< 28 feet (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	Curb or wheel guard must be removed

(1) Thrie beam may be mounted to the bridge rail to accommodate pedestrians (height = 35 inches).
(2) Contact the HQ Bridge and Structures Office for design details on bridge rail retrofit projects.



Thrie beam mounted to steel posts

Thrie beam mounted to steel posts with curb greater than 18 in or a sidewalk

Thrie beam mounted to existing posts

Thrie beam mounted to concrete baluster with curb greater than 18 in or a sidewalk

Thrie beam mounted to concrete baluster with curb 18 in or less or a sidewalk

Service Level 1 Bridge Railing

Thrie Beam Rail Retrofit Criteria
Figure 710-15

Chapter 810 Work Zone Safety and Mobility

810.01 General

Work zones are an important component in overall project design, but sometimes designers do not give them adequate consideration. All work zones create some level of traffic and safety impacts; therefore, all work areas and operations must be identified and addressed in project design. Complex work zones can account for up to 30% of project costs and can impact the safety and mobility of workers and road users. These impacts must be identified, mitigated, and managed. It is not acceptable to allow a project to move forward to advertisement without appropriately addressing work zone impacts. A Work Zone Traffic Control Checklist is included in Figure 810-4. Use the checklist to identify and address work zone safety and mobility impacts. Include the completed checklist in the Project File.

Depending on the work zone, traffic control measures such as lane closures, detours, shoulder closures, temporary channelization, flagging, and pilot cars are common and usually acceptable methods of maintaining traffic through or around work zones. Designers must also consider additional unique or innovative traffic control measures to adequately address those work zone impacts that cannot be mitigated through traditional means. Designers must find the most effective work zone solutions to overcome mobility and safety impacts and maintain levels of service and safety that match existing conditions or are otherwise mitigated through or around the work zone.

Planners, designers, construction engineers, maintenance personnel, and others all play a role in developing a comprehensive work zone design. Designers must completely assess all work zone impacts at the project planning and design stages.

This chapter provides the designer with guidance and direction in developing a comprehensive work zone design that addresses all related safety and mobility impacts. Consider that large numbers of drivers, workers, pedestrians, and others have to drive, build, and walk through the work zone. A comprehensive work zone design is not only a critical component, it is also required by state and federal law. The designer must also develop a transportation management plan (TMP) that incorporates the needs of roadway users and workers within the project design in an effective, constructible manner.

810.02 References

Federal/State Laws and Codes

Final Rule on Work Zone Safety and Mobility
http://www.ops.fhwa.dot.gov/wz/resources/final_rule.htm

Chapter 468-95 (WAC), "Manual on uniform traffic control devices for streets and highways" (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Design Guidance

Construction Manual, M 41-01, WSDOT

Directive D 55-20, Reduced speed in maintenance and construction zones

Executive Order E 1001.01, Work Zone Safety and Mobility

Executive Order E 1033.00, WSDOT Employee Safety

Highway Capacity Manual, 2000, TRB

Instructional Letter IL 4008.00, WSP traffic control assistance in work zones

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA, as adopted and modified by WAC 468-95

Planning and Scheduling Work Zone Traffic Control, USDOT, 1981

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

Supporting Information

American Traffic Safety Services Association (ATSSA) http://www.atssa.com/default.asp

AASHTO Roadside Design Guide, 2006

Crashworthy Work-Zone Traffic Control Devices Report 553, NCHRP, 2006

FHWA Work Zone Operations Best Practices
http://ops.fhwa.dot.gov/wz/practices/practices.htm

FHWA Work Zone Safety and Mobility
http://ops.fhwa.dot.gov/wz/index.asp

ITE Temporary Traffic Control Device Handbook, 2001

ITS in Work Zones
http://tig.transportation.org/?siteid=57&pageid=694

Recommended Procedures for the Safety Evaluation of Highway Features Report 350, NCHRP, 1993

Work Zone and Traffic Analysis
http://www.ops.fhwa.dot.gov/wz/traffic_analysis.htm

WSDOT – Project Delivery Lessons Learned
http://fmpwebi.wsdot.wa.gov/lessonslearned/FMPro?-db=DebriefReport&-lay=Web&-format=Main.htm&-op=eq&MonthlyHighlight=Yes&-find=

WSDOT – Work Zone Safety Webpage
http://www.wsdot.wa.gov/biz/trafficoperations/workzone/default.htm

810.03 Definitions

ADA Americans with Disabilities Act of 1990: federal law prohibiting discrimination against people with disabilities.

lag up Bringing adjacent lifts of hot mix asphalt (HMA) to match the latest lifts for safety.

tapered wedge joint A tapered edge of a lift of HMA to eliminate an abrupt drop-off.

traffic control devices Signs, signals, pavement markings, and other devices placed on, over, or adjacent to a street or highway to regulate, warn, or guide traffic.

transportation management plan (TMP) Provides a set of strategies for managing the work zone impacts of a project. The TMP is required for all projects and is the key element in addressing all work zone safety and mobility impacts.

work zone "An area of a highway with construction, maintenance, or utility work activities. A work zone is typically marked by signs, channelizing devices, barriers, pavement markings, and/or work vehicles. 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 traffic control The planning, design, and preparation of contract documents for the modification of traffic patterns during construction.

810.04 Work Zone Policy

The Washington State Department of Transportation (WSDOT) has an overarching policy on work zone safety and mobility. WSDOT does not delegate safety and mobility responsibility for the traveling public. Designers need to be familiar with Executive Order E 1001.01, Work Zone Safety and Mobility. This policy refers to the relationship between WSDOT programs that set the policy to identify and address work zone safety and mobility issues during planning programming, design, construction, and maintenance.

The policy on work zone safety and mobility ensures that all work zone impacts are appropriately identified, mitigated, and managed on a systematic basis. Safety considerations are the first priority and a high level of safety must be integrated into all work zone strategies. All those with work zone responsibilities are directed to make the safety of workers, responders, and the traveling public the highest priority. Closely following is the need to maintain traffic mobility through the work zone and any other routes impacted by the work zone. Mobility affects safety; many work zone crashes can be attributed to work zone congestion.

It is imperative that roadway workers have a safe work zone environment to conduct work operations. Without first addressing safety, the project cannot proceed. Roadway users must also have a safe and functional path through the work zone.

Mobility is secondary to safety in the hierarchy of work zone priorities, but is generally the number one operational problem related to overall work zone effectiveness. Mobility must be addressed at a level that is compatible with existing traffic demands. Ultimately, some loss of capacity through the work zone may be unavoidable, but not without providing other mitigating solutions as part of the project.

It is not acceptable to leave work zone impacts unresolved or otherwise not identified or addressed in the project design. Work zone strategies must be developed enough that an accurate scoping estimate can be prepared. Include any unique or innovative work zone elements that may require additional funding.

Work zone policy is required to be implemented within the intent and direction of FHWA Final Rule on Work Zone and Mobility, and WSDOT Executive Order E 1001.01. Specific direction and guidance is contained throughout this chapter and is linked to the appropriate work zone policy elements. (*See E 1001.01 Work Zone Safety and Mobility.)

810.05 Work Zone Process

WSDOT ’s policy on work zone safety and mobility is that work zone operations should be conducted in the best interests of worker safety, with minimal impacts to the traveling public. In order to fulfill the intent of this policy, projects must be designed to ensure that all work zone impacts are addressed.

Although WSDOT makes every attempt to not affect the traveling public, many highway construction projects have impacts based on the types of work activities being performed. In all but a very few instances, the public must have some form of access through or around the work site. The designer must identify all work areas and operations that interact with the existing project location traffic patterns. This includes all vehicles, pedestrians (including ADA considerations), bicycles, construction traffic, transit, schools, business access, U.S. postal service, emergency response, work zone ingress and egress, oversize loads, and any other transportation mode, construction activity, or operation that initiates the need for some form of traffic control or hazard protection. Intimate knowledge of the project location and local traffic patterns and how these relate to the work zone and related construction activities is key to developing a complete work zone design. Designers will need to gather this information through field reconnaissance and investigation as well as seeking input from others with expertise in these areas.

The responsibility of the designer to fully address all work zone traffic control impacts is very important in that the level of traffic safety and mobility will be directly affected by the effectiveness of the Transportation Management Plan (TMP). Several resources that are available to assist the designer with various aspects of the work zone design effort are as follows:

- **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.
    1. Region Traffic Office
    2. Region Work Zone Specialist
    3. Region Construction & Design Offices
- **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.
    1. State Work Zone Safety & Mobility Manager
    2. State Work Zone Engineer
    3. WSDOT Work Zone Web Page
- **FHWA Work Zone Resources.** The FHWA Washington Division Office and Headquarters Office may be able to provide some additional information through the WSDOT HQ Traffic Office. The FHWA also has a work zone web page:
  http://www.ops.fhwa.dot.gov/wz/

The frequency of traffic collisions in work zones is disproportionately higher than at any other highway location. Safety is the primary consideration for all people within the work zone: motorists, pedestrians, bicyclists, contractors' workers, agency inspectors, surveyors, responders, and other personnel on the site.

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. As construction progresses, existing traffic lanes may be either temporarily narrowed or closed. Even when the construction work does not affect adjacent traffic lanes, slowdowns in the traffic flow are common because these activities can be a distraction to the motorist. Providing improvements to alternate routes of travel, widening temporary traffic lanes, staging work to occur in off-peak traffic hours, and other means of offsetting the capacity reduction are part of a comprehensive work zone traffic control strategy. The impacts these operations have on the traffic flow are important, but not at the expense of safety. Reductions in traffic capacity must be mitigated and managed as part of the TMP. This all needs to be balanced with providing a reasonable work window that offers sufficient time to complete construction tasks.

It is important that the TMP, region policy, and commitments to impacted local government, public agencies, businesses, and communities are consistent. Region managers should be made aware of potential work zone traffic impacts as early as possible in the planning and design process.

This chapter provides specific direction and guidance to assist the designer with the development of an effective TMP.

810.06 Project Development

The project development process is the design engineering effort that brings the project from conceptual level to actual construction. It includes the traffic control strategy that establishes the framework to develop the Plans, Specifications, and Estimates (PS&E) relative to the traffic management of the project.

A comprehensive work zone traffic control plan (TCP) or transportation management plan (TMP) is actually a project within a project. WSDOT is obligated to provide a safe and workable proposal for controlling traffic, which is consistent with the project construction requirements. Even though there may be more than one workable solution, a thorough analysis of all the variables will help produce a TMP that addresses all impacts and establishes the appropriate levels of safety, mobility, and service. The goal of this effort is to reduce or eliminate the variations that contractors, work zone workers, and the traveling public are confronted with as they travel through construction projects.

Project development can be broken down into a three-step process that represents key milestones in the development of the project (see Figure 810-1). The process includes the following steps:

1. Planning and Strategy Development
2. Design and Analysis
3. Final Work Zone Traffic Control Plan (WZTCP)

Depending on the overall scope of the project, these three steps may overlap one another. Traffic control is very dynamic and fluid and the strategy may change or be refined as the design progresses. Good communication between the project designer and construction project engineer is recommended to ensure all work areas are included in the design and any potential constructibility issues can be identified and documented.

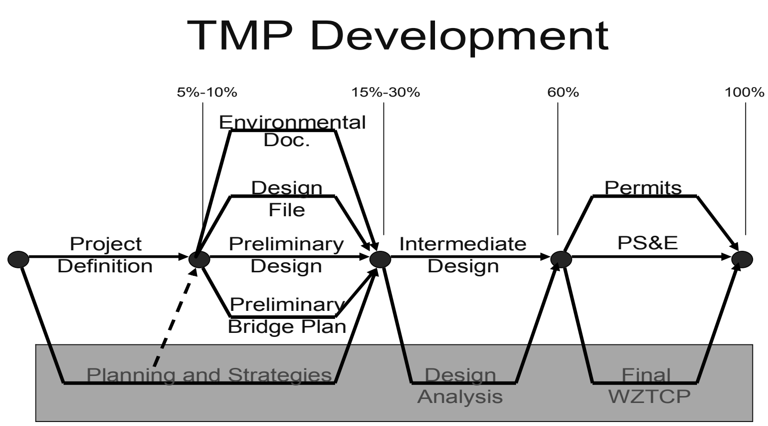
(1) Traffic Control Strategies

During the planning and strategy phase, basic information about the project is collected and examined. The intent of this phase is to select traffic control strategies that would be appropriate for the project. These strategies will establish the approach for the plan development process to construct the project while maintaining traffic movements. A complete and accurate preliminary estimate is essential to implement the strategies.

There are often several strategies that can be employed to manage traffic through a work zone. For any given project, the designer may consider several of these strategies for different construction phases. The final strategy is influenced by a number of factors such as traffic volumes and capacity, number of lanes available, and the anticipated work operation. Selecting a strategy is often a compromise and involves many engineering and nonengineering factors.

Strategies in managing work zone traffic control activities become increasingly important and sophisticated when the size, complexity of work, and time available to do the work become critical. For simple projects, the strategies may be very basic. However, for large, more complex projects, the TCP strategies are developed around the traffic control requirements to maintain traffic movements. On these types of projects, special traffic control details, layouts, work-hour restrictions, and staged plans may need to be developed.

The designer will use the strategy and preliminary estimate through the design effort as the project design elements are developed and a method is determined to best maintain traffic during construction. The plan development process must encompass all potential work operations and work areas within the project. (See 810.17 for tips and considerations on the development of the plans.) Other WSDOT and local agency construction projects may require coordination.



Transportation Management Plan Development
Figure 810-1

A Design Checklist (see Figure 810-4) has been developed to support the project development process. Use the checklist during all phases of the traffic control plan development to ensure that all applicable information is available, and that all necessary coordination work is accomplished.

(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.

810.07 Work Zone Safety

"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" (excerpt from E 1001.01).

An effective work zone traffic control strategy encompasses the safety of all users and is not limited to providing safety measures for the motorist only. Work zones present constantly changing roadway conditions that might increase the likelihood of confusion for users. An increased degree of vulnerability is present for workers, flaggers, motorists, pedestrians, and bicyclists in the work zone.

The designer's role in work zone safety is to provide for the safety of workers and roadway users as an integral part of the project work zone design strategy, and to conduct a comprehensive work zone safety assessment. This information provides the basis for incorporating safety into the actual work zone design and traffic control plan development.

Work zones present situations that can lead to the serious injury or death of workers and roadway users. Drivers, passengers, workers, inspectors, flaggers, law enforcement personnel, pedestrians, and bicyclists are among those that may interact within the work zone. Nationally, work zone fatalities have risen to over 1000 annually and appear to be on an upward trend. Washington State has averaged less than ten work zone fatalities annually for the past several years. While statistics provide valuable information on many levels, it is WSDOT's practice to use statistical data as an indicator or possible performance measure, but not as a value that would dictate a level of applied safety measures. Work zones are planned and designed to conduct work operations, which must include specific safety measures at a level that addresses all safety impacts. Workers, pedestrians, and others that are not drivers or passengers may be exposed to an even higher level of risk related to the actual work operation, plus exposure to moving vehicles.

Some work zone hazards are easily identified and addressed, while others may require more intense investigation. The following information on some of the risks and associated impacts on workers and roadway users in work zones is intended to provide awareness of the different types of hazards. Each individual work zone must be assessed for hazards, as each work zone usually has unique features. The work zone safety assessment process and checklist provided is intended to assist the designer in determining the hazards that need to be addressed.

(1) Work Zone Hazards

The following list provides many common examples of work zone risks to drivers, workers, and flaggers that designers need to be aware of and address with protection, removal, or other solutions. Also, work zones are very dynamic, with many operations in progress while maintaining the flow of traffic. Work zones must function safely while these activities occur. A work zone design is not complete without addressing issues of ingress and egress, truck and equipment movements, moving work operations, and more.

Designers must consider the following conditions for drivers when developing a work zone TCP:

- Pavement markings
- Clear zone/safety zone issues
- Night work visibility issues (poor illumination or lack of positive guidance)
- Confusing or conflicting signs, markings, and features
- Unstable traffic flow

- Roadway geometrics
- Unexpected queues
- Congestion-related crashes
- Unexpected roadway configuration, merging, tapers, and drop lanes
- Vertical hazards, drop-offs, and diverging roadway profiles
- Emergency vehicle access
- Disabled vehicle refuges

Designers must consider the following conditions for flaggers and workers when developing a work zone TCP:

- Work zone protection
- Impaired, distracted, or inattentive drivers
- Errant vehicles
- Narrow work zones, equipment, and material
- Lack of protection behind flaggers from approaching traffic
- No escape route
- Exposure to moving equipment
- Aggressive drivers
- Speeding drivers
- Vehicle crashes
- Work zone access (ingress/egress issues, merging trucks, etc.)

Examine every work zone to determine the specific conditions that may be unique to that work zone.

(2) Workers

Working on or along the highway on construction projects is one of the more hazardous work environments. The risk of being struck by a vehicle traveling through the work zone increases as traffic volumes and speeds increase. Long delays can cause some motorists to become impatient and act unpredictably. A number of drivers are impaired from alcohol intoxication and legal or illegal drugs. Other driver conditions such as being sleep-deprived, elderly, aggressive, or inattentive are also potential hazards to workers. Consider the risk to workers when developing traffic control plans.

(3) Positive Protection

Traffic barriers provide the most effective protection for workers and they eliminate many traffic control devices. The costs of furnishing and removing temporary traffic barriers on longer-duration projects can often be less than the costs associated with the frequent repositioning of other traffic control devices. Positive barrier protection is often the preferred method for work zone protection and separation from traffic. Consider a strategy that offers the highest level of protection for workers. Temporary concrete barrier is the most common and available type of positive protection. Movable temporary concrete barrier could also be considered for those projects that require lane closures outside the limits of the normal barrier location. Truck-mounted attenuators are mobile and can be used strategically to protect isolated work zones or access points in the event of an errant vehicle. Traffic safety drums are generally considered to be the most versatile and effective of the types of portable channelization devices, especially for high-speed (45 miles per hour or higher) and high-volume traffic locations.

The selection of barriers and devices to separate workers from traffic is a critical decision and may become the key component of the work zone strategy. (See the MUTCD.) Do not assume that long-term stationary projects are the only practical application for barrier-protected work zones. Consider a staging plan on other projects that would allow for the use of barrier, even though it may need to be relocated several times. Excessive use of barrier may increase the potential for collision. Avoid the use of barrier for longer lengths or durations than is required for protection of active work areas. Traditional lane closure work zones using channelization devices are acceptable and may be the practical choice, but all additional means of protecting workers should be considered. Consider work zones of an isolated or restrictive nature, as workers also need safe access to and from the work zone. (See Chapter 710 for guidance on barriers.)

(4) Flaggers and Spotters

Although flaggers are also workers, their function in the work zone is uniquely different than other workers and they are treated as a separate group. Flaggers must perform their duties in potentially hazardous situations. Flagger safety is a high emphasis area. Do not include flaggers in the development of traffic control strategies until all other reasonable means of traffic control have been considered. These include more innovative traffic control methods such as automated flagging assistance devices (AFAD), temporary traffic signals, detour routes, and alternative traffic control plans, which can eliminate the need for flaggers.

Flaggers are normally used to stop and direct traffic for work activities such as one-lane alternating traffic control, intersection control, and road closures. Using flaggers solely to instruct motorists to proceed slowly is ineffective and is an unacceptable practice. When flaggers are used, provide a method of alerting them to the hazard of a vehicle approaching from behind. When flagging is needed for nighttime construction activities, provide adequate illumination of the flagger's station. Two-way radios or cellular phones are necessary to allow flaggers to communicate with one another when they are required to control traffic movements in shared right of way work zones.

Flaggers need escape routes in case of an errant vehicle or other hazards. The flagger's location, escape route, protection, and any other safety-related issues all need to be incorporated into the traffic control plan for the flagging operation. The WSDOT publication, *Work Zone Traffic Control Guidelines* (M 54-44), and the Standard Specifications have more information on flaggers, including the Washington State Department of Labor and Industries safety regulations for flaggers.

A spotter (not to be confused with a flagger) is used solely to alert workers. The spotter can be used to watch traffic and alert workers of the approach of an errant vehicle. A spotter does not use a flagging paddle, but instead uses a warning sounding device like an air horn. Use spotters only when the risks to the workers exceed those of the spotter. Intended spotter locations are to be shown on traffic control plans.

Law enforcement personnel may be considered for some flagging operations and can be very effective where additional driver compliance is desired. Law enforcement personnel are the only personnel allowed to flag from the center of an intersection. If flaggers are used at an intersection, a flagger is required for each leg of the intersection. When multiple lanes are present at an intersection, close the lanes so there is only one lane of traffic approaching the flagger location. When an existing signal is present at the intersection, the signal is to either be turned off or set to flash mode. The *Traffic Manual* contains information on the use of law enforcement personnel at work zones.

(5) Road Users

Road users assume (rightfully) they have full use of the roadway, unless directed otherwise. The message conveyed to the user through signing, markings, and devices must be consistent and credible.

(a) **Drivers.** Drivers and their passengers account for approximately 90% of work zone fatalities. It is important that efforts be made to effectively guide and protect drivers in work zones. Effective planning and design of work zones begins with the driver, and work zone design must be initiated from the driver's perspective. If drivers can easily understand the traffic control and have adequate time to react or make rational decisions, they will generally operate their vehicles in a safe and expected manner.

It is essential that designs be based upon the characteristics and limitations of drivers who use the highway and street networks. As speeds increase on a facility, the motorist requires more time to respond to conditions. Work zone temporary channelization and alignment must be designed to accepted roadway geometric design policy, not based on a design that may fit a given location without regard to safe design or predicated on a reduced speed that drivers may not follow. Perceived, insufficient, or conflicting information and/or too much information conveyed by signing will confuse the motorist and contribute to erratic driving behavior. Drivers may begin to ignore signing and other devices if they warn the motorist of a condition that no longer exists.

(b) **Pedestrians.** Public highways and streets that permit pedestrian use cannot deny access to pedestrians if no other route is available to them. Even in work zones, adequate facilities are provided to allow pedestrians to travel through or around the work zone. In urban areas and other locations where pedestrian travel is pronounced, the construction of temporary pathways that route the pedestrian around the work zone may be necessary. Covered walkways are provided in the work zone when there is a potential for falling objects to strike pedestrians. When existing pedestrian facilities are disrupted, closed, or relocated in a work zone, the temporary facilities shall be detectable and shall include accessibility features consistent with the features present in the existing pedestrian facility. Give careful consideration to the existing pedestrian path in that, even though no ADA-compliant features may be existing, the path may still be accessible to some extent and would need to be maintained in that manner. (See Chapter 1025 for pedestrian work zone design requirements.)

(c) **Bicyclists.** Bicyclists are allowed on most highways and streets, and many use the bike as their principal means of transportation. In work areas where the speeds are in the range of 25 to 30 miles per hour, bicyclists can use the same route as motorized vehicles. Within work zones on higher-speed facilities, bicyclists will not be able to match the speed of motorized vehicles and a different route or detour is sometimes necessary for safety and to reduce vehicular delays. When this is not possible, bicyclists can be instructed to dismount and walk their bikes through the work zone on the route provided for pedestrians. Bicyclists' access should be considered when developing the traffic control plans and staging plans. If it is feasible to maintain bike access through the work area with shoulder use, the minimum shoulder width of 4 feet should be designed into the plans.

Bicycles may also be allowed where pedestrians are not and there may be no pedestrian path for temporary bike use. Those work zones where there may be no available bike or pedestrian path must be officially closed and a detour route provided. It may be possible to make other provisions to transport bikes and riders through the work zone, as needed, by the traffic control supervisor or with a walking escort around the active work area. Riding surfaces are important for safe bicycle operation.

Consider the condition of the surface the bicyclist will be required to use, as loose gravel, uneven surfaces, milled pavement, and various asphaltic tack coats endanger the bicyclist. Much information can be gathered on bike issues by contacting local bike clubs. Coordination with local bike clubs is recommended to ensure their members are notified of work zone impacts. (See Chapter 1020 for more bicycle design requirements.)

(d) **Motorcycles.** The riding surface is also important for the safety of motorcycle riders. The same surfaces that are a problem for bicyclists are also difficult for motorcyclists. Stability at high speed is a far greater concern for motorcycles than cars on grooved pavement, milled asphalt, and tapers from existing pavement down to milled surfaces. Contractors must provide adequate warning signs for these conditions to alert the motorcycle rider. The WSDOT publication, *Work Zone Traffic Control Guidelines* (M 54-44), has more information on the regulations for providing warning to motorcyclists. (See also RCW 47.26.200.)

(e) **Oversized Vehicles.** Oversized vehicles exceed the legal width, height, or weight limits for vehicles, but are allowed on certain state highways. The regions' maintenance offices and HQ Motor Carrier Services issue permits that allow oversized vehicles to use these routes. If the proposed work zone will not accommodate those vehicles, provide adequate warning signs and notify HQ Motor Carrier Services and the regions.

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 on warning or prohibition signs only. 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 may need to be reconsidered to more safely accommodate oversized loads by using an alternate girder type or other features, as well as staging and falsework opening size. The most common occurrence of this case may be a structure supported by falsework.

810.08 Mobility

Work zone congestion and delay is a significant issue for many highway projects. It is relatively easy to classify work zones on either end of the mobility spectrum. High-volume locations with existing capacity problems will most certainly be candidates for further capacity problems when a work zone is in place. Conversely, low-volume locations may not be affected at a significant level as long as the work zone impacts are not too severe. Work zones that fall somewhere between either end of the spectrum may not be so easy to recognize. All work zones need to be analyzed at an initial basic level to determine if further analysis is needed to address traffic capacity impacts. Significant impacts (see 810.15, Impacts Assessment) will most likely require a detailed capacity analysis to determine the most effective strategies for work zone mobility needs. It is not acceptable to develop a work zone strategy without traffic data to identify the projected impacts to traffic.

Mobility plays a role through and around work zones and other construction project activities in addition to traffic delays and congestion.

- **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 otherwise dangerous driving actions, causing crashes or danger to workers.
- **Constructibility.** The ability to construct a project efficiently relies (to a large extent) on the ability to pursue work operations while maintaining traffic flow. Delays in the form of material delivery, work hour restrictions, and constant installation and removal of traffic control devices all detract from constructibility.
- **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. Local roads may have lower geometric standards than state facilities. Placing additional and new types of traffic on a local road may create new safety hazards, especially when drivers are used to the geometrics associated with state highways.
- **Public Credibility.** Work zone congestion and delay can create poor credibility 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, etc.
- **User Cost Impacts.** Congestion and delay, as well as associated crashes and other impacts, can create significant economic impact to road users and the surrounding community. Calculate user costs as part of a work zone capacity analysis; the costs may be used to justify project congestion mitigation costs.
- **Bikes and Pedestrians.** Most roadways allow bike and pedestrian travel as legitimate modes of travel. Closing bike and pedestrian routes is generally not acceptable without providing alternate routes and access if they cannot be accommodated through the work zone.

WSDOT has a responsibility to maintain traffic mobility through and around its projects, which can be accomplished in many ways. The need to maintain mobility does not rule out innovative strategies such as planned roadway closures, because a mitigation strategy or other justification would be part of that overall strategy. It would not be appropriate to allow traffic restrictions without including a strategy to notify, mitigate, and manage the congestion. There is no absolute answer for how much congestion and delay is acceptable or unacceptable. The goal is a work zone strategy that maintains a work zone capacity level that minimizes all the related impacts. For further guidance on developing this type of strategy, see 810.16, Work Zone Design Strategy.

Traffic capacity mitigation measures are an important component in minimizing impacts, since many projects cannot effectively contain all the impacts through the work zone. Mitigation measures that provide the right combination of good public information, informative 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 absorbing the over-capacity traffic and maintaining mobility.

Designers may want to enlist the assistance of others to adequately address work zone mobility impacts, such as the following:

- HQ Transportation Data Office
- HQ & Region Traffic Offices
- Region Work Zone Specialist
- Traffic Analysis Engineers
- Region Public Information Office

Training or experience with the following traffic analysis programs is also recommended, since at some level a work zone capacity analysis will need to be conducted. (See 810.20, Training Resources, for more information on training.)

- Quewz 98
- QuickZone
- Other capacity programs

810.09 Work Zone Classification

The duration of work is a major factor in determining the number and types of devices used in traffic control work zones. There are three classes of zones categorized by the expected duration of work. Different criteria apply to the design and planning for each of these classes. Several work zone classifications might be present during the construction phase of a project. Refer to the MUTCD for additional information regarding work duration. The three classes of work zones are as follows:

(1) Long-Term Stationary Work Zones

Long-term stationary work zones occupy locations longer than one hour. At these locations, there is ample time to install and realize benefits from the full range of traffic control procedures and devices that are available for use. Generally, larger channelizing devices are used, as they have more retroreflective material and offer increased nighttime visibility. Consider the use of temporary illumination to improve nighttime visibility (see 810.10 for additional information and considerations). The larger devices are also less likely to be displaced or tipped over by passing traffic. This can be an important consideration during those periods when the work crew is not present.

Since long-term operations can extend into nighttime, retroreflective and illuminated devices are necessary. Temporary detours and barriers can be provided, and inappropriate pavement markings can be removed and replaced with temporary markings. The time required for the installation and removal of temporary barriers and pavement markings is justifiable when they are required for about a week. Long-term stationary work zones encompass many various work zone operations, which range from a lane closure operation lasting a full work shift, to a roadway-widening project with staged traffic control. Stationary work zone traffic control is usually associated with a substantial work operation that may have many workers, with large quantities of equipment, and increased truck hauling and flagging.

(2) Short-Duration Work Zones

Short-duration work zones occupy a location for up to one hour. During short-duration work, the work crew sets up and takes down the traffic control devices. Because the work time is short, the impact to motorists is usually not significant and simplified traffic control procedures are used. Due to the short work time, simplified traffic control set-ups are allowed, to reduce the traffic exposure to workers. 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 provide a safety benefit for both drivers and workers since the time duration is less than the implementation of stationary work zones, thereby reducing exposure time to traffic and work hazards. Motorists also receive a mobility benefit from reduced traffic impacts and associated rear-ending congestion crashes. These safety and mobility benefits are consistent with the department's responsibility and policy to protect both drivers and workers, while maintaining an acceptable level of mobility. Examples of short-duration work zone operations include relamping, pothole repair, surveying, minor repairs, bridge inspection, field recon, and prework layout.

These simplified control procedures can often be standardized plans, as contained in the HQ Design Office plan sheet library and the *Work Zone Traffic Control Guidelines* (M 54-44). The traffic control setup should fit the work operation.

(3) Mobile Work Zones

Mobile work zones are work activities that progress along the road either intermittently or continuously. Mobile operations often involve frequent stops for activities such as sweeping, paint striping, litter cleanup, pothole patching, or utility operations and are similar to short-duration work zones. Truck-mounted attenuators, warning signs, flashing vehicle lights, flags, and channelizing devices are used and 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. Flaggers encounter more exposure in these operations and safeguards are necessary. Electronic signs and flashing arrow displays are far more effective than flaggers in these situations. 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.

810.10 Work Zone Devices

FHWA regulations require that all roadside appurtenances such as portable sign stands, barricades, traffic barriers, barrier terminals, crash cushions, and work zone hardware shall be compliant with the federal National Cooperative Highway Research Program (NCHRP) 350 crash test requirements. For additional information on the NCHRP 350 requirements and for additional descriptions of devices, refer to the MUTCD. For additional information and use guidelines for the following work zone devices, refer to *Work Zone Traffic Control Guidelines*.

(1) Channelization Devices

Channelization devices are used to alert and guide road users through the work zone. They are a supplement to signing, pavement markings, and other work zone devices. Typical devices include:

(a) **Cones.** Traffic safety cones are the most commonly used devices for traffic control and are very effective in providing delineation to the work zone. Cones are orange in color and are constructed of a material that will not cause injury to the occupants of a vehicle when impacted. For daytime operations on lower-speed (40 miles per hour or less) roadways, 18-inch-high cones can be used. For nighttime operations and high-speed roadways, reflectorized 28-inch-high cones are necessary. Traffic cones are used to channelize traffic, divide opposing traffic lanes, and delineate short-duration work zones.

(b) **Traffic Safety Drums.** Traffic safety drums are preferred for use on high-speed, high-volume roadways, and are required in some regions. Drums are fluorescent orange in color, constructed of lightweight, flexible materials, and are a minimum of 3 feet in height and 18 inches in diameter. Drums are the more commonly used devices in lane closure tapers to channelize or delineate traffic routes. They are highly visible and appear to be formidable obstacles. Drums are used at locations where high vehicular speeds are present, because they have weighted bases and are less likely to be displaced by the wind generated by moving traffic. The use of Type C steady-burn lights atop drums is recommended for high-speed urban freeway lane closure operations to improve visibility.

(c) **Tall Channelizing Devices.** Tall channelizing devices are 42 inches tall, fluorescent orange in color, and are constructed of lightweight, flexible material that will not cause injury in an impact. Tall channelizing devices are used to channelize traffic, divide opposing traffic lanes, and delineate short-duration work zones. These devices provide a larger target value in terms of retroreflectivity than cones, but less than that of drums. They do have a smaller footprint than drums, so they are a good alternative in narrow shoulder conditions, but they should not be a primary choice of device.

(d) **Tubular Markers.** Tubular markers are not a recommended device, unless they are being used to separate traffic on low-volume, low-speed roadways. For descriptions and restrictions for use, refer to the MUTCD and the Channelization Device Application Matrix in the *Work Zone Traffic Control Guidelines* (M 54-44) for additional information.

(e) **Barricades.** The barricades used in work zone applications are portable devices. They are used to control traffic by closing, restricting, or delineating all or a portion of the roadway. There are four barricade types:

1. The Type I Barricade is used on lower-speed roads and streets to mark a specific hazard.
2. The Type II Barricade is used on higher-speed roadways and has more reflective area for nighttime use to mark a specific hazard.
3. The Type III Barricade is used for lane and road closures.
4. The Directional Indicator Barricade is a special-use device and not commonly used. The device is used to define the route of travel on low-speed streets or in urban areas where tight turns are required. In lane reductions, the directional arrow on this barrier can be used in the transition taper to indicate the direction of the merge.

(f) **Longitudinal Channelization Devices.** Longitudinal channelization barrier systems such as lightweight water-filled barrier are an improvement over traffic cones and drums used to channelize traffic through a work zone. Water-filled barriers are *not intended* as a replacement for concrete barriers; however, they may be considered for short-term use as a substitute for concrete barrier in emergency situations.

(2) Barriers

Barriers are used to separate opposing traffic movements and to separate the road users from the work zone. Work zone intrusions can jeopardize the safety of the motorist or the workers. Types of barrier protection used in construction work zones vary between temporary concrete barriers, movable barriers, steel barriers, and water-filled barriers.

Barriers are normally installed at the following locations:

- The separation of opposing traffic, where two-way traffic must be maintained on one roadway of a normally divided highway for an extended period of time
- The separation of opposing traffic, where a four-lane divided highway transitions to a two-lane two-way roadway that is being upgraded to become a divided four-lane roadway
- Where drums, cones, or barricades do not provide adequate guidance for the motorist or protection for the worker
- Multiple lane separations in a long-term stationary work zone
- Where workers are exposed to unusually hazardous traffic conditions

- Where existing traffic barriers and bridge railings are removed during a construction phase

(a) **Temporary Concrete Barriers** are the safety-shape barriers shown in the Standard Plans. They are used in long-term stationary work zones on high-speed multilane facilities. They are also used as a temporary bridge rail when existing bridges are being modified. These concrete barriers are often displaced in impacts with errant vehicles. Lateral displacement is usually in the range of 2 to 4 feet. When any barrier displacement is unacceptable, these barriers are anchored to the roadway or bridge deck. Anchoring systems are also shown in the Standard Plans.

(b) **Movable Barriers** are specially designed segmental barriers that can be moved laterally as a unit to close or open a traffic lane. Initial costs are high and they will only be considered in a long-term stationary work zone if frequent or daily relocation of a barrier is required. The ends of the barrier are not crashworthy and must be located out of the clear zone or fitted with an impact attenuator. Adequate storage sites at both ends of the barrier are required for the unique barrier-moving machine.

(c) **Portable Steel Barriers** have a lightweight stackable design, which reduces transport costs. They are most frequently used in short-term work zones because of the relative ease and rapidity of installation and removal. Lateral displacement is usually in the range of 6 to 8 feet.

(d) **Water-Filled Barriers** are not recommended for use due to their large deflection and potential for penetration when impacted. When they are used, special care must be taken to ensure they are used properly. They may be used as an improvement over traffic cones and drums to channelize traffic through a work zone. They are most frequently used in short-term work zones because of the relative ease and rapidity of installation and removal. Therefore, they cannot be considered as a substitute for concrete barrier. A common decision-making issue on many projects is when to use barriers. As discussed throughout this chapter, there are many considerations in selecting the devices and strategies that ultimately go into the TMP to be used on the project. In almost every case, there is some level of compromise between the major project elements of constructibility, mobility, safety, time duration, project features, and so on. The key is to find the best balance of all the elements in an effort to ensure an overall successful project. Safety, however, must not be compromised.

Barriers can be one of the most effective safety measures, because they accomplish, to a large extent, the separation of workers and the work area from traffic. The following is a listing of the elements to consider when deciding on the use of barriers:

- Project features and the associated construction activities must be addressed within the work zone design (this means applying the Work Zone Clear Zone to those features and activities that may represent a hazard)
- Excavations
- Drop-offs
- Unprotected features (walls, piers, sign structures, foundations, etc.)
- Working and nonworking equipment (hauling, excavating, etc.)
- Interim unprotected features or objects (nonstandard slopes, rock stockpiles, ditches within the clear zone, etc.)
- Worker exposure to traffic and work hazards
- Number of workers
- Proximity to hazards
- Time duration of exposure
- Suitable work area available to workers
- Traffic exposure (drivers and occupants) to work hazards or new hazards introduced by a temporary roadway configuration
- Type of work operation (mobile, stationary, or both)

The cost of using barriers is a valid consideration, but not in the sense that an exact cost can be placed on the safety benefit value vs. the actual cost to include it. An informed decision to use barriers or not requires careful consideration of all the related factors, and cost should not be the only or primary influence on that outcome. Many projects of a stationary nature, with some of the issues identified above, would be good candidates for the use of barriers and should be developed along that concept.

(3) Impact Attenuators

Within the Design Clear Zone, the approach ends of temporary concrete barriers are fitted with impact attenuators to reduce the potential for occupant injury during a vehicle collision with the barrier. Impact attenuators are addressed in Chapter 720.

The selection and location of impact attenuators in work zones can present situations that do not exist on a fully operational highway. Designers must consider all work zone and traffic protection needs. The information in Chapter 720 provides all the needed impact attenuator performance information, but the actual work zone location may require careful consideration by the designer to ensure that 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 enter into the equation of the final selection. Redirective and nonredirective devices can both be used as long as the aforementioned issues are resolved and the devices also meet the Chapter 720 criteria when applied to a given work zone location. Also, impact attenuators used in work zones are much more likely to be impacted, which again requires careful consideration of those devices that are durable and easy to repair. Some common impact attenuator work zone issues are:

- Nonredirective device improperly located. This is usually associated with an inadequate length of need calculation (see Chapter 710) or the oversight of not fully considering all the protection issues.
- Narrow temporary medians, narrow work zones, narrow or no shoulders, temporary median openings, and inadequate installation area (width, cross and approach slope, base material).
- Temporary or short-term protection issues associated with removal or relocation of existing or temporary barriers and impact attenuators.

Designers need to ensure that the approved list of temporary impact attenuators is in fact appropriate for the individual work zone plan locations. The designer may remove those devices from the list that are not appropriate for a given location.

(4) Truck-Mounted Attenuators

A truck-mounted attenuator (TMA) is a portable impact attenuator attached to the rear of a large truck. Ballast is added to the truck to minimize the roll-ahead distance when impacted by a vehicle. The TMA is used as a shield to prevent errant vehicles from entering the work zone. If a TMA is not available, the use of a protective or shadow vehicle is still highly recommended.

(5) Fixed Signing

Fixed signing are the signs mounted on conventional sign supports along or over the roadway. This signing is used for long-term stationary work zones. Ground-mounted sign supports are usually wood and details for their design are in Chapter 820 and the Standard Plans. Sign messages, color, configuration, and usage are shown in the MUTCD and the *Sign Fabrication Manual*, M 55-05. When preparing the work zone signing plan, review all existing signing in advance of and within the work zone for consistency and sign locations. Cover or remove existing signs that can be misinterpreted or be inappropriate during construction.

(6) Portable and Temporary Signing

Portable and temporary signing is generally used in short-term or mobile work zones where frequent repositioning of the signs is necessary to keep pace with the work along the highway. These signs are mounted on crashworthy, collapsible sign supports or vehicles.

(7) Delineation

Pavement markings provide motorists with clear guidance through the work zone and are necessary in all long-term work zones. Temporary pavement markings can be either painted, preformed tape, or raised pavement markers. Remove existing confusing or contradictory pavement markings. Other delineation devices are guideposts, concrete barrier delineators, and lateral clearance markers, which should be shown on the traffic control plans. These devices have retroreflective properties and are used as a supplement in delineating the traveled way during the nighttime. (See Chapter 830 for delineation requirements.)

Removal of some types of existing or temporary pavement markings (generally paint stripe, but can include RPMs and other materials like plastic and MMA stripes) can leave a "ghost stripe" effect on the pavement. This is a scar left by the removal process that discolors the pavement and/or leaves a portion of the existing marking where a ghost stripe creates a visual distraction to drivers. Destructive removal such as intensive grinding can actually leave a groove in the pavement that can hold rainwater and leave the appearance of a stripe, especially at night when headlight reflection intensifies the effect.

Designers need to consider the types of removal for markings and their potential for ghost stripes and other distracting or conflicting leftover markings. Less destructive types of removal such as hydroblasting and the use of removable temporary markings can significantly improve pavement marking performance through the work zone. Continuous positive guidance through high quality temporary pavement markings, alone or in combination with existing markings, is a substantial benefit to drivers in work zones. Contact the region or HQ Traffic Office for further information on this subject.

Lateral clearance markers are used at the angle points of barriers where they encroach on or otherwise restrict the adjacent shoulder. Concrete barrier delineation is necessary when the barrier is less than 4 feet from the edge of the traveled way. This delineation can be either barrier reflectors attached to the face of the barrier or saddle drum delineators that sit on the barrier.

(8) 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
- Road closures with diversions
- Median crossovers on freeways
- Complex or unexpected alignment or channelization
- Haul road crossings (if operational at night)
- Temporary traffic signals
- Temporary ramp connections
- Disruption of an existing illumination system

For information on light levels and other electrical design requirements, see Chapter 840.

When flaggers are necessary for nighttime construction activities, supplemental lighting of the flagger stations by using portable light plants or other approved methods is required.

(9) Portable Changeable Message Signs (PCMS)

PCMS displays have electronic displays that can be modified and programmed with specific messages, and are supplemental to other warning signs. These signs are usually mounted on trailers and use solar power or batteries to energize the electronic displays. The maximum number of message panels is two per location. If additional information is necessary, consider using a second PCMS sign. Place the PCMS far enough in advance of the roadway condition to allow the approaching driver adequate time to see and read the sign's message twice. The following are some typical situations where PCMS are used:

- Where traffic speed is expected to drop substantially
- Where significant queuing and delays are expected
- Where adverse environmental conditions, such as ice and snow, are present
- Where there are extreme changes in alignment or surface conditions

- Where advance notice of ramp, lane, or roadway closures is necessary
- When accident or incident management teams are used

(10) Arrow Panel

The arrow panel displays either an arrow or a chevron pointing in the direction of the intended route of travel. Arrow panel displays are used for lane closures on multilane roadways. When closing more than one lane, use an arrow panel display for each lane reduction. Place the arrow panel 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 panels are not used on two-lane two-way roadways. (See the MUTCD for additional information.)

(11) Temporary and Portable Traffic Signals

Temporary traffic control signals are typically used in work zones to control traffic such as temporary one-way operations along a one-lane two-way highway, where one lane is closed and alternating traffic movements are necessary. Examples of work operations are temporary one-way operations on bridges and intersections. Contact the region's Traffic Office and signal superintendent for specific guidance and advice on the use of these systems; a traffic control plan is required.

- **Temporary Signal System.** A permanent signal system typically modified in a temporary configuration such as temporary pole locations during intersection construction, span wire systems, and adjustment of signal heads to accommodate a construction stage. (See Chapter 850.)
- **Portable Traffic Signal System.** A trailer-mounted traffic signal used in work zones to control traffic. These versatile portable units allow for alternative power sources such as solar power, generator, and deep cycle marine batteries, in addition to AC power. (See the MUTCD for additional information.)

(12) Warning Lights

Warning lights are either flashing or steady burn (Types A, B, or C), mounted on channelizing devices, barriers, and signs. Secure warning lights to the channelizing device or sign so they will not come loose and become a flying object if impacted by a vehicle. (See the MUTCD for additional information.)

- **Type A** – Low-intensity flashing warning light used to warn road users during nighttime hours that they are approaching a potentially hazardous area.
- **Type B** – High-intensity flashing warning light used to warn road users during both daytime and nighttime hours.
- **Type C** – Steady-burn warning light designed to operate 24 hours per day to delineate the edge of the roadway.

(13) Portable Highway Advisory Radio (HAR)

A HAR is a roadside radio system that provides traffic and travel-related information (typically affecting the roadway being traveled) via AM radio. 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's Traffic Office for specific guidance and advice on the use of these systems.

(14) Automated Flagger Assistance Device (AFAD)

The AFAD is an automated flagging machine that is operated remotely by a flagger located off the roadway and away from traffic. The device is a safety enhancement for projects that use alternating traffic control by physically placing the human flagger off the roadway while maintaining control of the traffic movements approaching the work zone. Contact the region's Traffic Office for specific guidance and advice on the use of these systems. A traffic control plan is required for use of the AFAD.

(15) Screening

Screening is used to block the motorist's view of construction activities adjacent to the roadway. Construction activities can be a distraction, and motorist reactions might cause unsafe vehicle operation and undesirable speed reductions. Consider screening the work area when the traffic volume approaches the roadway's capacity. Screening can be either vertically supported plywood or plastic panels, or chain link fencing with vertical slats. These types of screening are positioned behind traffic barriers to prevent impacts by errant vehicles. The screening is 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 standards and is approved by the Engineer prior to installation.

Another type of screening, glare screening, is also used 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 the headlights of other vehicles on adjacent roadways or construction equipment. Make sure that motorists' sight distance to critical roadway features 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.

810.11 Work Zone Intelligent Transportation Systems (ITS)

Work zones present safety challenges to both travelers and road workers. Using ITS in work zones, however, can help ease the frustration and prevent crashes.

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. ITS applications in work zones can be used to provide traffic monitoring and management, data collection, and traveler information. ITS provide the most up-to-date information to motorists so they have the opportunity to make informed, educated choices regarding their travel plans.

ITS can help secure the safety of workers and travelers in a work zone while facilitating traffic flow through and around the construction area. ITS technologies do make a difference in reducing crashes, reducing delays, and reducing costs when used in work zones.

The use of ITS technology in work zones such as portable camera systems, highway advisory radios, variable speed limits, ramp metering systems, and queue detection information is aimed at increasing safety for both workers and road users and ensuring a more efficient traffic flow. ITS technologies for work zones is an emerging area; these technologies provide the means to better monitor and manage traffic flow through and around work zones. Minimizing the impact of work zone delays through technology has a positive impact on safety, mobility, access, and productivity.

(a) **Safety**. ITS work zone applications increase safety by providing drivers with advance notice of the presence of work zones and associated traffic conditions, such as slowed or stopped traffic ahead. Safety is measured in terms of the number and severity of vehicle crashes in the work zone that are attributable to the presence of construction or maintenance activities. Another factor used to measure the safety of work zones is the number of citations issued. Decreasing numbers of citations indicate improved safety conditions in the work zone.

Identify work zone ITS elements early in the strategy development process and include 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 (temporary poles, portable systems, etc.) may be necessary to ensure that 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, portable ITS systems may be a good opportunity to bring ITS technology to the route.

(b) **Mobility**. ITS applications in work zones improve mobility by providing drivers with traffic condition information so that they can adjust routes or travel times. ITS applications may also improve mobility by smoothing traffic flow through a work zone. Mobility is measured in terms of the absence or decrease of observed or reported traffic backups or delays at the work zone.

Refer to Chapter 860 for additional ITS information and guidance.

810.12 Work Zone Design Policy and Considerations

Work zone design is consistent with permanent design and must be maintained during temporary traffic control configurations. Use accepted geometric design when temporary alignments and channelization are necessary to perform the work tasks (if necessary, consider additional roadway design features.) The following information provides some basic guidance and considerations for temporary channelization designs:

(1) Lane Widths

Maintain existing lane widths during work zone operations whenever possible. For projects that require lane shifts or narrowed lanes due to work area limits and staging, before determining the final lane width to be implemented, consider the following:

- Overall roadway width available
- Posted speed limit
- Traffic volumes through the project limits
- Number of lanes
- Existing lane and shoulder widths
- Length of project
- Duration lane width reduction (if in place)
- Roadway geometry (vertical and horizontal curves)
- Truck percentage

The sudden transition to tighter geometrics and the close proximity of traffic control devices must be incorporated into the work area in a manner that will not violate driver expectancy. 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.

The minimum allowable lane width for low-speed, low-volume roadways is 10 feet, with 1 foot of shy distance. However, this requires prior approval from the region's Traffic Engineer before being accepted. For all other roadway situations, 11 feet is the minimum allowable striped lane width, with a 2-foot shy distance to a traffic control device or shoulder width. The maximum allowable lane width is 14 feet when the radius is not less than 500 feet. Follow existing lane widths when delineating temporary lanes with channelizing devices.

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. Lane lines and construction joints must be treated to provide a smooth flow through the transition area. In order to maintain the minimum lane widths and shy distances, temporary widening may need to be considered.

(2) Lateral Buffer Space and Shy Distance

Lateral buffer space provides space between the driver and the active work space, traffic control device, or to a potential hazard such as an abrupt lane edge or drop-off. Shy distance is the distance from the edge of the traveled way beyond which a roadside object will not be perceived as an immediate hazard by the typical driver to the extent that the driver will change the vehicle's placement or speed.

Refer to Chapter 710 and the Standard Plans for determining the appropriate lateral clearance and shy distance values.

In order to achieve the minimum lateral

clearances, there may be instances where temporary 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 clearance needs to be identified on the plan to ensure that additional width is available. Temporary roadway cross sections are a great way to show the space in relation to the traffic and work area.

(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, employee's private vehicles, and storage or stockpiling of project materials. The WZCZ applies during working and nonworking hours. The WZCZ applies only to roadside objects introduced by the contractor's operations and 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 Figure 810-2. 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 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 figure in Chapter 700 may be used as a tool to assess increases in WZCZ values.

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

Minimum Work Zone Clear Zone Distance
Figure 810-2

(4) Abrupt Lane Edges and Drop-offs

Minimize, mitigate, or eliminate abrupt lane edges adjacent to the traveled lane whenever possible. There are work operations where drop-offs are unavoidable in order to perform the work, but in these instances, the drop-off generally can be anticipated and included in the plan design. Lag up the paving on paving projects to minimize the instances of abrupt lane edges being exposed.

The driving or roadway surface is also important for motorcycle rider safety. The same surfaces that are a problem for bicyclists are also difficult for motorcyclists. Stability at high speeds is a far greater concern for motorcycles than cars on grooved pavement, milled asphalt and tapers from existing pavement down to milled surfaces. Adequate signing to warn for these conditions to alert the motorcycle rider is required. See Word Zone Traffic Control Guidelines (M 54-44) for signing details.

(5) Vertical Clearance

Per Chapter 1120, vertical clearance over highways is 16.5 feet. Anything less than the minimum must follow the reduced clearance criteria discussed in Chapter 1120 and included in the temporary traffic control plans. Maintain legal height on temporary falsework for bridge construction projects whenever possible. (See *Design Manual* Supplement 1120, April 24, 2006.) Anything less than this must consider overheight vehicle impacts and possible additional signing needs. Widening of existing structures can prove challenging when the existing height is at or less than legal height, so extra care may be necessary in the consideration of overheight vehicles when temporary falsework is necessary. Coordination with the HQ Bridge and Structures Office is essential to ensure that traffic needs have been accommodated. Vertical clearance requirements associated with local road networks may be different than what is shown in Chapter 1120. Coordinate with the local agency.

(6) Temporary Median Crossover Requirements

Geometrics for temporary crossovers need to follow the same guidance as permanent construction and have horizontal curves calculated to fit the location. When road closure, stage construction, detouring, and two-lane two-way traffic control must be maintained on one roadway of a normally divided highway, opposing vehicular traffic shall be separated with either temporary traffic barriers or with channelizing devices throughout the length of the two-way operation. The use of markings and complementary signing, by themselves, shall not be used.

The following are some of the guiding principles for the design of crossovers:

- The roadway surface shall be paved, and temporary pavement markings are required. Temporary illumination is required to improve the visibility of the crossover location. Temporary drainage may be necessary under the median fill when applicable.
- Design crossovers for operating speeds not less than 10 miles per hour below the posted speed limit, unless unusual site conditions require that a lower design speed be used.
- Separate tapers used for lane closures and crossovers. Separate and sign them far enough apart for drivers to clearly understand what is ahead of them.
- Flat, diagonal taper crossovers are better than reverse curves with super-elevation.
- Design crossovers to accommodate all roadway traffic, including trucks, buses, and motor homes.
- A good array of channelizing devices and properly placed pavement markings are essential in providing good, positive guidance to drivers.
- Temporary concrete barriers and excessive use of traffic control devices cannot compensate for poor geometric design of crossovers.
- Provide a clear roadside recovery area adjacent to the crossover. Consider how the roadway safety hardware (guardrail, crash cushions, etc.) 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.
- A site-specific traffic control plan is required.

(7) Temporary Alignment and Channelization

Temporary alignment and channelization plans are necessary for multiple staged projects that impact traffic by moving the lanes in order to accommodate a specific work operation or construction stage. Staged construction plans are generally separate from the temporary traffic control plans but share consistent concepts and features, and will be used in conjunction with one another.

Specific details shown on the plans include beginning and ending stations and taper rates when applicable for all alignment changes. The more detail that can be shown on the plans during the design phase, the more accurate the layout will be in the field and the less chance that the alignment will not fit the location or will cause a constructibility issue. Be aware of existing crown points, lane/shoulder cross slope breaks, and superelevation transitions that may affect a driver’s ability to maintain control of a vehicle through a work zone.

The following are a few guiding principles for the design of temporary alignment and channelization plans:

- Use site-specific base data.
- Provide beginning and ending station ties to all alignment changes and all angle points for temporary concrete barrier.
- Include lane and shoulder widths.
- Provide temporary roadway sections for emphasis.
- Avoid using angle points when showing temporary pavement markings.
- To avoid confusion, do not show existing conflicting details that are not necessary on the plan.
- No straight line tapers through curves; use circular alignment.
- As staging plans are developed, the plan details also need to change in regard to how existing features are changed or impacted by the stages. 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 constraints for the removal of existing markings and the time required to install new markings, especially if the work is for multi-lane staged construction. In urban areas where work hour restrictions for lane closures are limited, special consideration may be necessary to allow for time to address pavement markings or interim stages may be necessary. Re-opened temporary traffic lanes must be marked and in compliance with standards established in this chapter.
- When showing a run of temporary concrete barrier and the temporary impact attenuator location on a channelization plan, the shoulder approaching the attenuator location also must be closed using shoulder closure signing and channelizing device taper consistent with the MUTCD. Refer to the MUTCD for example detail.

810.13 Work Zone Types

The work zone type is the basic layout of the worksite and the configuration of traffic lanes through the work zone. Many variables such as location of work operation, duration, road user volumes, road vehicle mix (buses, trucks, and cars), and road user speeds affect the needs of each zone. The goal of temporary traffic control in work zones is safety with minimum disruption to road users. Site-specific traffic control plans are required for most of these operations. Standard plans that may be adapted for specific work zone applications are available at the following web site: http://www.wsdot.wa.gov/eesc/design/designstandards/psl/wz-1-17/wz-1-17.htm

A description of each of the work zone types is as follows:

(1) Reduced Lane Width

The lanes in this work zone type retain their normal number and general alignment. One or more of the traffic lanes have reduced widths to provide the necessary separation from the work zone. This arrangement causes the least disruption to traffic by maintaining capacity, but the narrowed lanes may still create congestion with drivers feeling pinched as they work their way through the work zone. Reduction of lane width for more than one lane of traffic in a direction requires modification to pavement markings and cannot be done using only channelization devices.

(2) Buffer Space and Shy Distance

Buffer space is a lateral and/or longitudinal area that separates road user flow from the work space or an unsafe area, and might provide some recovery space for an errant vehicle.

- Lateral buffer space provides space between the driver and the active work space, traffic control device, or a potential hazard such as an abrupt lane edge or drop-off. A minimum of a 2-foot lateral buffer space is recommended.
- Shy distance is the distance from the edge of the traveled way beyond which a roadside object will not be perceived as an immediate hazard by the typical driver to the extent that the driver will change the vehicle's placement or speed.

- Longitudinal buffer is the space between the protective vehicle and the work activity.

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. Refer to Chapter 710 of the *Design Manual* and the MUTCD to determine the appropriate buffer space and shy distance values.

In order to achieve the minimum lateral clearances, there may be instances where temporary 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 clearance needs to be identified on the plan to ensure that additional width is available; temporary roadway cross sections are a great way to show the space in relation to the traffic and work area.

(3) Lane Closure

One or more of the traffic lanes are closed in this work zone type. A capacity analysis is necessary to determine the extent of congestion that might result.

(4) Alternating One-Lane Two-way Traffic

This work zone type involves using one lane for both directions of traffic. Flaggers or traffic signals are normally used to control the alternation of traffic movements.

(5) Temporary Bypass

This work zone type 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's right of way. An example of this would be the replacement of an existing bridge by building an adjacent temporary structure and shifting traffic onto the temporary structure.

(6) Intermittent Closure

This work zone type involves stopping all traffic in both directions for a relatively short time to allow the work to proceed. After a certain amount of time, driven by the traffic volume, the roadway is reopened. An example of this type of closure would be a girder setting operation for a bridge project; typically, the closure would be limited to a ten-minute maximum and would occur in early morning hours when traffic volumes are at their minimum.

(7) Rolling Slowdown

A rolling slowdown is a legitimate form of traffic control commonly practiced by the Washington State Patrol (WSP), contractors, and highway maintenance crews. Their use is valuable for emergency or *very specific* short-duration closures (for example, to set bridge girders, remove debris from the roadway, push a blocking disabled to the shoulder, or pull power lines across the roadway). The traffic control vehicles 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.

Other traditional forms of traffic control should be considered before the rolling slowdown and be the primary choice. A site-specific traffic control plan (TCP) must be developed for this operation. The gap in traffic created by the rolling slowdown, and other traffic issues, need to be addressed on the TCP. Also, use of the WSP is encouraged whenever possible.

(8) Reduced Speeds in Work Zones

As part of the design process for construction projects, speed reductions are an option requiring a thorough traffic analysis conducted prior to making a change. Traffic control plans should be designed on the assumption that drivers will only reduce their speeds if they clearly perceive a need to do so. Reduced speed limits should be used only where roadway and roadside conditions or restrictive features are present such as narrow, barrier-protected work areas with major shifts in roadway alignment, and where a reduced speed limit is truly needed to address the safe speed of the roadway. Work zone design of roadway geometrics, hazards, and worker protection should be accomplished using the existing posted speed limits. Speed reductions should not be applied as a means for selecting lower work zone design criteria (tapers, temporary alignment, device spacing, etc.). However, frequent changes in the speed limit should be avoided. A TCP should be designed so that vehicles can reasonably safely travel through the work zone with a speed limit reduction of no more than 10 miles per hour.

Speed reductions must be approved by the Regional Administrator and included on a traffic control plan prior to implementation. Guidelines for speed changes are outlined in RCW 47.38.020, the *Traffic Manual*, Chapter 5, and Directive D55-20, "Reduced Speed in Maintenance and Construction Zones."

- **Advisory Speeds.** The advisory speed plaque shall not be used in conjunction with any sign other than a warning sign, nor shall it be used alone. In combination with a warning sign, an advisory speed plaque may be used to indicate a recommended safe speed through a work zone. Refer to the MUTCD for additional guidance.

(9) Median Crossover

This work zone type involves routing the traffic from one direction onto a portion of the median and roadway of the opposing traffic. It can also incorporate reduced lane widths in order to maintain the same number of lanes. On higher-speed roadways, temporary barrier is used to separate the two directions of traffic. (See the Temporary Median Crossover requirements in 810.12 for additional information.)

(10) Lane Shift

Traffic lanes may be shifted in order to accommodate a work area when it is not practicable, for capacity reasons, to reduce the number of available lanes. The benefit of this work zone type is being able to maintain traffic flow with the existing number of lanes. Shifting more than one lane of traffic requires the removal of conflicting pavement markings and the installation of temporary markings; the use of devices to separate traffic is not allowed. A warning sign shall be used to show the changed alignment when the lateral shifting distance is greater than one-half of a lane width.

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

(11) Median Use

This work zone type is similar to the shoulder use type and is used on divided highways where the median and adjacent shoulders are used for the traffic lanes. Barriers are usually necessary to separate opposing traffic. Remove and inlay existing median rumble strips.

(12) Diversion

A diversion is a temporary rerouting of drivers onto a temporary highway or alignment placed around the work area. This work zone type 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's right of way. An example of this would be the replacement of an existing bridge by building an adjacent temporary structure and shifting traffic onto the temporary structure.

(13) Total Road Closure

This work zone type requires the complete closure of the roadway in order to pursue the work operation. Traffic is rerouted to an adjacent street or highway to avoid the work zone. Advance notification of the closure is required and a signed detour route may be required. Clearly sign detours over the entire length so that drivers can easily use existing highways to return to the original highway. Closing a highway, street, or ramp, while not always practicable, is a desirable option from a safety viewpoint. 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.)

(14) Traffic Split or Island Work Zone

Island work zones and traffic splits should be considered only after alternative work operations have been explored before going forward with the design. In this work zone type, the traffic lanes in one direction are separated to allow construction activities within one of the lanes. On higher-speed roadways, temporary barriers are provided to prevent errant vehicles from entering the work area.

Typically, drivers have difficulty understanding "lane split" configurations, which sometimes results in poor driving decisions such as unnecessary lane changes, indecision on lane choice, or drivers being generally uncomfortable with driving through an island work zone. Most drivers are able to navigate these work zones at a reasonable level, but the few drivers who aren't can create unstable traffic conditions that are projected to arriving traffic upstream. This decreases the traffic capacity through the work zone resulting in queues that either increase or subside based on approaching traffic volume and the stability of the traffic flow at the lane split. Also, drivers often do not expect slow or stopped traffic approaching the work zone, so additional advance warning is a requirement.

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/disincentives for 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 PCMS, portable HAR, and other dynamic devices.
- 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, this eliminates much of the potential for truck/car conflicts and sorts out undesirable truck lane changes through the work zone.
- Consider the use of solid lane line markings to delineate the traffic split or island. There are two striping options to consider during the design of a traffic split: (1) when lane changes are DISCOURAGED, a single solid lane line shall be used, and (2) when lane changes are PROHIBITED, two solid lane lines shall be used. Refer to the MUTCD for additional details.
- Consider supplementing the existing roadway lighting with additional temporary lighting to improve the visibility of the island work area.
- 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 WSP.

810.14 Capacity Analysis

As emphasized throughout this chapter, work zone mobility is a high priority for many projects and is the number one operational issue for those projects. A work zone traffic analysis is conducted to identify impacts and manage those impacts with appropriate mitigating strategies and solutions.

Work zones can decrease the traffic capacity through the area where roadway restrictions are necessary to accomplish the project work operations and can form a "bottleneck" effect. Avoid and mitigate reductions in capacity to the extent that mobility is maintained at a level compatible with existing traffic demands. The area of influence generated by work zone restrictions can extend far beyond the work zone limits; sometimes for miles if these impacts are not fully mitigated. Work zones can create many different types of roadway restrictions such as lane closures, shoulder closures, narrow lanes, detours, and diversions, which all reduce capacity to some extent. Work zone features such as barriers, work distractions, signs, and construction traffic movements, when combined with actual roadway restrictions, can further reduce capacity.

Work zone capacity and related mobility impacts are the primary traffic analysis focus since those impacts have the greatest affect on overall mobility. This should be the initial starting point and most effective means of determining the extent of mobility impacts for selecting a given work zone strategy. Other mobility impacts may also need to be addressed, such as:

- Maintaining access points (road approaches, intersections, and turning movements)
- Ramp restrictions
- Local roadway impacts
- Detour capacity and related impacts
- Pedestrian and bike access

Not all projects require an extensive work zone traffic analysis. Conduct the analysis at a level consistent with project complexity and those impacts that are identified through strategy development and impact analysis (see 810.15, Impacts Assessment, and 810.16, Work Zone Design Strategy). The tools used to analyze traffic impacts can vary from complex to basic analysis programs, or a basic engineering assessment may be conducted for minor impacts. All analyses must be based on current existing traffic data compared to the proposed work zone strategy and the identified impacts.

Complex projects may have several potential work zone strategies, while other projects may only have one obvious work zone strategy. Even though innovative work zone strategy development is encouraged in an effort to maximize safety and mobility benefits, not all projects will have this potential. Furthermore, it is possible that significant mobility impacts will be present as a result of minimal strategy options. These impacts still need to be analyzed and mitigated. It is not acceptable to conclude that since there is only one way to maintain traffic and construct the project, the impacts do not need to be addressed and mitigation solutions do not need to be developed. In these cases, impacts can generally be mitigated by means other than the work zone traffic control method, such as work hour restrictions, alternate routes, advance notice, and other means. An analysis will show the results of these mitigating measures.

A work zone traffic analysis can provide an accurate look at the extent of impacts and lead to the selection of mitigating measures that offer the most benefit. Some of the impact issues and mitigating measures commonly addressed by traffic analyses are:

- Work hour time restrictions
- Hourly liquidated damage assessment
- Staged or nonstaged 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 (both internal and local agency)

In order to conduct a work zone traffic analysis, traffic volume data must first be collected and assembled. Accurate volume data is directly related to the usefulness of the traffic analysis results. Assess existing and needed data as early as possible to make sure it is available to conduct the analysis and therefore benefit the development of the work zone strategy. The region's Traffic Office and the HQ Traffic Data Office can assist with collecting traffic volume data. Coordination with local agencies may be needed to obtain data on affected local roads. Some locations may require conducting traffic counts in the field if recent data is not available. These offices will also be available to assist with the actual analysis upon request. Training is also available for those designers who have a need to obtain further knowledge and expertise or to actually conduct the analysis.

Several analysis programs are available to conduct the traffic analysis. The selection of the program is based on the complexity of the analysis and the individual impacts in question. Some common programs include:

- **Quewz 98** is a basic-level program that is mainly used to determine capacity-related issues on isolated multilane facilities. Outputs are queue length, delay time, user costs, and running speed. Basic hourly volume data input is required.

- **QuickZone** is a midlevel program that provides results for basic capacity issues. It also has the capability to analyze multiple alternatives and a basic roadway system that would include outputs for alternate routes or detours, as well as affected local roadways. More data input is also required.

More complex traffic analysis programs are available and may be appropriate for some work zone applications. Consulting region and HQ traffic analysis experts is recommended.

A basic level of analysis is recommended for all work zones to determine the initial level of traffic capacity impacts. 810.16, Work Zone Design Strategy, contains useful information on capacity thresholds and other values that are useful in determining not only the strategy selection, but the need for the level of analysis as well. Further analysis may be needed on some projects, and complex, high traffic volume projects will most likely need a higher level of analysis to determine the extent of capacity impacts. Maintain analysis documents in the Project File. The work zone capacity impacts assessment will become an important part of the overall work zone strategy. Significant projects will rely on the traffic analysis to shape the transportation management plan as the work zone strategy is brought to life in the form of traffic control plans and specifications.

810.15 Impacts Assessment

One of the top goals in developing a successful TMP and ultimately leading to a successful construction project is that all work zone safety and mobility impacts must be identified and assessed to determine the approach to mitigating and managing those impacts. Without a complete assessment of all work zone impacts, the TMP will not be as effective, since the missing impacts will undoubtedly become unresolved issues during the construction phase of the project.

These unresolved and unanticipated impacts can cause significant project cost and time increases, as well as significant traffic delays and safety concerns. Project staging, features, and work operations may have to be adjusted under less than ideal circumstances since the project may be well underway and the flexibility to change may be limited. A complete impacts assessment allows the project design to incorporate solutions as an integral component to the project, and it reduces costs, saves time, and helps maintain traffic safety and mobility.

This section is intended to provide the designer with guidance and decision-making support in conducting a complete work zone impacts assessment. All work zone issues reside in either the safety or mobility areas, but there are many specific elements within those areas that, once identified, will guide the designer to investigate the existence of an impact or potential impact. Each project is different and will have different impacts, but following this process will allow the designer to determine the actual impacts for a given project.

Some impacts may be difficult to resolve and may ultimately become a management decision to determine the level of mitigation or develop a strategy to manage the impact during construction, which may include accepting a certain level of impacts. The final impacts assessment must identify all impact issues.

The TMP will contain the strategies to mitigate the impacts and ultimately take the form of plans and specifications. It is important to remember that an unresolved impact still needs to be addressed in the TMP. Even though it may be unresolved, there needs to be awareness that it exists so it can be managed as effectively as possible and not become forgotten, only to appear later as the project work proceeds.

Work zone impacts are not limited to the actual work zone or project limits. Impacts can be far reaching and have a negative effect on local roadways, businesses and communities, other road projects, a highway corridor, or even a regional area if the project impacts are at a critically strategic location.

The following approach allows the designer to work through the listed levels of work zone impact items and compare them to specific project features, locations, schedule, and work operations, which will result in a list of actual and potential work zone impacts. Potential impacts will be further assessed as project development proceeds, but must be included in the TMP. Some work zone impacts may contain both safety and mobility issues and, in many cases, several impacts may be related to a combination of project features, locations, schedule, and work operations. The impacts assessment will start at the most basic level with the initial project information and proceed on a path that is dictated by the availability of information as the project scope and features are developed and traffic data is gathered. Even basic projects can have unique features that could result in a significant impact even though the project on the whole may not be significant. It is intended that the impacts assessment be conducted to a point where all impacts, even apparently minor ones, are identified, assessed for significance, mitigated or otherwise resolved, and included in the TMP to be incorporated and managed within the project.

(1) Work Zone Safety and Mobility Impacts Assessment

(a) **Design Level Safety and Mobility Impacts**

Construction Project:

- **Location** – Where the project is located (route, mileposts, structures, crossroads, interchanges, etc.)
- **Features** – What features will be constructed to build the improvement.
- **Operation** – How the project will be constructed at a conceptual level.
- **Schedule** – When the project is constructed (project milestones leading up to a projected start date).

Traffic Conditions:

- **Project Limits** – Existing traffic conditions and operational issues on site.
- **Local Area** – Existing traffic conditions adjacent to the project.
- **Regional Area** – Existing traffic conditions within the projected area of influence.

The combination of the above factors may begin to indicate safety and mobility impacts. Additional investigation may be needed at this point. Document findings and move to the next level as more specific information becomes available.

(b) **Project Level Safety and Mobility Impacts**

Construction Project:

- **Location**
  1. Existing site features within project limits
  2. Existing roadway configuration
  3. Right of way limits
  4. General site location issues (substandard features, rock slides, water/drainage issues)
- **Features**
  1. Major project features (paving, bridge, etc.)
  2. Related site work (excavation, grading, blasting)
- **Operation**
  1. Typical type of work operation (moving, stationary, or both)
  2. Assess potential worker safety issues
  3. Assess alternatives to flagging if needed
- **Schedule**
  1. Projected construction start and completion

Traffic Conditions:

- **Project Limits**
  1. Volume data (current traffic capacity)
  2. Operational data (level of service, crash data)
- **Local Area**
  1. Access points (interchange ramps, intersections, crossings)
  2. Alternate routes (parallel routes, frontage roads)
- **Regional Area**
  1. Strategic importance (critical system link, available alternate routes, commercial, recreational, connections to other routes)
  2. Other projects in progress
  3. Route corridor impacts (access to cities, businesses, schools, emergency services)
  4. Access and service to other modes (airports, ferries, trains, transit)

Safety and mobility impacts may start to become more apparent at this level, but not yet fully assessed, and more information and investigation may be needed. Document findings and move to the next level as more specific information becomes available.

(c) **Work Zone Level Safety and Mobility Impacts**

Construction Project:

- **Location**
  1. Limits of work encroachment (lanes, shoulders, clear/safety zone)
  2. Access to work (hauling, worker access)
- **Features**
  1. Constructibility/traffic-related issues
  2. Vertical clearance
  3. Drop-offs
  4. Narrow shoulders and lanes
  5. Work area protection of potential hazards to workers and traffic
     - Fixed objects
     - Equipment, work space, access, protection, clear/safety zone
     - Worker traffic exposure level
- **Operation**
  1. Staged/phased work
  2. Daily closures and openings
  3. Daily moving operation
  4. Stationary with off-peak closures
  5. Worker safety assessment
  6. Consider unique traffic control (portable signals, etc.)
- **Schedule**
  1. Critical dates (fish window, holidays, events)
  2. Seasonal issues
  3. Night vs. day work hours (work hour restrictions)

Traffic Conditions:

- **Project Limits**
  1. Analyze capacity impacts (QuickZone and Quewz)
  2. Assessment of capacity impacts (maintain on- or off-site)
  3. Mitigation possibilities
- **Local Area**
  1. Analyze capacity impacts
  2. Mitigation possibilities
- **Regional Area**
  1. Projected impacts
  2. Mitigation possibilities

Base the assessment of safety and mobility impacts at this level on information specific to a given work zone and operation. A complete assessment of most previously identified impacts should be possible. New impacts may also become apparent at this level due to the specific detailed nature of the available information. Document findings in the form of a list of actual and potential impacts with a brief description of each impact. This list will then be addressed in the TMP.

The above elements should alert the designer to investigate the specific details of a given project to determine the types of work zone impacts involved. The list of impacts and potential impacts needs to be assessed to determine the extent of the impacts. Some minor impacts may be manageable within the framework of the project without additional mitigation measures or design solutions, but still should be part of the TMP. Significant impacts will most likely need to be mitigated and addressed within the TMP. 810.05, Work Zone Process, and 810.16, Work Zone Design Strategy, provide additional guidance and direction to address, mitigate, and manage work zone impacts. It is recommended that designers seek the assistance of others with traffic, construction, and design experience, as needed, to fully address this area.

810.16 Work Zone Design Strategy

The work zone design strategy is the key element in establishing an effective work zone design, yet is often overlooked or underestimated in its value. Only through the development of a comprehensive work zone design strategy is it reasonable to expect the development of an effective transportation management plan

(TMP) that addresses all safety, mobility, and constructibility impacts associated with maintaining traffic and providing for worker and road user safety during project construction. Construction projects are sometimes limited by poor work zone design strategies with missing components or lack of a constructible concept.

A given project may and probably will have several work zone strategies that, when combined, become the project TMP. Strategies may be needed for several individual work zones, construction stages, and project features to address the related safety and mobility impacts. The individual elements needed to analyze and develop a strategy are gathered from the impacts assessment process described in 810.15. Work zone strategies are developed through a detailed analysis of all the relevant information and are generally included in the following categories:

- Traffic volume/capacity data
- Traffic/user access issues
- Local and regional traffic impacts
- Project schedule/time (working days, work hours restrictions, critical work/material time, seasonal issues)
- Project site conditions
- Project work operations (access, hauling)
- Project purpose and features (road encroachment impacts)
- Safety assessment (workers, road users)

Safety and mobility are the primary work zone strategy elements; however, project constructibility, costs, and time must also be addressed. Start strategy development from the most desirable work zone safety and mobility concept and then carefully apply the related project factors to determine the most overall effective and feasible strategy. Traffic mobility, work, and road user safety should not be needlessly compromised to facilitate a more effective construction approach, but should be held to a high level that initiates reasonable construction alternatives and innovations.

Construction needs to be accomplished while accommodating safety and mobility. Consider road work operations hazardous and disruptive; it is necessary to address those issues at a detailed level to make safety and mobility improvements. Many traditional approaches do not address or otherwise provide for safety and mobility issues, and those approaches need to be reevaluated for improvement opportunities. Do not assume that a traditional traffic control plan applied to certain types of construction completely addresses all safety and mobility impacts. There may be similarities with the type of work, but each project is unique and must be approached in that manner. Work zone strategies need to comply with and reflect the intent of policies and requirements as identified throughout this chapter.

Identify all safety and mobility impacts in the work zone assessment. These impacts are not restricted to the work zone location or even the project limits, but could extend far beyond the project. Adjacent or overlapping projects may also be impacted. Therefore, work zone strategies are not just limited to on-site issues, but will also need to address the impacts off-site wherever they may exist. Some strategies may need to be justified if costs begin to escalate. A benefit cost analysis comparing road user costs to affected project costs is useful. Safety benefits are somewhat more difficult to justify since cost is not the best measure. Safety and mobility impacts are presented in more detail throughout this chapter.

Start work zone strategies from a perspective of providing the highest level of safety, mobility, and constructibility possible. A total road closure may be the best example of this approach. It would appear to provide the safest, most mobile and constructible work zone since workers and road users would be exposed to far fewer hazards, road users would not be delayed through a restrictive work zone, and construction could proceed without accommodating traffic. This may be a desirable starting point and may actually be feasible for some projects or work stages. Unfortunately, most projects would not be good candidates for this strategy. The lack of alternate route capacity could cause severe congestion throughout a widespread area, the cost and feasibility of building a detour would not be acceptable, and having no local access through the project limits would also not be acceptable.

A more common and usually acceptable approach may be a mix of short-term closures and planned work stages, with work zones that positively separate and protect both workers and road users, while accommodating efficient work operations and traffic mobility. Many projects would benefit from efficiently staged and protected work operations instead of routine lane closures that close and open each day. Some projects may appear to have very few options or opportunities for innovation, but still need to have a strategy that addresses all impacts. Never assume that other options or innovative approaches are not available. 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.

The following strategies may be useful to consider for some projects:

- Closures: full, partial, short-term, ramps, approaches, detours, alternate routes
- Overbuilding: beyond normal project needs to maintain additional traffic
- Flagging alternatives: AFADs, portable signals, lane shifts
- Staged traffic control: moving work operations or unlimited work operations
- Local road improvements: capacity improvements, signals modifications, widening, frontage roads
- Vehicle restrictions: combination of hours and vehicle type (trucks, oversize, local traffic)
- Temporary connections: ramps, offset intersections
- Temporary access: road approaches, work zone access, ramps
- Innovative bidding: incentives, A+B bidding, lane rental (see http://www.wsdot.wa.gov/Projects/delivery/alternative/ABBidding.htm)
- Work zone ITS traffic management: driver information, queue detection, demand management
- Public information campaign: media, HAR, PCMS
- Accelerated work schedules: overall impact duration reduction
- Temporary median crossover detours: allows full work access to one-half of the roadway
- Temporary express lane: no access lane through the project
- Performance-based traffic control: contractor incentives for efficiency and safety
- Incident response patrols: delay reduction through quick response
- Law enforcement patrols: safety issues, speeding, DUI, aggressive drivers
- Driver Incentives: additional transit use, alternate route use
- Alternative bridge designs: super girders, falsework restrictions, temporary structures
- Emergency pullouts for disabled vehicles

It is also important to remember that there are practical limits to work zone strategies. Mobility and safety benefits that are relatively short term may not be practical if the implementation of that strategy offsets a significant portion of the benefit.

Some projects may benefit from a wider review and discussion on possible work zone strategies, such as:

- CRA (cost risk assessment)
- VE (value engineering) study
- Constructibility study
- Peer review
- Work zone strategy conference
- Traffic survey/study

As mentioned previously, constructibility is a key element in a successful work zone strategy. Within the constructibility element, those issues of material selection, production rates, and work operation efficiencies have a direct tie to the feasibility of the strategy. A strong emphasis has been placed on this area and several successful strategies have been implemented:

- Total short duration closures (weekend, week, or a combination)
- 72-hour continuous weekday closure
- 55-hour weekend closure
- 10-hour nighttime lane closures

These strategies use specific materials such as quick-curing concrete, accelerated work schedules, prefabricated structure components, on-site mix plants, etc., and are based on actual production rates. The WSDOT Materials Laboratory and the HQ Construction Office are good resources for more information on constructibility as a component of an effective work zone strategy.

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. To assist the designer with work zone strategy development, a work zone checklist and work zone tool box are included to provide additional detailed information and decision-making assistance.

810.17 Transportation Management Plan (TMP)

A transportation management plan (TMP) provides a set of strategies for managing the work zone impacts of a project. Detailed information on strategy development can be found in 810.16, Work Zone Design Strategy. The TMP is a requirement for all projects and is the key element in addressing all work zone safety and mobility impacts. The TMP is a dynamic document that is maintained and revised as the project development process progresses. Start preparing the TMP as early as possible in the design phase of the project by gathering project information, traffic data, impacts assessment, strategies, mitigation solutions, and design solutions. The work zone portion of the project Plans, Specifications, and Estimates (PS&E) will ultimately contain much of the TMP elements. Other TMP elements may become part of the overall project management strategy or contained within the project design features and work operations.

The three major components of a TMP are described below:

- **Traffic Control Plan (TCP).** TCPs and related elements are the common component for all projects and become actual plan sheets in the contract documents. TCPs are further defined below and in 810.18, Traffic Control Plans and Details Development.
- **Traffic Operations Plan (TOP).** TOPs are strategies that address operations and management of the affected roadway system in and around the work zone. These strategies may be work zone ITS elements to inform travelers and manage traffic, law enforcement, incident management, etc. These strategies may become actual contract plans, specifications, or pay items, but could also be a WSDOT-managed element outside of the contract items.
- **Public Information Plan (PIP).** PIPs are public information and stakeholder communication strategies that may be initiated before and during the construction. These strategies may take the form of brochures, web sites, news media releases, highway advisory radio, message signs, etc., to disseminate information both pretrip and enroute. The region Public Information Officer will be an important resource in this area. The elements of these strategies may be implemented by either the contractor or WSDOT, or both. A specification and contract pay item will be needed for contract work.

Within the TMP, these plans may take the form of strategies that contain specific information and solutions to address, mitigate, and otherwise resolve and manage work zone safety and mobility impacts. Ultimately, these strategies will become the basis for developing the actual contract traffic control plans, details, specifications, and estimates. It is important to remember that not all work zone impacts will be addressed within the specific work zone elements of the contract plans. This is why it is critical to consider work zone impacts during the ongoing design of the actual project features, materials selection, working day considerations, overbuilding, phasing, structures, etc. Many work zone impacts will need to be addressed by design solutions that resolve the impacts within staging plans, structure plans, and various construction plans and details. Some work zone impacts, especially those that are related to time duration may be resolved through innovative bidding and contract administration.

All projects must have a TMP, but the only required component is the TCP, unless the project is considered significant* (see below). The required TCP component is further defined as follows:

- TCPs must address all work zone impacts not otherwise resolved in the contract plans.
- TCPs that address work zones at an appropriate level of detail must be included. Typical TCPs are only allowed if they accurately address the work operations, worker safety, traffic safety, appropriate traffic control, and traffic delay, movements, and access. Typical, project-specific, site-specific, or a combination of all three types of TCPs may be needed to address all issues.
- An appropriate level of contract work zone traffic control specifications is required to fully address those issues not otherwise addressed within the TCPs or other contract documents.
- Pay items must be included that are consistent with the type of traffic control devices, work operations, and TCPs. Lump sum items are allowed if appropriate for the project.

Even though not all projects initially require TOP and PIP components, the intent is to include these components to address TOP and PIP issues not fully addressed in the TCP component, even though the project may not be defined as significant.

*A "significant project" is defined by FHWA as 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 an assessment of work zone safety and mobility impacts and the level of mitigation possible. Interstate system projects within the boundaries of a Transportation Management Area (TMA) that occupy a location for more than three days with either intermittent or continuous lane closures shall be considered a significant project. It is possible to request an exception from FHWA for interstate system projects if sufficient justification is present to demonstrate that the project will not have sustained work zone impacts. Significant projects must be identified as early as possible and indicated as such in Box Six, Work Zone Strategy Statement, on the Final Project Definition document.

Addressing project work zone impacts is further defined as:

- Any project, not just interstate or within a TMA, that indicates a work zone-related impact (see 810.15, Impacts Assessment) beyond existing conditions that cannot be mitigated to an acceptable level will be treated as significant based on those identified impact issues.
- Mitigating impacts to an acceptable level is defined as a regional determination of the extent and adverse affect a given impact may have beyond the average accepted impact levels incurred by work zones at the local or regional area. Examples of this may be:
    1. Traffic delay beyond a localized accepted level,—possibly in the range of 15 to 30 minutes (but could vary based on local expectations).
    2. Safety or access impacts to a school, hospital, or community that exceed local expectations based on public input.
    3. Economic impacts due to traffic delay or restricted access beyond normal local expectations.
    4. Seasonal-related impacts that affect recreation or business due to work zone impacts.
- Identified impacts must be included and managed within the structure of the TMP, even though the project may not be identified as significant.
- TCPs, TOPs and PIPs will be developed to address identified impacts, as needed, to effectively manage the project.

- Potential work zone impacts need to be resolved within the project design features as design decisions are made. Informed decisions that consider work zone impacts during bridge type selection, materials selection, advertisement dates, and more have the potential to resolve work zone impacts before they happen.
- Construction PEs need to be involved at the design level for input on the management of impact issues. Also, the TMP needs to reflect those decisions to manage impacts during construction.
- Innovative mitigation strategies such as staged closures or ITS solutions are strongly encouraged and may be a successful approach to solving an otherwise difficult impact that would be hard to manage during construction.

It is very important to actively pursue the development of the TMP throughout the project development process. Ongoing communication with those who are designing project features that may conflict with maintaining traffic mobility or that impact worker and road user safety is critical to facilitating the incorporation of design solutions and mitigation measures within the project. The approach of waiting until the design is complete to determine work zone impacts is not acceptable and may jeopardize the project budget and schedule.

810.18 Traffic Control Plans and Details Development

The traffic control plans (TCPs) shown in the MUTCD and the Design Standards Plan Sheet Library (http://www.wsdot.wa.gov/eesc/design/designstandards/) provide the basic traffic control for individual work zones. Most real-world work zones have a combination of several unique features that require further augmentation of traffic control.

The preparation of traffic control plans requires the designer to not only have a thorough knowledge of highway construction activities, but also traffic engineering knowledge and an understanding of the unique traffic flow patterns within the specific project.

The designer must be cognizant of the dynamic nature of construction activities and provide a constructible traffic control plan that will also safely and efficiently manage traffic. In addition, the users of the facility have little or no understanding of the construction occurring in the work zone and require far greater guidance than the contractor's or agency's people, who are familiar with the project.

TCPs can generally be broken down into three specific categories: (1) typical traffic control plans, (2) project-specific traffic control plans, and (3) site-specific traffic control plans. Depending on the scope of the project being designed and the level of detail necessary to construct the project, consider each of these categories as the project is initially scoped and as the design proceeds.

TCPs are always designed from the perspective of drivers, pedestrians, and bicyclists to provide the necessary information to allow them to proceed in a safe and orderly manner through a work zone. Unexpected roadway conditions, changes in alignment, and temporary roadside obstacles relating to the work activity need to be defined adequately to minimize the users' uncertainty. Also, working on or along the highway can present a potentially hazardous work environment. As the traffic control plans are being developed, keep in mind that the risk of injury or death to workers performing the construction operations is real and ever-present as the traffic control plans are being developed. Whenever possible, it is recommended to combine work operations under a single traffic control plan to minimize the impacts to traffic and encourage the efficiency of the contractor.

The intention is not to direct the contractor in how to pursue the work, but to provide a workable approach to protecting the work area and to establish the level of safety and traffic control while maintaining traffic movements. Consider the inspector and the traffic control supervisor in the field: will they be able to effectively lay out what you have designed, and does it fit in the "real world"? The contractor has the option of proposing an alternative method once the project is under construction. A constructible and biddable set of traffic control plans is the goal; the more specific and consistent we can make our traffic control plans, the better work zones will perform, regardless of which traffic control plans are modified and implemented.

"Typical" traffic control plans are generally considered generic in nature and are not intended to satisfy all conditions for all work zones. They are adaptable to many roadway conditions and work operations without being specific to any one condition. Typical plans are to be considered a "starting point" in the development of the traffic control plans for a project, with the goal being to have the plans consistent with the project needs.

For lump sum projects it is particularly important to have detailed traffic control plans to fully define the work zone expectations. It may be entirely appropriate and acceptable to utilize lump sum traffic control items as long as the project is not overly complex and lump sum items are compatible with the level of TCP development. Designers need to consider this issue from the bidder's perspective and ensure that TCPs are developed at a high enough level to adequately reflect the intent of the traffic control devices and strategies to be employed on the project.

Typical TCPs may need to be modified to a more specific level, or additional plans may be needed to adequately address those work zone issues that could affect the type, quantity, and placement of devices, or to ensure that a desired work zone strategy is appropriately implemented (road closure, lane shift, intersection control, etc.).

Typical plans can be expected to be included in every project to some degree. The majority of the time, they will be used to supplement project- or site-specific plans with generic details and will not be the only plans in the contract, especially for a project of any complexity. For projects that are routine in nature and do not change much in the day-to-day operations, such as a several-mile paving project on a two-lane roadway, typical plans may be more than adequate. Even "routine" projects may have some unique features that need further plan development.

A "project-specific plan" is generally a traffic control plan that has been modified to include project-specific details such as side roads, business approaches, horizontal curves, etc., in order to better address traffic control needs that generally cannot be covered without substantial modification in the field. A project-specific plan may also have been drawn using existing base data, but may not necessarily be a scaled drawing. Project-specific plans are a good compromise between a typical drawing without much specific detail and a full-blown site-specific plan when site-specific base data may not be available. Typical plans can be modified to more accurately represent the project location without being site-specific in nature, and thus be considered project-specific.

"Site-specific plans" are drawn using scaled base data and are encouraged whenever possible to achieve the highest level of accuracy. They ensure that the proposed work operation will actually fit the location and that a workable method to maintain traffic flow can be achieved. The use of site-specific plans will closely match the need to provide a transportation management plan, and the goal is to address the major impacts anticipated by the project through these more detailed plans. For complex projects and projects that contain staging, draw the traffic control plans with site-specific base data.

Do not mix typical details with a scaled, site-specific plan layout; this will cause confusion and often will not represent a truly constructible traffic control scenario. An example of this would be to use a scaled, site-specific intersection and then to include a generic "L" distance to represent the lane closure taper distance. Another example would be to include the construction signs on the plan by showing them at a specific location on the scaled plan, but then to refer to the generic "X" distance representing how far the sign should be (this will not work and is not representative of where the sign will actually need to be placed in the field).

Other considerations when designing traffic control plans include the following:

- **Temporary roadway cross sections**. These details can be invaluable in providing additional details not easily visible when looking at the plan view of a TCP, especially when the roadway is in a temporary shift or configuration. This is also an excellent way to identify roadway drop-off hazards and vertical clearance hazards.
- **Temporary channelization plans.** For projects with staged traffic control and lane shifts, temporary channelization plans show the station limits for the beginning and ending locations of the temporary markings and taper rates when applicable. These plans will also show the type of markings (lane line, edge line, etc.) on the plan with enough detail to assist the field inspector with field layout. When applicable, these plans also include temporary concrete barrier locations, flare rates, beginning and ending stations, and attenuator information (among others).
- **Temporary pavement marking details.** Detail sheets can be helpful in providing the specific details necessary to explain marking installation needs to supplement temporary pavement marking special provisions.
- **Temporary portable signal plan.** For projects that include temporary portable signal systems, a traffic control plan is required. Example projects would be alternating one-lane traffic operations on a two-way facility such as two-lane bridge widening, replacement projects, or emergency slide repair. The plan must include the entire advance signing for the system, temporary markings, location in relation to work operation, temporary lighting at stop bars, etc. Use a portable signal unit only for projects where the length between signal heads is 1,500 feet maximum. There are specific temporary signal requirements that go into a project; therefore, for assistance, contact with the region's Traffic Office is recommended.
- **Temporary signal plan.** The temporary signal plan will follow conventions used to develop permanent signals, as described in Chapter 850, but will be designed to accommodate temporary needs and work operations to ensure there will be no conflicts with construction operations. Some existing systems can be maintained using temporary span wires for signal heads and video, microwave actuation, or timed control.
- **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 840, but will be designed to accommodate temporary needs and work operations to ensure there will be no conflicts with construction operations.

  Consider using temporary illumination on the following projects:

  1. Multistaged projects with lane shifts and restricted geometrics
  2. Projects with existing illumination that must be removed as part of the construction process
  3. Road closures and detour alignments where grade and alignment are unusual or complex
  4. Temporary ramp connections and signal locations
  5. Construction activities will take place at night
  6. Traffic flow is split around or near an obstruction (illumination is required for this operation)
- **Detour and alternate route plan.** For projects that anticipate the need for a detour or alternate route, ensure that sign placement will fit the locations shown along the route and that the signs will not conflict with existing signs, driveways, or pedestrian movements. Depending on the duration, the detour that will be in place, and the anticipated amount of traffic that will use the route, consider upgrades to the route (signal timing, intersection turning radius for large

vehicle, structural pavement enhancements, shoulder widening, etc.). Coordination and possibly signed agreements with the appropriate local agency are required prior to implementing any detour routes on local roadways.

- **Pedestrian and bike detour route.** When existing pedestrian and signed bike routes are disrupted due to construction activities, detour routes must be addressed 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 safe and adequate to meet the needs of the user. Also, consider the impacts to the transit stops for pedestrians: Will the bus stops be able to remain in use during construction or will adjustments be necessary?
- **Advance warning sign plan.** While not required for all projects, consider advance warning signs. Show specific sign locations when known by either station or milepost. The signs are subject to movement in the field to fit specific conditions.
- **Sign specification and sign details.** While not a requirement, consider sign specifications and sign details for all complex or staged projects. The sign detail sheet is recommended to assist sign manufacturers with construction requirements for nonstandard signs.
- **Summary of Quantities and Quantity Tabulation sheets.** Traffic control items are required to be included in the Summary of Quantity sheets and, when applicable, the Quantity Tabulation sheets. Depending on the scale of the project and the number of temporary traffic control items, a separate Quantity Tabulation sheet may be appropriate for traffic items (temporary markings, temporary barrier, etc.).
- **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 will provide at a quick glance a cross-referencing tool to indicate what applicable traffic control plan is to be used for the specific work operation.
- **Temporary median crossovers.** These plans are not frequently used, but when they are, the design must be kept at a high level to ensure safety. Geometrics for the crossovers need to follow the same guidance as permanent alignments and have horizontal curves calculated to fit the location. The roadway surface shall be paved, and temporary pavement markings are required. Consider temporary illumination to improve the visibility of the operation. Temporary drainage may be necessary under the median fill (when applicable).
- **Roundabouts.** Site-specific staging plans need to be developed for the construction of roundabouts. Traffic operations during the construction phases are greatly impacted by construction activities when the roundabout is built on existing alignment, and it creates many unique challenges that other intersection construction operations do not typically face. There are no established national standards or guidelines for the construction of roundabouts. Each roundabout must be approached specifically for the location and the traffic operational movements that exist.
- **Often overlooked work operations.** Operations that are often overlooked during the design, but need to be considered to ensure that the traffic control plan will address the work, include the following:
    1. Bridge falsework openings often do not accurately represent the relationship between existing traffic movements and the bridge falsework. Coordination with the HQ Bridge and Structures Office is essential. 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 and possible additional signing needs. Refer to Chapter 1120 for additional requirements.
    2. Traffic signal head installation and adjustment (turn pockets and adjacent lane) overhead work is not allowed over live traffic.

3. Existing illumination: Can the existing lighting be maintained during the construction phases or do temporary connections need to be considered or temporary systems installed? Existing lighting at the exit and entrance ramps must be maintained at all times: it is often one of the first items of work that the contractor disables.
4. Permanent traffic loop installation (advance loops, turn pockets, stop bars, etc.).
5. Temporary traffic loops and signal detection. Consider the detection needs in relation to the work operation and duration (temporary loops, video, radar, timed system, etc.).
6. Pavement marking installations (crosswalks, arrows, etc.).
7. Temporary pavement marking needs: What type of marking is most appropriate for the work operation and the pavement surface? When removed, how are existing markings going to impact the roadway surface? Consider how to best minimize for ghost stripe potential.
8. Utility relocation needs: How will existing utilities conflict with temporary needs?
9. Temporary impact attenuator installation needs (appropriate type for work operation, specific needs or materials for installation pad).
10. Lane shifts onto existing shoulders.
    - Is the depth of the existing shoulder adequate to carry the extra traffic?
    - Are there any existing catch basins or junction boxes located in the shoulder that cannot accept traffic loads over them? Are there existing shoulder rumble strips? (Existing rumble strips must be filled.)
    - 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.
    - Existing drainage features: Will they be adversely impacted by temporary lane shifts or by anticipated work operations?
    - Signal head alignment: When the lane is shifted approaching the intersection, is the signal head alignment within appropriate limits?

810.19 Work Zone Toolbox

The information and values contained in this section are intended to assist designers with conceptual decision-making guidance and are not intended to replace a thorough analysis and detailed assessment of the applicable work zone issues. This toolbox may be helpful for preliminary analysis of potential impacts and strategy feasibility. Base final strategy decisions on a comprehensive assessment and analysis of the actual project data.

(1) Work Zone Requirements and Key Elements

This list provides a quick check of elements that are contained within or are related to this chapter and as part of WSDOT's work zone policy, and are required or key to the successful development of the work zone design decision. Federal and state regulations set the level of compliance for work zones. This list is intended to alert the designer that these items are not optional and must be addressed. The elements summarized below have more detailed information within this chapter or are contained within the related manuals and documents such as the MUTCD, Revised Codes of Washington, and Washington Administrative Codes:

- Safety is the highest priority.
- Minimize, mitigate, and manage work zone impacts.

- Early consideration and integration of work zone impacts during planning, programming, and design.
- Transportation Management Plan (TMP).
- Traffic Control Plan (TCP),
- Public Information Plans (PIPs) and Transportation Operations Plans (TOPs) must be considered to address those related issues.
- An accurate scoping estimate must be developed based on the work zone strategies.
- The Work Zone Design Checklist must be utilized.
- A Work Zone Design Strategy Conference is a key part of the design process.
- Flagger safety is a high emphasis area.
- Work zone mobility must be determined through a capacity analysis.
- Work zone impacts must be determined through the impact assessment process.
- Project constructibility must be integrated into the work zone design strategy.
- WSDOT does not delegate safety and mobility.
- Work zone training is required.
- The state of Washington traffic and safety regulations, as provided for by state law, must be addressed.
- The *Manual on Uniform Traffic Control Devices* (MUTCD) and Washington State modifications are the legally adopted minimum standard.
- The appropriate level of plan TCP development must be addressed.
- Work zone ITS solutions may be a key element.
- Work zone roadway and roadside design must be consistent with established design criteria.
- Pedestrians (including ADA requirements) and bicycles must be addressed.
- Risk management and tort liability exposure are key elements.
- Work efficiency and cost containment are important considerations.
- The work zone design must be approached from the road user's perspective.
- The work zone design must incorporate worker and other roadway user needs.
- All work areas and operations need to be accounted for.

(2) General Lane Closure Work Zone Capacity

Applying the following values to known volume data can provide a quick determination of the capacity level (over- or under-capacity) for a given lane closure scenario. (Alternating one-way flagger traffic control and 15- to 30-minute traffic delay.)

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*.

(3) General Road Closure Considerations

Road and access closures are generally allowable and should be considered for many strategies. Closures usually offer the highest levels of safety and productivity. Generally, the main roadblocks to a closure strategy are traffic concerns about congestion, delay, and access. The following closure issues may be useful to consider:

- Closures that affect large traffic volumes must be mitigated with alternate routes, off-peak closures, or other appropriate means.
- A closure strategy should be analyzed and compared to other strategies, such as staged work zones, to determine which is more beneficial overall.

- Closures that reopen to a new completed roadway or other noticeable improvements are generally more accepted by the public.
- A closure decision (other than short-term, minor impact closures) will generally be made by project stakeholder and manager input by judging the value of the closure benefit vs. impacts.
- Route-to-route connections and other strategic access points may have to be maintained, or a reasonable alternative provided.

810.20 Training Resources

Work zone-related training is an important component in an effective work zone safety and mobility program. Federal regulations require that those involved with work zone design and implementation be trained at a level consistent with their responsibility. It is valuable to know what training classes are available and how those classes relate to the project design and construction programs.

There are many work zone-related courses available, and the HQ Staff Development Office and HQ Traffic Office's Traffic Training Program Manager can assist with the availability and scheduling of classes. Consider the training courses listed below to develop an overall proficiency in work zone safety and mobility design:

- **Traffic Control Plan Design Course. –** This course, taught by Transpeed, focuses on work zone strategy development and TCP design and preparation, as well as key elements of the overall project development process.
- **QuickZone Course. –** This course, taught by McTrans, explores the QuickZone work zone traffic capacity analysis program. QuickZone is a useful tool for determining capacity needs and it allows comparison of alternative strategies.
- **MUTCD Course. –** This course, taught by Transpeed, focuses on the content and use of the MUTCD, including Part 6, Temporary Traffic Control.
- **Traffic Control Supervisor (TCS) Course. –** This course, taught by the Evergreen Safety Council, is primarily for those students who intend to become a TCS or those who have TCS-related responsibilities. TCS offers value to designers regarding how implementation issues interact with design issues. Designer attendance may be restricted to "space available" status.
- **Certified Flagger Training Course. –** This course is directed at students who will become certified flaggers in Washington State and is not intended for designers. Designers may want to use the *Flagger Handbook* as a resource to learn about flagger-controlled traffic control and flagging techniques and issues. This class may be valuable in increasing the safety of designers anticipating extensive field surveying and data gathering work during the project development phase.

Other courses on work zone safety, mobility, and related subjects may be available on a limited basis. Some of these courses would fall into the categories of traffic analysis and traffic engineering and may be appropriate, depending on individual designer needs and responsibilities.

810.21 Documentation

The list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/

Work Zone FAQs for Designers

1. **In the Final Project Definition form, what do I really need to write in Box 6, Work Zone Strategy?**
   A finalized strategy or TMP is not expected since some information may be conceptual at this level. The important information to include is as follows:
   - Indicate whether the project is considered significant or potentially significant.
   - Indicate known or potential major impacts.
   - Even if the project is not considered significant, list the known elements that the TMP will address (type of TCPs, TOP issues, and PIP needs).
   - It is not acceptable to leave the box empty or to write 'to be determined later.'
2. **How am I supposed to know how the contractor will build the project?**
   There are often many ways to stage a construction project, bearing in mind traffic safety and construction efficiencies. During the design of a project, there is the requirement to provide a constructible, maintainable, safe, and mobile project concept that is translated into an effective TMP, even though the contractor may propose another TMP.
3. **How do I know what is meant by safe and mobile?**
   These terms are definable within the context of the project. There is no one answer to fit every case and no project is completely safe or fully mobile. Complete consideration of all the factors involved will lead to conclusions that include known effective safety and mobility measures.
4. **Aren't we exposed to more legal liability by providing a TMP at such a detailed level?**
   No. A well-developed TMP that is based on known accepted policy and accurate information is actually the best defense against legal action. Poor implementation of the TMP would more likely be the cause for concern.
5. **Doesn't a comprehensive TMP add more cost to the project?**
   Cost is a legitimate concern and cost-effectiveness and containment are intended to be part of the selected strategy analysis and TMP. The bottom line is that it is less costly to include work zone costs as part of the project than it is to add them later by change order. Also, providing for safety and mobility can add costs, but these costs are usually more than offset by the benefits provided. These costs need to be identified early on in the scoping phase to provide an adequate project estimate.
6. **Why can't I just reuse the TCPs from a previous project?**
   You may be able to do so, but not without careful consideration of all the project information. Usually, each project has some unique features or different traffic conditions, even though the work may be similar. It is strongly recommended to conduct the impact assessment process first, then determine what plans may be appropriate. You may also be able to consult with the construction office that implemented a previous TCP to determine if it was effective.
7. **Where do I go for work zone assistance and answers?**
   Working within the structure and protocol of your office and region, there are several resources in the form of expert advice or information available. Also, inquire at the region and the HQ Design, Construction, and Traffic offices. Generally, work zone design is not a "cookbook" approach, and the designer needs to be prepared to actively pursue all available information and resources.

Work Zone Frequently Asked Questions

Figure 810-3

REMEMBER, a comprehensive traffic control PS&E is actually a project within a project. WSDOT is obligated to provide a safe and workable proposal for controlling traffic that is consistent with the project construction requirements. Even though there may be more than one workable solution, a thorough analysis of all the variables will help to produce a traffic control PS&E that sets the appropriate level of safety. The Work Zone Traffic Control Design Checklist must be thoroughly reviewed to assist in capturing all related work zone elements.

PROJECT DEFINITION & PLANNING

- ☐ **Work Zone Traffic Control Strategy Statement for Design Documents**
  - ☐ **Informal in-house conference with PEO & Region WZTC specialist**
  - ☐ **WZTC options and strategies**
  - ☐ formal conference with local agencies & WSDOT
  - ☐ **Final WZTC strategy statement for project definition documentation**
  - ☐ **Traffic Management Plan**
- ☐ **Work Zone Capacity Analysis**
  - ☐ **Existing level of service**
  - ☐ **Existing lane capacity (VPHPL)**
  - ☐ **Work hour restrictions (days & hours)**
  - ☐ **Detour route capacity analysis**
  - ☐ **Select appropriate work zone type(s)**
    - (1) long-term stationary
    - (2) intermediate stationary
    - (3) short-term stationary
    - (4) short-duration
    - (5) mobile
- ☐ **Existing Operational Factors**
  - ☐ **Coordinate with region traffic operations**
  - ☐ **Localized traffic operational problems**
  - ☐ **Accidents (include previous WZTC, maintenance or contract)**
  - ☐ **Geometric conflicts or issues**
  - ☐ **High-speed/low-speed**
  - ☐ **Coordinate with local maintenance supervisor**
  - ☐ commercial/private access impacts
  - ☐ adjacent project coordination
  - ☐ special events
  - ☐ ferry schedules
  - ☐ seasonal factors
  - ☐ on-street parking
  - ☐ emergency services
  - ☐ other regulatory conditions
  - ☐ transit, schools, parks, etc.
- ☐ **Work Zone Location Considerations**
  - ☐ **Define all work zone limits/locations**
  - ☐ existing lane conflicts
  - ☐ roadside conflicts/hazards
  - ☐ overhead & overwidth clearance conflicts
  - ☐ vertical/grade/profile conflicts
  - ☐ staged work zones
  - ☐ work zone base plan (CADD files & aerial photo)
- ☐ **Worker Safety**
  - ☐ **Positive protection (barriers)**
  - ☐ **Worker exposure during:**
    (1) set up
    (2) removal
    (3) work operations
  - ☐ **Flagger protection (no freeway use)**
  - ☐ **Truck-mounted attenuator**
  - ☐ **Portable barriers (temporary concrete, movable barrier, steel, etc.)**
  - ☐ **Inspector protection**
  - ☐ **Work zone intrusion analysis & mitigation techniques**

NOTES:

Required checklist items are **bold**.

Not all items listed on the checklist apply to every project, but it does provide a comprehensive list of possible items that may apply and should be considered when applicable.

Work Zone Traffic Control Design Checklist

Figure 810-4

TYPES OF WORK ZONE TRAFFIC CONTROL

☐ **Long-Term**

STRATEGY	*PLAN TYPE*
☐ total road closure	detour
☐ partial road closure	crossover
☐ interchange closure	detour
☐ ramp closure	detour/alt route
☐ crossroad closure	detour/alt route
☐ lane shift	**Temporary channelization**
☐ lane closure	temporary channelization
☐ shoulder closure	temporary channelization
☐ reversible lanes	TCP
☐ temp./portable traffic signal control	TCP
☐ temp. yield/stop control	TCP
☐ temp. widening/connections	temporary channelization
☐ temp. structures	temporary channelization
☐ staged traffic control	staging plans

☐ Short-Term

STRATEGY	*PLAN TYPE*
☐ off-peak roadway closures:	detour
(1) total & partial road closure	detour
(2) interchange & ramps	detour/alt route
(3) crossroad, intersection	detour/alt route
☐ off-peak lane closures	TCP
☐ shoulder closure	TCP
☐ flagger control	TCP
☐ pilot car control	TCP
☐ traffic stop	TCP

Refer to the MUTCD for guidelines on work zone type and duration.

☐ **Construction Considerations for WZTC**

- ☐ **Removal of permanent traffic control features**
- ☐ **Maintaining existing features (illumination, signing, etc.)**
- ☐ **Work area access control (safe ingress & egress)**
- ☐ **Adequate work zone space for contractor**
- ☐ **Time frame to complete work and reopen to traffic**
- ☐ innovative work methods
- ☐ time-saving materials
- ☐ temporary illumination or signals
- ☐ winter shut-down (intermediate WZTC stage?)
- ☐ cure time, closure pours
- ☐ temporary drainage
- ☐ construction/traffic compatibility
- ☐ staged WZTC switchover time to new stage (pavement marking revisions)
- ☐ existing shoulder durability for temporary lane shift (shoulder failure)

Refer to the MUTCD, the *Traffic Manual*, the *Design Manual*, the Standard Specifications, and the *Construction Manual* for further guidance.

Work Zone Traffic Control Design Checklist (continued)
Figure 810-4

TRAFFIC CONTROL FEATURES

- ☐ **Work Zone Devices**
  - ☐ work zone ITS
  - ☐ portable/temp. traffic signal
  - ☐ intrusion alarms
  - ☐ truck-mounted attenuator
  - ☐ buffer/shadow vehicles
  - ☐ high-level warning flags
  - ☐ glare/work zone screen
  - ☐ pedestrian fence
  - ☐ automated flagger assistance device
  - ☐ portable HARs
  - ☐ port. changeable message sign
  - ☐ advance notice of closure signs
  - ☐ speed advisory signs
  - ☐ regulatory speed zone signs
  - ☐ temporary rumble strips
- ☐ **Special Considerations**
  - ☐ **WSP assistance**
  - ☐ **Public information**
  - ☐ **Night work**
  - ☐ **Oversized loads**
  - ☐ **Peds and bikes (ADA needs)**
  - ☐ **WZTC supervisor**
  - ☐ **WZTC patroller**
  - ☐ roadway flares
  - ☐ reduced sight distance
  - ☐ safe speed for temp. alignment (ball bank)
  - ☐ liquidated damages
  - ☐ A+B bidding, lane rental, etc.
  - ☐ innovative contract techniques
  - ☐ haul routes
  - ☐ blasting operations
  - ☐ emergency traffic control
  - ☐ emergency parking
- ☐ **Special Lighting**
  - ☐ **Flagger station illumination**
  - ☐ detour illumination
  - ☐ temporary illumination
  - ☐ high mast lighting
  - ☐ warning lights
- ☐ **Work Zone/Positive Protection**
  - ☐ **Roadside hazard protection**
  - ☐ **Buffer space (lateral and longitudinal)**
  - ☐ temporary impact attenuators
  - ☐ barrier/guardrail connections
  - ☐ movable concrete barrier
  - ☐ water-filled barrier
  - ☐ temporary concrete barrier
  - ☐ barricades
  - ☐ recovery area
  - ☐ shy distance
- ☐ **Positive Continuous Guidance**
  - ☐ temporary RPMs
  - ☐ temporary pavement marking
  - ☐ mimic permanent markings
  - ☐ traffic safety drums
  - ☐ type "c" steady burn lights
  - ☐ reduced device spacing
  - ☐ temporary guidepost

Work Zone Traffic Control Design Checklist (continued)

Figure 810-4

DESIGN CONSIDERATIONS

- ☐ preliminary field review
- ☐ design with existing driver expectation in mind
- ☐ design for existing speed: posted or higher
- ☐ start design from work zone perspective
- ☐ design based on the most desirable, yet practical, traffic configuration
- ☐ design from drivers' point of view
- ☐ layout temporary channelization
- ☐ build in recovery area and buffer space
- ☐ provide adequate detail (station callouts for temporary features) for field layout
- ☐ temporary channelization must provide positive driver guidance
- ☐ clear separation between work zone and traffic (use positive protection?)
- ☐ use permanent design guidelines whenever possible
- ☐ build in work area ingress and egress access
- ☐ design above minimums when possible
- ☐ establish highly visible sign locations (verify where possible, field review, SRView, etc.)
- ☐ don't depend on signs to guide traffic
- ☐ mentally drive through the TCP from all approaches and all lanes
- ☐ will TCP actually fit site conditions? (scaled site-specific plan)
- ☐ final field review
- ☐ risk assessment: comfortable with level of safety, liability issues?
- ☐ constructibility issues (can this be built?)
- ☐ final approval with traffic engineer and construction P.E.

PROJECTED IMPACTS

- ☐ **Worker/traffic exposure**
- ☐ **Local agency impact**
- ☐ **Coordination with region PIO for public awareness & media notification**
- ☐ traffic delay (time)
- ☐ user costs ($)
- ☐ backups (queue length)
- ☐ traffic control costs
- ☐ constructibility issues
- ☐ commercial impacts
- ☐ overlapping project coordination/WZTC conflicts
- ☐ conflicts with existing permanent traffic control features, signs, markings, etc.
- ☐ removal of existing conflicting pavement markings
- ☐ reversed/revised intersection control

FINAL APPROVAL

- ☐ **Regional Traffic Engineer or Regional Traffic Control Specialist**
- ☐ **Regional Management Approval**
- ☐ **Construction P.E. Concurrence**
- ☐ **Consistent with FHWA (MUTCD) & WSDOT policies**
- ☐ Detour Agreement Approval
- ☐ WSP Agreement Approval
- ☐ Local Agency Approvals & Agreements
- ☐ Noise Ordinance
- ☐ Blasting Ordinance

Work Zone Traffic Control Design Checklist (continued)

Figure 810-4

Chapter 840 Illumination

840.01 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 (per WAC 468-18-050 and WAC 468-18-040) with partial limited access control, modified limited access control, or full limited access control, regardless of the location. WSDOT is responsible for illumination on state highways and crossroads (per WAC 468-18-050) with managed access control, located outside the corporate limits of cities. Cities are responsible for illumination of managed access state highways within their corporate limits.

For the definition of the types of access control—limited access control and managed access control—see Chapter 1425. For further information, see the "Access Control Tracking System, Limited Access and Managed Access Master Plan," under the 'related sites' heading at: http://www.wsdot.wa.gov/eesc/design/access/. This document provides a listing (by milepost) of the limited access or managed access status for all state highways. (See also the WSDOT/Association of Washington Cities agreement "City Streets as Part of State Highways" at: http://www.wsdot.wa.gov/TA/Operations/LAG/CityStreets.html.)

840.02 References

Federal/State Laws and Codes

National Electrical Code, 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"

Chapter 468-95 WAC, "Manual on uniform traffic control devices for streets and highways" (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Design Guidance

American National Standard Practice for Roadway Lighting, IES RP-8-00, New York, NY 2000

Directive D 22-21, "Truck Weigh Stations and Vehicle Inspection Facilities on State Highways"

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA, as adopted and modified by WAC 468-95

NFPA 502: Standard for Road Tunnels, Bridges and Other Limited Access Highways, 2004, NFPA, Quincy, MA

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

Roadway Lighting Handbook, Federal Highway Administration, Implementation Package 78-15, Washington, DC 1978 (Reprinted April 1984)

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

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

Roadway Lighting Design Guide, AASHTO, October 2005

Supporting Information

An Informational Guide for Roadway Lighting, AASHTO, Washington, DC 1984

City Streets as a Part of State Highways, Final Report, WSDOT, 1997

Light Trespass: Research Results and Recommendations, IES TM-11-00, New York, NY 2000

Recommended Practice for Tunnel Lighting, IESNA RP-22-05, New York, NY 2005

840.03 Definitions

average light level The average of all light intensities within the design area.

complex ramp alignment and grade The exit advisory speed is 35 miles per hour 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.

continuous load When the electrical load on a circuit lasts for a duration of three hours or more on any day.

footcandle (fc) The illumination of a surface one square foot in area on which is uniformly distributed a flux of one lumen. One footcandle equals one lumen per square foot.

lamp lumens The total light output from a lamp, measured in lumens.

lumen The unit used to measure luminous flux.

luminaire A complete lighting unit comprised of a light bulb, 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.

maximum uniformity ratio The average light level within the design area divided by the minimum light level within the design area. (See Figure 840-25.)

maximum veiling luminance ratio This ratio is the maximum veiling luminance divided by the average luminance over a given design area for an observer traveling parallel to the roadway centerline. (See Figure 840-25.)

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 Figure 840-25, Note 1.)

minimum average light level The average of all light intensities within the design area, measured just prior to relamping the system. (See Figure 840-25, Note 1.)

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.

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).

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 discernable at a distance of 500 feet. (See RCW 46.04.200, Hours of Darkness.)

pedestrian crossing For the purpose of lighting design, the number of pedestrian movements that cross through the design area.

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.

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.

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.

slip base A mechanical base designed to allow the luminaire pole to break away from the fixed foundation when hit by a vehicle traveling at the design speed.

spacing The distance in feet measured on centerline between adjacent luminaires.

transit flyer stop A multimodal connection located within the boundaries of a limited access facility.

transit stop A connection on the highway where the transit bus stops to pick up or drop off passengers.

uniformity ratio The ratio of the minimum average light level on the design area to the minimum light level of the same area. (See Figure 840-25.)

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.

840.04 Design Considerations

An illumination system is built from many separate components. The simplest illumination system contains:

- 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 luminaire pole 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 was acceptable for use under the design requirements and National Electric Code (NEC) rules in effect at the time of installation. When modifying an existing electrical system, the designer is responsible for bringing the whole system up to current NEC design standards. Retrofitting an existing fixed base luminaire pole with a slip base feature requires the installation of quick disconnect fittings and fuses in the circuit, at the luminaire. 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 designed to current standards. This may mean replacing the whole circuit back to the nearest overcurrent protection device (circuit breaker). The following are design considerations to be addressed 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)
- 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 existing foundation to meet current design standards
- The design life remaining for the existing luminaire pole (deficient electrical component)
- The condition of the existing luminaire pole (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 scoping process. Ensure that potential system deficiencies are reflected in the estimate of work.

Another consideration is the need to maintain illumination during construction. Site preparation, widening, drainage, guardrail installation, or other work can easily impact existing conduit runs or luminaire locations. Furthermore, changed conditions such as merging, weaving, or unusual alignment due to traffic control often require additional temporary illumination. The same lighting requirements apply whether a condition is temporary or permanent.

840.05 Required Illumination

The design matrices identify the design levels for illumination on all preservation and improvement projects. (See Chapter 325.)

At the basic design level for minor safety or preservation work, providing slip base features on existing light standards (when in the Design Clear Zone or recovery area), and bringing electrical components to current standards, is required. Consider other minor safety work as necessary. Providing additional lighting or relocating light standards on preservation projects may be considered spot safety enhancements. When the Illumination column has an EU (evaluate upgrade to full design level), consider providing illumination if it would be beneficial to the specific project, and document accordingly.

- **Evaluate Upgrade:** Review the service to see that it meets current standards for design load. It should be located so that it can be safely accessed from the right of way. Poles, foundations, heads, etc., that have reached their design life should be replaced. Slip base features should be per current design standards. Uniformity should be evaluated in the design areas (see 840.07(2)). Locations that are illuminated per 840.05 should be brought to full standards or documented regarding why they are not (deferred to another project, etc.). Consider additional illumination per 840.06, if warranted, or design additional illumination if it is called for in the Project Definition.

  When it is necessary to relocate existing illumination pole foundations, evaluate the entire conduit run serving those poles and replace deficient components to current (NEC) standards.
- **Full Standards:** For full design level, the illumination specified in this chapter is required when constructing a new system and/or bringing the entire existing system to full standards (such as slip base features, grounding, conduit, light levels, and uniformity). On existing systems, this includes all components not otherwise affected by the project. Review all conduit runs, not just the one affected by relocating poles on that run.

Figures 840-1 through 840-24 show examples of illumination for roadway, transit flyer stops, parking lots, truck weigh stations, tunnels, bridges, work zones, and detour applications. Illumination is required in these examples and in the locations listed below.

For Minor Operational Enhancement projects using the design matrices in Chapter 340, illumination is not required.

(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 840.07(2) and Figures 840-1a, 1b, and 1c.)

(2) Freeway Ramp Terminals

Provide the necessary illumination for the design area. (See Figure 840-2.) Additional illumination is required if the intersection has left-turn channelization or a traffic signal.

(3) Intersections With Left-Turn Lane Channelization

Illumination of the intersection area and the left-turn storage 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 from the beginning of the left-turn approach taper. Illumination of the secondary road intersecting the state highway can be beneficial to the motoring public. Funding and design, however, are the local agency's responsibility. Contact that agency to see whether they are interested in participating. (See Figures 840-3a and 3b.)

(4) Intersections With Traffic Signals

Illuminate all intersections with traffic signals on state highways. (See Figure 840-4.) Illumination of the crossroad is beneficial and the participation of the local agency is desirable. In cities with a population under 22,500, the state may assume responsibility for illumination installed on signal standards.

(5) 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, so that illumination is behind the train. (See Figure 840-5.)

(6) Transit Flyer Stops

Illuminate the pedestrian-loading areas of transit flyer stops located within the limited access boundaries. (See Figure 840-6.)

(7) 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 Figure 840-25. (See Figure 840-7 for the parking area and bus loading zone.) During periods of low usage at night, security lighting of only the parking area and bus loading zone is required. Provide an electrical circuitry design that allows the illumination system to be reduced to approximately 25% of the required light level.

(8) 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 Figure 840-8.)

(9) Truck Weigh Sites

Provide illumination of the roadway diverge and merge sections, scale platforms, parking areas, and inspection areas of weigh sites. (See Figure 840-9.)

(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 this raised channelization. (See Figure 840-10.)

(11) Tunnels

Long tunnels have a portal-to-portal length greater than the stopping sight distance. Provide both nighttime and daytime illumination for long tunnels. Consider illumination for short tunnels if the horizontal to vertical ratio is > 10:1. (See Chapter 650 and Figure 840-11.)

(12) 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 Figure 840-12.) This requirement does not apply to:

- The end of slow-moving vehicle turnouts.
- The end of the area where driving on shoulders is allowed.

(13) Intersections With Right-Turn Channelization

Illumination of the intersection area and the right-turn storage area is required for intersections with painted or other low-profile pavement markings such as raised pavement markings. Raised channelization such as curb, raised medians, and islands are to be illuminated from the beginning of the right-turn taper. For concurrent left-turn and right-turn channelization, where the left-turn lane and the left-turn taper are longer than the right-turn lane and taper, illuminate the roadway as described in 840.05(3), and include the right-turn lane area in the design area. (See Figure 840-13.) Illumination of the secondary road intersecting the state highway can be beneficial to the motoring public. Funding and design, however, are the local agency's responsibility. Contact that agency to see whether it is interested in participating.

(14) 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, the obstruction is to be illuminated for the duration of the traffic split. (See Figure 840-14.)

(15) Add Lane Channelization

Provide the necessary number of light standards to illuminate the design area of freeway add lanes on high-volume roadways within the urban boundary. (See Figure 840-15.) This requirement does not apply to the following:

- The beginning of an add lane on a low-volume roadway in a rural area beyond the urban boundary
- The beginning of a slow-moving vehicle turnout
- The beginning of an area where driving on shoulders is allowed

(16) Roundabouts

Provide the necessary number of light standards to illuminate the design area of roundabouts. (See Chapter 915, "Roundabouts," and Figure 840-16.)

(17) Bridge Inspection Lighting

Provide the necessary number of light fixtures to illuminate the interior inspection areas of floating bridges and steel box girder bridges. (See Figure 840-17.)

(18) Freeway On-Ramps With Ramp Meter Signals

Provide the necessary number of light standards to illuminate freeway on-ramps with ramp meters, from the beginning of the on-ramp to the ramp meter stop bar. When there is an HOV bypass lane or a two-lane merge beyond the ramp meter, then provide illumination for the entire ramp from the beginning of the on-ramp to the ramp merge point with the main line. (See Figure 840-18.)

(19) Freeway-to-Freeway Ramp Connections

Provide the necessary number of light standards to illuminate freeway-to-freeway ramps that connect full limited access freeway systems from the exit ramp gore area to the main line merge area. (See Figure 840-19.)

(20) HOT (High Occupancy Toll) Lane Enter/Exit Zones

Provide the necessary number of luminaires to illuminate the design area of the enter/exit zones of the HOT Lane. (See Figure 840-20.)

(21) Chain-Up Parking Areas

Provide the necessary number of luminaires to illuminate the design area of the chain-up parking area. (See Figure 840-21.)

(22) Rest Areas

Provide illumination at the roadway diverge and merge sections within rest areas, the walkways between parking areas and rest room buildings, and the parking areas as for a major parking lot. (See Figure 840-22.)

(23) Overhead Sign Illumination

Provide sign lighting on overhead signs as discussed in Chapter 820. (See ***Design Manual*** Supplement, Overhead Sign Illumination [Lighting], August 5, 2005.)

840.06 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 is considered under certain circumstances, which are listed in this section. Justify the additional illumination in the Design Documentation Package (DDP).

Some conditions used in making the decision to provide additional illumination are:

- **Diminished Level of Service.** A mobility condition where the nighttime peak hour level of service is D or lower. To determine the level of service, use traffic volume counts taken during the evening peak hour. Peaking characteristics in urban areas are related to the time of day. Traffic counts taken in the summer between 4:30 P.M. and 7:30 A.M. may be used as nighttime volumes if adjustment factors for differences in seasonal traffic volumes are applied for November, December, and January.
- **Nighttime Collision Frequency.** When the number of nighttime collisions equals or exceeds the number of daytime collisions. An engineering study indicating that illumination will result in a reduction in nighttime collisions is required as justification. Consider the seasonal variations in lighting conditions when reviewing reported collisions. Collision reporting forms, using a specific time period to distinguish between “day” and “night,” might not indicate the actual lighting conditions at the time of a collision. Consider the time of year when determining whether a collision occurred at nighttime. A collision occurring at 5:00 P.M. in July would be a daytime collision, but a collision occurring at the same time in December would be during the hours of darkness.
- The mitigation of nighttime pedestrian accident locations (PAL) requires different lighting strategies than vehicular accident locations. Provide light levels to emphasize crosswalks and adjacent sidewalks. 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 for this condition.

(1) Highways

Proposals to provide full (continuous) illumination require the approval of the State Traffic Engineer. Regions may choose to develop system plans (regional or corridor-specific) for providing full (continuous) illumination. The approval of a system plan will eliminate the need for a project-specific approval from the State Traffic Engineer.

The decision whether to provide full (continuous) illumination is to be made in the scoping stage and communicated to the designers as soon as possible.

(a) On the main line of full limited access highways, consider full (continuous) illumination if a diminished level of service exists and any two of the following conditions are satisfied:

- There are three or more successive interchanges with an average spacing of 1 1/2 miles or less, measured from the center of each interchange or a common point such as a major crossroad.
- The segment is in an urban area.
- A nighttime collision frequency condition exists.
- A benefit/cost analysis between the required and full (continuous) illumination indicates a value added condition with the addition of continuous illumination.

(b) 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 either a diminished level of service exists or a nighttime collision frequency exists, and an engineering study indicates that nighttime driving conditions will be improved.

(2) Ramps

At ramps, consider additional illumination when a diminished level of service exists for the ramps and any of the following conditions are present:

- The ramp alignment and grade are complex
- There are routine queues of five or more vehicles per lane at the ramp terminal during the nighttime peak hour due to traffic control features
- A nighttime collision frequency condition exists
- The criteria for continuous main line illumination have been satisfied

(3) Highway-to-Highway Ramp Connections

Provide the necessary number of light standards to illuminate highway-to-highway ramps that connect partial or modified limited access freeway systems or managed access highway systems, from the exit ramp gore area to the main line merge area. For an example of the ramp connection, see Figure 840-19.

(4) Crossroads

At crossroads, consider additional illumination when a diminished level of service exists and a nighttime collision frequency exists. Also, consider additional illumination if the crossroad is in a tunnel, an underpass, or a lid.

(5) Intersections Without Channelization

Consider illumination of intersections without channelization if a nighttime collision frequency requirement is satisfied or the intersection meets warrants for left-turn channelization. (See Figure 840-23.)

(6) Short Tunnels, Underpasses, or Lids

Consider illumination of short tunnels, underpasses, or lids if portal conditions result in brightness that is less than the measured daytime brightness of the approach roadway divided by 15 and the length to vertical clearance ratio is 10:1 or greater.

(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, and when the following conditions may be present: (See Figure 840-24)

- When nonstandard roadway features such as narrow lanes, shoulders, or shy distance to barriers or structures are present

- When the temporary alignment includes abrupt changes in highway direction or lane shifts with substandard lane shift tapers
- When other unusual highway features such as abrupt lane edge drop-offs, sudden changes in pavement conditions, or temporary excavation or trenching covers are present
- When there is an anticipation of heavy construction truck traffic, possibly requiring flaggers, entering and exiting the highway during nighttime hours

For further information, see Chapter 810.

(8) Transit Stops

The responsibility for lighting at transit stops is shared with the transit agency. Consider illumination of transit stops with shelters, as they are usually indicative of higher 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, a single light standard positioned to illuminate both the transit pullout area and the loading area can be considered.

(9) Bridges

Justification for illuminating the roadway and 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 840.06(11).

(10) Railroad Crossing Without Gates or Signals

Consider illumination of these facilities when:

- The collision 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.

(11) Walkways and Bicycle Trails

Consider illumination of a pedestrian walkway if the walkway is a connection between two highway facilities. This might be between parking areas and rest room buildings at rest areas, between drop-off or pick-up points and bus loading areas at flyer stops, or between parking areas and bus loading areas or ferry loading zones (for example). Consider illuminating existing walkways and bicycle trails if security problems have been reported. Also, consider illumination if security problems are anticipated. Under these conditions, the walkways and bicycle trails are illuminated to the level shown in Figure 840-25.

840.07 Design Criteria

(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 Figure 840-25. 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* for:

- Walkway or path illumination where, for public safety, the complete walkway or path is to be illuminated.

For design-level classifications of highways, see Chapters 325, 410, 430, and 440.

(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:

- **High Activity.** Areas with over 100 pedestrian crossings during the 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.
- **Medium Activity.** Areas with pedestrian crossings that number between 11 and 100 during the 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.
- **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.

(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, the design area includes these features, except that sidewalks adjacent to the traveled way are exempt from maximum veiling luminance ratio requirements. The access areas used for interior inspection of a floating bridge or steel box girder bridge are exempt from lighting level and lighting ratio design requirements.

Design area requirements for various applications are shown in Figures 840-1 through 840-24 and the following:

- **Single-Lane Off-Ramp.** Two main line through lanes and the ramp lane, including gore area, from the gore point to a point 200 feet (minimum) downstream of the gore point. A 100-foot longitudinal tolerance either way from the gore point is allowed.
- **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 to a point 200 feet downstream of the gore point. A 100-foot longitudinal tolerance either way from the gore point is allowed.
- **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).
- **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.
- **Intersections Channelized With Pavement Markings.** The design area has two components: the intersection area and the approach areas. The intersection area is the area between the stopping points 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 stopping point and where the left-turn lane is full width.
- **Intersections With Raised Channelization.** The design area has two components: the intersection area and the approach areas. The intersection area is the area between the stopping points 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 stopping point and where the left-turn taper begins.

- **Unchannelized Intersection.** The area between the stopping points on both the main road and the minor road, including marked or unmarked crosswalks.
- **Railroad Crossing.** The roadway width from a point 50 feet on either side of the track (the approach side only for one-way roadways).
- **Transit Loading Area.** The lane width and length designated for loading.
- **Major Parking Lot.** The entire area designated for parking, including internal access lanes.
- **Scale Platform at Weigh Site.** The approach width from the beginning of the scale platform to the end of the platform.
- **Inspection Area at Weigh Site.** The area dedicated to inspection as agreed upon with the Washington State Patrol.
- **Bridge Inspection Lighting System.** Fixtures are to be ceiling-mounted with a maximum spacing of 25 feet. Illumination is to consists of a 100 watt incandescent (or fluorescent equivalent) fixture. 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.

(3) Light Levels for Tunnels and Underpasses (Daytime Illumination)

It is important to provide sufficient lighting when illuminating the inside of a tunnel. When driving into and through a tunnel, 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 the eye 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 to the lower light levels in the tunnel and the motorist experiences a "black hole" or "blackout" effect. This "black hole" effect may cause a motorist to slow down, reducing the efficiency of the roadway. As the motorist leaves 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 840.02, References, in the Supporting Information section. All designs for lighting 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. Each zone is equal in length to the pavement stopping sight distance. The entrance zone beginning point is a point outside the portal where the motorist's view is confined to the predominance of the darkened tunnel structure.
- The daytime entrance zone light level is dependent upon the brightness of the features within the motorists' view on the portal approach. The brightness level is defined as the average brightness measured over a 20° cone at a point 500 feet in advance of the portal. The entrance zone light level produced within the tunnel must be sufficient to provide a brightness level of approximately 5% of the measured portal brightness, after adjustment for the reflectivity of the roadway, walls, and ceiling. Design successive zones for a daytime light level of 5% of the previous zone light level to a minimum value of five footcandles. Requirements for nighttime light levels for long tunnels on continuously illuminated roadways are the same as the light level required on a roadway outside the tunnel. Provide illumination of fire protection equipment, alarm pull boxes, phones, and emergency exits in long tunnels. (See NFPA 502 for additional information.)
- A short tunnel or underpass has a length-to-vertical clearance ratio of 10:1 or less. 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 with length-to-vertical clearance ratios greater than 10:1 are treated the same as an entrance zone on a long tunnel to establish daytime light levels.

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. 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.

(4) Light Standards

(a) **Light Standards**. Light standards are the most common supports used to provide illumination for highway facilities. The 40-foot and 50-foot-high light standards with slip bases and Type 1 mast arms are used predominately on state highways. The angular Type 2 mast arms are allowed only to match existing systems. Use Type 1 mast arms on all new systems. Cities and counties may elect to use different mounting heights to address factors unique to their environments. On state highways, alternate 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. 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 (see WAC 296-24-960). Consult the Headquarters (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 of impacts from errant vehicles. The preferred position for the luminaire is directly over the edge line. However, some flexibility is acceptable with the luminaire position to allow for placement of the light standard. 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 or 50-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 or 50-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 700 for additional guidance on clear zone issues.)

In curb and sidewalk sections, locate the light standard behind the sidewalk. Slip bases on light standards are a safety requirement for roadways where the posted speed is 35 miles per hour or higher. They are not always desirable at other locations. Following are locations where fixed bases are installed:

- Parking lots
- Medians where the light standard is mounted on median barrier
- Behind traffic barrier, beyond the barrier's deflection design value (see Chapter 710)
- Along pedestrian walkways, bike paths, and shared-use paths

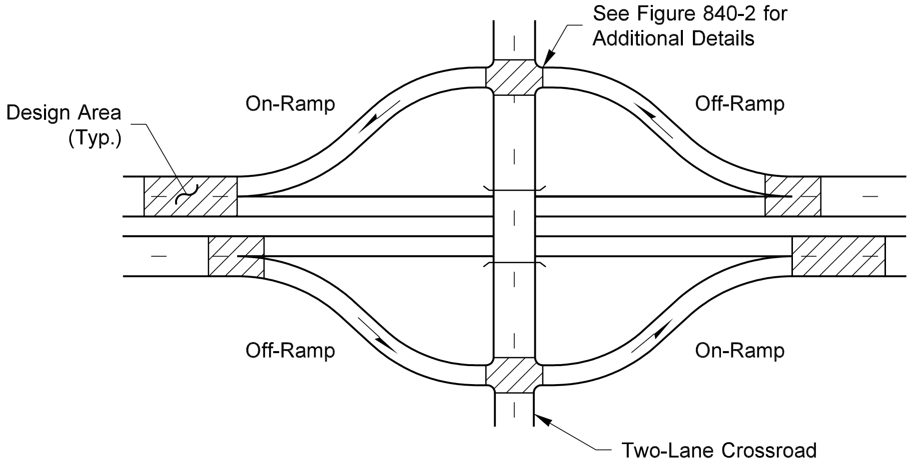
(b) **Light Standard Heights.** Standard pole heights (20-foot, 30-foot, 40-foot, or 50-foot) are readily available from local distributors and manufacturers. Light standards can also be supplied with other lengths. However, WSDOT maintenance offices cannot stock poles with nonstandard lengths for use 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, 43-foot, or 47-foot) will not only require a longer delivery time, they will also be more expensive.

In almost all cases, use standard pole heights of 40 feet and 50 feet for roadway illumination. Structure-mounted light standards may need to be shorter than the standard 40-foot or 50-foot grade-mounted pole. Use of 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 is acceptable. 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. 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.

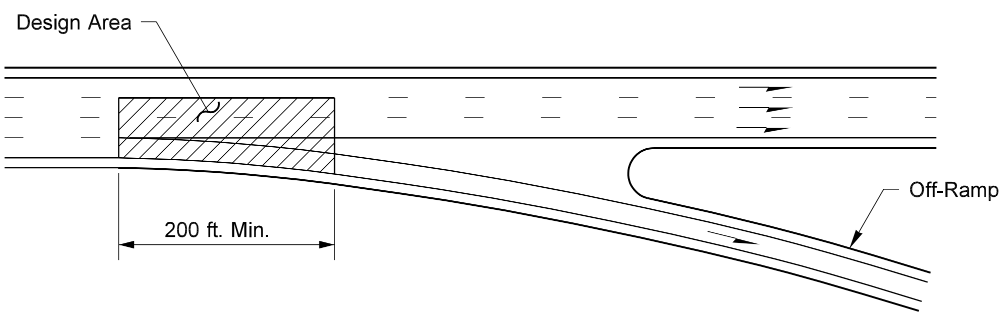
(c) **Standard Luminaire.** The cobra head-style, high-pressure sodium vapor luminaire with Type III, medium cut-off light distribution is the normal light source used for state highway lighting. A Type III distribution projects an oval pattern of light on the roadway, and a Type V distribution projects a circular pattern of light on the roadway. Post top-mounted luminaires and other decorative light fixtures with Type V patterns are more effective for area lighting in parking lots and other locations where more symmetrical light distribution patterns are used.

840.08 Documentation

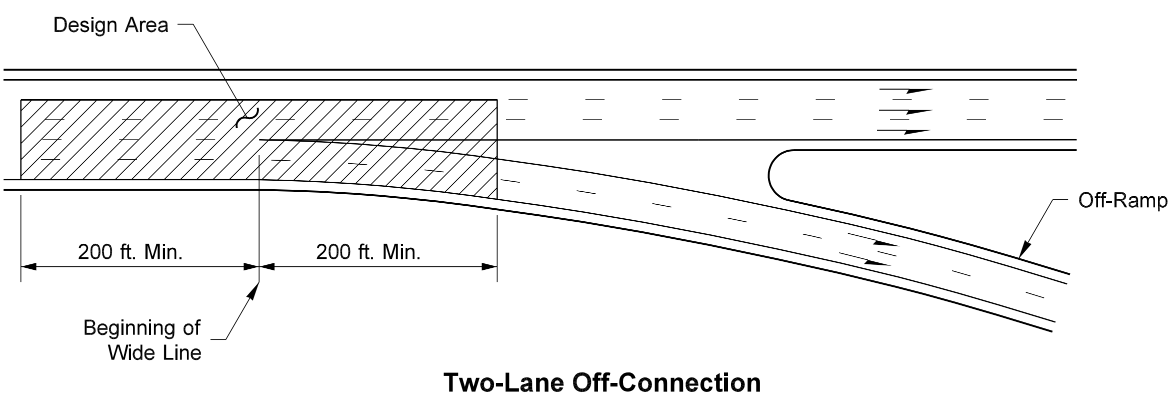
A list of the documents that are to be included in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/



Required Illumination for a Typical Diamond Interchange
(Shown for single-lane ramp connection and a two-lane crossroad without channelization)



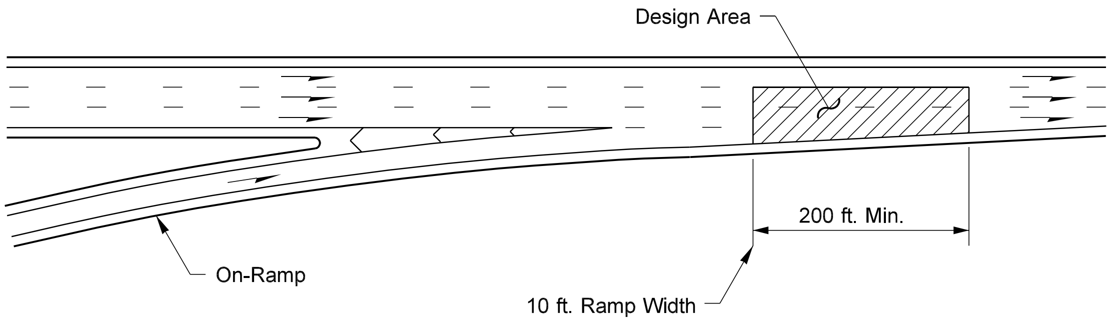
Single-Lane Off-Connection
(The Design Area may be shifted up to 100 feet from the beginning of the wide line)



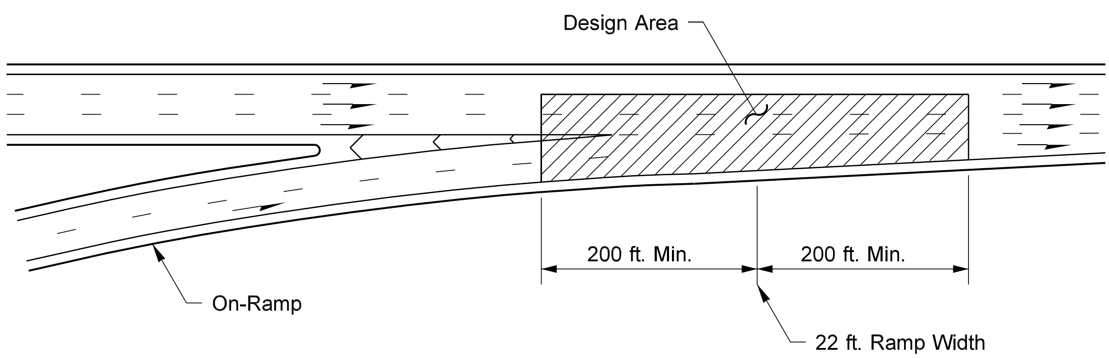
Two-Lane Off-Connection
(The Design Area can be shifted up to 100 feet from the beginning of the wide line)

Freeway Lighting Applications

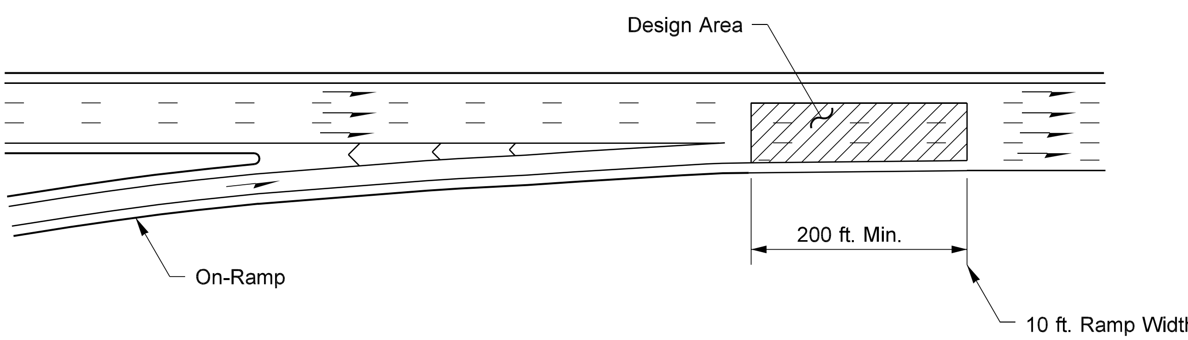
Figure 840-1a



Single-Lane On-Connection
(The Design Area may be shifted up to 100 feet from the 10-foot-wide ramp point)

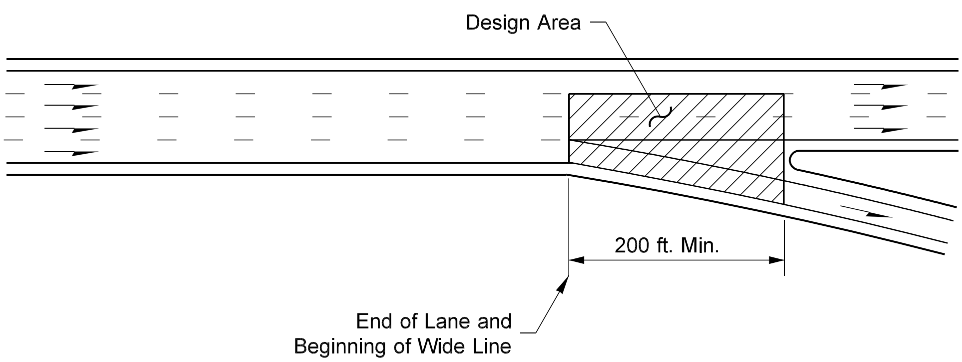


Two-Lane On-Connection
(The Design Area may be shifted up to 100 feet from the 22-foot-wide ramp point)



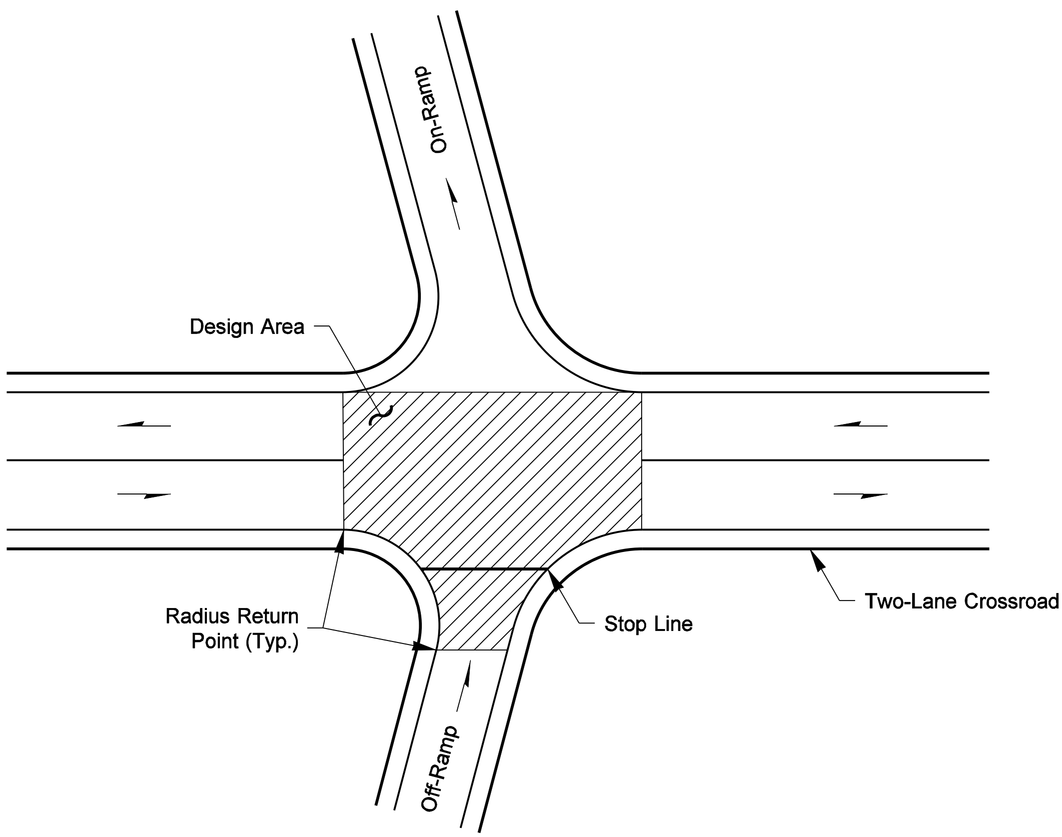
Auxiliary Lane at On-Connection
(The Design Area may be shifted up to 100 feet from the 10-foot-wide ramp point)

Freeway Lighting Applications
Figure 840-1b

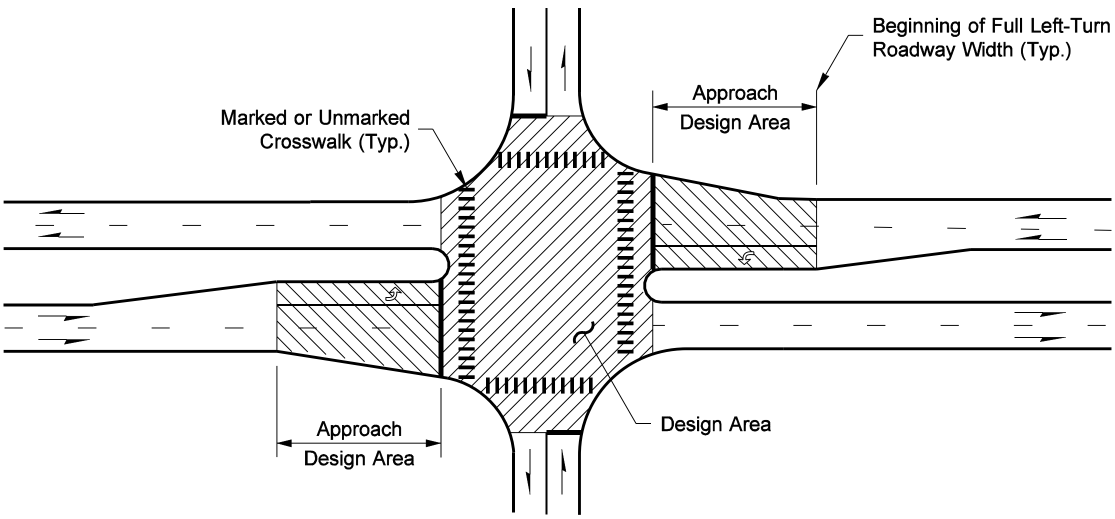


Exit-Only Lane
(The Design Area may be shifted up to 100 feet from the end of lane and the beginning of wide line)

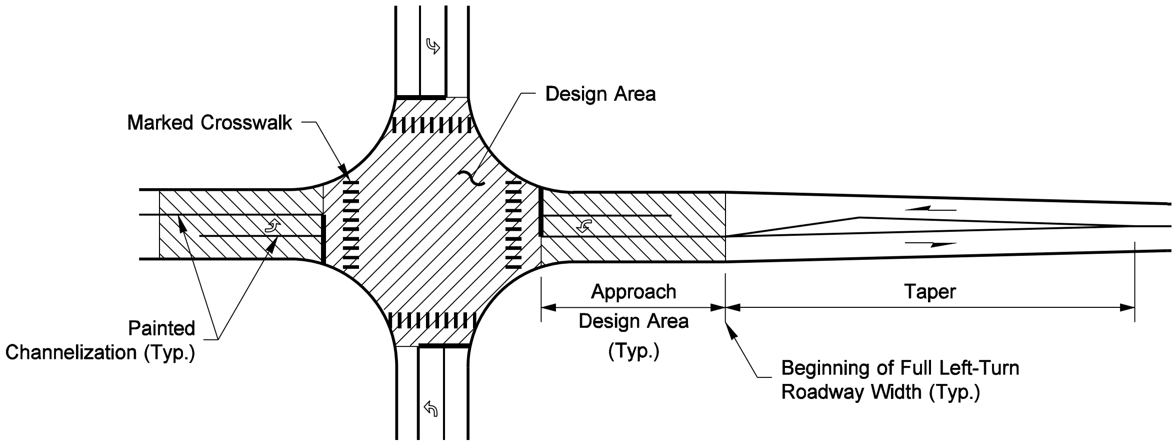
Freeway Lighting Applications
Figure 840-1c



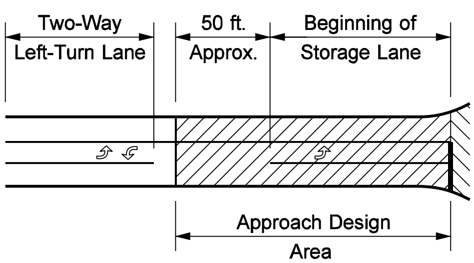
Freeway Ramp Terminals
Figure 840-2



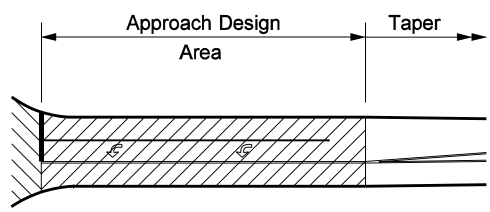
Intersection With Left-Turn Channelization
Figure 840-3a



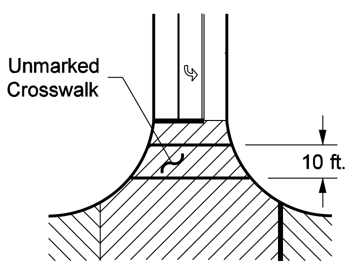
Intersection With Left-Turn Lane Channelization



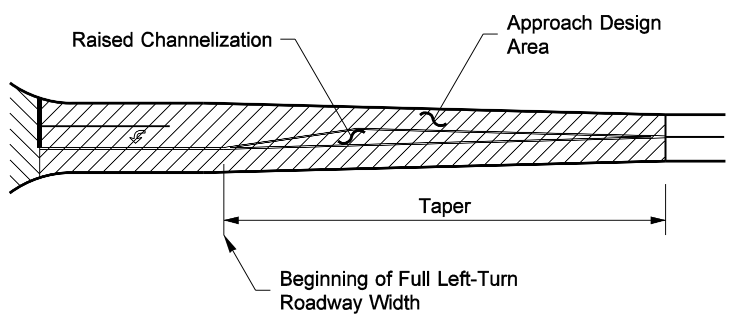
Alternate for Transitions to Two-Way Left-Turn Lanes



Alternate for Long Storage Lanes



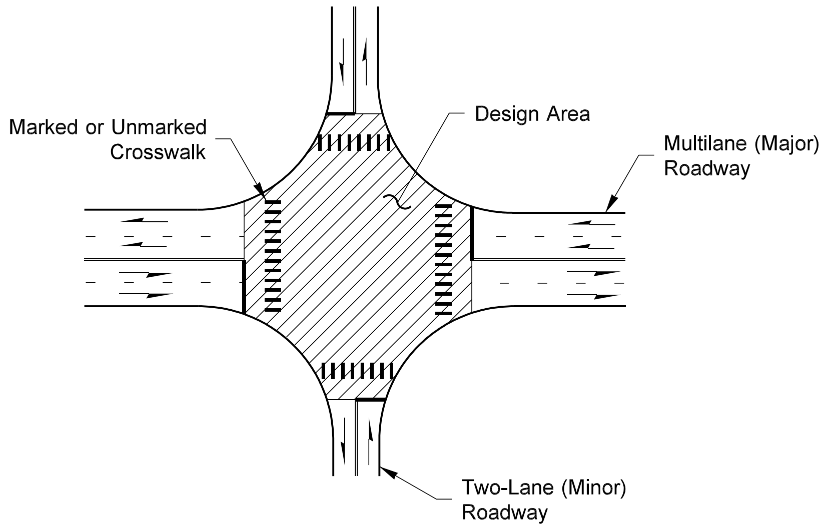
Unmarked Crosswalk Detail



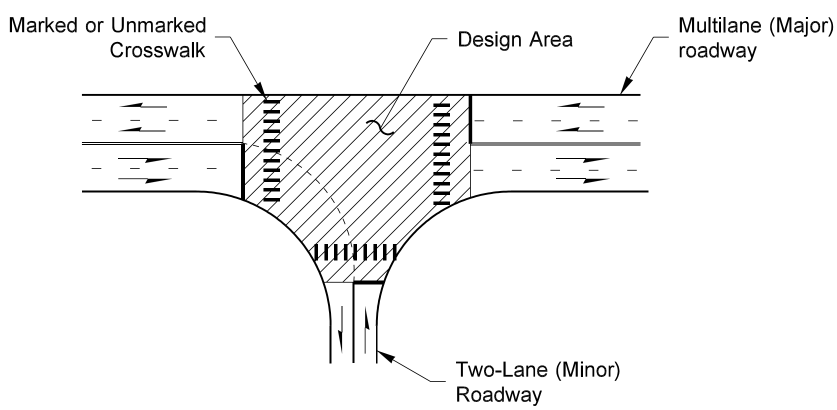
Alternate for Raised Channelization

Intersection With Left-Turn Lane Channelization

Figure 840-3b

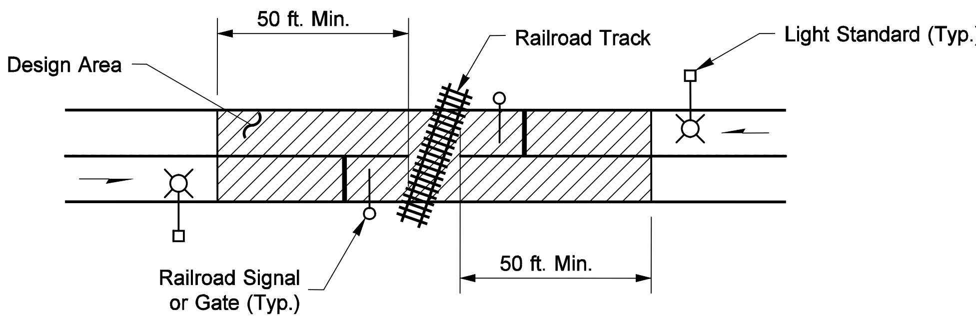


Four-Way Intersection
(Without left-turn channelization)

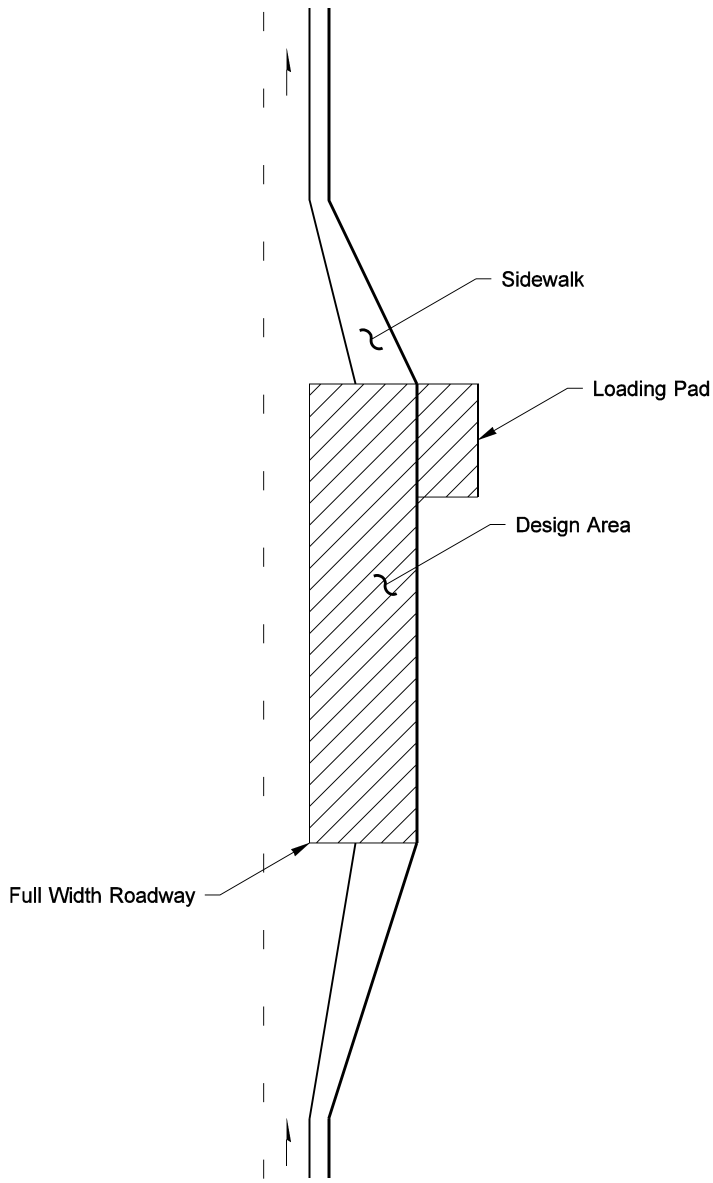


Major Tee Intersection
(Without left-turn channelization)

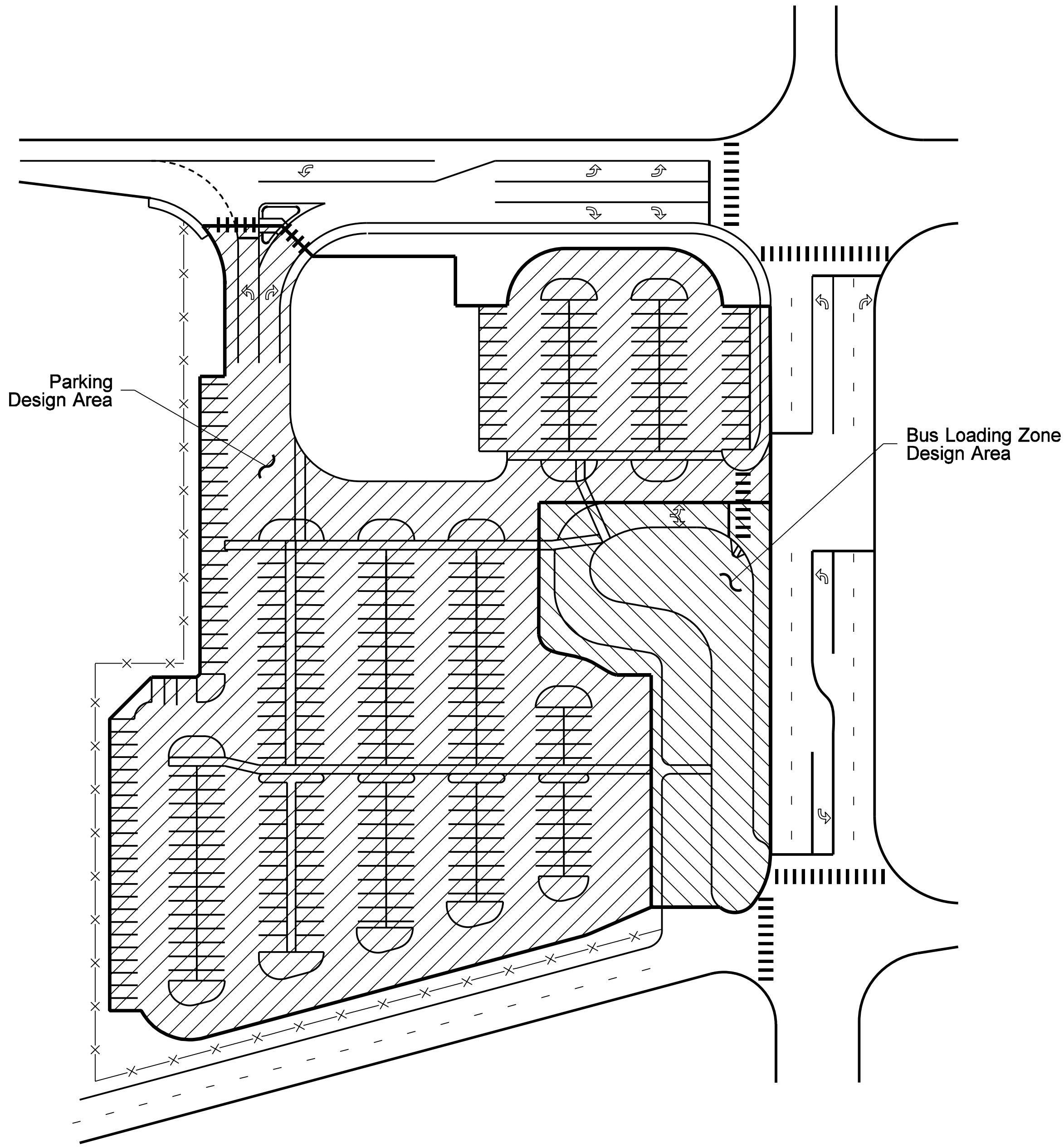
Intersection With Traffic Signals
Figure 840-4



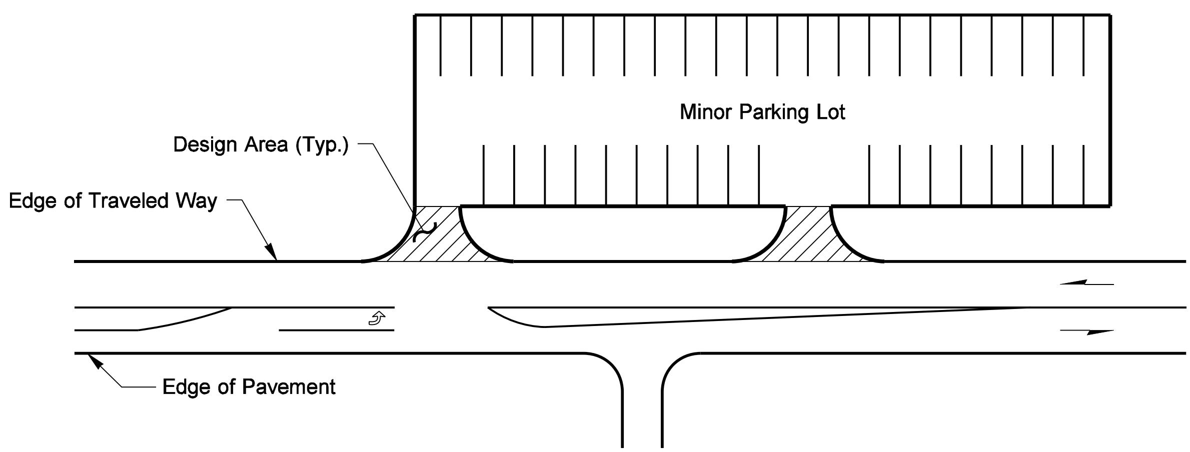
Railroad Crossing With Gates or Signals
Figure 840-5



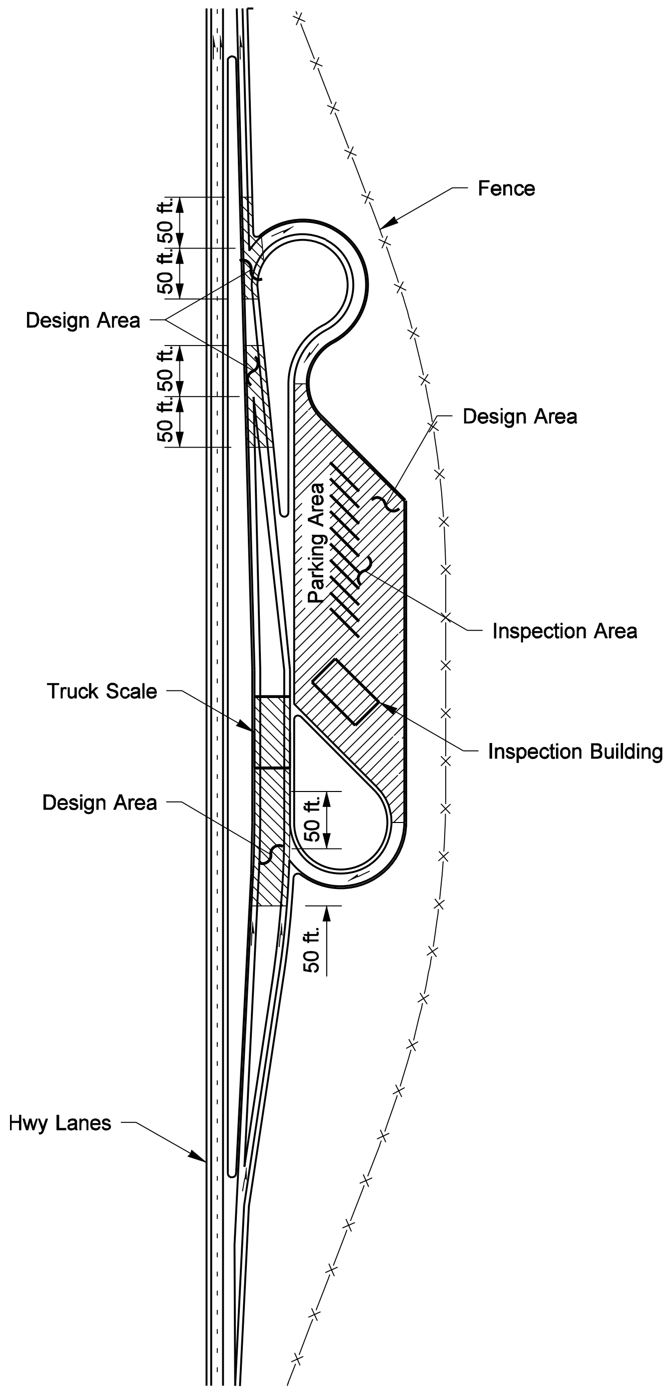
Transit Flyer Stop
Figure 840-6



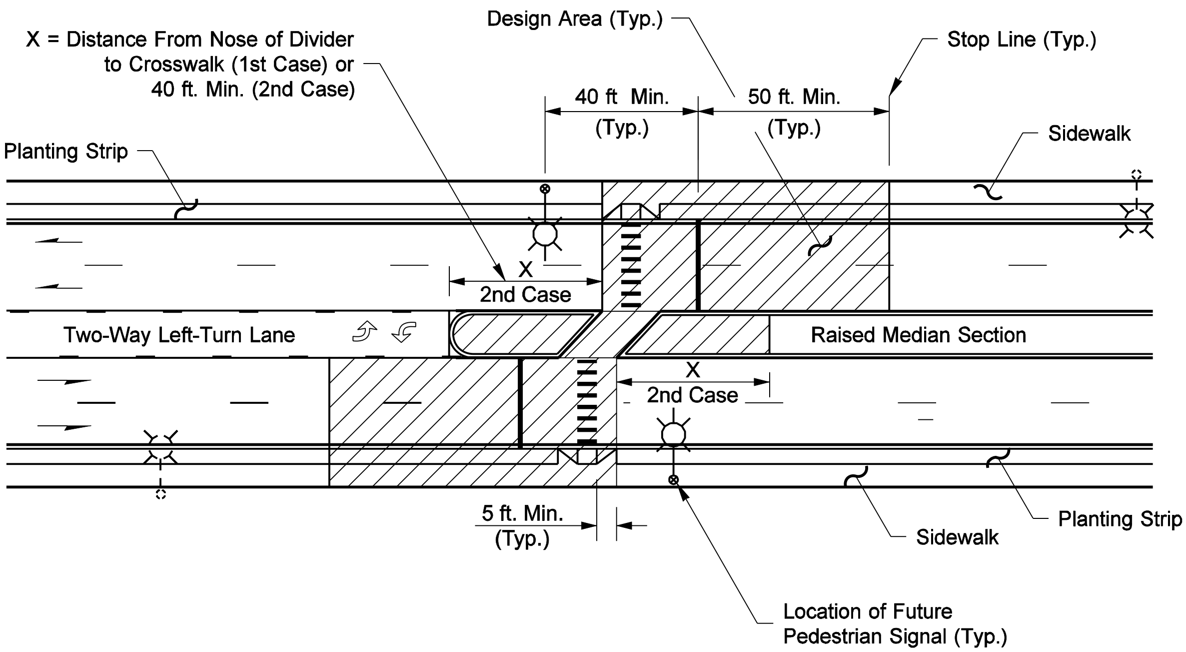
Major Parking Lot
Figure 840-7



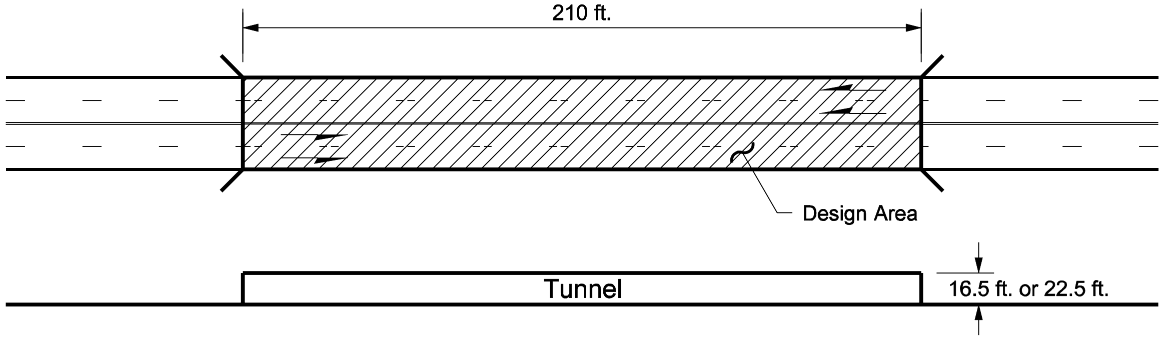
Minor Parking Lot
Figure 840-8



Truck Weigh Site
Figure 840-9



Midblock Crossing
Figure 840-10



If Tunnel Length Exceeds Stopping Sight Distance, Then It Is Classified as a Long Tunnel:

Example #1

- The stopping sight distance for a 30 mph roadway is 196.7’
- The tunnel length is 210’

196.7’ < 210’ – This would be a long tunnel.

Example #2

- The stopping sight distance for a 40 mph roadway is 300.6’
- The tunnel length is 210’

300.6’ > 210’ – This would be a short tunnel.

Determining Whether a Short Tunnel Needs Illumination:

Example #1

- Vertical clearance is 16.5’
- Tunnel length is 210’

If horizontal-to-vertical ratio is 10:1 or greater, then illuminate.

210’ divided by 16.5’ = 12.7:1 ratio – This ratio exceeds the short tunnel horizontal-to-vertical ratio of 10:1, so this tunnel would need illumination—OR–How long can the tunnel be at a given height before it needs to be illuminated?

Tunnel height x maximum ratio factor of short tunnel (10:1 or less).

16.5’ x 10 = 165’

165’ < 210’ – This tunnel would need illumination.

Example #2

- Vertical clearance is 22.5’
- Tunnel length is 210’

If horizontal-to-vertical ratio is 10:1 or greater, then illuminate.

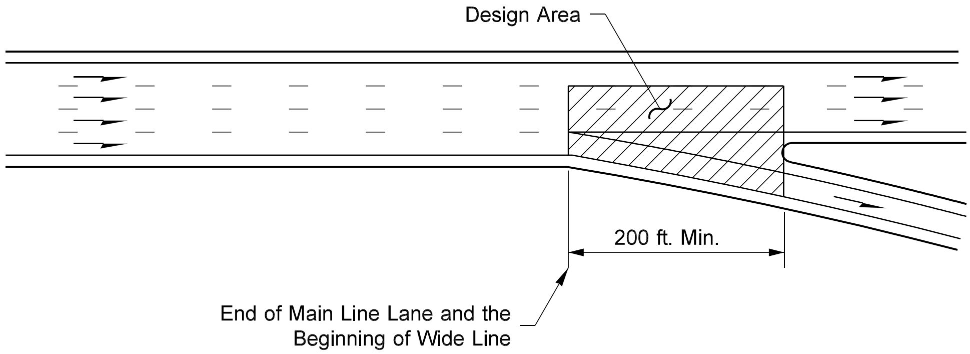
210’ divided by 22.5’ = 9.3:1 ratio – This ratio is less than the short tunnel horizontal-to-vertical ratio of 10:1, so this tunnel would not need illumination—OR—How long can the tunnel be at a given height before it needs to be illuminated?

Tunnel height x maximum ratio factor of short tunnel (10:1 or less).

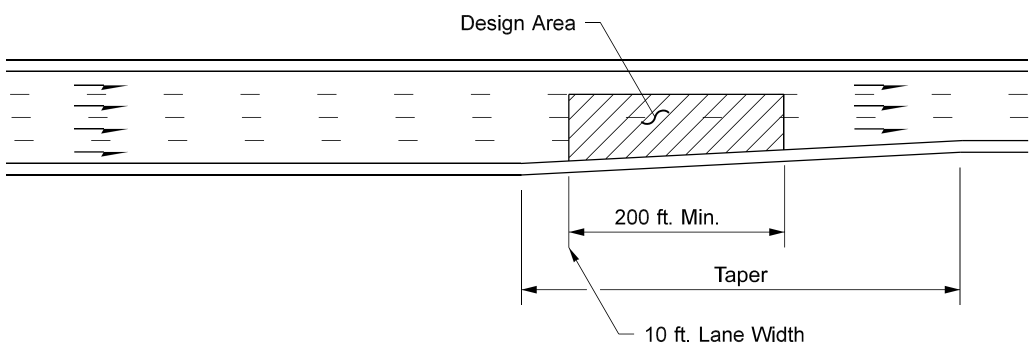
22.5’ x 10 = 225’

225’ > 210’ – This tunnel would not need illumination.

Tunnels
Figure 840-11

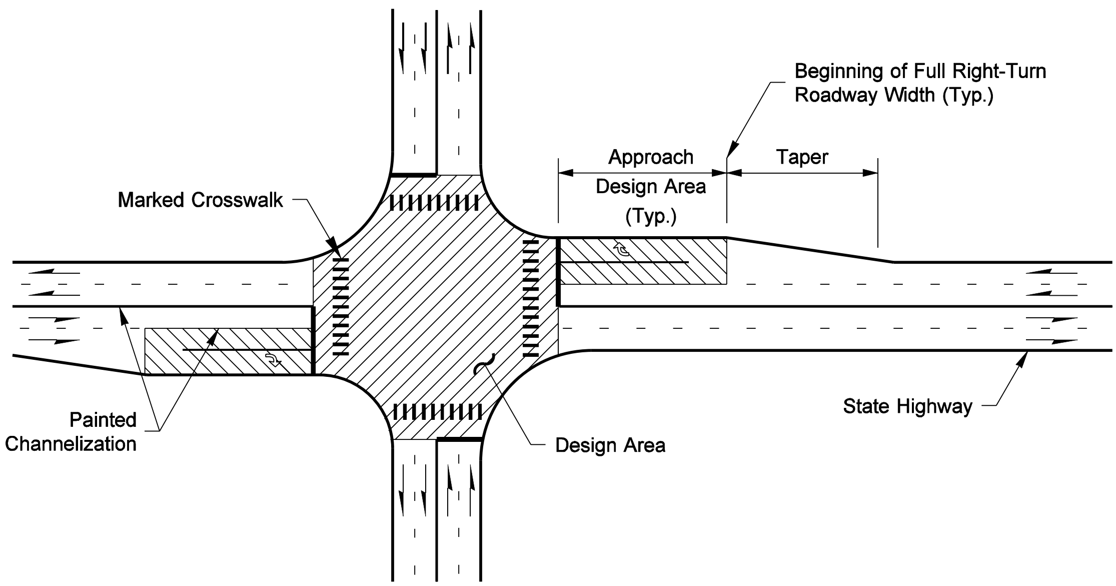


Main Line Lane Reduction
(The Design Area can be shifted up to 100 feet from the end of lane and the beginning of wide line)

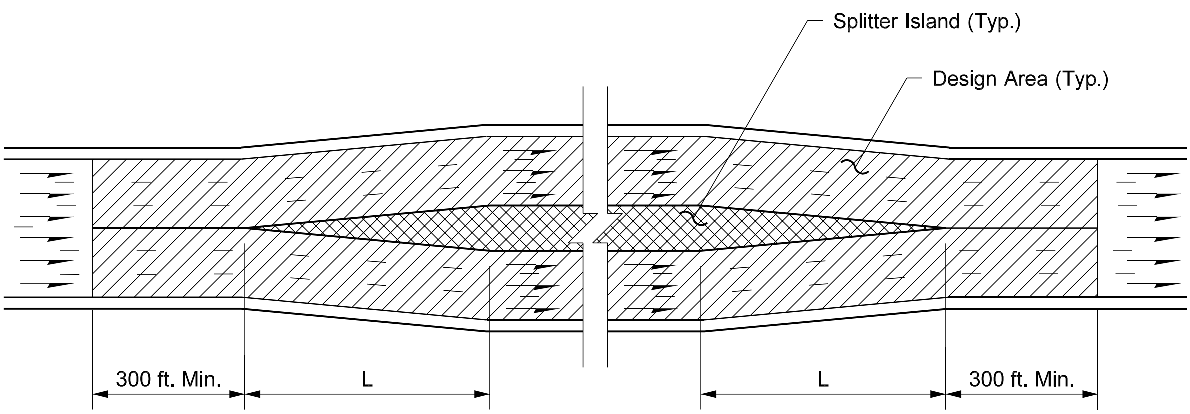


Lane Reduction

Lane Reductions
Figure 840-12



Intersection With Right-Turn Lane Channelization
Figure 840-13

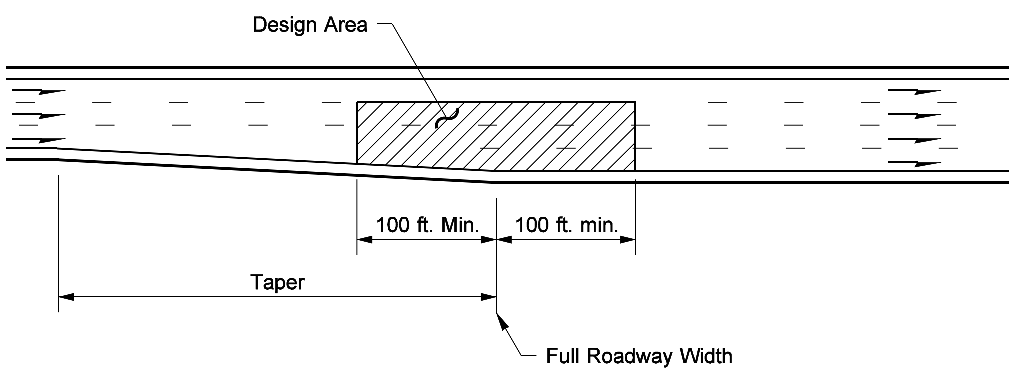


For speeds 45 mph or more: L = WS
For speeds less than 45 mph: L = WS/60

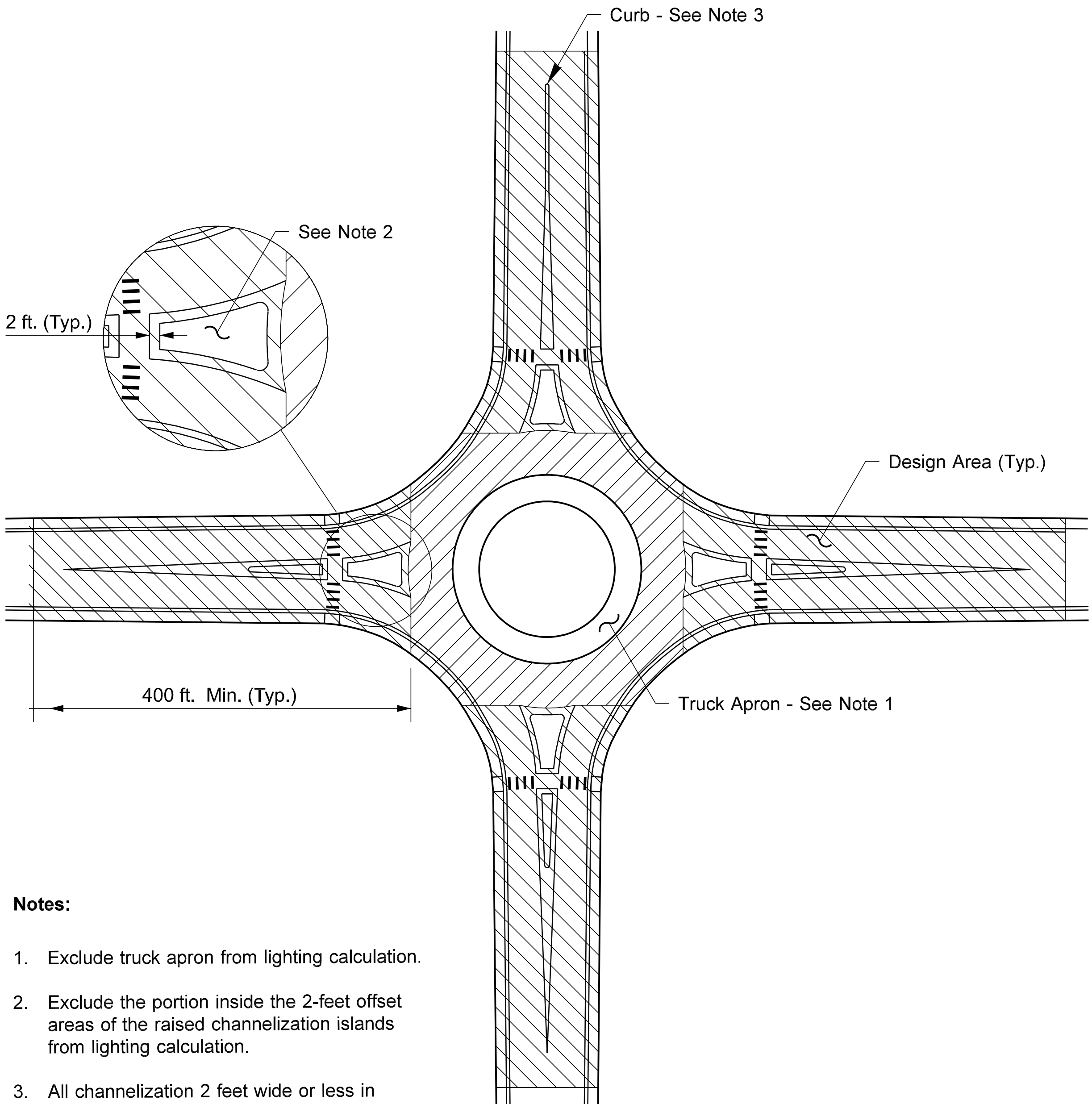
L = Taper length in feet
W = Width of offset in feet
S = Posted speed

For temporary Work Zone Plan applications, a site-specific Traffic Control Plan is required. Refer to Chapters 710 and 720 for traffic barrier and attenuator information, Chapter 810 for Work Zone information, and Chapter 820 for signing information.

Traffic Split Around an Obstruction – Same Direction
Figure 840-14



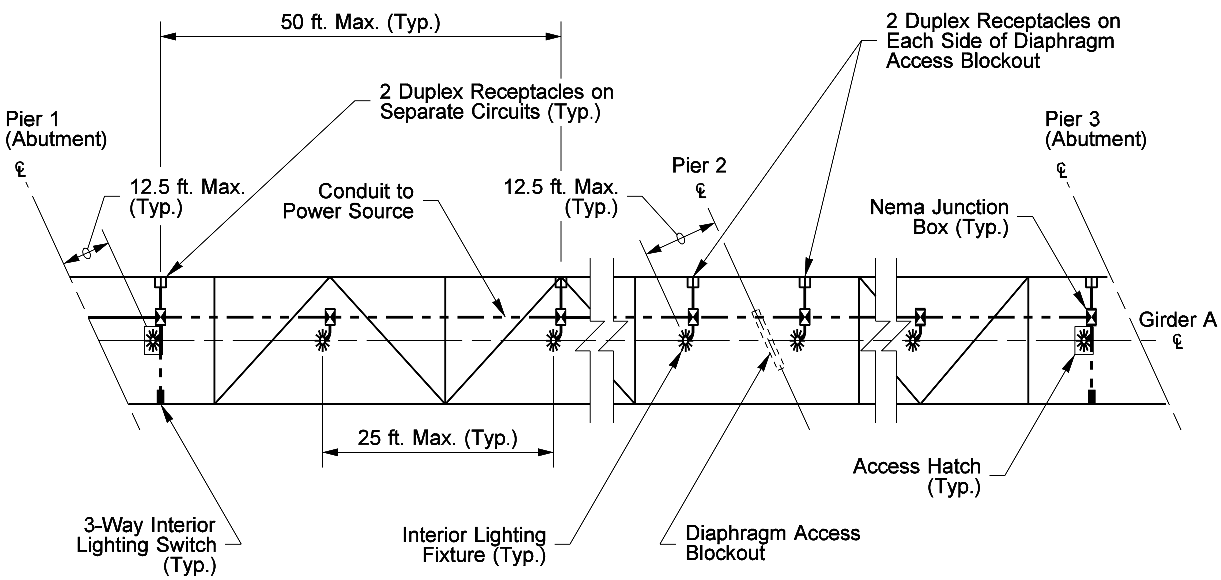
Add Lane
Figure 840-15



Notes:

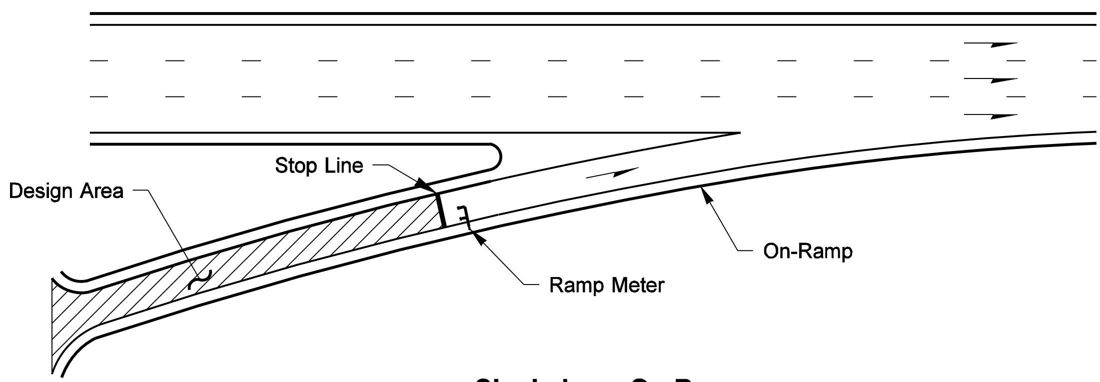
1. Exclude truck apron from lighting calculation.
2. Exclude the portion inside the 2-feet offset areas of the raised channelization islands from lighting calculation.
3. All channelization 2 feet wide or less in Design Area to be included in lighting calculation.

Roundabout
Figure 840-16

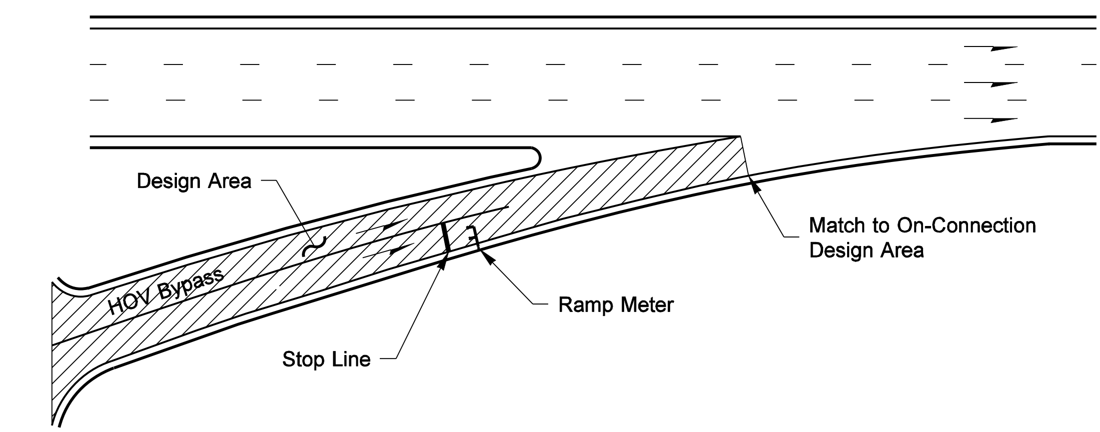


Bridge Inspection Lighting System

Figure 840-17

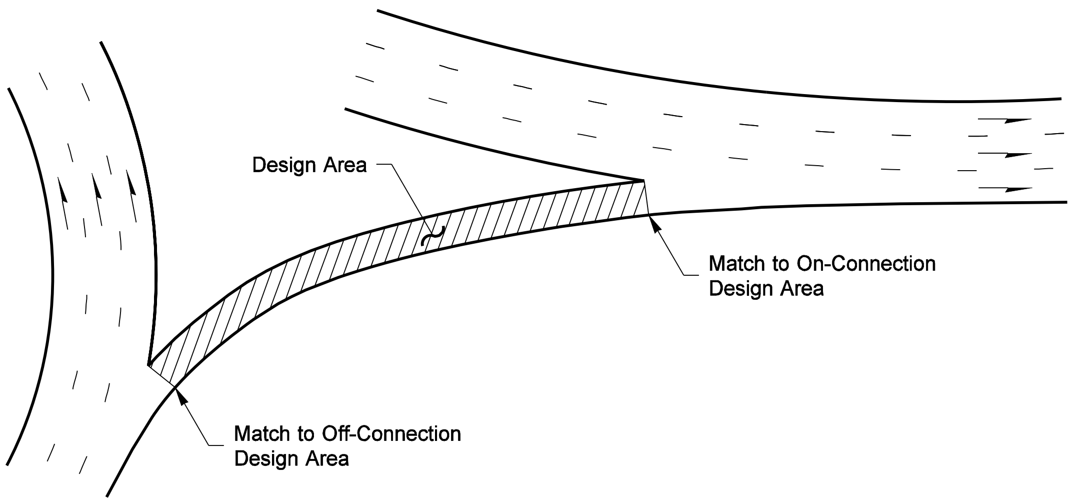


Single-Lane On-Ramp

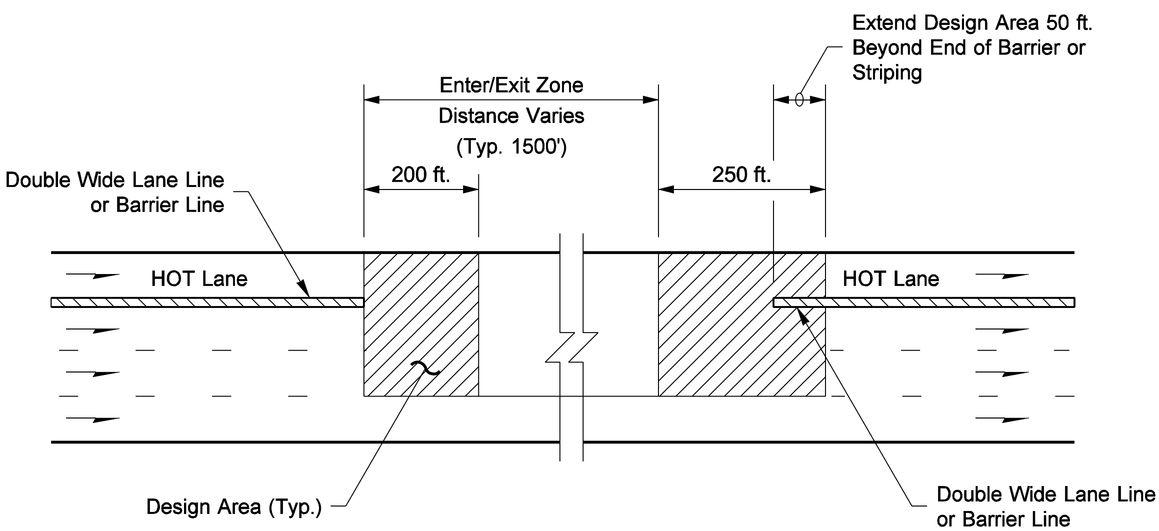


Two or More Lanes

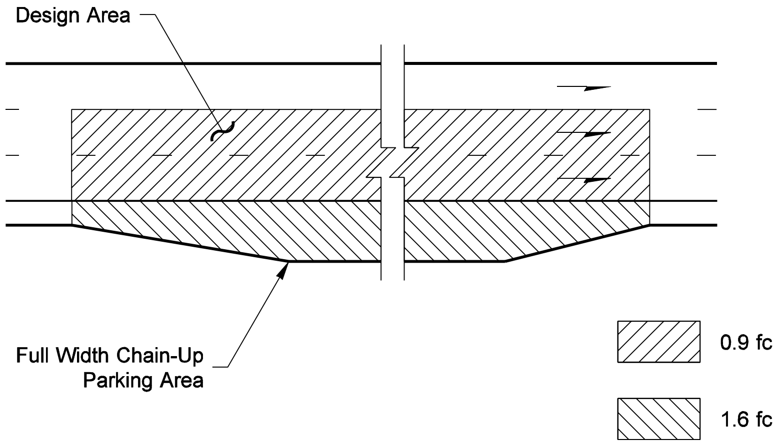
Ramp With Ramp Meter
Figure 840-18



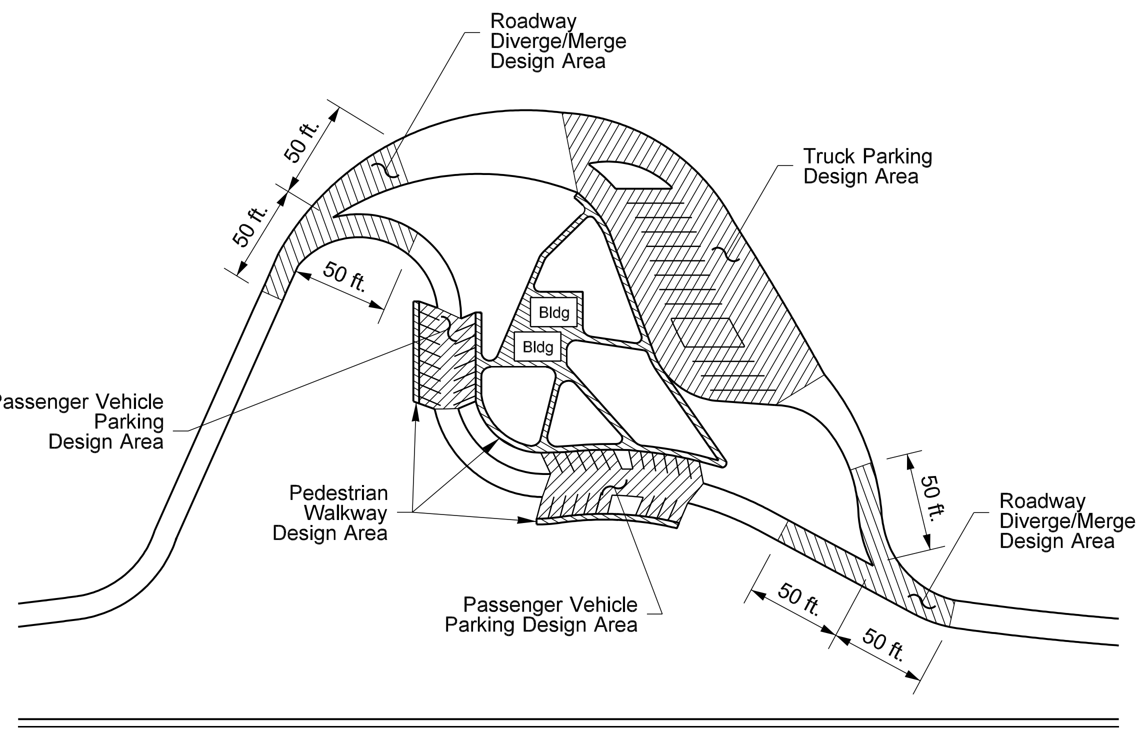
Freeway-to-Freeway Ramp Connection
Figure 840-19



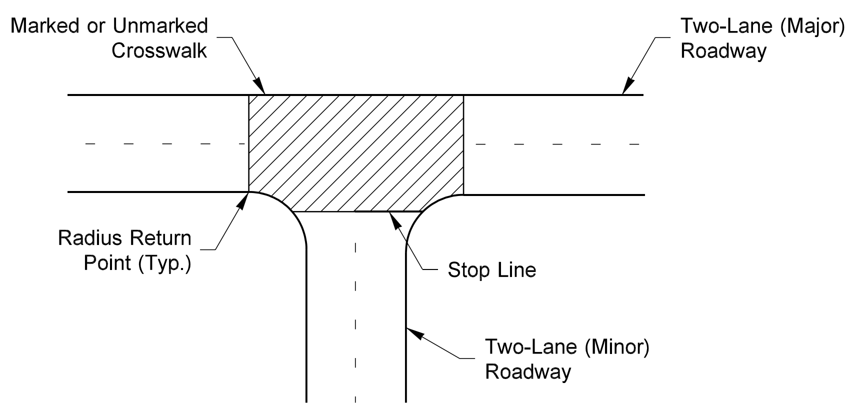
HOT (High Occupancy Toll) Lane Enter/Exit Zone
Figure 840-20



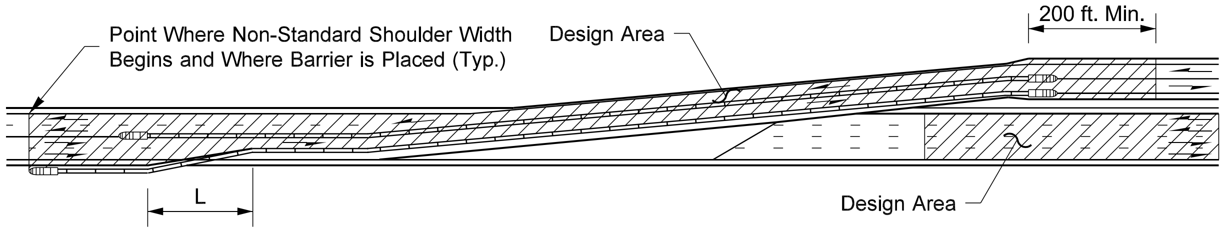
Chain-Up Parking Area
Figure 840-21



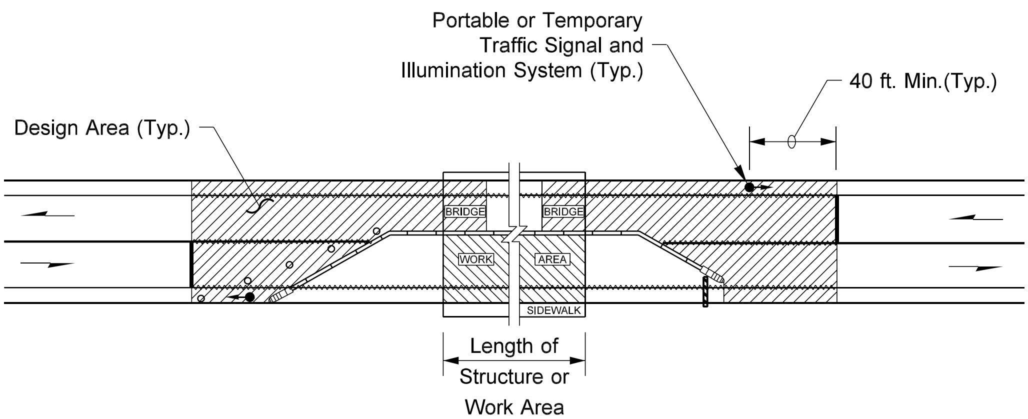
Rest Area
Figure 840-22



Intersection Without Channelization
Figure 840-23



Detour Traffic



Lane Closure With Barrier & Signals Without Flaggers or Spotters
(One Direction Closure Shown/Other Direction Closure Typical)

For temporary Work Zone Plan applications, a site-specific Traffic Control Plan is required.
Refer to Chapters 710 and 720 for traffic barrier and attenuator information,
Chapter 810 for Work Zone information, and Chapter 820 for signing information.
Refer to MUTCD Typical Application 12 for additional details.

Construction Work Zone and Detour
Figure 840-24

Light Level and Uniformity Ratio Chart					
Highway Design Class	Minimum Average Maintained Horizontal Light Level(2)			Maximum Uniformity Ratio(6)	Maximum Veiling Luminance(7)
	Pedestrian/Area Classification				
	High (footcandles)	Medium (footcandles)	Low (footcandles)		
Highways With Full Access Control(1)					
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	3:1	0.3:1
Ramp Intersections	0.9	0.9	0.9	3:1	0.3:1
Principal Arterials(3)					
Main Line	1.6	1.2	0.6	3:1	0.3:1
Intersections	1.6	1.2	0.9	3:1	0.3:1
Minor Arterials					
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
Collectors					
Main Line	1.1	0.8	0.6	4:1	0.3:1
Intersections	1.1	1.0	0.9	4:1	0.3:1
Construction Lanes and Detours	1.0	1.0	1.0	3:1	0.3:1
Major Parking Lots/ Rest Areas(5)	0.8	0.8	0.8	3:1	0.3:1
Vehicle Inspection Areas	2.0	2.0	2.0	3:1	0.3:1
Walkways & Bicycle Trails	0.8	0.8	0.8	3:1	0.3:1
Weigh Scales	0.8	0.8	0.8	3:1	0.3:1
Transit Stops(4)	2.0	2.0	2.0	NA(8)	0.3:1
Midblock Ped X-ing	2.0	2.0	2.0	3:1	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 840.06(6).)
(5) Includes illumination at ramp on and off connections.
(6) Minimum Average Maintained Light Level / Minimum Light Level = Maximum Uniformity Ratio.
(7) Maximum Veiling Luminance / Average Luminance = Maximum Veiling Luminance Ratio.
(8) The Maximum Uniformity Ratio is 3:1 when more than one light standard is justified.

Light Levels and Uniformity Ratios
Figure 840-25

940.01 General

The primary purpose of an interchange is to eliminate conflicts caused by vehicle crossings and to minimize conflicting left-turn movements. Interchanges are provided on all Interstate highways, freeways, other routes on which full access control is required, and at other locations where traffic cannot be controlled safely and efficiently by intersections at grade.

See the following chapters for additional information:

Chapter	Subject
640	Ramp Sections
641	Turning Widths
642	Superelevation
910	Intersections
1050	HOV Lanes
1055	HOV Direct Access Connections
1420	Access Control
1425	Interchange Justification Report
1430	Limited Access

940.02 References

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

Plans Preparation Manual, M 22-31, WSDOT

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

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

A Policy on Design Standards - Interstate System, 1991, AASHTO

Highway Capacity Manual (Special Report 209), Transportation Research Board

Procedure for Analysis and Design of Weaving Sections, A User's Guide, October 1985, Jack E. Leisch

940.03 Definitions

auxiliary lane The portion of the roadway adjoining the traveled way for parking, speed change, turning, storage for turning, weaving, truck climbing, passing, and other purposes supplementary to through traffic movement

basic number of lanes The minimum number of general purpose lanes designated and maintained over a significant length of highway.

collector distributor road (C-D road) A parallel roadway designed to remove weaving from the main line and to reduce the number of main line entrances and exits.

decision sight distance The sight distance required for a driver to detect an unexpected or difficult-to-perceive information source or hazard, interpret the information, recognize the hazard, select an appropriate maneuver, and complete it safely and efficiently.

frontage road An auxiliary road that is a local road or street located on the side of a highway for service to abutting properties and adjacent areas, and for control of access.

gore The area downstream from the intersection of the shoulders of the main line and exit ramp. Although generally 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.

intersection at grade The general area where a state highway or ramp terminal is met or crossed at a common grade or elevation by another state highway, a county road, or a city street.

Interstate System A network of routes selected by the state and the FHWA under terms of the federal aid acts as being the most important to the development of a national transportation system. The Interstate System is part of the principal arterial system.

lane A strip of roadway used for a single line of vehicles.

median The portion of a divided highway separating the traveled ways for traffic in opposite directions.

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.

painted nose The point where the main line and ramp lanes separate.

physical nose The point, upstream of the gore, with a separation between the roadways of 16 to 22 ft. See Figures 940-11a and 11b.

ramp A short roadway connecting a main lane of a freeway with another facility for vehicular use such as a local road or another freeway.

ramp connection The pavement at the end of a ramp, connecting it to a main lane of a freeway.

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 The end of a ramp at a local road.

roadway The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways.

sight distance The length of highway visible to the driver.

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 permitted) use by bicyclists and pedestrians.

stopping sight distance The sight distance required to detect a hazard and safely stop a vehicle traveling at design speed.

traffic 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.

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.

940.04 Interchange Design

(1) General

All freeway exits and entrances, except HOV direct access connections, are to connect on the right of through traffic. Deviations from this requirement 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 1055.

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.

Few complications will be 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. The economic and operational effects of locating traffic interchanges along a freeway through a community requires more careful consideration, particularly with respect to local access, to provide the best local service possible without reducing the capacity of the major route or routes.

Where freeway to freeway interchanges are involved, do not provide ramps for local access unless they can be added conveniently and without detriment to safety or reduction of ramp and through-roadway capacity. When exchange of traffic between freeways is the basic function and local access is prohibited by access control restrictions or traffic volume, it may be necessary to provide separate interchanges for local service.

Chapter 1020 Bicycle Facilities

1020.01 General

The Washington State Department of Transportation (WSDOT) encourages bicycle use on its facilities, except where prohibited by law. Bicycle facilities or improvements for bicycle transportation are included in the project development and highway programming processes.

This chapter is to serve as a guide for designing the most useful, cost-effective, and safe bicycle facilities when the design matrices (see Chapter 325) indicate full design level for bicycle and pedestrian design elements. These guidelines apply to normal situations encountered during project development. Unique design problems are resolved on a project-by-project basis using guidance from the region's Bicycle Coordinator or bicycle and pedestrian expert.

State law (RCW 46.61.710) prohibits the operation of mopeds on facilities specifically designed for bicyclists, pedestrians, and equestrians. Mopeds and other motorized personal assistive mobility devices (excluding power wheelchairs) are not considered in the design process for the purposes of this chapter.

In general, do not mix equestrian and bicycle traffic on a shared-use path. Consider designing an equestrian trail that is separate from the shared-use path in common equestrian corridors.

1020.02 References

Federal/State Laws and Codes

Americans with Disabilities Act of 1990 (ADA)

23 Code of Federal Regulations (CFR) Part 652, Pedestrian and Bicycle Accommodations and Projects

Revised Code of Washington (RCW), Chapter 35.75, Streets – Bicycles – Paths

Chapter 46.04 RCW, Definitions

Chapter 46.61 RCW, Rules of the Road

RCW 46.61.710, Mopeds, electric-assisted bicycles – General requirements and operation

RCW 47.26.300, Bicycle routes – Legislative declaration

Washington Administrative Code (WAC) Chapter 468-95, "Manual on uniform traffic control devices for streets and highways" (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Design Guidance

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by WAC 468-95

Selecting Roadway Design Treatments to Accommodate Bicycles, USDOT, Federal Highway Administration (FHWA), 1994

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT http://www.wsdot.wa.gov/eesc/design/designstandards/

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005 http://www.wsdot.wa.gov/eesc/design/Urban/Default.htm

Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

Designing Sidewalks and Trails for Access, Part I of II, FHWA, 2001

Guide for the Development of Bicycle Facilities, AASHTO, 1999

1020.03 Definitions

bicycle Every 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 are used or have a high potential for use by bicyclists or that are 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.

shared roadway A roadway that is open to both bicycle and motor vehicle travel. This may be an existing roadway, a street with wide curb lanes, or a road with paved shoulders.

signed shared roadway A shared roadway that has been designated by signing as a route for bicycle use.

shared-use or multiuse 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. It is designed and built primarily for use by bicycles, but is also used by pedestrians, joggers, skaters, wheelchair users (both nonmotorized and motorized), equestrians, and other nonmotorized users.

wye (Y) connection An intersecting one-way roadway, intersecting at an angle less than 60°, in the general form of a "Y."

1020.04 Facility Selection

(1) Facility Location

Provide bicycle facilities on routes that have been identified as a local, state, or regional significant bike route. Fill gaps in the existing network of bicycle facilities when the opportunity is available. For all other roadways, provide full design level shoulders for bicycle needs, unless:

- Bicyclists are prohibited by law from using the facility.
- The cost is excessively disproportionate to the need or probable use.
- Other factors indicate there is no need.

For additional information, see *Understanding Flexibility in Transportation Design – Washington*.

(2) Selection of the Type of Facility

Selection of the facility type includes consideration of community needs and safe and efficient bicycle travel. A generalized method of assessing the type of bicycle facility needed can be found in Figure 1020-1.

Roadway Classification, Land Use, Speed, and ADT	Facility Recommendation
Rural and suburban highways and streets (less than 4 dwelling units per acre), speeds above 25 mph, and ADT above 2000.	Full design level shoulder (see Chapter 440) on both sides (4 ft minimum width), or shared-use path.
Major arterial in residential area; school zones; streets in commercial or industrial areas.	Bike lanes on both sides (see 1020.07), or shared-use path.
Local street in residential area where speed is 25 mph or less, or ADT is 2000 or less. Rural highways and streets where sight distance is adequate for passing, and speed is 25 mph or less or ADT is 2000 of less. Collector or minor arterial where speed is 25 mph or less, or ADT is 2000 or less.	Shared roadway.

Bike Facility Selection
Figure 1020-1

An important consideration is route continuity. Change facility types at logical locations.
For additional information, see *Understanding Flexibility in Transportation Design – Washington*.

1020.05 Project Requirements

For urban bicycle mobility improvement projects (see Bike/Ped connectivity projects in the matrices, Chapter 325), apply the guidance in this chapter to the bicycle facility.

For highway design elements affected by the project, apply the appropriate design level from the matrices (see Chapter 325) and as found in the applicable chapters.

For highway design elements not affected by the project, no action is required.

1020.06 Shared-Use Path Design

When designing shared-use paths (see Figure 1020-2), accommodate all users and minimize conflicts. When equestrians are present, a separate bridle trail along a shared-use path is recommended to minimize conflicts with horses. Some common locations are along rivers, streams, ocean beachfronts, canals, utility rights of way, and abandoned railroad rights of way; within college campuses; and within and between parks. Another common application of shared-use paths is to close gaps in the bicycle network. There might also be situations where such facilities can be provided as part of planned developments.

Shared-use paths often provide recreational opportunities. They also serve to minimize motor vehicle interference by providing direct bicycle commute routes.

Shared-Use Path
Figure 1020-2

(1) Widths

The desirable width of a shared-use path is 12 feet. The minimum width is 10 feet. Use 12 to 14 feet when maintenance vehicles use a shared-use path as an access road for utilities. Use of 12- to 14-foot paths is recommended when there will be substantial use by bicyclists, or joggers, skaters, and pedestrians. Contact the region's Bicycle Coordinator for bicycle use information. (See Figures 1020-11a and 11b for additional information and cross sections.)

An existing path with a width of 8 feet may remain when all the following conditions apply:

- Bicycle traffic is expected to be low
- Pedestrian use is not expected to be more than occasional
- The horizontal and vertical alignment adequately provide safe and frequent passing opportunities
- Normal maintenance activities can be performed without damaging the pavement edge

For path width on structures, see 1020.06(14).

(2) Horizontal Clearance to Obstructions

The desirable horizontal clearance from the edge of pavement to an obstruction (such as bridge piers or guardrail) is at least 2 feet. Where this clearance cannot be obtained, install signs and pavement markings to warn bicyclists of the condition. (For pavement marking details, see the MUTCD and the Standard Plans.)

Where a shared-use path is adjacent to canals, ditches, fill slopes steeper than 3H:1V, or where hazards exist at the bottom of an embankment, consider a minimum 5-foot separation from the edge of the pavement. A physical barrier, such as dense shrubbery, railing, or chain link fence, is needed at the top of a high embankment. When barrier or railing is installed, see 1020.06(6).

(3) Vertical Clearance

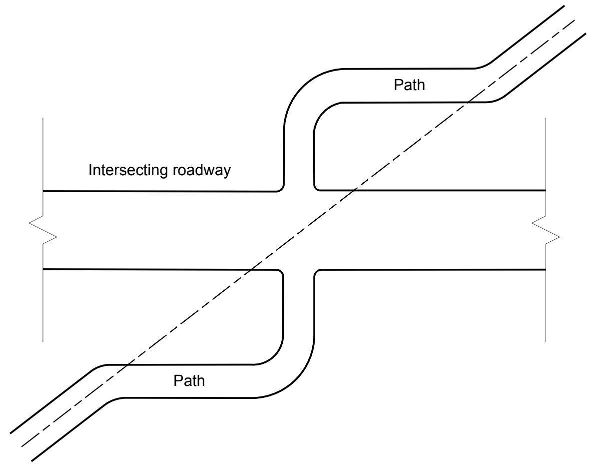
Provide a vertical clearance of 10 feet or more from bikeway pavement to overhead obstructions. The vertical clearance may be reduced to an 8-foot minimum, with justification. A 10-foot or higher vertical clearance is needed for the passage of equestrians and for maintenance and emergency vehicles.

(4) Intersections With Roadways

Shared-use path and roadway intersections must clearly define who has the right of way and provide adequate sight distance for all users. There are three types of shared-use path/roadway at-grade intersection crossings: adjacent path, midblock, and complex. Only at-grade adjacent and midblock crossings are addressed here. Complex intersections involve special designs that must be considered on a case-by-case basis. Contact the region's Bicycle Coordinator for assistance.

Adjacent path crossings are located adjacent to the at-grade intersections of two roadways. These crossings are normally placed with pedestrian crossings, where motorists can be expected to stop. If alternate intersection locations for a shared-use path are available, select the one with the greatest sight distance.

Midblock crossings are located between roadway intersections. They are the least complex of the crossing types. When possible, locate the path crossings far enough away from intersections to minimize conflicts between the path crossing and the intersection motor vehicle traffic. A 90° crossing is preferable; however, a 75° angle is acceptable. A 45° angle is the minimum acceptable to minimize right of way requirements. A diagonal midblock crossing can be altered as shown in Figure 1020-3. (See the MUTCD and the Standard Plans for signing and pavement marking requirements, and Chapter 1025 for pedestrian and ADA requirements.)



Note: Path and highway signing and markings are given in the MUTCD and the Standard Plans.

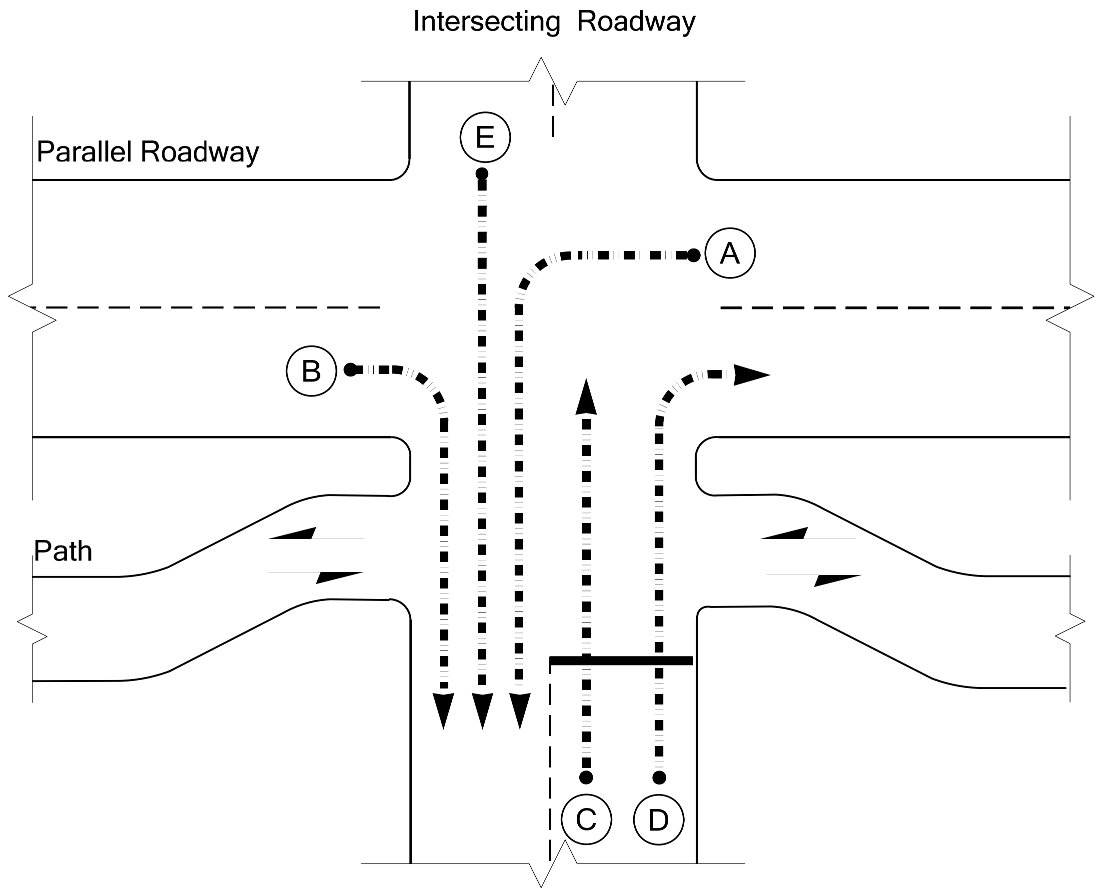
Typical Redesign of a Diagonal Midblock Crossing
Figure 1020-3

There are other considerations when designing midblock crossings, including traffic right of way assignments, traffic control devices, sight distances for both bicyclists and motor vehicle operators, refuge island use, access control, and pavement markings.

Adjacent path crossings occur where a path crosses an existing intersection of two roadways, a T intersection (including driveways), or a four-way intersection, as shown in Figure 1020-4. It is preferable to integrate this type of crossing close to an intersection so that motorists and path users recognize one another as intersecting traffic. The path user faces potential conflicts with motor vehicles turning left (A) and right (B) from the parallel roadway, and on the crossed roadway (C, D, and E).

Complex intersection crossings are all other types of path/roadway or driveway junctions. These include a variety of configurations where the path crosses directly through an existing intersection of two or more roadways and where there can be any number of motor vehicle turning movements.

Improvements to complex crossings must be considered on a case-by-case basis. Suggested improvements include: move the crossing, install a signal, change signalization timing, or provide a refuge island and make a two-step crossing for path users.



Note: Signing requirements are given in the MUTCD and the Standard Plans.

Adjacent Shared-Use Path Intersection
Figure 1020-4

The major road might be either the parallel or the crossed roadway. Important elements that greatly affect the design of these crossings are traffic right of way assignments, traffic control devices, and the separation distance between path and roadway.

Other roadway/path intersection design considerations include:

- **Traffic Signals/Stop Signs.** Determine the need for traffic control devices at all path/roadway intersections by using MUTCD warrants and engineering judgment. Bicycles are considered vehicles in Washington State, and bicycle path traffic can be classified as vehicular traffic for MUTCD warrants. Ensure that traffic signal timing is set for bicycle speeds.
- **Signal Actuation Mechanisms.** Place the manually operated signal button in a location that complies with ADA requirements. For additional information, see Chapters 850 and 1025. A detector loop in the path pavement may be provided in addition to the manually operated signal button. Consider MUTCD bicycle detector symbol pavement marking when a detector loop is placed in the path.
- **Signing.** Sign type, size, and location must be in accordance with the MUTCD. Place path stop or yield signs as close to the intended stopping point as possible. Do not place the shared-use path signs where they will confuse motorists or place roadway signs where they will confuse bicyclists. For additional information on signing, see the MUTCD and Chapter 820.

- **Approach Treatments.** Design shared-use path and roadway intersections with flat grades and adequate sight distances. Provide adequate advance warning signs and pavement markings (see the MUTCD) that alert and direct bicyclists to yield or stop before reaching the intersection, as appropriate, especially on downgrades. Provide unpaved shared-use paths with paved aprons extending a minimum of 10 feet from the paved road surfaces. Do not use speed bumps or other similar surface obstructions intended to cause bicyclists to slow down.
- **Sight Distance.** Sight distance is a principal element of roadway and path intersection design. At a minimum, provide stopping sight distance for both the roadway and the path at the crossing. Decision sight distance is preferred for the roadway traffic. (See Chapter 650 for stopping sight distance for the roadway and 1020.06(9) for shared-use path stopping sight distance.)
- **Transition Zones.** Integrate the shared-use path into the roadway where the path terminates. Design these terminals to transition the bicycle traffic into a safe merging or diverging condition. Appropriate signing is necessary to warn and direct both bicyclists and motorists.
- **Curb Ramp Widths.** Design curb ramps with a width equal to the shared-use path width. Curb ramps and barrier-free passageways are to provide a smooth transition between the shared-use path and the roadway. Consider a 5-foot radius or flare to facilitate right turns for bicycles. This same consideration applies to the intersections of two shared-use paths. Curb ramps at path/roadway intersections must meet the requirements for sidewalk curb ramp at a crosswalk. For design requirements, see Chapter 1025, and for curb ramp treatments at roundabouts, see Chapter 915.
- **Refuge Islands.** Consider refuge islands when one or more of the following applies: high motor vehicle traffic volume and speeds; wide roadways; or the crossing will be used by the elderly, children, the disabled, or other slow-moving users. (See Figure 1020-12 for details.)

(5) At-Grade Railroad Crossings

Whenever a bikeway crosses railroad tracks, continue the crossing at least as wide as the approach bikeway. Use special construction and materials to keep the flangeway depth and width to a minimum. Wherever possible, design the crossing at right angles to the rails. (See Figure 1020-13.) For on-street bikeways where a skew is unavoidable, widen the shoulder (or bike lane) to permit bicyclists to cross at right angles. (See Figure 1020-13.)

For signing and pavement marking for a shared-use path crossing a railroad track, see the MUTCD and the Standard Plans.

(6) Separation, Barrier, and Fencing

When possible, provide a wide separation between a shared-use path and the roadway's traveled way where the path is located near a roadway. (See 1020.06(2).)

If the shared-use path is inside the Design Clear Zone, provide a concrete traffic barrier. (See Figure 1020-11b.) A concrete barrier presents less of a hazard to bicyclists than beam guardrail and is preferred. However, if the edge of the path is farther than 10 feet from the barrier, a beam guardrail is also acceptable. For Design Clear Zone guidance, see Chapter 700, and for barrier location and deflection, see Chapter 710.

All barrier and railing adjacent to a shared-use path must meet the requirements for pedestrians. (See Chapter 1025.) When the edge of the path is within 5 feet of a barrier or railing, provide a taller barrier (a minimum of 42 inches) to reduce the potential for bicyclists falling over the barrier. For barrier between the path and a roadway, if the roadway shoulder is 6 feet or wider, additional barrier height is not required. The 42-inch height applies to railing required per 1020.06(2). (See Figures 1020-14a and 14b.)

Where the path is to be located next to a limited access facility, provide an access barrier. Where space permits, provide fencing as described in Chapter 1460, in conjunction with a normal height barrier. Otherwise, provide a taller barrier (54-inch minimum height).

Fencing between a shared-use path and adjacent property may also be necessary to restrict access to the private property. Discuss the need for fencing and the appropriate height with the property owners during project design.

On structures, the bridge railing type and height are part of the structure design. Contact the Headquarters (HQ) Bridge and Structures Office for additional information. (See Chapter 1120 for further considerations.)

Evaluate the impacts of barriers and fencing on sight distances.

(7) Design Speed

The design speed for a shared-use path is dependent on the expected conditions of use and on the terrain. Design the path to encourage bicycles to maintain speeds at or below the speeds shown in Figure 1025-5. Higher speeds are inappropriate in a mixed-use setting.

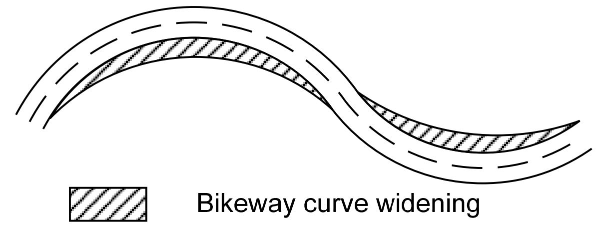
Conditions	Design Speed (mph)	Min. Curve Radius (ft)
Open country (level or rolling); shared-use path in urban areas	20	90
Long downgrades (steeper than 4% and longer than 500 ft)	30	260

Bicycle Design Speeds
Figure 1020-5

(8) Horizontal Alignment and Cross Section

On tangent path sections, the recommended cross slope is 2%. The maximum superelevation is also 2%. A greater superelevation can cause maneuvering difficulties for adult tricyclists and wheelchair users. (See Figures 1020-11a and 11b.)

When radii less than given in Figure 1020-5 are required, increase pavement width by up to 4 feet on the inside of a curve to compensate for bicyclist lean. (See Figure 1020-6.) For sharp curves on two-way facilities, consider providing centerline pavement markings.



Radius (ft)	Additional Pavement Width (ft)
0 – 25	4
25 – 50	3
50 – 75	2
75 – 100	1
100 +	0

Bikeway Curve Widening
Figure 1020-6

(9) Stopping Sight Distance

Figure 1020-15 gives the minimum stopping sight distances for various design speeds and grades.

(10) Sight Distance on Crest Vertical Curves

Figure 1020-16 gives the minimum lengths of crest vertical curves for varying design speeds. The values are based on a 4.5-foot eye height for the bicyclist and a 0-foot height for the object (roadway surface).

(11) Sight Distance on Horizontal Curves

Figure 1020-17 indicates the minimum clearances to line-of-sight obstructions for sight distance on horizontal curves. Calculate the required lateral clearance based on the sum of stopping sight distances from Figure 1020-15 for bicyclists traveling in both directions and the proposed horizontal curve radius. Where this minimum clearance cannot be obtained, provide curve warning signs and use centerline pavement markings in accordance with the MUTCD.

(12) Grades

Some pedestrians, people with disabilities, and bicyclists are unable to negotiate long, steep grades. The maximum grade recommended for a shared-use path is 5%. It is desirable that sustained grades (800 feet or longer) be limited to 2% to accommodate a wide range of users. When shared-use paths must be made steeper, minimize the lengths of segments greater then 5% and keep them free of other access barriers. It is desirable that the total running slope not exceed 8.3% for 30% or more of the path. A shared-use path must meet the grade and resting area requirements for a sidewalk on an independent alignment. (See Chapter 1025.)

Grades steeper than 3% might not be feasible for shared-use paths with crushed stone or other unpaved surfaces for both bicycle handling and traction, and for drainage and erosion reasons.

Options to mitigate steep grades are:

- When using a steeper grade, add an additional 4 to 6 feet of width to permit slower-speed maneuverability and to provide a place where bicyclists can dismount and walk.
- Use signing in accordance with the MUTCD to alert bicyclists of the steep downgrades and the need to control their speeds.
- Provide adequate stopping sight distance.
- Increase horizontal path side clearances (4 to 6 feet is recommended), and provide adequate recovery area or railing.

(13) Pavement Structural Section

Design the pavement structural section of a shared-use path in the same manner as a highway, considering the quality of the subgrade and the anticipated loads on the bikeway. Design loads will normally be from maintenance and emergency vehicles. Provide a smooth pavement surface to address safety and comfort issues.

Unless otherwise justified, use hot mix asphalt (HMA) pavement or Portland cement concrete pavement in the construction of a shared-use path. The desirable minimum HMA thickness is 0.20 feet. Design the final pavement structural section as recommended by the region's Materials Engineer.

Contact the HQ Materials Laboratory for determination of the subgrade R value.

R Value	Subsurfacing Thickness (ft)
< 40	0.35
40 to 65	0.25
> 65	0.20

R Values and Subsurfacing Needs
Figure 1020-7

(14) Structures

Structures intended to carry a shared-use path only are designed using pedestrian loads and emergency and maintenance vehicle loading for live loads. Provide the same minimum clear width as the approach paved shared-use path, plus the graded clear areas. (See Figures 1020-11a and 11b.)

Carrying full widths across all structures has two advantages:

- The clear width provides a minimum horizontal shy distance from the railing or barrier
- It provides needed maneuvering room to avoid pedestrians and other bicyclists

Undercrossings and tunnels require a minimum vertical clearance of 10 feet from the bikeway pavement to the structure. This allows access by emergency, patrol, and maintenance vehicles on the shared-use path.

Consult the region's Maintenance Office and the HQ Bridge Preservation Office to verify that the planned path width is adequate for their needs. If not, widen to their specifications.

Provide a smooth, nonskid surface for bicycles to traverse bridges with metal grid bridge decking. A sidewalk meeting the width requirement of a shared-use path may be used for a bicycle facility on a bridge with this type of decking when no other practical alternative exists, or signs may be placed instructing the bicyclist to dismount and walk for the length of the bridge.

Use bicycle-safe expansion joints for all decks with bicycle facilities.

On structures, the bridge railing type and height are part of the structure design. Contact the HQ Bridge and Structures Office for further information. (See Chapter 1120 for additional considerations.)

(15) Drainage

Sloping the pavement surface to one side usually simplifies longitudinal drainage design and surface construction, and is the preferred practice. (See 1020.06(8) for cross slope requirements.) Generally, surface drainage from the path will be adequately dissipated as it flows down the side slope. However, a shared-use path constructed on the side of a hill might require a drainage ditch on the uphill side to intercept the hillside drainage. Where necessary, install catch basins with drains to carry intercepted water under the path. (See Chapter 1210 for other drainage criteria.)

Locate drainage inlet grates and manhole covers off the pavement of shared-use paths. If manhole covers are needed on a path, install them to minimize the effect on bicyclists. Design manhole covers level with the surface of the path.

Drainage inlet grates on bicycle facilities must have openings narrow enough and short enough to ensure that bicycle tires will not drop into the grates. Replace existing grates that are not bicycle-safe with grates designed for bicycles (a WSDOT vaned grate, herringbone grate, or other grate with an opening perpendicular to the direction of travel, 4 inches or less center to center).

(16) Bollards

Install bollards at entrances to shared-use paths to prevent motor vehicles from entering. When locating such installations, ensure that barriers are well marked and visible to bicyclists, day or night. Do not use bollards to divert or slow path traffic. (For bollard designs, see the Standard Plans, and for pavement markings at bollards, see the MUTCD.)

A single bollard installed in the middle of the path reduces a user's confusion. When multiple posts are required, use a 5-foot spacing to permit passage of bicycle-towed trailers, wheelchairs, and adult tricycles, and to ensure adequate room for safe bicycle passage without dismounting. Use removable bollards (Bollard Type 1) to permit access by emergency and service vehicles. Ensure that the bollard sleeve is flush with the pavement surface. Nonremovable bollards (Bollard Type 2) may be used where access is not required.

(17) Signing and Pavement Markings

For guidance and directions regarding signing and pavement markings on bicycle facilities, see the MUTCD. Consider centerline markings to separate opposing directions of travel where there is heavy use, on curves where there is restricted sight distance, and where the path is unlighted and nighttime riding is expected. An edge line helps to delineate the path if nighttime use is expected.

(18) Lighting

The level of illumination required on a bicycle facility is dependent upon the amount of nighttime use expected and the nature of the area surrounding the facility. Provide illumination at intersections. (See Chapter 840 for guidance on bicycle facility illumination.)

1020.07 Bike Lane Design

Bike lanes are established along streets in corridors where there is current or anticipated bicycle demand and where it would be unsafe for bicyclists to ride in the travel lane. Provide bike lanes where it is desirable to delineate available road space for preferential use by bicyclists. Consider bike lanes in and around schools, parks, libraries, and other locations where young cyclists are present. (See Figure 1020-8.) Bike lanes delineate the rights of way assigned to bicyclists and motorists and provide for movements that are more predictable by each. Bike lanes can be provided by reducing the number or width of lanes or prohibiting parking, if an analysis shows that traffic will not be unduly degraded and adjacent businesses will not be excessively impacted by the loss of parking.

Bike Lane
Figure 1020-8

Where street improvements are not possible, improve the bicyclist's environment by providing shoulder sweeping programs and special signal facilities.

(1) Widths

The minimum width for a bike lane is 4 feet. Some typical bike lane configurations are illustrated in Figure 1020-18 and are described below:

- **Figure 1020-18, Design A,** depicts bike lanes on an urban-type curbed street where parking stalls (or continuous parking stripes) are marked. Locate bike lanes between the parking area and the traffic lanes. Minimum widths are shown. When the combined width of the bike lane and the parking lane is less than 15 feet, an increased probability of bicycle/car door collisions exists. When wider widths are not available, consider eliminating bike lane marking and signing.

  Do not place bike lanes between the parking area and the curb. Such facilities create hazards for bicyclists, such as the opening of car doors and poor visibility at intersections. Also, they prevent bicyclists from leaving the bike lane to turn left and they cannot be effectively maintained.
- **Figure 1020-18, Design B,** depicts bike lanes on an urban-type curbed street where parking is permitted without pavement markings between the bike lane and the parking lane. Establish bike lanes in conjunction with the parking areas. 12 feet (15 feet preferred) is the minimum total width of the bike lane and parking lane. This design is satisfactory where parking is not extensive and where the turnover of parked cars is infrequent. However, an additional width of 1 to 2 feet is recommended if parking is substantial or the turnover of parked cars is high. Delineated parking lanes are preferred.
- **Figure 1020-18, Design C,** depicts bike lanes along the outer portions of a roadway, with and without curb, where parking is prohibited. This configuration eliminates potential conflicts (such as the opening of car doors) with motor vehicle parking. Minimum widths are shown. Both the 5-foot width with curb or barrier and the 3 feet between a gutter and the traveled way must be achieved. With curb, guardrail, or barrier, the minimum bike lane width is 5 feet. When a gutter is present, a minimum width of 3 feet is required from the edge of the gutter. Additional width is desirable, particularly where motor vehicle operating speeds exceed 40 miles per hour. Prohibit parking when necessary.

High-speed truck, bus, and recreational vehicle traffic can cause problems along a bike lane because of aerodynamic effects and vehicle widths. Increase shoulder widths to accommodate large vehicles and bicycle traffic when truck, bus, or recreational vehicle traffic makes up 5% or more of the daily traffic.

Bike lanes are not advisable on long, steep downgrades where bicycle speeds greater than 30 miles per hour can be expected. As grades increase, downhill bicycle speeds will increase, which increases the handling problems if bicyclists are riding near the edge of the roadway. In such situations, bicycle speeds can approach those of motor vehicles, and experienced bicyclists will generally move into the motor vehicle lanes to increase sight distance and maneuverability. However, this situation might place other bicyclists in a hazardous position. When steep downgrades are unavoidable, provide full design-level shoulder width and signing in accordance with the MUTCD to alert bicyclists of the grade and the need to control their speeds.

Bike lanes are usually placed on the right side of one-way streets. Consider placing the bike lane on the left side when it produces fewer conflicting movements between bicycles and motor vehicles.

(2) Intersection Design

Design bike lanes at intersections in a manner that will minimize confusion for motorists and bicyclists and will permit both users to operate in accordance with the Rules of the Road (see RCW 46.61).

Figure 1020-19 illustrates a typical intersection of multilane streets, with bike lanes on all approaches. Some common movements of motor vehicles and bicycles are shown.

Figures 1020-20a and 20b illustrate two design options where bike lanes cross off- and on-ramps or wye connections. Option 1 provides a defined crossing point for bicyclists who want to stay on their original course. This option is desirable when bicyclists do not have a good view of traffic. Use Option 2 where bicyclists normally have a good view of traffic entering or exiting the roadway and will adjust their path to cross ramp traffic. A bike-crossing sign to warn motorists of the possibility of bicyclists crossing the roadway is recommended.

Figure 1020-21 illustrates the recommended options where bike lanes cross a channelized right-turn-only lane. When approaching such intersections, bicyclists will have to merge with right-turning motorists. Since bicyclists are typically traveling at speeds less than motorists, they can signal and merge where there is a sufficient gap in right-turning traffic, rather than at any predetermined location. For this reason, it is most effective to end bike lane markings at the approach of the right-turn lane or to extend a single, dotted bike lane line across the right-turn lane. Parallel lines (delineating a bike lane crossing) to channelize the bike merge are not recommended, as they encourage bicyclists to cross at predetermined locations. In addition, some motorists might assume they have the right of way and neglect to yield to bicyclists continuing straight.

A dotted line across the right-turn-only lane is not recommended where there are double right-turn-only lanes. For these types of intersections, drop all pavement markings to permit judgment by the bicyclists to prevail.

For signing and pavement marking requirements, see the MUTCD and the Standard Plans.

(3) Traffic Signals

At signalized intersections, consider bicycle traffic needs and intersection geometry when timing the traffic signal cycle and when selecting the method of detecting the presence of the bicyclist. Contact the region's Bicycle Coordinator for assistance in determining the timing criteria. Consider the installation of effective loop detectors or other methods of detecting a bicycle within the bike lane (in advance of the intersection) and turn lanes, in addition to push button actuators. Select loop detectors sensitive enough to detect bicycles. Bicyclists generally prefer not to use push button actuators, as they must go out of their way to actuate the signal. For additional guidance on signal design, see Chapter 850.

(4) Signing and Pavement Markings

Use the MUTCD and the Standard Plans for signing and pavement marking criteria. (See Chapter 820 for additional information on signing and Chapter 830 for information on pavement markings.)

(5) Drainage Grates and Manhole Covers

Locate drainage inlet grates and manhole covers to avoid bike lanes. When drainage grates or manhole covers are located in a bike lane, minimize the effect on bicyclists. A minimum of 3 feet of lateral clearance is needed between the edge of a drainage inlet grate and the shoulder stripe. Install and maintain grates and manhole covers level with the surface of the bike lane.

For additional information on drainage, see 1020.06(15).

1020.08 Shared Roadway Design

Generally, lower-speed/lower-volume streets are adequate for bicycle travel, so additional signing and pavement markings for bicycle use are unnecessary. (See Figure 1020-9.)

Shared Roadway
Figure 1020-9

The region's Traffic Engineer is responsible for determining which sections of state highways are inappropriate for bicycle traffic. The State Traffic Engineer, after consultation with the Bicycle Advisory Committee, prohibits bicycling on sections of state highways through the traffic regulation process. Contact the region Traffic Operations Office for further information.

Bicyclists traveling between cities or on recreational trips may use many rural highways. Providing and maintaining paved shoulders, with or without an edge stripe, can significantly improve safety and convenience for bicyclists and motorists along such routes.

A shared roadway bike route with improvements for bicycles can offer a greater degree of service to bicyclists than other roadways. Improvements on shared roadways to facilitate better bicycle travel include widening the shoulders to full design level width (a minimum of 4 feet); adding pavement markings; improving roadside maintenance (including periodic sweeping); and removing surface hazards such as drain grates not compatible with bicycle tires.

Where public transport and cycling facilities meet, an integrated design that ensures neither mode inconveniences the other is desirable. When buses and bicyclists share the same roadway, consider the following recommendations:

- Where bus speeds and volumes are high, separate facilities for buses and bicyclists are desirable
- Where bus speeds and volumes are low, consider a shared-use bus/bicycle lane

Consider providing bicycle parking facilities near public transportation stops.

1020.09 Signed Shared Roadway

Signed shared roadways are shared roadways that have been identified as preferred bike routes by posting bike route signs. (See Figure 1020-10.) Provide connections for continuity to other bicycle facilities. Designate preferred routes through high bicycle-demand corridors. As with bike lanes, signing shared roadways as bike routes is an indication to bicyclists that there are advantages to using these bike routes, as compared with alternative routes. (Signing also alerts motor vehicle operators that bicycles are present.) Provide improvements to make these routes suitable as bike routes, and maintain in a manner consistent with the needs of bicyclists.

Signed Shared Roadway
(Designated Bike Route)
Figure 1020-10

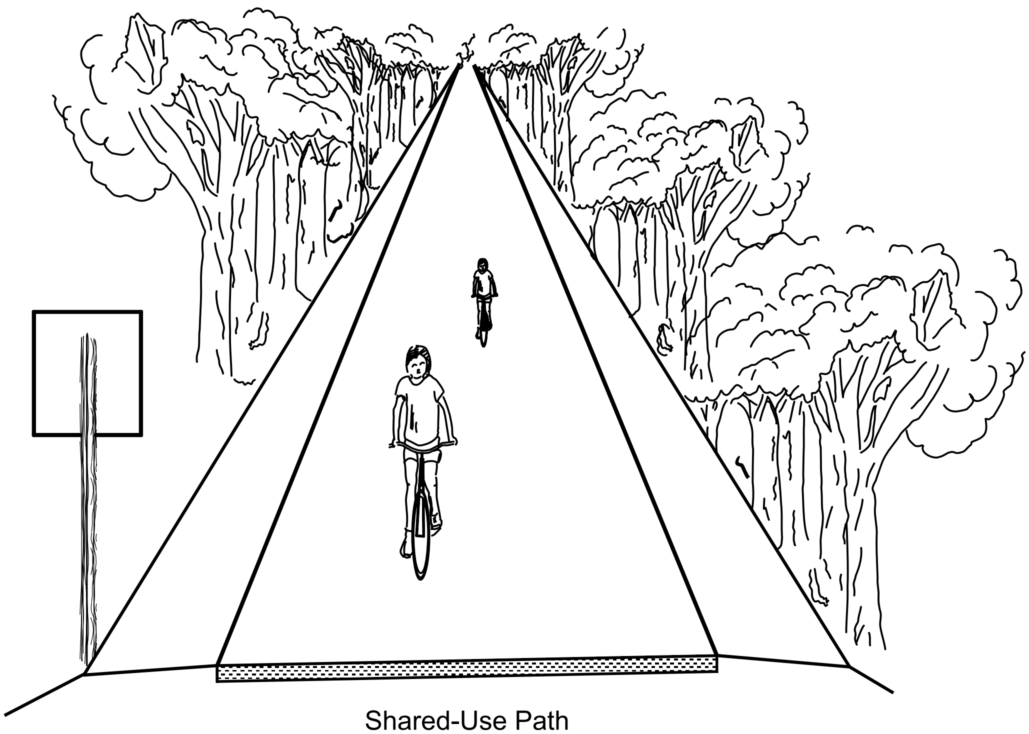
Use the following criteria to aid in determining whether or not to designate and sign a bike route:

- The route offers a higher degree of service than alternative streets
- The route provides for through and direct travel in bicycle corridors
- The route connects bicycle facilities
- Traffic control devices have been adjusted to accommodate bicyclists
- Street parking is prohibited for improved safety where lane width is critical
- Surface hazards to bicyclists have been corrected
- Maintenance of the route is at a higher level than comparable streets, such as more frequent street sweeping and repair

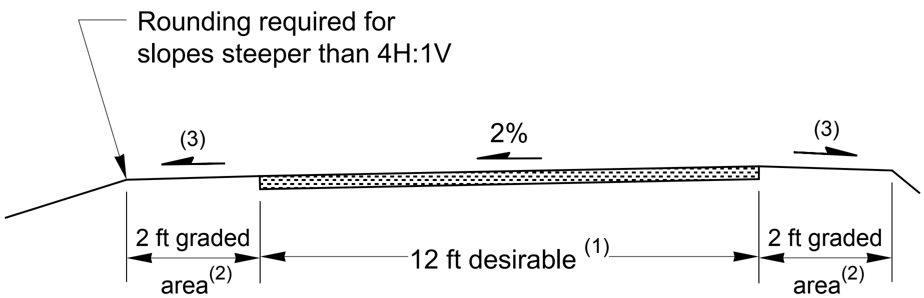
Establish a signed shared roadway bike route by placing the MUTCD Bicycle Route signs or markers along the roadways. When the signed shared roadway designates an alternate route, consider destination signing.

1020.10 Documentation

The list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/



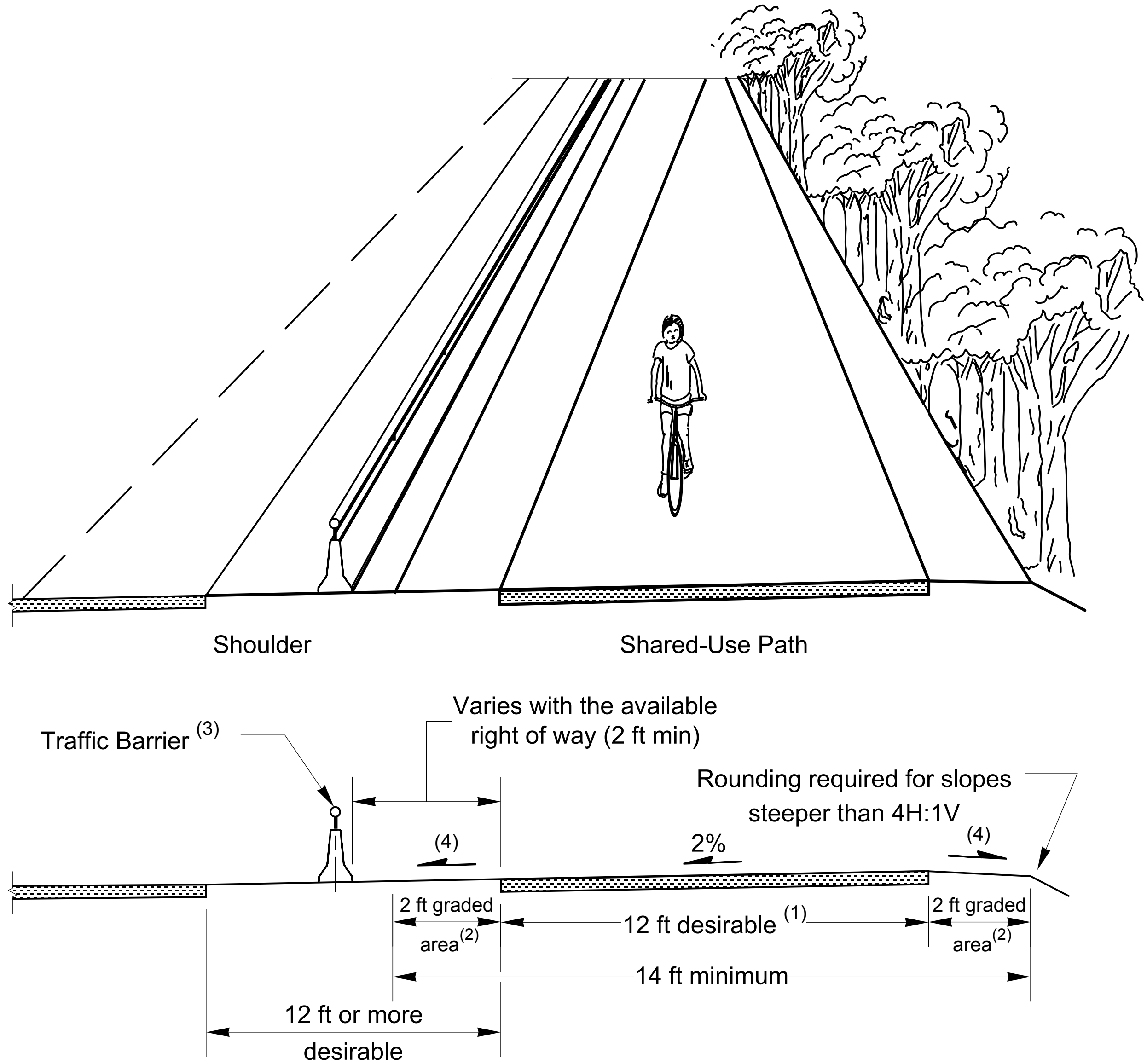
Shared-Use Path



Notes:

(1) For further discussion on bicycle path widths, see 1020.06(1).
(2) Where the paved width is wider than 10 feet, the graded area may be reduced accordingly.
(3) Not steeper than 6H:1V.

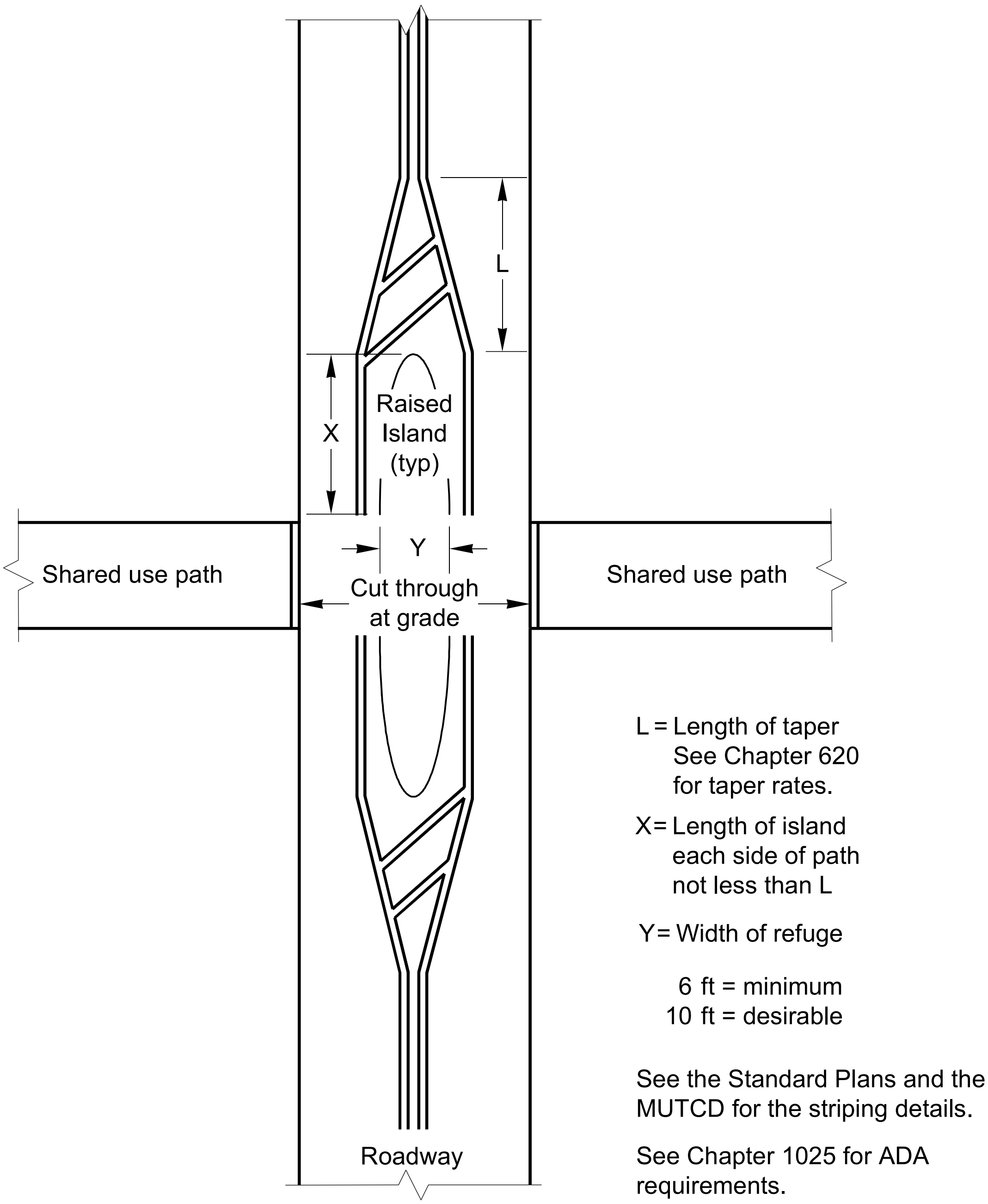
Two-Way Shared-Use Path
(Separate Right of Way)
Figure 1020-11a



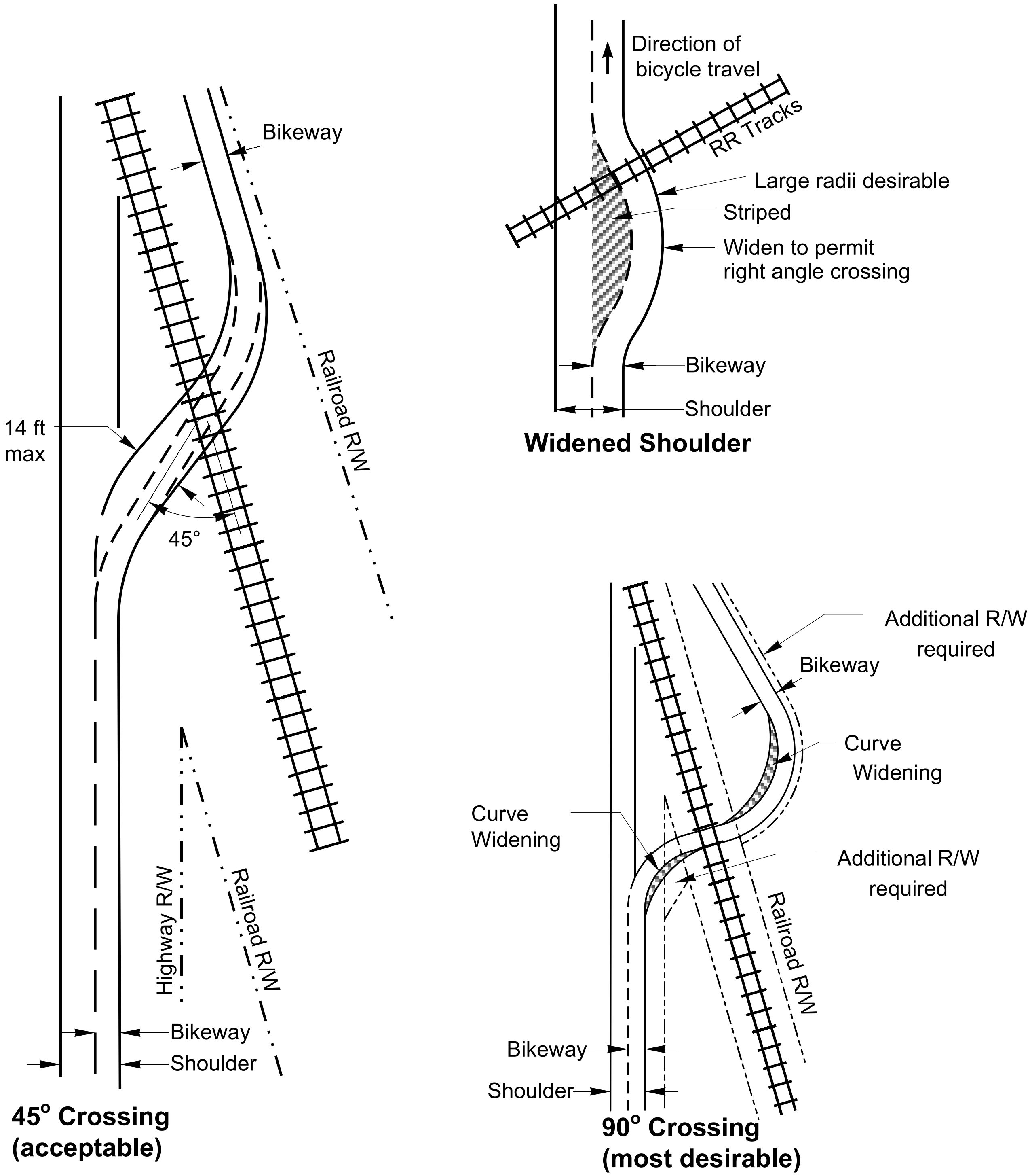
Notes:

(1) For further discussion on bicycle path widths, see 1020.06(1).
(2) Where the paved width is wider than 10 feet, the graded area may be reduced accordingly.
(3) For selecting barriers between bicycle path and shoulder, and for determining the need for fencing on limited access roadways, see 1020.06(6).
(4) Not steeper than 6H:1V.

Two-Way Shared-Use Path (Adjacent to Roadway)
Figure 1020-11b



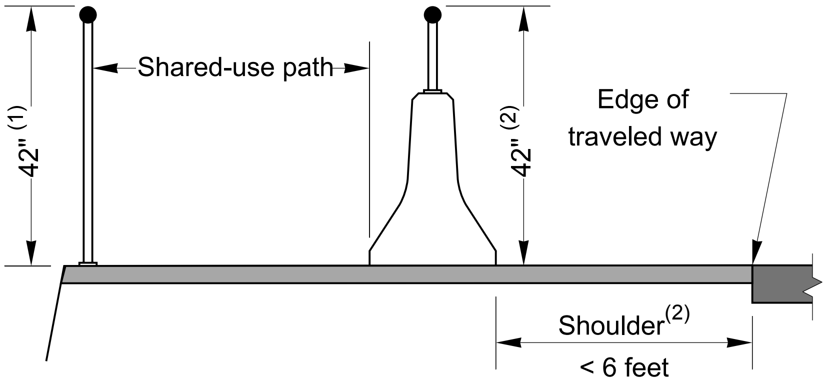
Refuge Area
Figure 1020-12



Note:

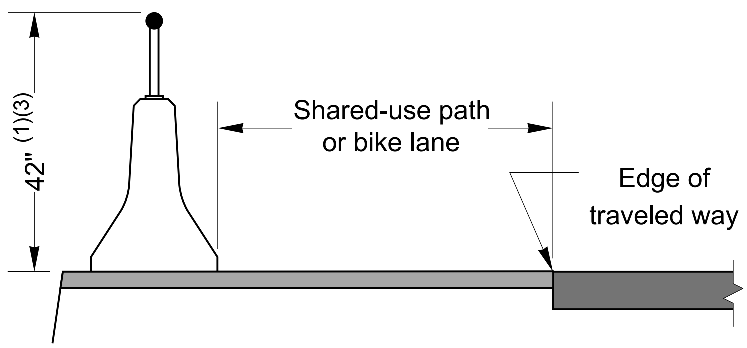
Provide additional width to a maximum total width of 14 feet at railroad crossing to allow bicyclists to choose their own crossing routes.

At-Grade Railroad Crossings
Figure 1020-13



Separated (shared-use paths)

Bicyclists and pedestrians use a path separated from the roadway with barrier.



Unseparated (bike lanes)[(4)]

Bicyclists use the shoulder/bike lane between the edge of traveled way and the barrier.

Notes:

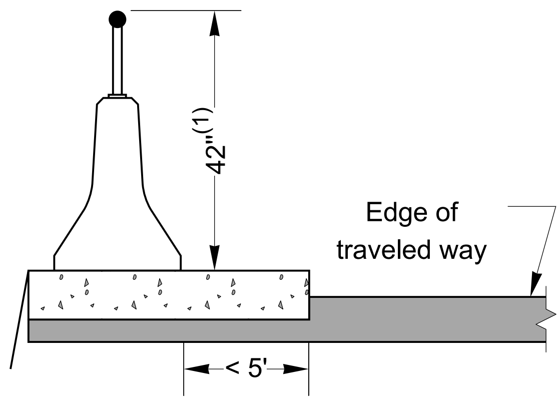
(1) Height does not apply to bridge rail. On structures, the bridge railing type and height are part of the structure design. Contact the HQ Bridge and Structures Office for additional information.

(2) When shoulder width is 6 feet or more, additional height for bicycles is not required. (See 1020.06(6) for additional information.)

(3) Applies to bike lanes. Additional height is not required for shared-use roadways.

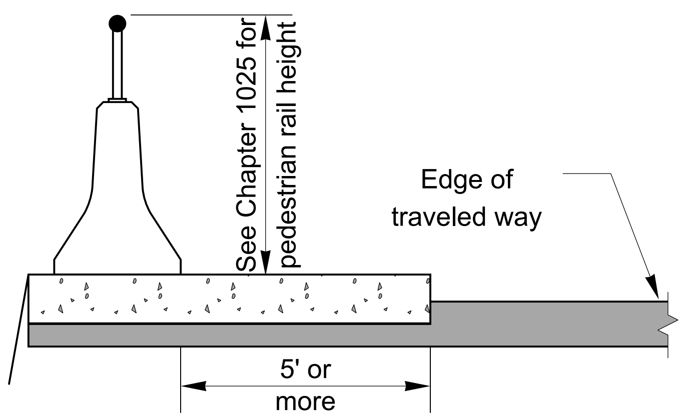
(4) Includes exceptional conditions where sidewalks are used by bicyclists.

Barrier Adjacent to Bicycle Facilities
Figure 1020-14a



Unseparated bike lanes with a sidewalk less than 5 ft wide

Bicyclists use the shoulder between the edge of traveled way and the sidewalk.



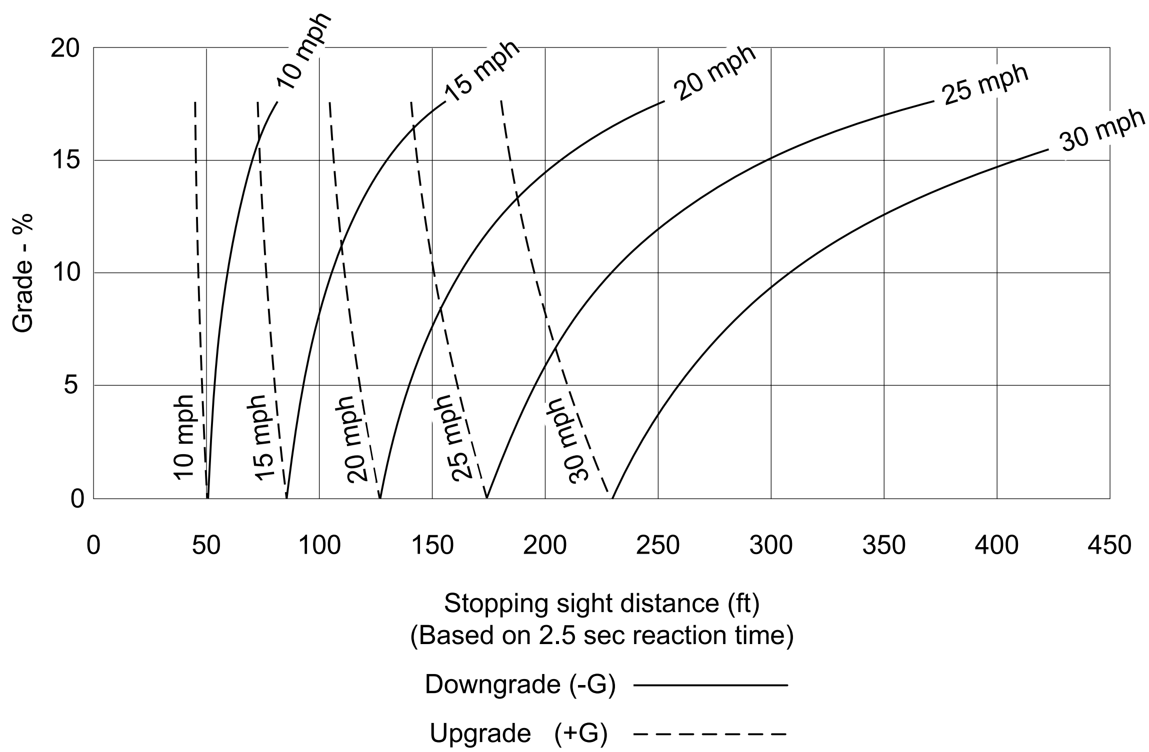
Unseparated bike lanes with a sidewalk 5 ft or more wide

Bicyclists use the shoulder between the edge of traveled way and the sidewalk.

Note:

(1) Height does not apply to bridge rail. On structures, the bridge railing type and height are part of the structure design. Contact the HQ Bridge and Structures Office for additional information.

Barrier Adjacent to Bicycle Facilities
Figure 1020-14b



$$S = \frac{V^2}{0.30\,(f \pm G)} + 3.67V$$

Where:

S = Stopping sight distance (ft)
V = Speed (mph)
f = Coefficient of friction (use 25)
G = Grade (%)

Stopping Sight Distance

Figure 1020-15

A (%)	Stopping Sight Distance, S (ft)													
	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2	3	3	3	3	3	3	3	3	3	3	30	70	110	150
3	3	3	3	3	3	3	20	60	100	140	180	220	260	300
4	3	3	3	3	15	55	95	135	175	215	256	300	348	400
5	3	3	3	20	60	100	140	180	222	269	320	376	436	500
6	3	3	10	50	90	130	171	216	267	323	384	451	523	600
7	3	3	31	71	111	152	199	252	311	376	448	526	610	700
8	3	8	48	88	128	174	228	288	356	430	512	601	697	800
9	3	20	60	100	144	196	256	324	400	484	576	676	784	900
10	3	30	70	111	160	218	284	360	444	538	640	751	871	1000
11	3	38	78	122	176	240	313	396	489	592	704	826	958	1100
12	5	45	85	133	192	261	341	432	533	645	768	901	1045	1200
13	11	51	92	144	208	283	370	468	578	699	832	976	1132	1300
14	16	56	100	156	224	305	398	504	622	753	896	1052	1220	1400
15	20	60	107	167	240	327	427	540	667	807	960	1127	1307	1500
16	24	64	114	178	256	348	455	576	711	860	1024	1202	1394	1600
17	27	68	121	189	272	370	484	612	756	914	1088	1277	1481	1700
18	30	72	128	200	288	392	512	648	800	968	1152	1352	1568	1800
19	33	76	135	211	304	414	540	684	844	1022	1216	1427	1655	1900
20	35	80	142	222	320	436	569	720	889	1076	1280	1502	1742	2000
21	37	84	149	233	336	457	597	756	933	1129	1344	1577	1829	2100
22	39	88	156	244	352	479	626	792	978	1183	1408	1652	1916	2200
23	41	92	164	256	368	501	654	828	1022	1237	1472	1728	2004	2300
24	43	96	171	267	384	523	683	864	1067	1291	1536	1803	2091	2400
25	44	100	178	278	400	544	711	900	1111	1344	1600	1878	2178	2500
Minimum Length of Vertical Curve, L (ft)														

$L = \frac{AS^2}{900}$ when $S < L$

$L = 2S - \frac{900}{A}$ when $S > L$

Shaded area represents $S \leq L$.

Where:
S = Stopping sight distance (ft)
A = Algebraic difference in grade (%)
L = Minimum vertical curve length (ft)
Based on an eye height of 4.5 ft and an object height of 0 ft.

Sight Distances for Crest Vertical Curves

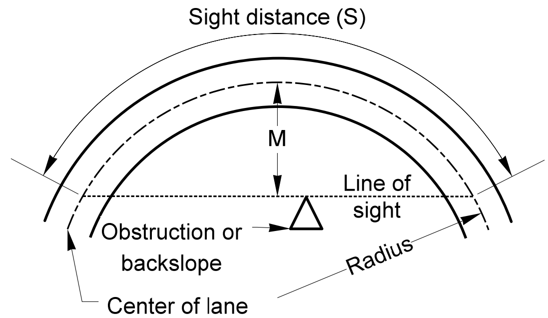
Figure 1020-16

Height of eye: 4.50 ft
Height of object: 0.0 ft
Line of sight at the M distance is normally 2.25 ft above centerline of inside lane at point of obstruction, provided no vertical curve is present in horizontal curve.

$$M = R\left(1 - \cos\frac{28.65S}{R}\right)$$

$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R - M}{R}\right)\right]$$

$S \leq$ Length of curve
Angle is expressed in degrees.



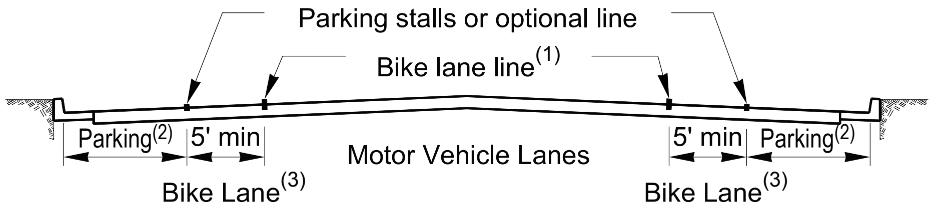
Where:
S = Sight distance (ft)
R = Centerline radius, of inside lane (ft)
M = Distance from inside lane centerline (ft)

R (ft)	Stopping Sight Distance, S (ft)[1]													
	40	60	80	100	120	140	160	180	200	220	240	260	280	300
25	7.6	15.9												
50	3.9	8.7	15.2	23.0	31.9	41.5								
75	2.7	5.9	10.4	16.1	22.7	30.4	38.8	47.8	57.4	67.2				
95	2.1	4.7	8.3	12.9	18.3	24.6	31.7	39.5	47.9	56.9	66.2	75.9	85.8	
125	1.6	3.6	6.3	9.9	14.1	19.1	24.7	31.0	37.9	45.4	53.3	61.7	70.5	79.7
150	1.3	3.0	5.3	8.3	11.8	16.0	20.8	26.2	32.1	38.6	45.5	52.9	60.7	69.0
175	1.1	2.6	4.6	7.1	10.2	13.8	18.0	22.6	27.8	33.4	39.6	46.1	53.1	60.4
200	1.0	2.2	4.0	6.2	8.9	12.1	15.8	19.9	24.5	29.5	34.9	40.8	47.0	53.7
225	0.9	2.0	3.5	5.5	8.0	10.8	14.1	17.8	21.9	26.4	31.2	36.5	42.2	48.2
250	0.8	1.8	3.2	5.0	7.2	9.7	12.7	16.0	19.7	23.8	28.3	33.0	38.2	43.7
275	0.7	1.6	2.9	4.5	6.5	8.9	11.6	14.6	18.0	21.7	25.8	30.2	34.9	39.9
300	0.7	1.5	2.7	4.2	6.0	8.1	10.6	13.4	16.5	19.9	23.7	27.7	32.1	36.7
350	0.6	1.3	2.3	3.6	5.1	7.0	9.1	11.5	14.2	17.1	20.4	23.9	27.6	31.7
400	0.5	1.1	2.0	3.1	4.5	6.1	8.0	10.1	12.4	15.0	17.9	20.9	24.3	27.8
500	0.4	0.9	1.6	2.5	3.6	4.9	6.4	8.1	10.0	12.1	14.3	16.8	19.5	22.3
600	0.3	0.7	1.3	2.1	3.0	4.1	5.3	6.7	8.3	10.1	12.0	14.0	16.3	18.7
700	0.3	0.6	1.1	1.8	2.6	3.5	4.6	5.8	7.1	8.6	10.3	12.0	14.0	16.0
800	0.2	0.6	1.0	1.6	2.2	3.1	4.0	5.1	6.2	7.6	9.0	10.5	12.2	14.0
900	0.2	0.5	0.9	1.4	2.0	2.7	3.6	4.5	5.5	6.7	8.0	9.4	10.9	12.5
1000	0.2	0.4	0.8	1.2	1.8	2.4	3.2	4.0	5.0	6.0	7.2	8.4	9.8	11.2
Minimum Lateral Clearance, M (ft)														

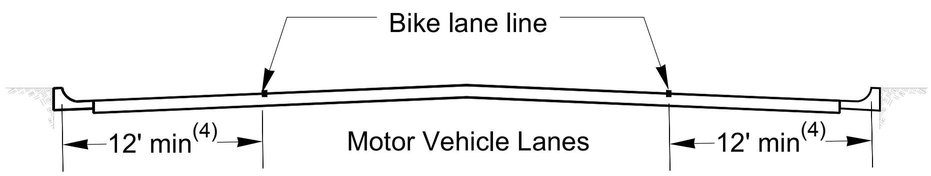
Note:
(1) S is the sum of the distances (from Figure 1020-15) for bicyclists traveling in both directions.

Lateral Clearance on Horizontal Curves

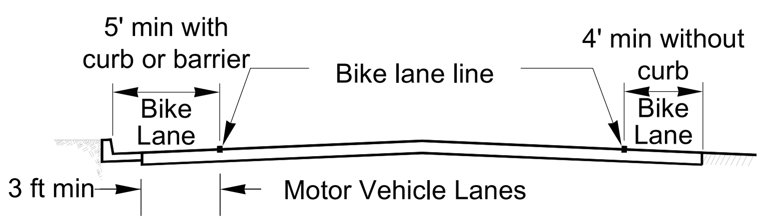
Figure 1020-17



Design A marked parking



Design B parking permitted without parking line or stall



Design C parking prohibited

Post NO PARKING signs as required

Notes:

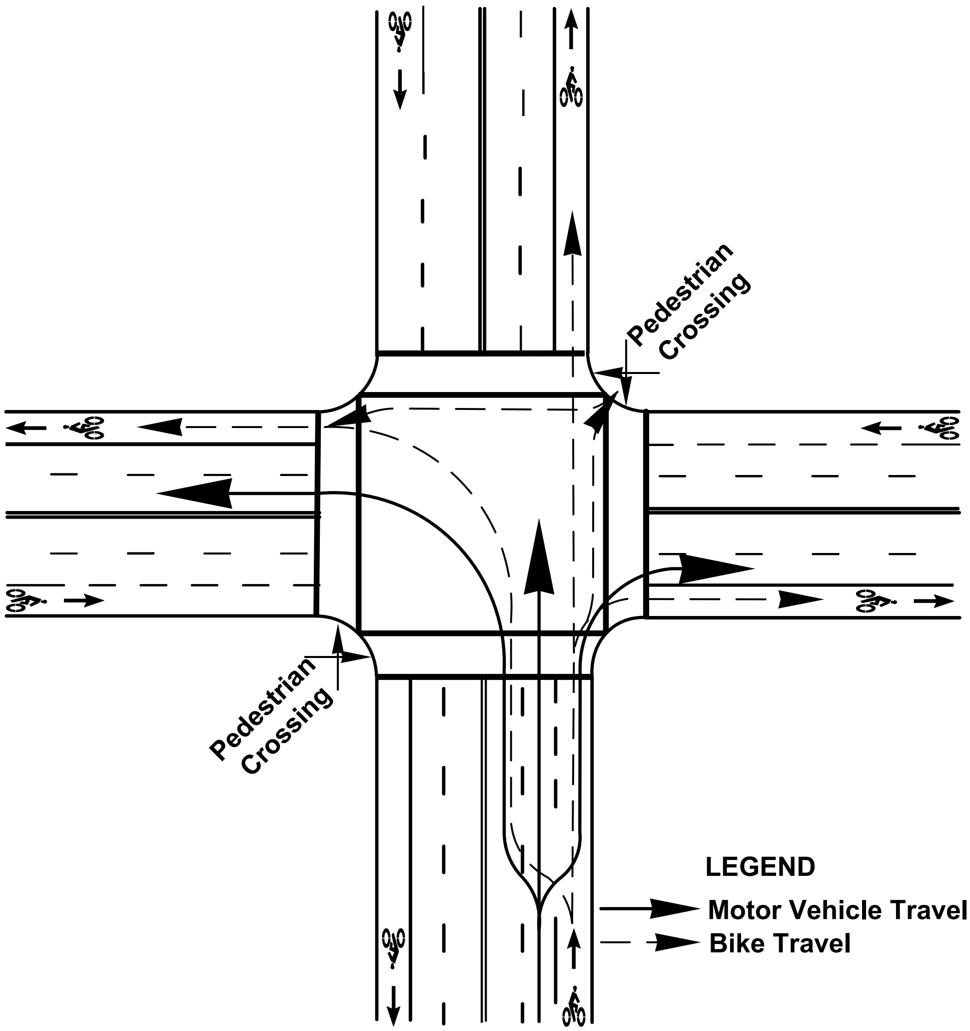
(1) The optional line between the bike lane and the parking lane might be advisable where stalls are unnecessary (because parking is light), but there is concern that motorists might misconstrue the bike lane to be a traffic lane. (See the MUTCD and the Standard Plans for pavement marking requirements.)

(2) For parking lane width, see Chapter 440. Consider a combined bike lane/parking lane width of 15 feet to reduce the risk of bicycle/car door collisions.

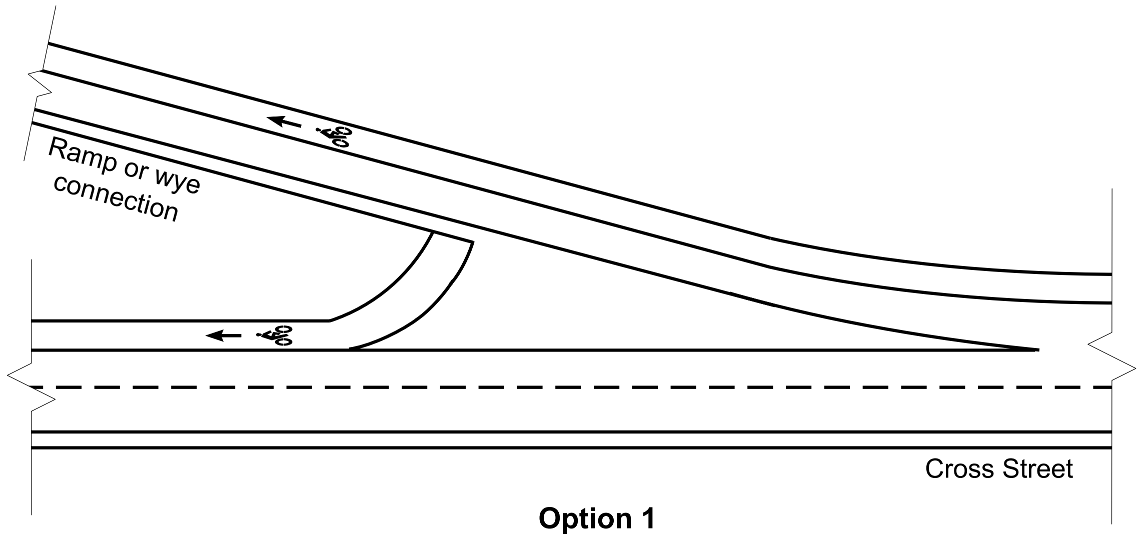
(3) 6 feet is the minimum width when parking lane is less than 10 feet.

(4) 13–14 feet is recommended where there is substantial parking or the turnover of parked cars is high. Consider a width of 15 feet to reduce the risk of bicycle/car door collisions.

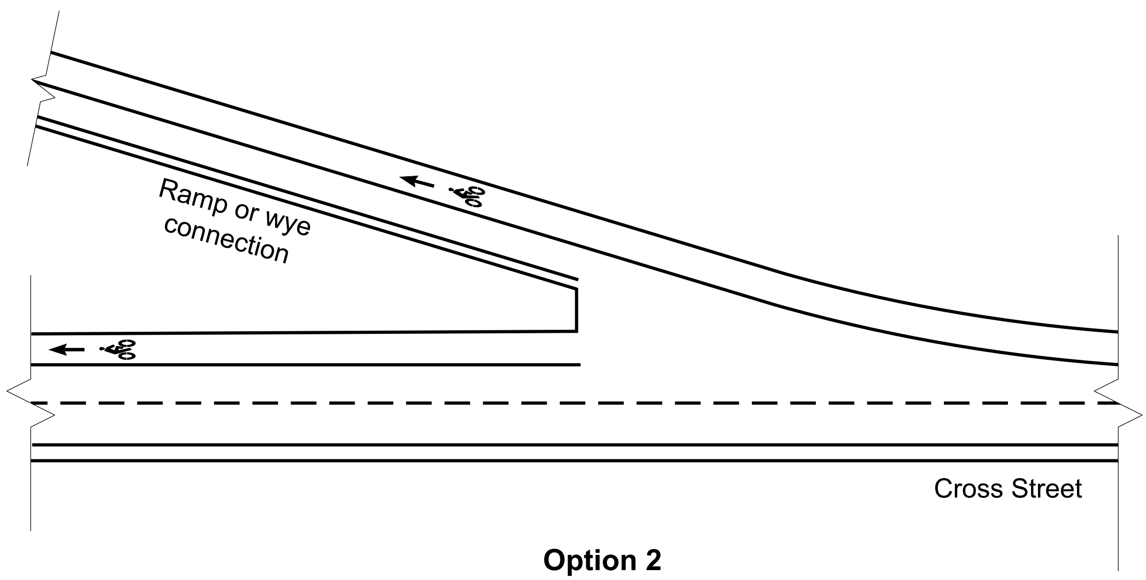
Typical Bike Lane Cross Sections
Figure 1020-18



Typical Bicycle/Auto Movements at Intersection of Multilane Streets
Figure 1020-19

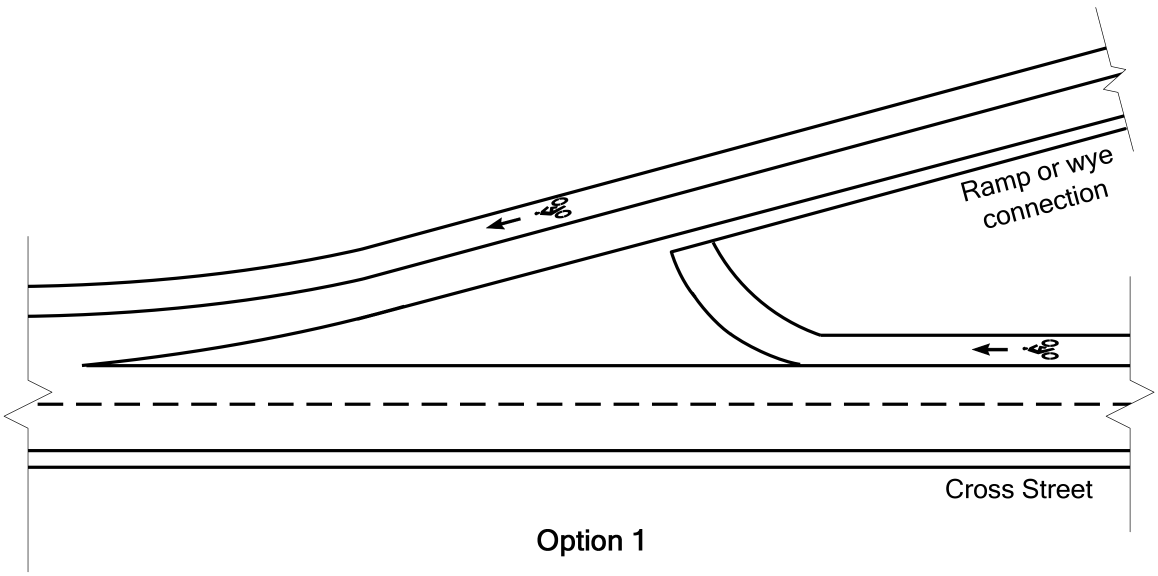


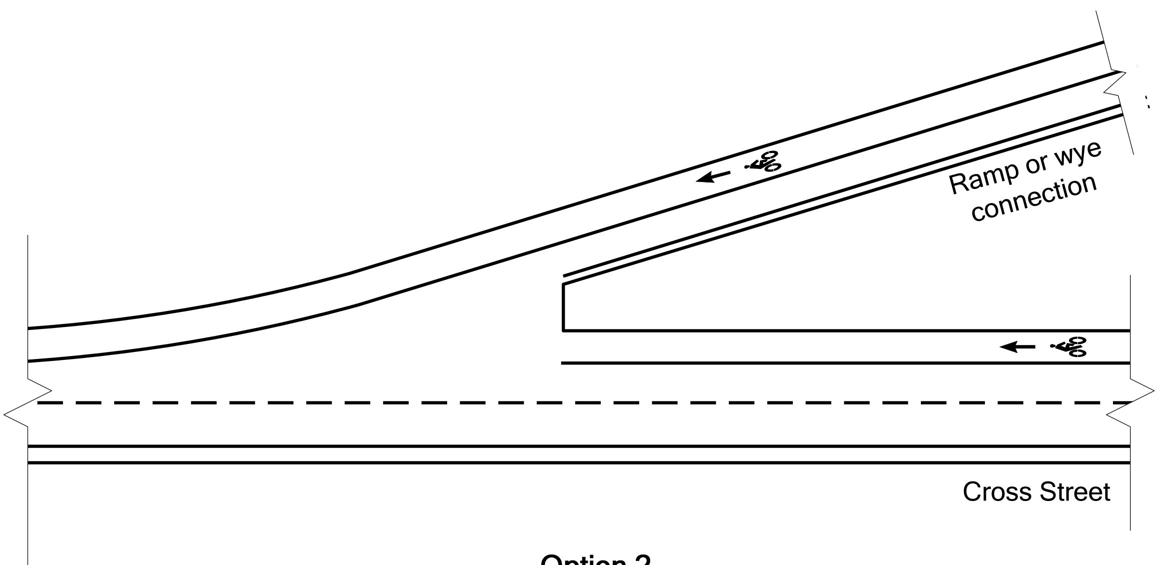
Option 1



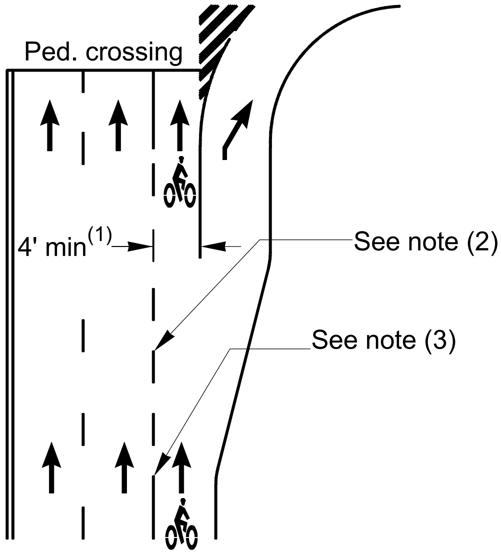
Option 2

Bicycle Crossing of Interchange Ramp
Figure 1020-20a

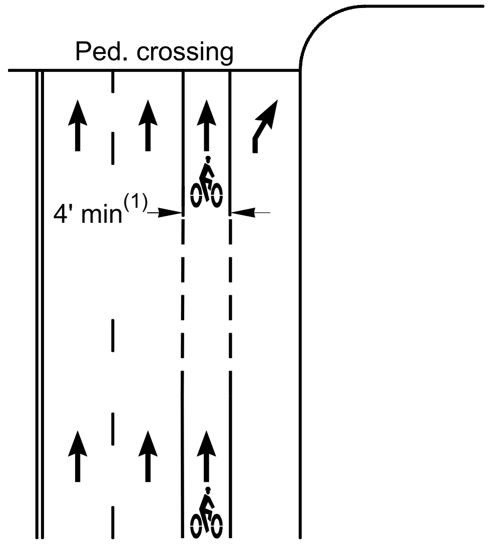




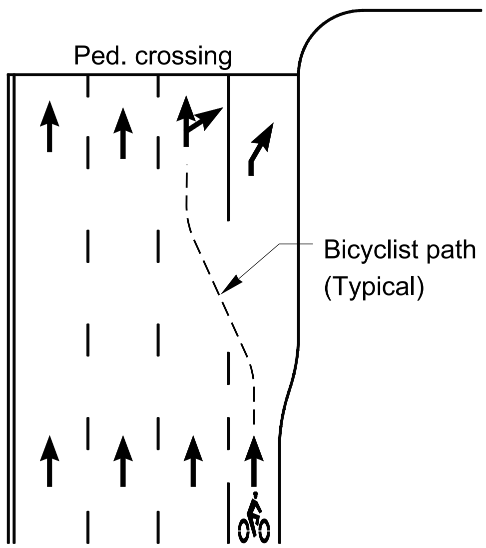
Bicycle Crossing of Interchange Ramp
Figure 1020-20b



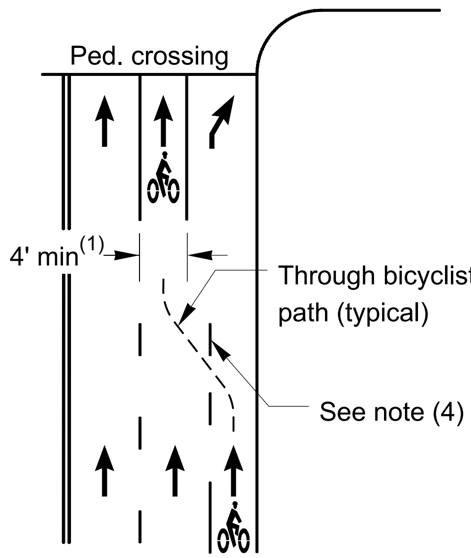
RIGHT-TURN-ONLY LANE



PARKING AREA BECOMES RIGHT-TURN-ONLY LANE



OPTIONAL DOUBLE RIGHT-TURN-ONLY LANE



RIGHT LANE BECOMES RIGHT-TURN-ONLY LANE

Notes:
(1) If space is available.
(2) Optional dashed line. Not recommended where a long right-turn-only lane or double turn lanes exist.
(3) When optional dashed line is not used, drop all bike lane delineation at this point.
(4) Drop bike lane line where right-turn-only is designated.

Bike Lanes Approaching Motorists' Right-Turn-Only Lanes
Figure 1020-21

allowable soil bearing capacities does not exceed the values provided in Figure 1130-5, the Standard Plans cannot be used for wall design and the Bridge and Structures Office must be contacted for a nonstandard wall design.

If the standard wall must support surcharge loads from bridge or building foundations, other retaining walls, noise walls, or other types of surcharge loads, a special wall design is required. The wall is considered to be supporting the surcharge load and is treated as a nonstandard wall if the surcharge load is located within a 1H:1V slope projected up from the bottom of the back of the wall. Contact the Bridge and Structures Office for assistance

The Standard Plans provide six types of reinforced concrete cantilever walls (which represent six loading cases). Reinforced concrete retaining wall Types 5 and 6 are not designed to withstand earthquake forces and are not used in Western Washington (west of the Cascade crest).

Once the geotechnical and architectural assessment have been completed, the region completes the PS&E for the standard wall option(s) selected including a generalized wall profile and plan, a typical cross-section as appropriate, details for desired wall appurtenances, drainage details, and other details as needed.

Metal bin walls, Types 1 and 2, have been deleted from the Standard Plans and are therefore no longer standard walls. Metal bin walls are seldom used due to cost and undesirable aesthetics. If this type of wall is proposed, contact the Bridge and Structures Office for plan details and toe bearing pressures. The applied toe bearing pressure will then have to be evaluated by the Geotechnical Services Branch to determine if the site soil conditions are appropriate for the applied load and anticipated settlement.

(b) **Preapproved Proprietary Walls.** Final approval of preapproved proprietary wall design, with the exception of geosynthetic walls, is the responsibility of the Bridge and Structures Office. Final approval of the design of preapproved proprietary geosynthetic walls is the responsibility of the Geotechnical Services Branch. It is the region's responsibility to coordinate the design effort for all preapproved wall systems.

The region materials laboratory performs the geotechnical investigation for preapproved proprietary walls 10 ft in height or less that are not bearing on soft or unstable soils. In all other cases, it is the responsibility of the Geotechnical Services Branch to conduct, or review and approve, the geotechnical investigation for the wall. The region also coordinates with the State Bridge and Structures Architect to ensure that the wall options selected meet the aesthetic requirements for the site.

Once the geotechnical and architectural assessments have been completed and the desired wall alternatives selected, it is the responsibility of the region to contact the suppliers of the selected preapproved systems to confirm in writing the adequacy and availability of the systems for the proposed use.

A minimum of three different wall systems must be included in the PS&E for any project with federal participation that includes a proprietary wall system unless specific justification is provided. Standard walls can be alternatives.

Once confirmation of adequacy and availability has been received, the region contacts the Bridge and Structures Office for special provisions for the selected wall systems and proceeds to finalize the contract PS&E in accordance with the *Plans Preparation Manual*. Provide the allowable bearing capacity and foundation embedment criteria for the wall, as well as backfill and foundation soil properties, in the special provisions. In general, assume that gravel borrow or better quality backfill material will be used for the walls when assessing soil parameters.

Complete wall plans and designs for the proprietary wall options will not be developed until after the contract is awarded, but will be developed by the proprietary wall supplier as shop drawings after the contract is awarded. Therefore, include a general wall plan, a profile showing neat line top and bottom of the wall, a final ground line in front of and in back of the wall, a typical cross-section, and the generic details for the desired appurtenances and drainage requirements in the contract PS&E for the proprietary walls. Estimate the ground line in back of the wall based on a nominal 1.5 ft facing thickness (and state this on the wall plan sheets). Include load or other design acceptance requirements for these appurtenances in the PS&E. Contact the Bridge and Structures Office for assistance regarding this.

It is best to locate catch basins, grate inlets, signal foundations, and the like outside the reinforced backfill zone of MSE walls to avoid interference with the soil reinforcement. In those cases where conflict with these reinforcement obstructions cannot be avoided, the location(s) and dimensions of the reinforcement obstruction(s) relative to the wall must be clearly indicated on the plans. Contact the Bridge and Structures Office for preapproved wall details and designs for size and location of obstructions, and to obtain the generic details that must be provided in the plans. If the obstruction is too large or too close to the wall face, a special design may be required to accommodate the obstruction, and the wall is treated as a nonpreapproved proprietary wall.

A special design is required if the wall must support structure foundations, other retaining walls, noise walls, signs or sign bridges, luminaires, or other types of surcharge loads. The wall is considered to be supporting the surcharge load if the surcharge is located within a 1H:1V slope projected from the bottom of the back of the wall. For MSE walls, the back of the wall is considered to be the back of the soil reinforcement layers. If this situation occurs, the wall is treated as a nonpreapproved proprietary wall.

For those alternative wall systems that have the same face embedment criteria, the wall face quantities depicted in the plans for each alternative must be identical. To provide an equal basis for competition, the region determines wall face quantities based on neat lines.

Once the detailed wall plans and designs are available as shop drawings after contract award, the Bridge and Structures Office will review and approve the wall shop drawings and calculations, with the exception of geosynthetic walls which are reviewed and approved by the Geotechnical Services Branch.

(c) **Nonpreapproved Proprietary Walls.** Final approval authority for nonpreapproved proprietary wall design is the same as for preapproved proprietary walls. The region initiates the design effort for all nonpreapproved wall systems by submitting wall plan, profile, cross-section, and other information for the proposed wall to the Bridge and Structures Office, with copies to the Geotechnical Services Branch and the State Bridge and Structures Architect. The Bridge and Structures Office coordinates the wall design effort.

Once the geotechnical and architectural assessments have been completed and the desired wall types selected, the Bridge and Structures Office contacts suppliers of the nonpreapproved wall systems selected to obtain and review detailed wall designs and plans to be included in the contract PS&E.

To ensure fair competition between all wall alternatives included in the PS&E, the wall face quantities for those wall systems subject to the same face embedment requirements must be identical.

The Bridge and Structures Office develops the special provisions and cost estimates for the nonpreapproved proprietary walls and sends the wall PS&E to the region for inclusion in the final PS&E in accordance with the *Plans Preparation Manual*.

(d) **Nonstandard Nonproprietary Walls.** With the exception of rockeries over 5 ft high, nonproprietary geosynthetic walls and reinforced slopes, and soil nail walls, the Bridge and Structures Office coordinates with the Geotechnical Services Branch and the State Bridge and Structures Architect to carry out the design of all nonstandard, nonproprietary walls. In this case, the Bridge and Structures Office develops the wall preliminary plan from site data provided by the region, completes the wall design, and develops the nonstandard nonproprietary wall PS&E package for inclusion in the contract.

For rockeries over 5 ft high, nonproprietary geosynthetic walls and reinforced slopes, and soil nail walls, the region develops wall/slope profiles, plans, and cross-sections and submits them to the Geotechnical Services Branch to complete a detailed wall/slope design.

For geosynthetic walls and slopes, and for rockeries, the region provides overall coordination of the wall/slope design effort, including coordination with the State Bridge and Structures Architect regarding aesthetics and finishes, and the region's or HQ Landscape Architect if the wall uses vegetation on the face. The Geotechnical Services Branch has overall approval authority for the wall design. Once the wall design has been completed, the Geotechnical Services Branch, and in some cases the Bridge and Structures Office, provides geotechnical and structural plan details to be included in the region plan sheets and special provisions for the PS&E. The region then completes the PS&E package.

For soil nail walls, once the Geotechnical Services Branch has performed the geotechnical design, the Bridge and Structures Office, in cooperation with the Geotechnical Services Branch, coordinates the design effort and completes the PS&E package.

(3) Guidelines for Wall/Slope Data Submission for Design

(a) Standard Walls, Proprietary Walls, Geosynthetic Walls/Slopes, and Soil Nail Walls. Where HQ involvement in retaining wall/slope design is required (as for standard walls and preapproved proprietary walls over 10 ft in height, gabions over 6 ft in height, rockeries over 5 ft in height, all nonpreapproved proprietary walls, geosynthetic walls/slopes, and all soil nail walls), the region submits the following information to the Geotechnical Services Branch or Bridge and Structures Office as appropriate:

- Wall/slope plans.
- Profiles showing the existing and final grades in front of and behind the wall.
- Wall/slope cross-sections (typically every 50 ft) or CAiCE files that define the existing and new ground-line above and below the wall/slope and show stations and offsets.
- Location of right of way lines as well as other constraints to wall/slope construction.
- Location of adjacent existing and/or proposed structures, utilities, and obstructions.
- Desired aesthetics.
- Date design must be completed.
- Key region contacts for the project.

Note that it is best to base existing ground measurements, for the purpose of defining the final wall geometry, on physical survey data rather than solely on photogrammetry. In addition, the region must complete a Retaining Wall/Reinforced Slope Site Data Check List, DOT Form 351-009 EF, for each wall or group of walls submitted.

(b) **Nonstandard Walls, Except Geosynthetic Walls/Slopes and Soil Nail Walls.** In this case, the region must submit site data in accordance with Chapter 1110. Additionally, a Retaining Wall Site Data Check List, DOT351-009EF, for each wall or group of walls must be completed by the region.

1130.07 Documentation

A list of the documents that are required to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/

Specific Wall Type	Advantages	Disadvantages	Limitations
Steel soil reinforcement with full height precast concrete panels	Relatively low cost	Can tolerate little settlement; generally requires high quality backfill; wide base width required (70% of wall height)	Applicable primarily to fill situations; maximum feasible height is approximately 20 ft
Steel soil reinforcement with modular precast concrete panels	Relatively low cost; flexible enough to handle significant settlement	Generally requires high quality backfill; wide base width required (70% of wall height)	Applicable primarily to fill situations; maximum height of 33 ft; heights over 33 ft require a special design
Steel soil reinforcement with welded wire and cast in place concrete face	Can tolerate large short-term settlements	Relatively high cost; cannot tolerate long-term settlement; generally requires high quality wall backfill soil; wide base width required (70% of wall height); typically requires a settlement delay period during construction	Applicable primarily to fill situations; maximum height of 33 ft for routine designs; heights over 33 ft require a special design
Steel soil reinforcement with welded wire face only	Can tolerate large long-term settlements; low cost	Aesthetics, unless face plantings can be established; generally requires high quality backfill; wide base width required (70% of wall ht.)	Applicable primarily to fill situations; maximum height of 33 ft for routine designs; heights over 33 ft require a special design

Table 1(a)
Summary of mechanically stabilized earth (MSE) gravity wall/slope options available.

Index

A

B

C

D

E

F

G

H

M

N

O

P

Q

R

S

T

U

V

W