Design Manual

M 22-01

Washington State Department of Transportation
Environmental and Engineering Programs
Design Office

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Foreword

This *Design Manual* is for use by Washington State Department of Transportation engineering personnel. It provides policies, procedures, and methods for developing and documenting the design of improvements to the transportation network in Washington. The *Design Manual* has been developed for state facilities and may not be appropriate for all county roads or city streets that are not state highways.

The manual supplements the engineering analyses and judgment that must be applied to improvement and preservation projects. It provides uniform procedures for documenting and implementing design decisions. When proposed designs meet the requirements contained in the *Design Manual*, little additional documentation is required. The Federal Highway Administration (FHWA) has agreed to approve designs that follow the guidance in the *Design Manual*; therefore following the guidance presented is mandatory for state highway projects.

The design environment changes rapidly, and often without warning to the practitioner. To track every change, and to make improvements based upon each change, is not feasible. The intent of this manual is to provide recommended values for critical dimensions. Flexibility is permitted to encourage independent design that is tailored to particular situations. When flexibility is applied, and critical dimensions of a proposed design do not meet the *Design Manual* criteria, additional documentation is required to record the decision- making process.

The addition of new or modified design criteria to the *Design Manual* through the revision process does not imply that existing features are deficient or inherently dangerous. Nor does it suggest or mandate immediate engineering review or initiation of new projects.

Cost-effective and environmentally conscious design is emphasized, and consideration of the use of the highway corridor by transit, pedestrians, and bicyclists is included. Designers are encouraged to view the highway corridor beyond the vehicular movement context. To accommodate multimodal use, the criteria provided for one mode is to be appropriately adapted, as needed, at individual locations.

The complexity of transportation design requires the designer to make fundamental trade-off decisions that balance competing considerations. Although weighing these considerations adds to the complexity of design, it accounts for the needs of a particular project and the relative priorities of various projects and programs. Improvements must necessarily be designed and prioritized in light of finite transportation funding.

Updating the *Design Manual* is a continuing process, and revisions are issued periodically. Questions, observations, and recommendations are invited. Page iii is provided to encourage comments and to assure their prompt delivery. For clarification of the content of the *Design Manual*, contact the Headquarters Design Office. The e-mail address is: DesignManual@wsdot.wa.gov .

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Design Manual Supplements and Instructional Letters

June, 2005

In Effect	Chapter	Date	Type	Subject/Title
No No No	**HOV*** 940 1050	9/28/99	DM Supplement	Left-Side HOV Direct Access Connections (Chapter 940 revised September 2002) (Chapter 1050 revised May 2003)
No No	**HOV*** 1050	05/03/00	DM Supplement	Left-Side HOV Parallel On-Connection (Chapter 1050 revised May 2003)
Yes	650	10/09/02	DM Supplement	Stopping Sight Distance
Yes No	430 440	3/25/2004	DM Supplement	Design Speed
Yes Yes No **No**	430 1025 325 **340**	6/29/2004	DM Supplement	ADA Accessible Facilities on Road, Street, and Highway Projects
Yes	520	5/16/2005	DM Supplement	Pavement Type Selection Protocol (PTSP)

* The *HOV Direct Access Design Guide,* Draft M 22-98 – Replaced by new chapter 1055

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/fasc/engineeringpublications/DesignLettersMemInstruction.htm

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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 judgement. 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 and Standards home 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, telephone numbers for the authors are available through the Design Policy and Standards home page, and the manual has its own e-mail address.

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 Chapter 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 Design 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 are encouraged to use the Managing Project Delivery (MPD) process to map out the direction and the expectations for the project. The MPD process focuses on planning the work and executing the plan. (See Chapter 140.)

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 140–Managing Project Delivery: Provides the designer with the resources to build an effective project development work plan.
- 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: 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–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 Matrices: 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 (Q Program): 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–Highway Capacity: 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 Traffic Control: 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 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–Access Point Decision Report: Describes the process for access point revisions on state highways and explains the steps leading up to an Access Point Decision 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.

120.01 General

Transportation planning is a decision making process, required by federal and state law that is used to solve complex, interrelated transportation and land use problems. Various transportation interests from affected jurisdictions including local, regional, and state governments, as well as businesses, transportation providers, and community groups typically identify transportation needs. The needs are then evaluated within the framework provided by local, regional, and state land use and transportation policies as well as state and federal laws. These needs are interpreted in terms of constructed or service strategies that would meet those needs and these strategies are then evaluated based on projected fiscal constraints.

120.02 References

Transportation Equity Act for the 21st Century (TEA-21) of 1998

Code of Federal Regulations (CFR)

23 CFR 450 subpart B, "Statewide Transportation Planning"

23 CFR 450 subpart C, "Metropolitan Transportation Planning and Programming"

40 CFR, "Clean Air Act," parts 51 and 93

United States Code (USC)

23 USC 134, "Metropolitan planning"

23 USC 135, "Statewide planning"

Revised Code of Washington (RCW)

RCW 35.58.2795, "Public transportation systems — Six-year transit plans."

RCW 35.77.010(2), "Perpetual advanced six-year plans for coordinated transportation program expenditures — Nonmotorized transportation — Railroad right-of-way"

RCW 36.70A, "Growth management — Planning by selected counties and cities"

RCW 36.81.121(2), "Perpetual advanced six-year plans for coordinated transportation program, expenditures — Nonmotorized transportation — Railroad right-of-way"

RCW 43.21C "State Environmental Protection Act"

RCW 47.05, "Priority Programming for Highway Development"

RCW 47.06, "State-Wide Transportation Planning"

RCW 47.06B, "Coordinating Special Needs Transportation"

RCW 47.38, "Roadside Areas - Safety Rest Areas"

RCW 47.39, "Scenic and Recreational Highway Act of 1967" and changes thereto

RCW 47.50, "Highway Access Management"

RCW 47.76.220, "State rail plan - Contents"

RCW 47.80, "Regional Transportation Planning Organizations"

RCW 70.94, "Washington Clean Air Act" (Includes Commute Trip Reduction Law)

Washington Administrative Code (WAC)

WAC 468-51 and 52, "Highway Access Management"

WAC 468-86, "RTPO Planning Standards and Guidelines"

Roadside Manual, M 25-30, WSDOT

120.03 Acronyms and Definitions

ACCT Agency Council on Coordinated Transportation

ARB Agency Request Budget

B/C Benefit/Cost

CFR *Code of Federal Regulations*

CIPP *Capital Improvement and Preservation Program*

CLB Current Law Budget

CMP Corridor Management Plan

CTR Commute Trip Reduction

FAST Freight Action Strategy for the Everett-Seattle-Tacoma Corridor

FGTS Freight and Goods Transportation System

FHWA Federal Highway Administration

FTA Federal Transit Administration

GMA Growth Management Act

HSP *State Highway System Plan*

HSS Highways of Statewide Significance

ISTEA Intermodal Surface Transportation Efficiency Act of 1991

LOS Level of Service

MTIP Metropolitan Transportation Improvement Program

MPO Metropolitan Planning Organization

PSRC Puget Sound Regional Council

RCW *Revised Code of Washington*

RDP *Route Development Plan*

RTID Regional Transportation Investment District

RTIP Regional Transportation Improvement Program

RTPO Regional Transportation Planning Organization

SEPA State Environmental Policy Act

SHSP *State Highway System Plan* also known as the **HSP**

STIP Statewide Transportation Improvement Program

TDM Transportation Demand Management

TEA-21 Transportation Equity Act for the 21stCentury of 1998

TIP Transportation Improvement Program

TPO Transportation Planning Office

UPO Central Puget Sound Urban Planning Office

USC *United States Code*

WAC *Washington Administrative Code*

WSDOT Washington State Department of Transportation

WTP *Washington's Transportation Plan*

120.04 Legislation and Policy Development

The Washington State Legislature requires the Washington State Department of Transportation (WSDOT) to plan, develop, maintain, and preserve the transportation network in accordance with all state laws and federal requirements. The Washington State Transportation Commission interprets these requirements through a set of policies that guide the process.

The Washington State Transportation Commission consists of seven members who are appointed by the Governor. This body serves as the board of directors for WSDOT and provides oversight to ensure that WSDOT delivers a high quality, multimodal transportation system that moves people and goods safely and efficiently. The Commission also develops plans and funding recommendations for Legislative approval.

The following are highlights of federal and state legal requirements that influence or direct planning activities conducted by WSDOT. These legal requirements must be satisfied for WSDOT to be eligible to receive or expend federal and state transportation funds.

(1) Federal Law: Transportation Equity Act (TEA-21)

The Transportation Equity Act (TEA-21), passed in 1998, authorizes highway safety, transit, and other surface transportation programs through the year 2004. TEA-21 continues the trend initiated in 1991 by the Intermodal Surface Transportation Efficiency Act (ISTEA). ISTEA brought closure to the federal Interstate highway construction era and established new methods for distributing federal transportation dollars.

TEA-21 acknowledges the importance of statewide and metropolitan transportation planning activities at the state and regional levels. Below is a list of mandatory federal planning requirements included in TEA-21.

(a) Statewide Planning. 23 USC 135 and 23 CFR 450 — subpart B outline the federal requirements for statewide planning by state departments of transportation.

(b) Metropolitan Planning. 23 USC 134 and 23 CFR 450 subpart C — outline the federal requirements for Metropolitan Planning Organizations (MPO).

Each urbanized area (an area determined by the US Census Bureau to have a population of 50,000 or more with a density of at least 500 per square mile) is required to have an MPO. The MPO must develop and obtain approval of a metropolitan transportation plan and transportation improvement program to receive and expend federal transportation capital or operating assistance. The 2000 census identified 13 urbanized areas in Washington; these areas have established eleven MPOs. (See ftp://ftp.wsdot.wa.gov/public/Cartography/RTPO/rtpompoSimple.jpg

They are:

- Benton-Franklin Council of Governments (BFCOG)
- Cowlitz – Wahkiakum Council of Governments (CWCOG)
- Lewis-Clark Valley Metropolitan Planning Organization (LCVMPO)
- Puget Sound Regional Council (PSRC)
- Skagit Metropolitan Planning Organization (Skagit MPO)
- Southwest Washington Regional Transportation Council (SWRTC)
- Spokane Regional Transportation Council (SRTC)
- Thurston Regional Planning Council (TRPC)
- Wenatchee Valley Transportation Council (WVTC)
- Whatcom County Council of Governments (WCCOG)
- Yakima Valley Conference of Governments (YVCOG)

MPOs cover the metropolitan areas prescribed by federal law and also serve as the lead agency for Regional Transportation Planning Organizations (RTPOs) as enabled by state law (RCW 47.80), that form to include the MPO area (in some cases RTPOs cover a larger area). MPOs with a population over 200,000 are also designated as Transportation Management Areas (TMA).

Each MPO has a transportation policy board consisting of local elected officials from cities and counties. These boards may also consist of representatives from ports, transit agencies, tribes, WSDOT, major employers, the public, and other local transportation interests. Typically, each MPO also has a technical committee composed of staff from local planning and public works departments, and WSDOT Regional staffs.

The results of this transportation planning process are transportation plans and programs that are consistent with, and implement local comprehensive plans. The MPO planning process provides for:

- A forum for gaining local consensus on regional transportation needs.
- The creation of a metropolitan transportation plan identifying future transportation facilities and services needed to support and implement local comprehensive plans.

- Targeted transportation studies used to develop the metropolitan transportation plan.
- A forum to decide how to allocate certain categories of transportation funds.
- The development of a three-year list of facilities and services (to be funded by member organizations) called the Metropolitan Transportation Improvement Program (MTIP).

Metropolitan transportation plans provide a significant building block for the development of *Washington's Transportation Plan* created by WSDOT.

(2) State Laws: Planning Mandates Shape Project Selection

The state of Washington has adopted several important laws affecting transportation planning at various levels. These laws provide the framework for transportation decision-making, ultimately guiding the programming, design, and construction of transportation facilities and services. The following is a partial list of the state laws that address transportation planning.

(a) Statewide Transportation Planning (RCW 47.06). This set of laws establishes that " . . . the state has an appropriate role in developing statewide transportation plans." RCW 47.06 specifies that state owned transportation facilities and services, as well as those transportation facilities and services of state interest, must be addressed in these plans and that these plans shall guide short-term investment decisions and the long-range vision for transportation system development.

(1) *Washington's Transportation Plan* (WTP). The WTP provides guidance for the development, maintenance, and operation of a comprehensive and balanced multimodal transportation system. The overall direction of the WTP, prepared pursuant to RCW 47.06, is provided by the Washington State Transportation Commission. The WTP provides the direction for investment decision-making at WSDOT for all modes of transportation.

The WTP includes the following subjects concerning all major transportation modes:

- Meeting the federal requirements identified in TEA-21.
- Critical factors affecting transportation.
- Important issues concerning each mode and strategies to solve problems or improve function.
- Plans for development and integration of the various modes of transportation.
- Major improvements in facilities and services to meet transportation needs.
- Financial resources required to implement the recommendations.

The WTP is a dynamic plan that is updated on a regular basis to address changing conditions. Information and recommendations for the WTP are received from WSDOT regions and Headquarters (HQ), Metropolitan Planning Organizations, Regional Transportation Planning Organizations, local governmental agencies, private transportation operators, and the public.

The WTP addresses transportation facilities owned and operated by the state, including state highways, Washington State Ferries, and state-owned airports. It also addresses facilities and services that the state does not own, but has interest in. These include public transportation, freight rail, intercity passenger rail, marine ports and navigation, nonmotorized transportation, and aviation.

(2) *State Highway System Plan* (SHSP or HSP). The *State Highway System Plan* is the highway component of the WTP. The HSP defines *Service Objectives*, *Action Strategies,* and costs to plan for, maintain, operate, preserve, and improve the state highway system for the next 20 years.

Because needs listed in the HSP exceed projected revenue, the Transportation Commission established a set of priorities for funding projects. (See the *State Highway System Plan*.) The Commission has adopted service objectives and action strategies as a way to establish a logical process for identifying and categorizing projects that will receive funding over the next 20 years. These service objectives and action strategies provide the framework for defining 20-years of needs on the state highway system. Work that does not fit any of the action strategies will not be authorized or considered in the development of, the Statewide Transportation Improvement Program (STIP) or any other budget proposal.

The HSP is updated every two years, in coordination with local plan updates, to reflect completed work and changing transportation needs, policies, and revenues.

(3) State Environmental Policy Act. The State Environmental Policy Act (SEPA) requires the environmental effects of state and local agency actions be evaluated per WAC 197-11. Certain categorical exemptions exist. Agencies are required to adopt these regulations by reference and may develop more specific regulations for their own agency to specify how SEPA will be implemented.

WSDOT adopted agency specific SEPA regulations in 1986. Per WAC 468-12-800 (3) the following transportation planning activities are categorically exempt under these rules:

"The development, adoption, and revision of transportation plans and six year construction programs and any other studies, plans and programs which lead to proposals which have not yet been approved, adopted or funded and which do not commit the WSDOT to proceed with the proposals."

It should be noted the local government Comprehensive Plans developed pursuant to the Growth Management Act (GMA) contain a transportation element and these Comprehensive Plans must include a SEPA review.

Typically, transportation planning does not require review under the National Environmental Policy ACT (NEPA) because there is no federal action in the development of state and local transportation plans.

(b) The Growth Management Act (RCW 36.70A). Enacted in March 1990, the state's Growth Management Act (GMA) requires cities and counties that meet certain population or growth-rate thresholds to adopt comprehensive plans. Jurisdictions that are required to or choose to plan under the GMA must also adopt and enforce ordinances that implement the policies adopted in the comprehensive plans. Under the GMA, comprehensive plans carry the force of law and require full public participation in their development.

A comprehensive plan is a series of coordinated policy statements and formal plans that direct growth. Comprehensive plans articulate how a community will be developed in the future. They include elements that address housing, utilities, capital facilities, economic development, land use, and transportation. GMA planning requires that the transportation element be consistent with and support the land use elements in comprehensive plans.

Continuous coordination and open discussion during the development of local comprehensive plans is key to developing valid plans that direct the growth of a community. Representatives from neighboring jurisdictions, special purpose districts, WSDOT, and others with an interest in future development must be involved at the beginning and throughout the planning process. This is to ensure that comprehensive plans are consistent with all other state and local plans.

Local comprehensive plans are important to WSDOT because they influence how state facilities not classified as Transportation Facilities of Statewide Significance, should be addressed, how state highways will be impacted by local land use, and how access requirements will be met or maintained.

WSDOT seeks to work in partnership with local governments as they develop comprehensive plans to help create a balance between the need for mobility and access, while emphasizing design components that improve or maintain the livability of communities. It is also the responsibility of WSDOT to review and comment on local comprehensive plans and amendments.

(c) Regional Transportation Planning Organizations (RTPOs) (RCW 47.80.020). Washington has two types of "regional" or "area wide" transportation planning organizations: MPO and RTPO. MPOs, which serve areas with urbanized populations over 50,000, were introduced in the discussion on federal laws in Section (1)(b). A Regional Transportation Planning Organization (RTPO) is a voluntary organization enabled under state law. In an area where an MPO exists, the MPO is required by state law to be the lead agency for the RTPO.

Although voluntary, cities, counties, ports, tribes, and transit agencies usually become members of the RTPO; their participation is their best way to influence local and statewide transportation planning.

RTPOs perform some functions similar to MPOs and, like MPOs, provide a forum for information exchange and collective decision making between local governments and WSDOT. WSDOT is represented on each RTPO technical advisory committee and on most RTPO Policy Boards.

Fourteen RTPOs exist in Washington State, covering all counties of the state except San Juan County. (See Figure 120-1.) Of the eleven MPOs listed in 120.04(1)(b), only Lewis-Clark Valley MPO is not the lead agency for an RTPO. In addition to the ten RTPOs with MPOs as lead agencies, there are the following RTPOs:

- Palouse RTPO (Asotin County is an Adjunct member)
- Peninsula RTPO
- QUADCO RTPO
- Northeastern Washington RTPO (N. E. W.)

(d) Transportation Facilities and Services of Statewide Significance (RCW 47.06.140). The Legislature has declared certain transportation facilities and services, which promote and maintain significant statewide travel and economic development, to be of statewide significance.

Transportation facilities and services of statewide significance (TFSSS) are considered essential state public facilities. (See RCW 36.70A.200.) Essential state public facilities cannot be precluded from operation or expansion by local comprehensive plans and development regulations. This means that the WSDOT interest in these facilities and services takes precedence over local interests in the planning process. These facilities must comply with local ordinances and permits.

Therefore, planning for TFSSS must be conducted with a statewide perspective in mind. WSDOT, in consultation with transportation providers and regulators, is responsible for development of a statewide, multimodal plan for these facilities and services. The balance between providing for the movement of people and goods and the needs of local communities is the main consideration.

Highways of Statewide Significance (HSS) are one category of transportation facilities and services of statewide significance. The HSS designation was established by the Washington State Transportation Commission, and approved by the Legislature, to identify significant state-owned transportation facilities and establish the following:

1. Standardized levels of service (LOS) for mobility on HSS routes
2. HSS routes receive a higher priority for WSDOT mobility improvement funding
3. HSS routes are specifically exempt from concurrency requirements (except in Island County) and
4. HSS routes will be the focus of Regional Transportation Improvement District funding (King, Pierce, and Snohomish Counties).

The HSS includes the Interstate highway system, interregional state principal arterials, and ferry connections that serve statewide travel.

WSDOT makes the final decision regarding the acceptable Level of Service (LOS) for highways of statewide significance. The MPOs and the RTPOs, in consultation with WSDOT, set the acceptable LOS on Regionally Significant state highways (Non-HSS).

For a list of Highways of Statewide Significance in Washington, see http://www.wsdot.wa.gov/ppsc/hsp/hss.htm.

(e) Functional Classification of Highways and Roadways (RCW 47.05.021). Functional classification is the grouping of highways, roads, and streets that serve similar functions into distinct systems or classes within the existing or future highway network. The objective of functional classification is to define the appropriate role (mobility versus access) of various highways in providing service and influencing development. Generally, the higher functional classification routes provide mobility between communities, have higher travel speeds, and serve longer distance travel. The lower functional classification routes focus on providing localized access to the land adjacent to the roadway. Functional classification is important in:

- Identifying routes for inclusion in the National Highway System.
- Providing the basis for administering the Surface Transportation Program.
- Determining design levels for a specific route.
- Planning.
- Establishing access control.
- Providing information for land use plans and decisions.
- Conducting needs assessments and cost allocation studies.
- Helping to determine the level of maintenance.
- Conducting the priority programming process.

All state highways are subdivided into three functional classifications. See Chapter 440, "Full Design Level," for definitions of the collector, minor arterial and principal arterial classifications.

(f) Freight and Goods Transportation System (FGTS). The FGTS has been established due to increasing interest in developing the most effective and efficient system for moving freight from suppliers to consumers. The FGTS is required by RCW 47.05.021 section 4, which states:

> "The transportation commission shall designate a freight and goods transportation system. This statewide system shall include state highways, county roads, and city streets. The commission, in cooperation with cities and counties, shall review and make recommendations to the legislature regarding policies governing weight restrictions and road closures which affect transportation of freight and goods."

The FGTS ranks state highways, county roads and city streets based on annual tonnage carried.

The Freight Mobility Strategic Investment Board (FMSIB) uses the FGTS to designate strategic freight corridors and is obligated to update the list of designated strategic corridors every two years (RCW 47.06A.020 (3)). WSDOT provides staff and logistical support to FMSIB, including updates to the FGTS.

(g) Access Control (RCW 47.50, WAC 468-51, and WAC 468-52). Access control is a program that combines traffic engineering and land use regulatory techniques. Access control balances the desire and need for access (from adjacent properties to streets and highways) with other elements such as safety, preservation of capacity, support for alternative transportation modes, and preservation and enhancement of communities.

There are two forms of access control within WSDOT: limited access control and managed access control. (See Chapters 1420, 1430, and 1435) For limited access control, WSDOT purchases the right to limit access to a highway. Managed access control is a regulatory program established by a state law that requires that access to state highways in unincorporated areas be managed by WSDOT to protect the public and preserve highway functionality. Cities also have authority to grant access to state highways with managed access within incorporated areas. WSDOT retains authority on state highways with limited access.

WSDOT has established the Master Plan for Limited Access Highways for access control that is consulted when planning transportation improvement strategies.

120.05 Planning at WSDOT

The role of planning at WSDOT is to identify transportation needs and facilitate the development and implementation of sound, innovative investments and strategies. Many groups within WSDOT conduct planning activities that directly or indirectly influence the design of transportation facilities.

These groups serve a variety of departmental purposes including advocating multi-modal strategies, providing technical assistance, and implementing a wide variety of programs, projects, and services.

The following is a list of the groups, involved in planning, with their responsibilities, and their effect on the design of transportation facilities.

(1) Transportation Planning Office

The Transportation Planning Office of the Strategic Planning and Programming Division in WSDOT Headquarters consists of three branches: the Systems Analysis and Program Development Branch, the Policy Development and Regional Coordination Branch, and the Central Puget Sound Urban Planning Office (UPO).

(a) Systems Analysis and Program Development Branch. The major responsibilities of the Systems Analysis and Program Development Branch are to:

- Coordinate planning activities and provide technical assistance to WSDOT regions.
- Oversee the development and programming of *Washington's Highway System Plan (HSP)*.
- Collect and process data, conduct studies, and develop travel forecasts.
- Coordinate project-planning activities and provide technical assistance to WSDOT regions.

(b) Policy Development and Regional Coordination Branch. The Policy Development and Regional Coordination Branch responsibilities include:

- Coordination of planning activities and technical assistance to WSDOT regions, the Central Puget Sound Urban Planning Office, eleven MPOs, and fourteen RTPOs.
- Management oversight of the MPOs to ensure fulfillment of federal metropolitan transportation planning regulations in 23 USC 134, and the RTPOs regarding state requirements in RCW 47.80, WAC 468-86, and the WSDOT Regional Planning Standards.
- Administration of federal and state planning grants for planning organizations.
- Development of the *Washington Transportation Plan* (WTP) in partnership with other WSDOT organizations, MPOs and RTPOs. See 120.04(2)(b) for a description of the WTP.

The responsibilities of the Central Puget Sound Urban Planning Office are discussed under Section 120.05(4).

(2) Public Transportation and Rail Division

The Public Transportation and Rail Division works to enhance mobility options by managing, coordinating, and advocating for rail, commuting options, and public transportation programs throughout the state. The division's mission is to improve transportation choices, connections, coordination, and efficiency. The division promotes freight rail programs and, in cooperation with Amtrak, passenger rail programs. The division also provides planning, project oversight, financial, and technical assistance to public transportation providers. Division staff oversees the state commute trip reduction program and provides technical assistance and grants to help reduce vehicle miles traveled by commuters in urban regions of the state.

Public Transportation and Rail Division's plans and programs add value to highway and roadway design decisions by emphasizing enhancement, improvement, and coordination of intermodal connections. It is recommended that these plans and programs be referenced during the design process to ensure coordination and efficiency.

(a) Public Transportation and Commute Options Office. Programs organized by the Public Transportation and Commute Options Office support passenger transportation systems and services through grants, technical assistance, research, and planning. The office works in partnership with local communities and governments to promote, improve, and expand and coordinate public transportation resources, and access to those resources, throughout the state. The major emphases in the Public Transportation program are:

- Implement projects and strategies identified in the *Public Transportation and Intercity Rail Passenger Plan for Washington State* and *Washington's Transportation Plan*.
- Identify, support, coordinate, and monitor the planning, capital, and operating funding needs of small urban and rural public transportation providers.
- Improve effectiveness and efficiency of public transportation through training, technical assistance, and coordination to all agencies engaged in public transportation including nonprofit agencies, and private for-profit bus and taxi companies.
- Establish mobility options in areas where public transportation is limited or does not exist.
- Develop, implement, and manage grant programs to enhance and sustain statewide mobility.
- Monitor compliance for safety, including the drug and alcohol programs of rural public transportation providers.
- Manage information and data for the efficient coordination of transportation programs and providers.
- Provide leadership and support for the Agency Council on Coordinated Transportation (ACCT). ACCT is an interagency team responsible for recommending policies and guidelines to promote institutional and operational structures that encourages the efficient coordination of transportation programs and providers.

(b) Rail Office. Intercity passenger rail and freight rail are the focus of this office. Passenger and freight rail services are an important part of our state transportation system. Moving people and goods by rail is often safer and more environmentally friendly than adding traffic to our already congested highways. Improvements to the state's rail system, whether funded by the private sector or the public sector, can help mitigate the impacts of our fast growing economy and population.

The *Intercity Rail Passenger Plan for Washington State* defines a passenger rail system that links major population centers throughout the state and provides the blueprint for needed improvements to these intercity rail systems. The plan emphasizes incrementally upgrading the Amtrak passenger rail system along the Pacific Northwest Rail Corridor in western Washington. The vision is to reduce travel times and provide better passenger rail service in the Pacific Northwest. A number of activities unrelated to passenger rail are continuously underway in the corridor, requiring extensive coordination among various agencies and private organizations. The corridor also serves some of the world's busiest ports. WSDOT is working with the Puget Sound Regional Council and other area agencies through the Freight Action Strategy for the Everett-Seattle-Tacoma Corridor (FAST Corridor) project to plan for the elimination of at-grade highway/railroad crossing conflicts and to improve port access.

The *Washington State Freight Rail Plan* fulfills a Federal Railroad Administration requirement that the states establish, update, and revise a rail plan. It also fulfills the Washington State Legislative directive (RCW 47.76.220) that WSDOT prepare and periodically revise a state rail plan that identifies, evaluates, and encourages essential rail services. The plan identifies the abandonment status of various rail lines, provides analysis of the various alternatives to these proposed abandonment's, and provides recommendations that are incorporated into *Washington's Transportation Plan*.

(c) Transportation Demand Management Office. The Transportation Demand Management (TDM) Office advocates for, creates, and develops effective solutions to capacity constraints within the state transportation system. TDM Office staff provides financial and technical support within WSDOT, and external transportation organizations, to help ensure that demand management can be implemented whenever such programs are appropriate and cost effective. Program support is provided in areas such as land use planning, TDM research, parking management, high capacity transportation planning, and policy development for the state's freeway high occupancy vehicle system.

The office also assists public and private employers, jurisdictions, and other interested parties with implementation of RCW 70.94.521 through 551. The goals of the commute trip reduction (CTR) statutes are to reduce air pollution, traffic congestion, and the consumption of fossil fuels. The TDM office provides financial and technical support to employers to meet their mandated CTR requirements.

The TDM Office provides leadership through developing policies and guidelines that help direct public and private investment in the state's transportation system. An essential function of the TDM Office is to develop and maintain a TDM Strategic Plan for WSDOT. This plan helps ensure that *Washington's Transportation Plan* and all other internal planning processes incorporate TDM activities. Regional and local TDM activities and planning functions are further supported by the TDM Office through coordination and implementation of statewide TDM programs, providing public information and marketing tools, and providing training opportunities. The office also administers local TDM grant programs and planning grants that generate commute efficiencies in certain urban areas of the state.

(3) Highways and Local Programs Division

Highways & Local Programs (H&LP) Division of the Washington State Department of Transportation (WSDOT), has been serving the local agencies of Washington State for over 60 years. H&LP is a statewide organization with Local Programs staff located in all six WSDOT regions and in Headquarters. Under WSDOT's stewardship agreement with the Federal Highways Administration (FHWA), H&LP serves as the steward of the local agency federal-aid program by administering and managing federal funds from project development through construction administration. H&LP provides assistance to cities, counties, ports, tribal governments, transit, and metropolitan and regional planning organizations in obtaining federal and state grant funds to build and improve local transportation systems. H&LP, on behalf of the Secretary of WSDOT, is responsible for preparing and submitting the Statewide Transportation Improvement Program (STIP) to FHWA, without which no federal project would be authorized. In addition, H&LP provides federal compliance oversight on federally funded projects, technical assistance and training, and promotes cooperative planning and partnerships between WSDOT and local agencies.

(4) WSDOT Regions and The Central Puget Sound Urban Planning Office (UPO)

The roles of planning at WSDOT regions and at the Central Puget Sound Urban Planning Office (UPO) are similar in many ways. What follows are descriptions of the roles of planning at WSDOT regions and the UPO.

(a) WSDOT Region Planning. Each WSDOT region has a Planning Office that has several roles, such as:

- Conducting and overseeing a variety of long-range planning studies.
- Coordinating and assisting planning organizations outside WSDOT.
- Assisting in development of prioritized plans.
- Administering internal WSDOT programs.
- Overseeing access control activities.
- Performing Development Services activities.

For the Olympic and Northwest Regions, many of these long-range planning functions are assigned to the Central Puget Sound Urban Planning Office (UPO).

Each Region Planning Office conducts long range planning studies such as Route Development Plans, Corridor Master Plans, and site-specific transportation alternatives and studies. These studies evaluate alternative solutions for both existing and projected transportation needs, initiate the long-range public involvement process, and ultimately provide the foundation for inclusion of identified improvement strategies into *Washington's Transportation Plan* (WTP) and the *State Highway System Plan* (HSP).

Each Region Planning Office coordinates with and assists the local Metropolitan Planning Organization (MPO) and Regional Transportation Planning Organizations (RTPO). In some cases, the Region Planning Office provides staff support for the local RTPO.

The region works with the Washington State Patrol to include their weigh site and other highway related needs in WSDOT projects.

Often, the Region Planning Office is responsible for administering internal WSDOT programs such as traffic modeling, the Travel Demand Management program (TDM), and responding to citizen concerns about pedestrian, bicycle, and other transportation related issues.

Development Services is the process of reviewing new developments affecting state highways, such as master planned communities, major subdivisions, and commercial projects. Developers provide mitigation for their impacts to the state highway system under the State Environmental Policy Act (SEPA) and Highway Access Management. The Development Services section works closely with the local lead agency during SEPA reviews and the permitting process to secure appropriate improvements to the state transportation system from developers.

The region's Planning Office also reviews and comments on local Comprehensive Plans so development regulations, local transportation elements, and WSDOT goals and interests are consistent.

(b) The Central Puget Sound Urban Planning Office. The Central Puget Sound Urban Planning Office (UPO), based in Seattle and part of the Strategic Planning and Programming Division, has a similar role to a region Planning Office yet the UPO role is more specialized. The UPO oversees long range planning efforts of WSDOT in the four-county Central Puget Sound area of King, Pierce, Snohomish, and Kitsap Counties. This is the same area covered by the MPO called the Puget Sound Regional Council (PSRC), located in Seattle. The four-county region is geographically split between WSDOT's Olympic and Northwest Regions. UPO also has the responsibility of coordinating plans developed by Washington State Ferries with the strategies contained in the *State Highway System Plan*.

The Central Puget Sound Urban Planning Office also participates in the review of documents mandated by the Growth Management Act (GMA). This includes the review of draft Comprehensive Plans as well as the Draft Environmental Impact Statements that provide supporting documentation to the Comprehensive Plans. The Central Puget Sound Urban Planning Office also provides staffing and logistical support for the Regional Transportation Investment District (RTID). The RTID, a regional transportation planning committee created by legislation, provides funding for major transportation projects in King, Pierce, and Snohomish counties.

Development Services responsibilities remain with the Northwest and Olympic Regions Planning Offices.

(5) Washington State Ferries Division

The *Long Range Ferry System Plan*, prepared by the Washington State Ferries Division, considers recent trends in ferry ridership, system costs, regional economy, and other system and site factors. It is recommended that designers contact the Washington State Ferries planning office during the design phase of any conceptual solution occurring near a ferry terminal or for a project that might add significant traffic to or around a ferry terminal.

(6) Aviation Division

The WSDOT Aviation Division:

- Provides general aviation airport aid, including an award-winning lighting program.
- Provides technical assistance for airspace and incompatible land use matters that may affect airport operations or compromise safety.
- Coordinates all air search, rescue, and air disaster relief.
- Administers pilot and aircraft registration.

This division is responsible for development of the *Washington State Airport System Plan.* The division also operates sixteen state airports strategically placed throughout the state.

120.06 Linking Transportation Plans

A main concern of the traveling public is that the transportation system allows them to move from point A to point B quickly, safely, and with the least possible inconvenience and expense. To fulfill the public's desire for a seamless transportation system, coordination of transportation planning efforts is essential.

(1) Coordination of Planning Efforts

Coordination of planning efforts between city, county, MPO, RTPO, public and private transportation providers, and state transportation plans is not only required by federal and state laws — it makes good business sense. Coordination of transportation planning is a cyclical process and begins as a bottom-up approach. Figure 120-1 is a diagram that explains the general relationships between the various transportation planning processes and organizations.

Cities and counties explore their needs and develop *comprehensive plans.* Among other components, each comprehensive plan contains a land use element and a transportation element, which must be consistent with each other. The transportation element (sometimes known as the *local transportation plan*) supports the land use element. The requirements in the Growth Management Act (see 120.04 (2)(d)) guide most of the comprehensive plans developed in the state of Washington.

MPOs and RTPOs coordinate and develop metropolitan and regional transportation plans. These plans cover multiple cities and, for RTPOs, encompass at least one county. The purpose of metropolitan transportation plans and regional transportation plans is to ensure that all the region's transportation needs are accurately captured in one document, to develop a financial strategy to address the unfunded needs, and to assure local plan consistency across jurisdictional boundaries.

Planning is undertaken to ensure consistent policy among all the various jurisdictions, whether state, regional, or local. It does not matter where the planning process begins because the process is both cyclic and iterative. If one component of a plan changes, it may or may not affect other components. If any one plan changes significantly, it can affect each of the other plans in the cycle. Early communication and coordination of conceptual solutions are critical to ensuring project delivery.

(2) Transportation Improvement Programs

Figure 120-2 shows the coordination of effort that produces consistent and comprehensive transportation plans and programs.

From these transportation plans, each town, city, county and public transportation provider develops a detailed list of projects that will be constructed in the ensuing three to six years. This detailed list of transportation projects is called the six year Regional Transportation Improvement Program also known as the Six-Year RTIP or the three-year Metropolitan Transportation Improvement Program (MTIP).

The six-year RTIP and the three-year MTIP must be financially constrained, meaning that the total cost of all projects cannot exceed the established revenue authority. Financially constraining the RTIP and the MTIP is one method used to ensure that the list of projects represents what the local agency intends to build in the near future to implement local transportation plans. Once each jurisdiction develops its individual TIP, the RTPO and the MPO compile these individual TIPs into a regional or metropolitan TIP.

Each RTPO/MPO completes a Regional or Metropolitan Improvement Program (RTIP or MTIP) at least once every two years (RCW 47.80.023). The RTIP/MTIPs must meet the requirements of federal and state laws regarding transportation improvement programs and plans. To achieve this, the RTIP/MTIP:

- Is developed cooperatively by local government agencies, public transit agencies, and the WSDOT Regions within each area.

- Includes all federally funded WSDOT Highway Construction Program projects.
- Includes all significant transportation projects, programs, and transportation demand management measures proposed to be implemented during each year of the next period.
- Identifies all significant projects, whether funded by state or federal funds.
- Includes all significant projects from the local transit development plans and comprehensive transportation programs required by RCW 35.58.2795, 35.77.010(2), and 36.81.121(2) for transit agencies, cities, towns, and counties.
- Includes all transportation projects funded by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA).
- Includes all federally funded public lands transportation projects.
- Includes all WSDOT projects regardless of funding source and clearly designates regionally significant projects as such.
- Complies with all state (RCW 70.94) and federal (40 CFR 51 & 93) Clean Air Act requirements (where applicable).
- Includes only projects consistent with local, regional, and metropolitan transportation plans.
- Includes a financial section outlining how the RTIP/MTIP is financially constrained, showing sources and amounts of funding reasonably expected to be received for each year of the ensuing six/three-year period, and includes an explanation of all assumptions supporting the expected levels of funding.

Funding agencies often give preference to jointly sponsored transportation projects. RTPOs and MPOs can develop jointly sponsored projects since they represent multiple agencies. Major projects backed by an RTPO or an MPO have a heightened chance of receiving funding.

(3) Development of the STIP

An important role of the WSDOT Highways and Local Programs Division is to collect all RTIP, MTIP, and HSP projects in appropriate years and assemble all of the state and federally funded projects, and the projects of regional significance, into the (three-year) Statewide Transportation Improvement Program (STIP).

Development of a new STIP every two years is required by federal law in order to expend federal transportation dollars. The state of Washington, however, develops a new STIP each year to enhance project flexibility and to ensure project delivery.

The Governor's approval of the MTIPs; plus the Federal Highway Administration's, and the Federal Transit Administration's approval of the STIP; are required prior to expenditure of federal funds.

120.07 Linking WSDOT Planning to Programming

Figure 120-3 is a flow chart describing the process conceptual solutions must go through to receive funding. This chart also describes the link between planning and program development. Project Definition is presented in Chapter 330, Design Matrices are in Chapter 325, and Environmental Documentation is in Chapter 220.

The role of WSDOT planning is to determine *what* facilities or services will be provided *where*. The role of WSDOT Systems Analysis and Program Development is to determine *when* the improvements will be provided. The WSDOT Systems Analysis and Program Development Branch prioritizes the projects that are selected from the *State Highway System Plan* component of *Washington's Transportation Plan*. (See 120.04(2)(b).)

(1) The Role of the Systems Analysis and Program Development Branch

Taking the HSP from the planning stage through the programming stage is one role of the Systems Analysis and Program Development Branch. The Systems Analysis and Program Development Branch and the Project Control and Reporting Office manage the statewide highway construction program including:

- Recommending subprogram funding levels.
- Developing project priorities.
- Preparing, executing, and monitoring the highway construction program.

One responsibility of the Systems Analysis and Program Development Branch is oversight of the *Programming Process*. The legislative authorization for this activity is in RCW 47.05, Priority Programming. The Programming Process describes how projects that have been identified in the HSP are prioritized.

(2) Subprogram Categories

Subprogram categories for the service objectives and action strategies have been established, by the Transportation Commission, within WSDOT's budget to allow decision makers to determine timing and the amount of money to invest in solving transportation needs. (See the HSP for the service objectives and action strategies.) The order of the needs within each subprogram category is usually prioritized based on benefit/cost methodology: however, some subprograms do not have a prioritization methodology attached to them (such as Economic Initiatives).

The Department may combine projects that are scheduled to be constructed within six-years of each other to eliminate projects at the same location just a few years apart.

Following completion of construction, WSDOT evaluates the effectiveness that the project had on the performance of the transportation system.

(3) WSDOT Budgets

WSDOT uses the *State Highway System Plan* component of the twenty-year *Washington's Transportation Plan* as the basis for prioritizing and programming to select projects for the Agency Request Budget (ARB) and Current Law Budget (CLB). To be selected, a project must already be included in the HSP.

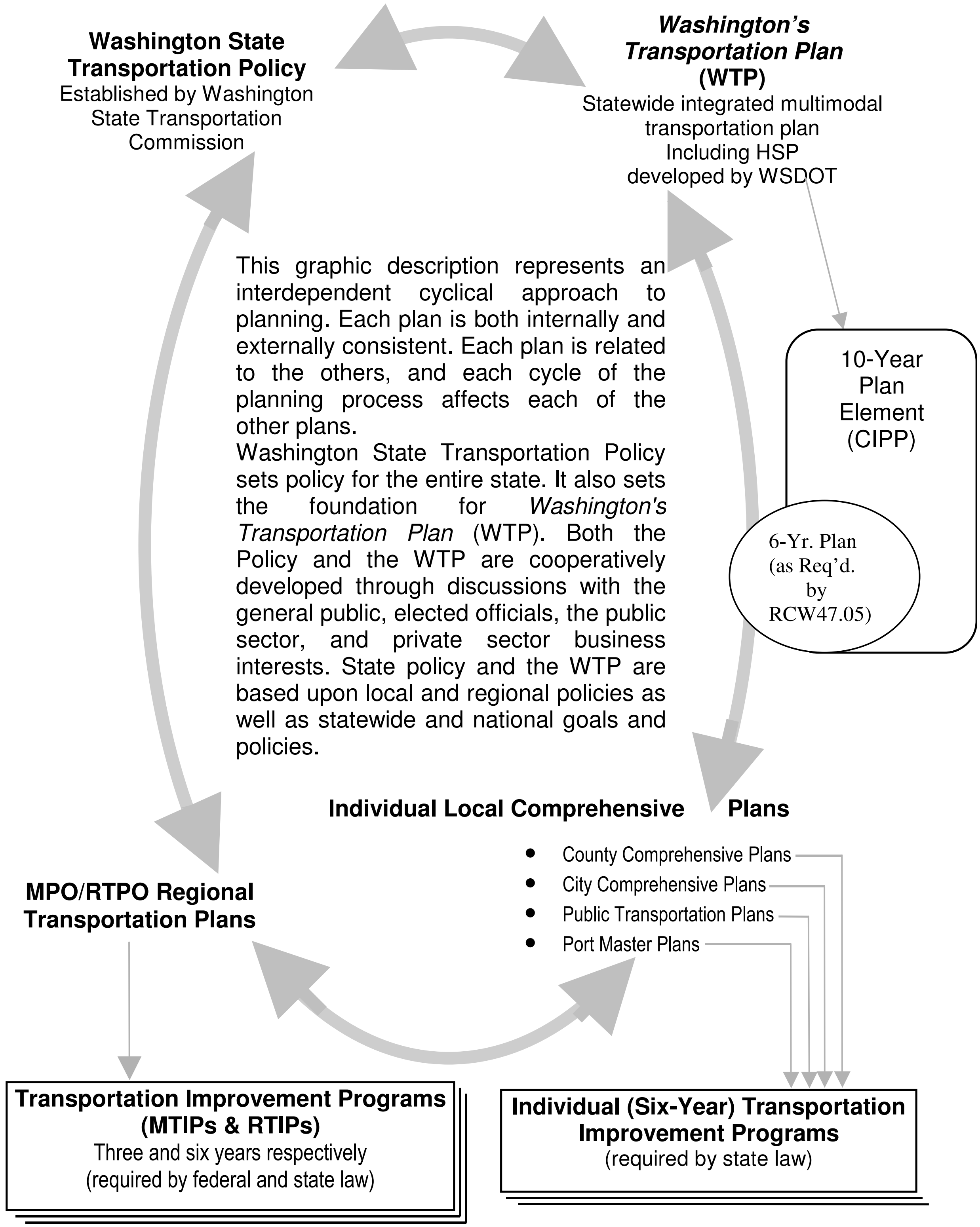
WSDOT operates on a two-year funding cycle. This is primarily because the state Legislature appropriates state transportation funds on a biennial basis. The Washington State Transportation Commission has developed a Six-Year Plan Element and the ten year Capital Improvement and Preservation Program (CIPP). The plans were developed to better implement the intent of federal and state laws influencing transportation and land use, to encourage a longer range perspective in the funding of transportation projects, and to be consistent with local and regional transportation planning processes. These plan elements will be used by the Commission to develop the two-year budget proposals.

When appropriated by the Legislature, WSDOT's two-year budget is forwarded to the appropriate RTPOs and MPOs for any needed revisions to the RTIPs and MTIPs.

(4) Key Points of Planning and Programming at WSDOT

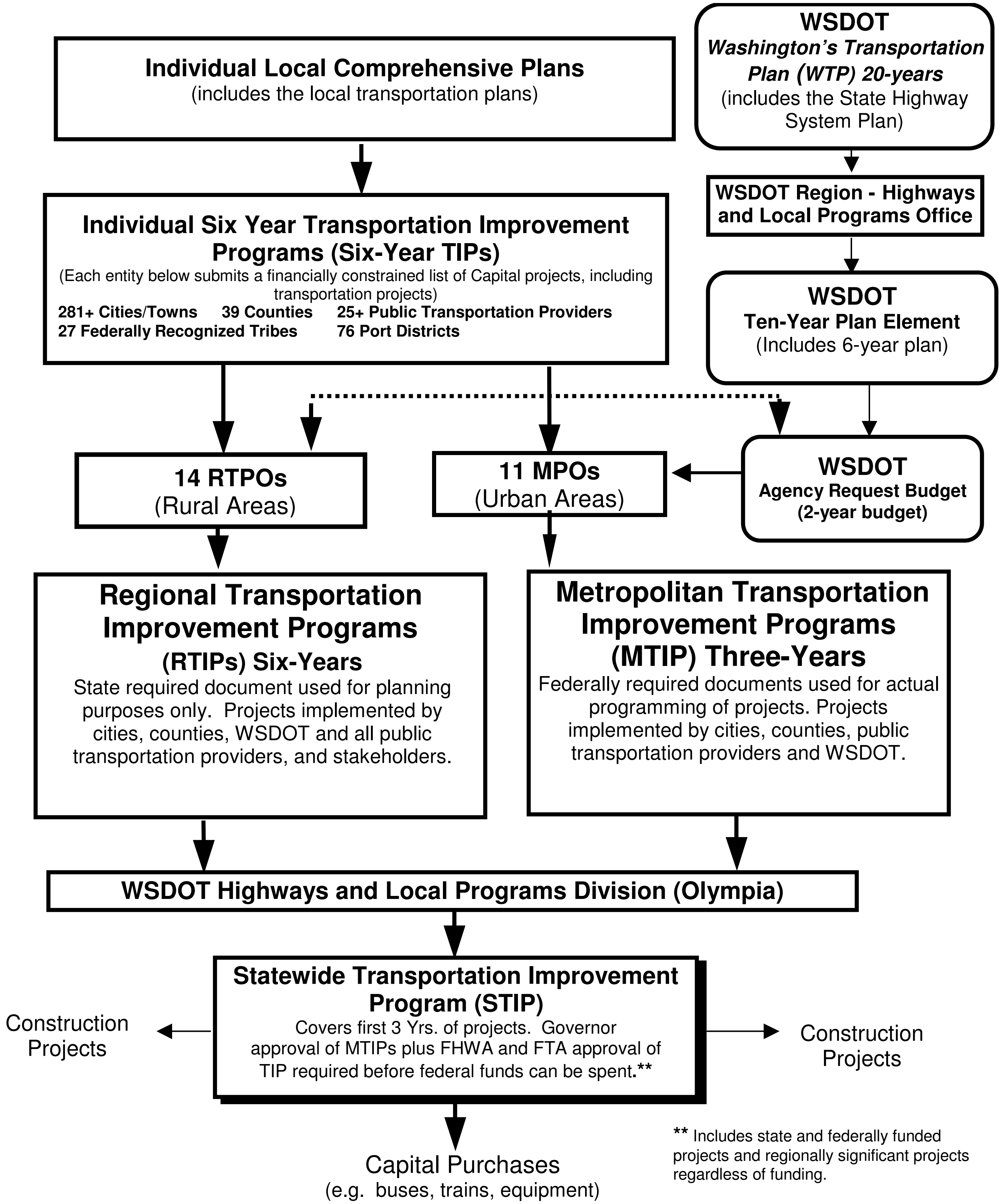
Below is a list of key points to remember about WSDOT's planning and programming process:

- Commission Policy sets the direction for *Washington's Transportation Plan* (WTP).
- Federal transportation laws and state transportation and land use laws guide solutions to address the needs for transportation facilities and services.
- The WTP is developed in partnership with MPOs and RTPOs and is tied to the land use plans of towns, cities, and counties.
- The region's Planning Offices have the main responsibility for meeting many of the state and federal planning requirements.
- The *State Highway System Plan* is a component of the WTP.
- The *State Highway System Plan* sets forth service objectives and action strategies to implement Commission policy.
- Conceptual solutions are prioritized within most budget categories based on benefit/cost analyses to obtain the greatest benefit at the least cost.
- Tradeoffs between project categories are made by policy choice through a multitiered process (WSDOT executives, Commission, and Legislature).
- An improvement strategy must be listed in the *State Highway System Plan* to be considered for project funding.

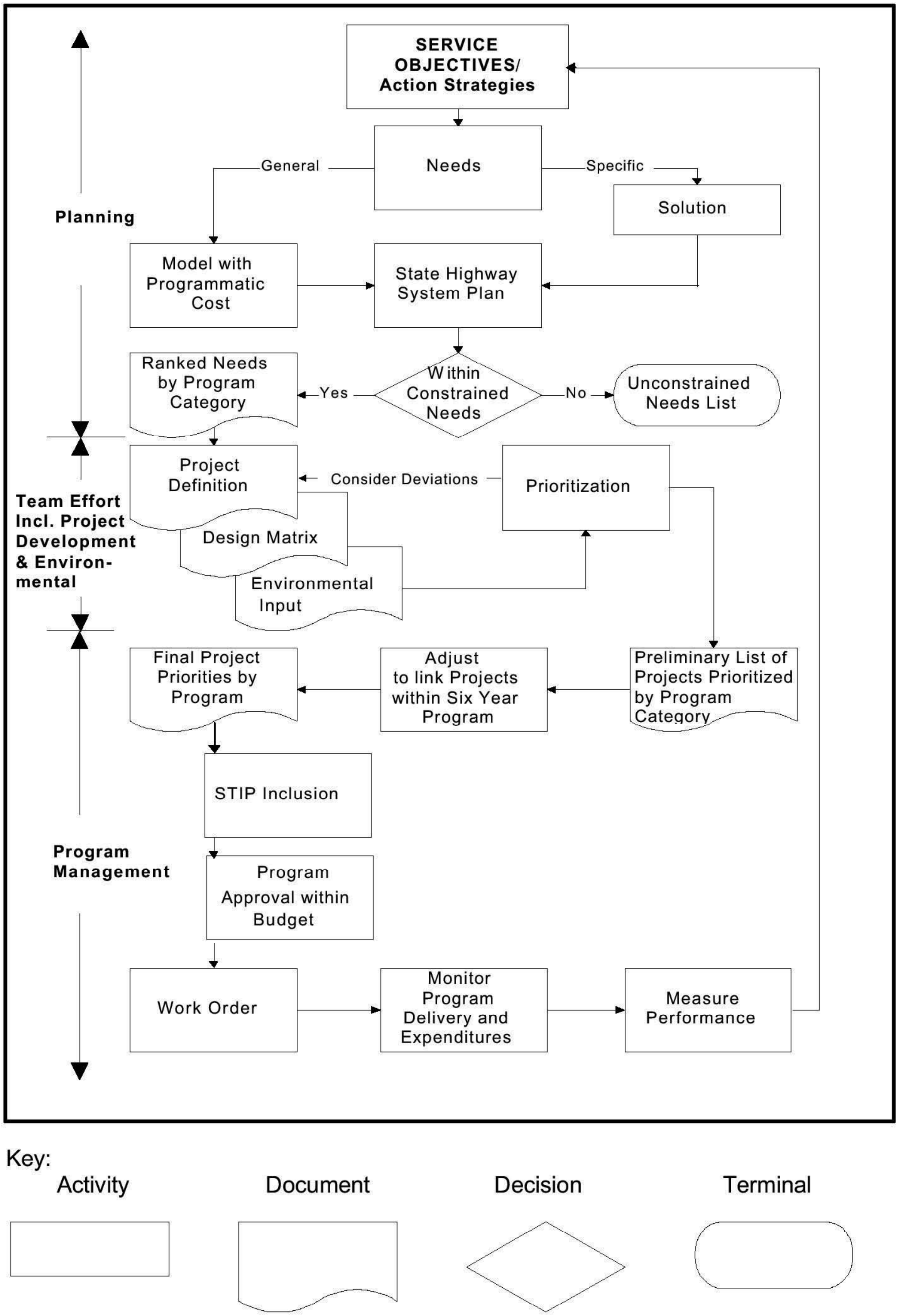


Relationship Between Transportation Plans and Planning Organizations

Figure 120-1



Transportation Improvement Programs
Figure 120-2



Linking Planning and Programming
Figure 120–3

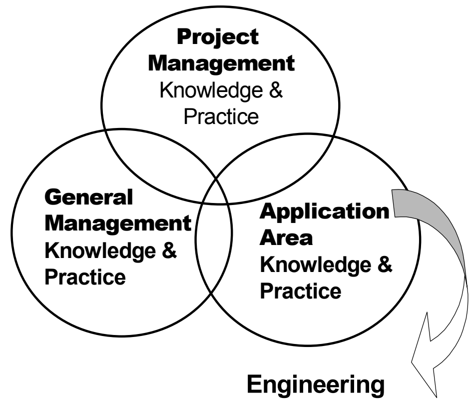
140.01 General

This chapter outlines the principles and methodology adopted by the Washington State Department of Transportation (WSDOT) for successful project management and delivery. Managing Project Delivery (MPD) is the standard practice adopted by WSDOT to manage projects and provides a method to meet the WSDOT Management Principles. (See WSDOT Management Principles at http://www.wsdot.wa.gov/accountability/mgmtprinciples.htm)

Project management requires the application of skills, knowledge, tools, and techniques to deliver the project on time, within budget, and according to specifications. There are proven industry standards for project management, such as the Project Management Body of Knowledge (PMBOK) through the Project Management Institute (PMI). The MPD process, as adopted by WSDOT, is based upon those industry standards.

While terminology may vary, the principles of project management are consistent. A project manager needs more than tools to succeed in delivering quality projects on time and within budget. Project managers with the knowledge and skill to lead a team toward a common goal will optimize team member talents to the best benefit of the team.

The WSDOT project manager must apply three overlapping disciplines (skills) for effective project management as illustrated in Figure 140-1.



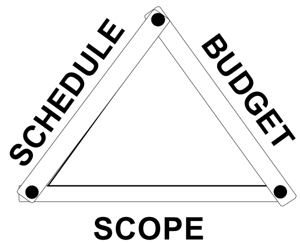
Overlapping Disciplines for Successful Project Delivery
Figure 140-1

Key features of effectively managing project delivery include the following:

- Building an interdisciplinary team with the necessary skills and understanding of the project.
- Effectively defining the project scope and managing that scope throughout the project delivery process.
- Scaling the process based on project complexity and team size.
- Including customers in the project delivery process.
- Effectively and continuously communicating.
- Managing customer expectations.
- Managing change.

Transportation projects are complex and require the coordination of interrelated activities. Meaningful communication between the project manager, team members, sponsor, stakeholders, and customers is a critical component of project management. A skilled, coordinated, and collaborative team will find effective solutions and deliver projects more successfully than individuals working alone. Managing Project Delivery tools align teams by establishing a common understanding of the project. They enable development and execution of a collaborative work plan that is comprehensive, realistic, and deliverable.

Ongoing and active management of the project's scope, schedule, and budget ("Trade-Off" triangle) as shown in Figure 140-2 is a primary focus of project management. Scope, Schedule, & Budget are each project constraints and must be actively monitored and managed throughout the project delivery process.



Project Management Trade-Off Triangle
Figure 140-2

The Project Delivery Information System (PDIS) is a tool for effective and efficient management of project schedules, assigned resources, and the resulting cost to complete projects. PDIS enhances communication and coordination between staff engaged in project and program delivery at the project team, office, region, and statewide levels. See the PDIS definition for the PDIS web address.

140.02 References

WSDOT Management Principles, April 2002

WSDOT "Managing Project Delivery" training manual

A Guide to the Project Management Body of Knowledge (PMBOK), 2000, The Project Management Institute

140.03 Definitions

customers The customers for a project are the users of, and those directly affected by, the project's product.

CIPP The Capital Improvement and Preservation Program for which change management procedures are in place including the Project Control Form at: wwwi.wsdot.wa.gov/ppsc/pgmmgt/dpsb/

CMP Change Management Plan. See 140.05(2)(h).

deliverable A tangible work product; such as Channelization Plans, Environmental reports, Traffic Analysis reports.

MDL The Master Deliverables List implemented as part of the PDIS, is a standardized work breakdown structure, down to the deliverable level. See 140.05(2)(a)

MPD The process called Managing Project Delivery that is described in this chapter.

PDIS The Project Delivery Information System is an MPD tool for project planning, scheduling, resource balancing, and cost management. See wwwi.wsdot.wa.gov/projects/PDIS/

project A temporary endeavor undertaken to create a unique product or service.

project manager The person responsible for conducting the project's effort and delivering the end product.

resources People, tools, and/or materials necessary for project delivery.

scalability Scale, defined by Webster's, is a progressive classification, as of size, amount, importance, or rank. In other words, scalability is the level of work planning required based on the project size, project complexity and team size. The project manager determines the appropriate level of detail.

specialty groups Functional groups responsible for specialized services or products (Environmental, Traffic, Bridge & Structures, Landscape Architecture, Geotech, Right of Way, Materials, and so forth.) Specialty groups are both customers and suppliers to the project design team.

sponsor The person assigning the project manager the responsibility to conduct the project's effort and deliver the end product.

stakeholders Those with a particularly significant interest in the project's outcome including those providing funding or right of way for the project and property owners who are affected by the project. Stakeholders are unique for each project.

team A designated group of people working together with a common purpose.

WBS Work Breakdown Structure. In its simplest form, the WBS is a list of deliverables and tasks to be completed to accomplish the project purpose. The MDL is a standardized WBS developed by WSDOT to assist in the development of a project specific WBS. See 140.05(2)(a) and 140.05(2)(b).

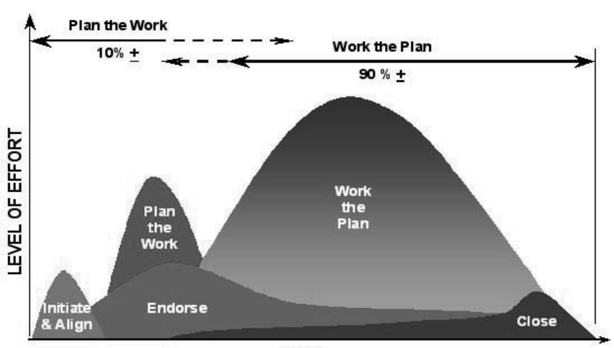
work plan A comprehensive, realistic, and deliverable plan to accomplish the team mission and deliver the project. It includes Plan the Work elements, including a schedule and a budget.

140.04 Resources

The HQ Project Delivery Resource Group (PDRG) provides training, and assistance in implementing the principles of Managing Project Delivery and the use of PDIS tools.

140.05 Managing Project Delivery

Successful project delivery requires active project management and a team that acts with a common purpose. Managing Project Delivery is applied by project managers and teams. It includes five basic steps, each with supporting elements, as shown in Figures 140-3 and 140-4. Each of these steps and elements are described below.



Relative Effort
Figure 140-3

The five steps of Managing Project Delivery can be further simplified into two basic phases:

- Preparation – “Plan the Work”
- Execution – “Work the Plan”

In a typical project application, planning the work, (the first three steps) will constitute approximately 10% of the total project effort and time. Steps four and five will constitute approximately 90% of the project effort and time.

The need for some project tasks to start immediately can be so apparent that “working while planning” is, at times, both necessary and appropriate. The project manager, team, and sponsor must endorse the advance work to be done before work planning is complete. For example, Site surveying, aerial photography, and traffic counts.

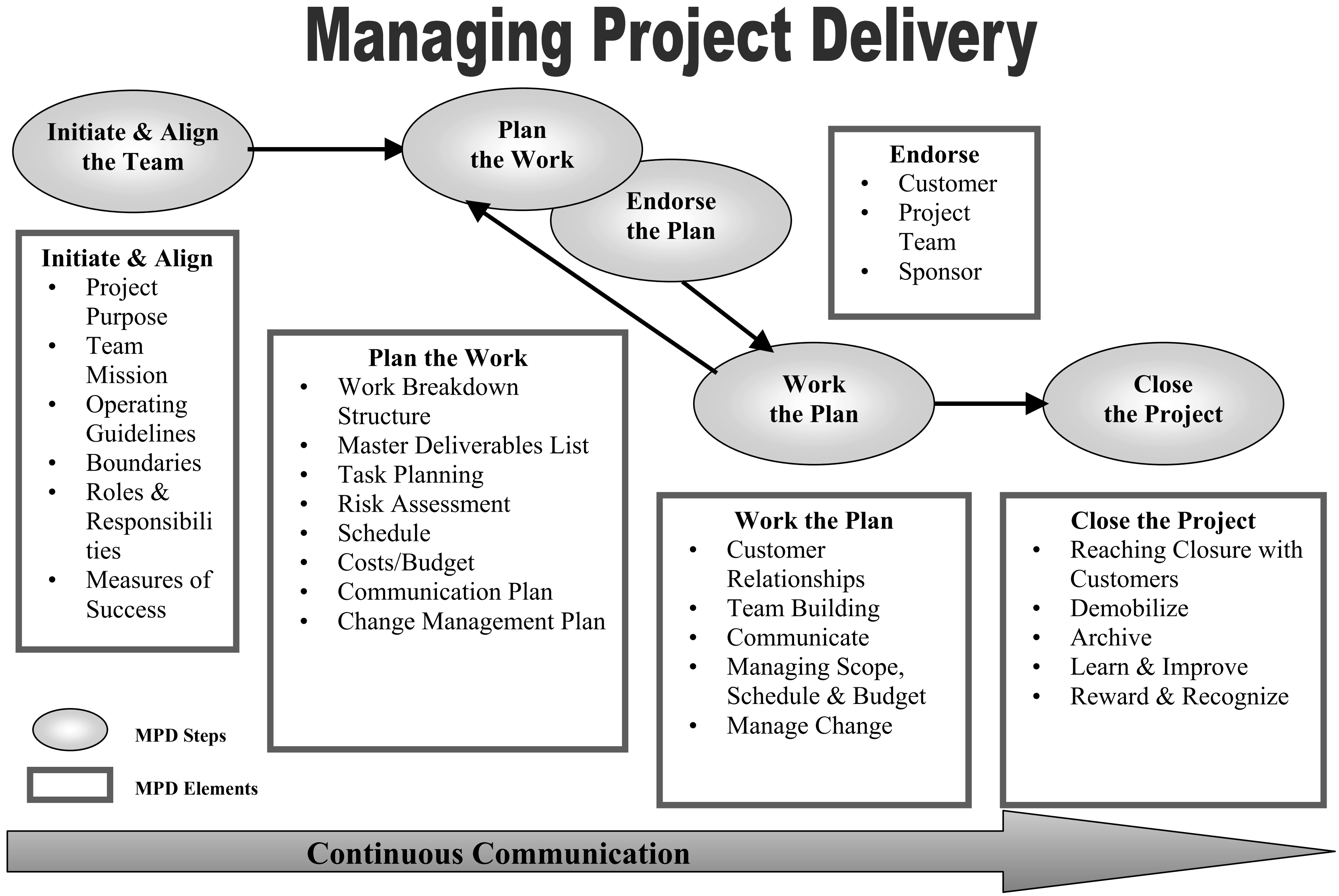
Adapt MPD to Your Project and Team

How and to what degree each of the MPD steps and elements are applied depend on:

- Project Size
- Project Complexity
- Team Size
- Stakeholder Involvement
- Potential resistance to the project

This is called scalability. The project manager determines the appropriate level of detail on a project by project basis. Typically, all steps and elements are applied to large projects, in order to build a common understanding of the project and ensure the development of a comprehensive work plan.

An efficient approach to developing a project work plan is to have a core group develop initial drafts of the various elements (project purpose, team mission, and WBS, for example). The full project team can then review and alter them as appropriate. This reduces the need for involvement by specialty groups who participate in numerous project teams. *However, specialty groups still need to endorse the plan.*



Steps and Elements
Figure 140-4

(1) Initiate and Align the Team

Initiate The process of formally recognizing that a new project exists (this includes transition of projects from one phase to another (Scoping to Design).

Align Building a common understanding of the project and developing a common view of what the solution will and will not address; setting the stage for scope development. A project purpose and mission can help align the team.

While the assignment of organizations and individuals to a project is an essential first step, mere assignment does not result in an effective team. Teams must be built and sustained. For successful project delivery, the participants must conduct their efforts in a coordinated and complementary manner. Establishing communication among the people who will develop and deliver the project is the most important function of this first step of Managing Project Delivery. Gaining each persons understanding of the problem and their buy-in to the solution is key to effectively managing the project scope. (See 140.04(4)(b) for further definition of Team Building)

A project team is a designated group of people, including specialty groups, working together with a common purpose related to a specific project.

The project manager assesses the project and assembles a team with the necessary skills to accomplish the project effort. Most projects require multidisciplinary participation. The project manager must secure individuals from appropriate specialty groups (potentially including Bridge, Environmental, Geotechnical, Landscape Architecture, Local Programs, Materials, Real Estate Services, Traffic, Utilities, and others).

To be effective and efficient, the teams' efforts must complement one another in support of accomplishing a common purpose, in other words, to function as a collaborative team. *This does not mean that all team members must participate in every team meeting or project work session.*

Continuous communication with and seeking endorsement from customers is an essential aspect of successfully managing project delivery. Depending on the scope of the project, participation on the team by customer "partners" is appropriate and can serve to ensure that the product meets customer expectations. Some project managers form a Steering Team or Citizen Advisory Committee to facilitate this communication. Individual representatives of a larger customer group on a steering team must be delegated the authority to make decisions for that group. The group is then held accountable to abide by the decisions made at team meetings. The WSDOT customer base is very diverse. Customers use and are affected by our projects. They have concerns for mobility and safety within their communities. Examples of customers that may have interest in the project are:

- Elected officials at the federal, state, and local level.
- Representatives of Indian tribes.
- Staff from appropriate agencies or jurisdictions.
- Staff from permitting agencies.
- Stakeholders.
- Neighborhood residents.
- Citizen groups.
- Individuals who regularly use the facility.

Meaningful customer interaction involves communicating directly with individuals and groups in a manner that lets them know they have been heard. Such interaction is fundamental to accomplishing context sensitive design. Continuous communication is another key to successful project delivery.

(a) Project Purpose

What will be the result of this project?

The project purpose establishes the common goal toward which all project activities and efforts strive. It describes the desired or intended result or effect.

(b) **Team Mission**

How will the team accomplish the project?

The Team Mission describes the overall actions the team will take to accomplish the project. It is usually a short paragraph developed with input from the team, including project sponsors, participating stakeholders and customers.

In this chapter, "the project" means the Team Mission — The word "project" is used throughout this chapter. It is important to understand the distinction between the Team Mission and a "Highway Construction Program project." A Highway Construction Program project is developed in phases [scoping, design/ PS&E (including right of way), and construction.] A specific Team Mission may be limited to a specific phase or phases of a Highway Construction Program project. The Team Mission of any given project team may not attain the ultimate end product of the Highway Construction Program project as described by "the project purpose."

The Team Mission statement is of particular importance during project work planning as it clearly defines the scope of the Work Breakdown Structure (WBS) starting with tailoring the Master Deliverables List [140.05(2)(a)].

(c) **Operating Guidelines**

Operating guidelines describe how the team will govern itself. The functions most commonly performed by the team and guidelines to steer it in those functions are identified. Listed below are some guidelines the team might wish to develop:

- Team decision process.
- Team meetings (such as structure, timing).
- Communication (such as methods, uses, frequency, protocols).
- Measuring team performance (such as team surveys, self-assessments/evaluations).
- Managing team disagreement and conflict.
- Managing team change (such as changes in team membership).

(d) **Boundaries**

Boundaries define the limits relevant to the project and the team's mission. Most boundaries are set by the organization and transmitted to the team by the project sponsor. Some boundaries are established by other entities beyond the team. Boundaries might fall within the following areas:

- Geographic.
- Financial.
- Legal and regulatory.
- Mandatory product or project delivery dates.
- Required project activities.
- Excluded project activities.

The identification of project boundaries provides a valuable opportunity for the team, the sponsor, and appropriate customers to enhance their common understanding of the project environment. Well-defined project boundaries are very useful for identifying potential risks or change.

(e) **Roles and Responsibilities** (See 140.06 for further definition)

The definition and mutual acceptance of organizational and individual roles and responsibilities delineates "who will do what". Roles and responsibilities are defined at the organizational level down to the level of each individual on the project team.

The team member's *roles* are the specific titles or positions occupied, such as team leader, designer, permit coordinator, drafter, and so forth. The *responsibility* is the output or outcome expected of the team or individual, such as plan sheets, hydraulic analysis, schedules, and others.

A project-specific table of organization is a good tool for visualizing needed and assigned human resources, their roles and responsibilities, and the relationships between the participants.

(f) **Measures of Success**

Measures of success are tools to assess the accomplishment of critical success factors. Critical success factors define the most important things the team must accomplish to fulfill its mission and achieve project success. These factors are tied to the team mission and project purpose.

The first step is to define critical success factors, and then to determine how to measure accomplishment. Critical success factors are measured incrementally "along the way," not just at the point of project completion. This allows for corrective action (changes) to get "back on track", if needed.

(2) Plan the Work

Development of a work plan begins during Initiate and Align. As the team moves to the next step, Plan the Work, the work plan becomes more refined. The goal is a work plan that is comprehensive, realistic, deliverable and endorsed by all team members.

Planning the work to accomplish the team mission —

It is important to understand and communicate the distinction between the work plan to accomplish the team mission and the completion of the overall project. The overall project includes all phases; Scoping, Design/PS&E (including right of way), and Construction. A team mission is constrained to the phase(s) the team is assigned to work on.

Scoping Project Team Mission

The Scoping Project team develops a work plan, which includes budget estimates and schedules, in PDIS, for Preliminary Engineering (PE), such as Plans, Specifications & Estimates (PS&E); Right of Way (ROW) acquisition activities; and Construction (CN).

Once endorsed, the work product from any phase is a work plan for the subsequent phase(s). For example, the products from the scoping phase are commitments entered into the Capital Improvement & Preservation Program (CIPP). Once in the CIPP, changes to scope, schedule, or budget require completion of the Project Control Form. See the CIPP definition for a web address.

PS&E Project Team Mission

The team that delivers the PS&E project develops a work plan, with a schedule and budget, to perform the work necessary to deliver the products for the Plans, Specifications, and Estimates contract package and advertise for bids. This phase typically includes the Design Documentation package required for design approval, acquisition of right of way, and environmental permits.

(a) **Work Breakdown Structure**

The Work Breakdown Structure (WBS) is a systematic mapping out of all of the project tasks to the lowest level of detail necessary to accomplish the team mission. The WBS is useful toward developing a project scope, schedule, and budget. A task is an assignable item of work, necessary to project delivery that has:

- A definable beginning and end.
- A finite duration.
- An associated level of effort (such as labor, money, equipment, and materials).
- A state of completion that can be estimated at any time.
- A deliverable at the task's completion.

(b) **Master Deliverables List**

WSDOT's standardized Master Deliverables List (MDL) is the starting point for a project-specific Work Breakdown Structure (WBS). The MDL is a comprehensive list that identifies project phases, sub-phases, work processes, and deliverables. In a few cases, the MDL goes to the task level, for example in the environmental area.

Rather than build a work breakdown structure from scratch, project teams eliminate items from the MDL, and add the appropriate tasks. The project team identifies project specific tasks with input from project customers, sponsors, and stakeholders. The tasks developed at the project level must roll up into the deliverables in the standardized MDL. It is to be used by all projects in the Highway Construction Program. The MDL is available on the WSDOT PDIS Internet site; see the PDIS definition for a web address.

(c) **Task Planning**

Task planning serves as an essential intermediate step in progressing from the WBS to schedule layout. Tasks must be defined completely to develop an accurate schedule. The Task Planning Worksheet is available for use in accomplishing this step. It is available at http://wwwi.wsdot.wa.gov/Projects/PDIS/Resources.htm

Task planning includes:

- **Task scope definition.** Just as the overall project requires a well developed and communicated scope, so do the supporting tasks. For example, for "Public Information Newsletters" task, will there be 1, 3, or 5 mailings, to 500, 5000, or 10,000 addresses, and will they be 1, 3, or 5 pages in length? How will they be distributed?
- **Task sequencing.** The accurate sequencing of tasks is critical to the effective development of a realistic and deliverable schedule. The recurring question asked in this process is "To execute this task, what do I need from some other task, and when do I need it?" Identifying task dependencies between specialty areas (Design and Bridge, Environmental and Design, Hydraulics and Right of Way, and others) is critical.
- **Resource assignments.** What organization and what specific individuals will conduct this task? Will 1 or 3 drafters be assigned to this task? Are the specific individuals highly experienced or "first timers"? What availability constraints apply to the individuals assigned to this task: other project assignments, percentage of time committed to this project, training needs, vacations, and the like?

  A resource loaded schedule is key to creating a project schedule that accurately estimates costs and project timelines. The software entry of resources is dependent on this task planning function.
- **Task duration estimates.** Individuals with the applicable expertise can make the most accurate estimates of task duration. Expert judgment guided by historical information is used whenever possible. Project managers must seek input from those who will accomplish specific tasks to accurately estimate the duration, including estimates from specialty groups.

(d) **Risk Assessment**

Project risks can be opportunities (positive events) as well as threats (negative events) that might affect scope, schedule, or budget. Risk assessment is the first phase of project risk management. Its purpose is to maximize the results of positive events and minimize the consequences of adverse events. See *A Guide to the Project Management Body of Knowledge* for more details. Risk assessment includes the following:

1. **Risk Identification** is determining which risks are likely to affect the project and the characteristics of each. This includes both internal (things the project team can control) and external (beyond the direct control of the team) risks. Identify risks by reviewing historical information, interviewing stakeholders and subject matter experts, and team brainstorming.
2. **Risk Quantification** is identifying the risks for which a contingency plan will be developed.

An effective tool for quantifying project risks is the Risk Probability – Impact Matrix shown in Figure 140-5. Each identified risk is assessed for probability of occurrence and degree of impact to the project, should it occur. Risks identified as both high probability and high impact (red risk) are potential "show stoppers" and must be addressed immediately. All risks determined to be medium to high in both probability and impact (yellow risk) are given continuous management, and may warrant the development of contingency plans.

3. **Risk Response Development.** Responses to risk threats include the following:

   - Avoidance — eliminating the threat, usually by eliminating the cause.
   - Mitigation — reducing the potential probability of occurrence or resulting adverse impacts.
   - Acceptance — accepting the consequences either actively (with a contingency plan) or passively.

The reason for conducting risk assessment before schedule and budget building is to provide the opportunity to develop and incorporate schedule and budget contingencies for "at risk" tasks.

Impact			
High	Gray Area	Yellow Risk	Red Risk
Med.		Yellow Risk	Yellow Risk
Low			Gray Area
	Low	Med.	High
	Probability		

Risk Probability – Impact Matrix
Figure 140-5

The Cost Estimate Validation Process (CEVP®) identifies and quantifies potential risks that can impact a project's budget or schedule. CEVP® is an intense workshop, by a team of engineers and risk managers, where transportation projects are evaluated using risk assessment methods to identify cost and schedule risks. Importantly, the process examines how risks can be lowered and cost vulnerabilities managed or reduced. A dividend of CEVP® is promotion of the activities that will improve final cost and schedule results and communicate those results to the public.

Contact the Cost Risk Estimating & Management office (CREM) or visit their website at http://www.wsdot.wa.gov/projects/cevp/ for additional information.

(e) Schedule

All projects in the WSDOT Highway Construction Program are managed using PDIS to schedule required activities that are based on the standardized Master Deliverables List.

The schedule to complete the Team Mission is developed from the Work Breakdown Structure and the subsequent task planning. The schedule is a dynamic tool, that defines the start, order, and duration of project tasks and milestones. A collaboratively developed and comprehensive schedule is a fundamental tool for the management and delivery of the project. It is used to communicate, coordinate, and measure project progress.

Identifying and managing task dependencies between specialty groups (Design to Environmental, Geotechnical to Bridge, Traffic to Design, and so forth) is key to successful project delivery. Establishing milestones and interim deliverables make schedules, and project management easier and more effective by providing short-term goals and clear measurements of progress.

Resource loaded schedules in PDIS allows balancing assigned resources and identifying over-allocated resources. Resource balancing can be accomplished with individual or multiple projects when all schedules are resource loaded. The development of a schedule-based budget is also feasible once a schedule is fully resource loaded.

(f) Costs and Budget

The estimated cost to complete the Team Mission is developed from the Work Breakdown Structure, assigned project resources, and a comprehensive project schedule. This estimate is broken down by specialty groups (Bridge, Environmental, Landscape Architecture, Real Estate, and others.), as well as by month ("aged"). It typically includes an appropriate contingency allowance for identified risk areas and inaccuracies in the cost estimating process.

The estimated cost to accomplish the Team Mission includes all activities that will be directly or indirectly charged against the project such as project management, "planning the work," quality assurance and control, and project closure.

(g) Communication Plan

Communication, the exchange of information to the relevant parties (including ideas, expectations, goals, commitments, requirements, recommendations, and status), is vital to project success. Effective communication cannot be left to chance. While the theme of communication permeates the entire Managing Project Delivery process, a specific communication plan is an essential tool for successful project delivery. See Chapter 210, "Public Involvement and Hearings."

Communication has many dimensions:

- Internal (within the project).
    1. Vertical (up and down the organization).
    2. Horizontal (with peers).
- External (to stakeholders, local agencies, the media, the customers).
- Written, oral, and various media.
    1. Letters, memos, e-mail.
    2. Internet.
    3. Media (radio, TV, newspapers).
    4. Personal contacts.
    5. Public meetings and hearings.

Every project develops or adopts a communication plan. Communication plan elements include the following:

- Requirements — Determining the information and communication needs of the project stakeholders and participants: who needs what information, when will they need it, and how will they get it.
- Distribution Structure – Defining the following:
    1. To whom information will flow (status reports, data, schedule, etc.)
    2. What methods will be used to distribute various types of information (written reports, letters, meetings, e-mail, Internet).
    3. When each type of communication will be produced.
    4. Who, in the project organizational structure, is responsible for preparing and distributing the identified items.

(h) Change Management Plan

Successful project delivery requires active identification and analysis of change when it is encountered. A common human tendency is to deny that change is occurring until it becomes overwhelming. A Change Management Plan (CMP) provides the framework for effective decision making when change occurs. Since it is not possible to foresee all potential changes, a project manager plans the methods by which change will be addressed when encountered.

The CMP includes the following elements:

- A means to anticipate and identify potential changes.
- A process for assessing the effects of a change.
- Techniques and procedures for developing a response strategy.
- A change endorsement process, including identification of the level of endorsement necessary for various types of change. Endorsement of any change is necessary before resources are expended to implement the change.

- A communication strategy to inform all affected parties of the project changes.
- A process for revising the work plan and monitoring performance in accordance with the revised work plan.

WSDOT has adopted standardized change management procedures for the Capital Improvement and Preservation Program (CIPP). These procedures, including a standardized Project Control Form, are used by both Project Development and Program Management. Detailed information on this CIPP change management process, including the Project Control Form, are available on the web. See the definition for CIPP for the web address.

(3) Endorse the Plan

Endorsement constitutes commitment to the work plan and project effort by the key participants. Endorsement is proactive, whereas approval is typically reactive, frequently meaning no more than a lack of objection. By endorsing the work plan, key participants take ownership of the team mission and agree upon the method by which it will be accomplished.

The optimal way to gain endorsement of the project work plan is to include participants in the collaborative development of the work plan. This promotes ownership and facilitates endorsement of the plan by the participants.

The project manager determines whether endorsement for the project work plan will be achieved verbally or documented in writing.

(a) **Customers**

A primary purpose of endorsement is to gain customer commitment to support the project team and work plan. Endorsement by the customers will ensure understanding and acceptance of the project scope, schedule, and budget.

(b) **Project Team**

The project team consists of anyone involved in the development of the project, including specialty groups (such as Environmental, Traffic, Utilities, and others). The purpose of endorsement by the project team is to:

- Share a mutual understanding of the work plan.
- Actively concur that the plan is comprehensive, realistic, and deliverable.
- Build commitment from the entire team to complete the project scope as described in the work plan.

This endorsement validates the working relationship between members of the team and the project manager.

(c) **Sponsor**

Endorsement of the project work plan by the project sponsor, and other managers designated by the project sponsor, provides:

- Sponsor commitments to the defined scope, schedule, and budget.
- Appropriate staff (skill base, knowledge, experience).
- Required tools and resources (computers, technology, office space).
- Sponsor acknowledgement of known risks and associated contingencies.
- Sponsor commitment to advising and assisting in executing the project.
- Sponsor commitment to applying management's authority toward successful accomplishment of the work plan and project.

In order to facilitate sponsor/management endorsement, it is advisable to involve the sponsor(s) in the project work plan development. The level of involvement will vary by project.

(4) Work the Plan

By developing a work plan, the team, project manager, and sponsors comprehensively define project requirements. Endorsement of the work plan represents commitment by key participants and ensures it is consistent with sponsor and customer expectations.

Working the plan is:

- Actively managing those planned elements, including the scope, schedule, & budget.
- Effectively communicating and building on relationships with the team, customers, and sponsors.
- Actively monitoring and managing identified risks and change.
- Communicating changes before they occur.

All projects in the WSDOT Highway Construction Program will maintain current schedules in the PDIS. Project schedules will be updated frequently enough to ensure the project delivery date shown in PDIS is accurate and can be met. Changes that affect the scope, schedule, and budget must be updated in the PDIS schedule.

(a) **Customer Relationships**

- Know the customer's expectations.
- Involve the customers as they wish to be involved.
- Communicate progress to customers.
- Resolve conflict as necessary.
- Manage customer expectations.

(b) **Team Building**

A team must be built and sustained. Teams are dynamic. Team development (forming, storming, norming, performing, excelling) is ongoing and must be continually managed to attain high performance, produce results, and deliver the project.

- A team is a group of individuals who work for a common purpose to produce a specific outcome.
- A team continuously develops group and individual skills to enhance team performance on the project.
- An effective team develops and implements a reward and recognition strategy.
- A team works together to correct mistakes to minimize negative impacts on the project.
- A team works together to learn from accomplishments and mistakes.

(c) **Communicate**

Appropriate frequency and quality of communication between the project manager, team members, sponsor, and customers is essential for project delivery. Project managers and teams apply the Communications Plan adopted for the project.

(d) **Managing Scope, Schedule, and Budget**

Successful project delivery requires active management of the scope, schedule, and budget. Successful project management will meet or exceed customer, sponsor, and stakeholder expectations (on time, within budget, and meeting requirements).

Active management of scope, schedule, and budget includes:

- Endorsing a base line scope, schedule, and budget.
- Ongoing communication with all team members to get frequent and accurate data.
- Regular schedule and budget monitoring and evaluation with revisions to reflect actual progress, as appropriate.
- Regularly reporting progress to customers and stakeholders.

The tradeoff triangle, as shown in Figure 140-2, represents the linkages between the scope, schedule, and budget. It functions as a link and pin truss where the sides must remain connected. When one side changes, the influences or impacts of that change on the other two sides must be managed. One side is prioritized, one side optimized and the remaining side is accepted.

A cardinal rule in project management is that, whenever scope, schedule, or assigned project resources change, a corresponding budget change is mandatory. The application of this rule often requires involvement and assistance from others who will be expected to endorse the resulting updated plan.

(e) **Manage Change**

Frequent and meaningful communication between project participants (including team members, sponsor, and customers/stakeholders) is an essential element of actively managing change. Recognizing and confronting change rather than avoiding it is key to successful project delivery. It is the responsibility of the team members familiar with the scope, schedule, and budget to continuously identify potential changes.

Value can be added through appropriate change management, including dollar and time savings. Active change management, through use of an established Change Management Plan, can minimize adverse effects on project delivery. Proactive endorsement (by the necessary authority) of changes to project scope, schedule, or budget must be obtained before resources are expended to implement the change.

See 140.05(2)(h), Change Management Plan, for additional information on the change management process, including projects in the CIPP.

(5) Close the Project

To conduct an effective closure, or phase transition, it is important for the project manager and team to define what closure means for this team and project. (See Figure 140-6). Adequate time to accurately and sufficiently prepare project documentation for closure should be planned for and included in the project schedule. The following are common closure situations:

- Final closure. The final project purpose has been attained. If so, this is probably an ultimate closure for the overall project effort.
- Transition. One team has accomplished its mission; a transition or handoff is made to a subsequent team tasked to continue development toward the project purpose. This is typical between major project development phases such as design and construction. A smooth transition is critical for successful delivery of the product for the customers.
- Shelf. A project effort that has reached a temporary closure point and is being put "on the shelf" is a transitional event to a future team. Comprehensive documentation of the project status, backup, and decisions (with justifications) is especially critical in this situation to minimize rework when the effort is restarted.

(a) **Reaching Closure With Customers**

This is the process of following up with the project customers and all affected parties. This includes the review of successes and failures in the eyes of the customers, team, and sponsors in relation to the project. This is planned for throughout the project and might occur at multiple intermediate stages of the project.

(b) **Demobilize**

A planned strategy for the reassignment or redistribution of project staff and resources. A demobilization/remobilization strategy is tied to the project schedule and evaluated and updated accordingly.

(c) **Archive**

The team addresses archiving as follows:

- Plan archiving at the beginning of the project.
- Plan the documentation for the permanent design file as required by other *Design Manual* chapters and selected MPD documents including the project work plan.
- Include archiving the PDIS project schedule.
- Budget for archiving effort.
- Tailor the archiving effort based on project size and complexity to comply with legal requirements (including preparedness for Freedom of Information Act requests) and to provide an administrative record of the project.

- Archive throughout the project.
- Adhere to agency-wide archiving process and standards.
- Communicate guidelines to team through the closure plan.

(d) **Learn and Improve**

The purpose of this element is to build corporate knowledge and skills and minimize the need for those in the future to "reinvent the wheel." This evaluation element is valuable for sharing with others (including other WSDOT staff and potential future team members) what was learned on this project: "What went well, what didn't, and why." The areas of evaluation usually include:

- Staff evaluation and development.
- Comparison of initial objectives with results.
- Review of significant changes, reasons, and results.
- Review identified risks; did they occur and what impacts did they have on the project?
- Effectiveness of the work plans.
- Budget assessment.
- Customer satisfaction.
- Comparison to measures of success as established in the work planning process.

(e) **Reward and Recognize**

Rewarding and recognizing team members and customers, as well as celebrating overall team success, are important steps and contribute toward the success of future project team endeavors.

140.06 Responsibilities

(1) Project Sponsor

The project sponsor provides the direction, authority, and resources for implementing Managing Project Delivery on projects. Typically, the project sponsor is a department executive, office manager, or organizational unit manager who assigns the project manager.

(2) Project Manager

The project manager follows the Managing Project Delivery process and applies specialized knowledge, skills, tools, and techniques to carry out the project sponsor's direction through project completion. A project manager has the following responsibilities:

(a) **To the project sponsor:**

- Come to a mutual understanding of the project work plan (including scope, schedule, budget, and other primary elements of the project) to obtain the endorsement of the project sponsor.
- Communicate project progress using appropriate project status reports and meetings.
- Identify when project sponsor endorsement will be required throughout the project.
- Communicate any significant changes in scope, schedule, budget, or customer satisfaction, during the project.
- Deliver the project in accordance with the endorsed work plan, including schedule and budget.

(b) **To the project customers:**

- Understand customer needs and expectations (listen).
- Communicate progress to customers (keep them informed).
- Communicate change and provide options to gain endorsement of preferred choices.
- Deliver the project in accordance with the endorsed project work plan.
- Solicit and incorporate customer feedback in project closure.

(c) **To the project team members:**

- Provide leadership and management.
- Be an advocate for the team.
- Obtain team endorsement on the project work plan, and major changes.

- Facilitate internal and external communication.
- Manage changes in scope, schedule, and budget.
- Initiate and manage ongoing team building.
- Mentor team members in project management.

(d) **To other project managers:**

- Mentor each other by sharing experiences and knowledge.
- Encourage each other to achieve project management excellence.
- Share resources when appropriate.
- Coordinate project work plans.

(3) Project Team

Each member of the project team follows the Managing Project Delivery process and applies specialized knowledge, skills, tools, and techniques to carry out the team's mission through project completion. A project team member has the following responsibilities:

(a) To fellow team members:

- Communicate in an open, honest, and sincere manner.
- Make a deliberate effort to maintain and build team cohesiveness.
- Ask for what you need.
- Deliver what others need.
- Be prepared and willing to work with team members to accomplish project goals.

(b) To the project manager:

- Manage tasks proactively.
- Report progress in a clear, coherent, timely, and accurate manner.
- Offer your best opinions on project issues.
- Present a "get the job done" attitude.

140.07 Documentation

Managing Project Delivery reflects WSDOT best practices along with the industry standards for project management. A project work plan provides team leaders, management and executives a method of communicating all aspects of a project. It is routine for work plans to be reviewed by Executives during regional Quarterly Report Meetings. Documentation of these elements is an effective means of attaining a common understanding among team members, the project sponsor, and customers. Documentation of a project work plan includes:

(a) Team initiation and alignment elements

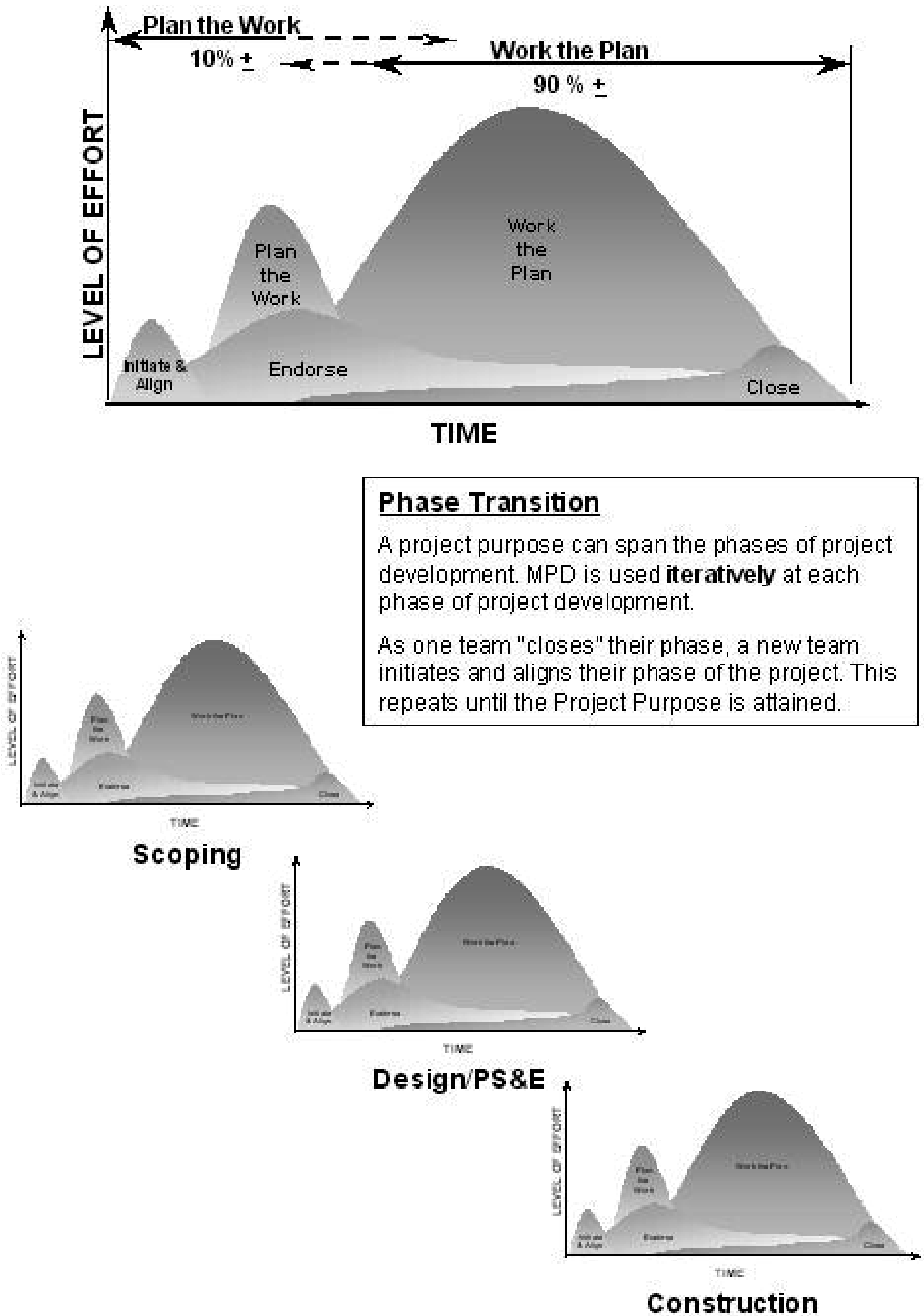
(b) Schedule developed and maintained in PDIS

(c) Budget

(d) Communication Plan

(e) Change Management Plan

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



Using MPD Iteratively

Figure 140-6

Chapter 141 Project Development Roles and Responsibilities for Projects with Structures

141.01 General

This chapter presents the project development process used by Washington State Department of Transportation (WSDOT), the Regions and the Bridge and Structures Office together, to determine the roles and responsibilities for projects with structures during the project development phase of a project. This chapter complements chapter 140. See Division 11 chapters and the *Bridge Design Manual* for design procedures.

The primary objective of this process is to provide a consistent means of selecting a bridge design team to perform all or part of the structural design work, whether it be a consultant or the WSDOT Bridge and Structures Office.

If the Local Agency will be requesting any services from WSDOT, the Local Agency will contact WSDOT's Local Program Engineer. The Local Program Engineer will help define the level of WSDOT's involvement in design and construction.

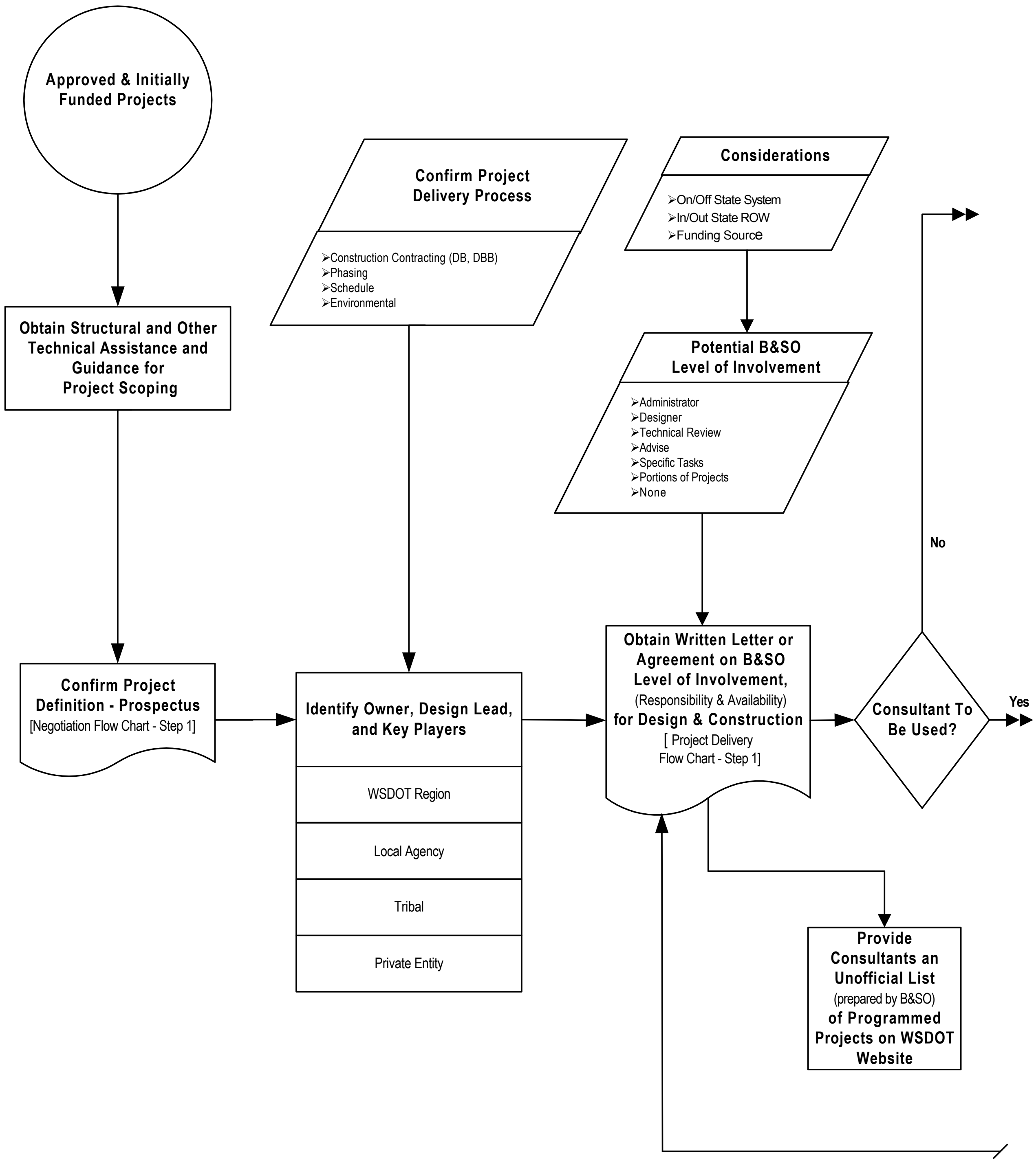
141.02 Procedures

The flow diagram, Figures 141-1a and 141-1b, begins at the left with the initial approval and funding of the project and ends at the right with the start of the project delivery process.

After a project is programmed, WSDOT is tasked with confirming the project scope and defining the structural team's level of involvement in design and construction. If a consultant is not used, all bridge design work will be performed by the Bridge and Structures Office. If a consultant is used, the WSDOT Region and Bridge and Structures Office will determine the level of involvement and responsibility for the design.

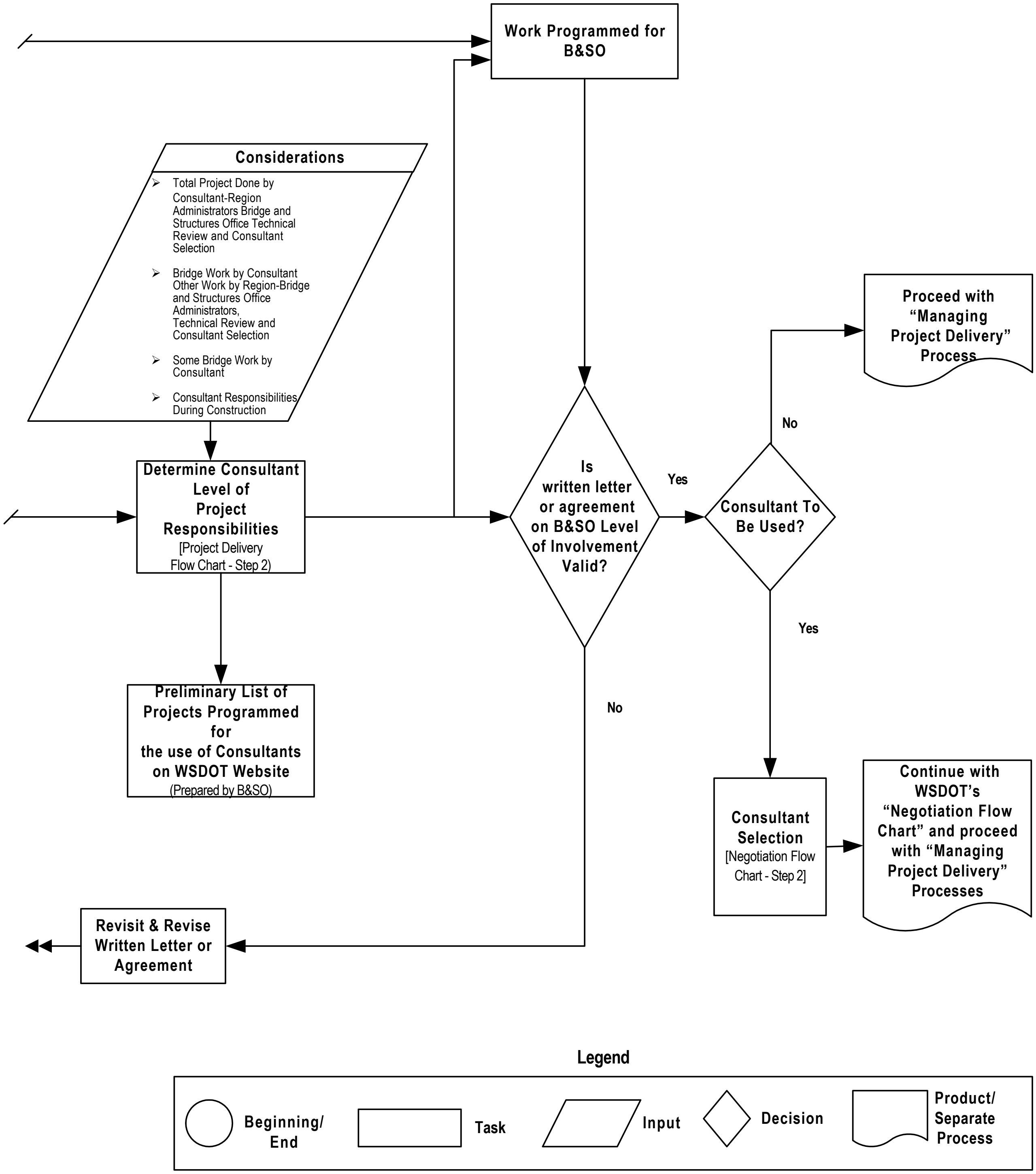
Agreements defining the level of involvement and responsibility will be developed and executed between the appropriate Regional office responsible for project development and the Bridge and Structures Office and the appropriate project delivery process will be implemented.

More information on this process and the desired outcomes is available on the Bridge and Structures Office's homepage at http://www.wsdot.wa.gov/eesc/bridge/rrps/index.cfm.



FHWA - Federal Highway Administration
WSDOT - Washington State Department of Transportation
DB - Design Build
DBB - Design Bid Build
B&SO - Bridge & Structures Office
ROW - Right of way

Determination of the Roles and Responsibilities for Projects with Structures (Project Development Phase)
Figure 141-1a



Determination of the Roles and Responsibilities for Projects with Structures (Project Development Phase)

Figure 141-1b

Chapter 150 Project Development Sequence

150.01 General

The purpose of Chapter 150 is to describe the project development sequence from the *Washington Transportation Plan* (WTP) through the contract document.

Projects go through a development process to ensure that all elements are considered, that local agencies and the public have an opportunity to comment on the department's proposed action, and that the final product successfully fulfills a transportation need. Changes in project scope, schedule, or budget are reviewed and approved using the Project Control and Reporting Process. Approved changes are reported in the department's quarterly performance report, known as the Gray Notebook.

150.02 References

Revised Code of Washington (RCW) 47.05

Programming and Operations Manual (http://wwwi.wsdot.wa.gov/ppsc/pgmmgt/manual/)

Environmental Procedures Manual – M 31-11, WSDOT

Plans Preparation Manual – M 22-31, WSDOT

*Construction Manua*l – M 41-01, WSDOT

Local Agency Guidelines (LAG) – M 36-63, WSDOThttp://wwwi.wsdot.wa.gov

150.03 Definitions

benefit cost (b/c) ratio A method for prioritizing highway improvement projects. The b/c ratio is determined by dividing measurable benefits by measurable costs for a specific time period; typically 20 years.

Capital Improvement and Preservation Program (CIPP) The Washington State Department of Transportation's (WSDOT's) plan to deliver the program of capital investments in transportation that have been funded in part or in whole by the state Legislature. The CIPP also serves as project documentation relating to the capital budget requests adopted by the Transportation Commission.

capital program management system (CPMS) A mainframe computer database used to develop and manage the highway and marine construction programs. It allows users to establish and maintain project data and is used to manage and deliver statewide construction programs. System screens allow the user to input and maintain project data, manage changes to approved projects, and generate reports to monitor program delivery. CPMS interfaces with the Transportation Information and Planning Support (TRIPS), Priority Array Tracking System (PATS), and Transportation Reporting and Accounting Information System (TRAINS) data bases.

carryforward – federal The apportionment balance, in each federal program, that will be available for the next federal fiscal year. Carryforward consists of the apportionment balance that accumulated and was not used in the three previous federal fiscal years. Unused apportionment is forfeited if it is older than three previous federal fiscal years.

carryforward – state The amount of funds necessary to complete project phases authorized in a previous biennium that will not be available to begin new projects or project phases in a subsequent biennium.

Federal Highway Administration (FHWA) The section of the United States Department of Transportation with jurisdiction over the use of federal transportation funds for state highway and local road and street improvements.

Federal Transit Administration (FTA) The section of the United States Department of Transportation with jurisdiction over the use of federal funds for financial assistance to develop new transit systems and improve, maintain, and operate existing systems.

Financial Information Retrieval System (FIRS) A computer application that allows the retrieval of accounting and work order information from the Transportation Reporting and Accounting Information System (TRAINS) data base at a "rolled-up" level. For further information, see: http://wwwi.wsdot.wa.gov/FASC/Accounting/firs.pdf.

Geographic Information System (GIS) A computerized geographic information system used to store data. Data may be used with GIS if the data includes the Accumulated Route Mile (ARM) or State Route Mile Post (SRMP). Global Positioning System (GPS) technology provides a means of collecting data and is an alternative to ARM and SRMP. WSDOT's primary desktop tool to view and analyze GIS data is ArcGIS software.

high accident corridor (HAC) A highway corridor one mile or greater in length where a five-year analysis of collision history indicates that the section has higher than average collision and severity factors.

high accident location (HAL) A highway section typically less than 0.25 mile in length where a two-year analysis of collision history indicates that the section has a significantly higher than average collision and severity rate.

highway construction program (HCP) The comprehensive two-year program and ten-year financial plan of highway improvement and preservation projects selected by priority.

Highway System Plan (HSP) A WSDOT planning document that addresses the state highway system element of the *Washington Transportation Plan* (WTP). The HSP defines the service objectives and the action strategies and costs to maintain, operate, preserve, and improve the state highway system for 20 years. It is the basis for the state highway element for the six-year plan and the biennial state highway construction program. It is periodically updated to reflect completed work, and changing transportation needs, policies, and revenues. It compares highway needs to revenues, describes the "financially constrained" costs of the highway programs, and provides details of conceptual solutions in the improvement program.

Metropolitan Planning Organization (MPO) A lead agency designated by the Governor to administer the federally-required transportation planning process in a metropolitan area with a population over 50,000. The MPO is responsible for the 20-year long-range plan and *Transportation Improvement Plan* (TIP).

National Highway System (NHS) A network of roadways designated by Congress that consists of all Interstate routes; a large percentage of urban and rural principal arterials; and strategic highways and highway connectors.

pedestrian accident location (PAL) A highway section typically less than 0.25 mile in length where a six-year analysis of accident history indicates that the section has had four accidents in a 0.1 mile segment.

Plans, Specifications, and Estimates (PS&E) The project development activity that follows project definition and culminates in the completion of contract-ready documents and the Engineer's Cost Estimate. These documents include final plans, specifications, and estimates.

preliminary engineering (PE) A term used to describe the effort needed to arrive at the conceptual solution to address a transportation need, including project establishment and route selection through the PS&E review.

priority array A collection of similar needs identified in the HSP, prioritized based on the methodology adopted by the department to meet the requirements of RCW 47.05.

Priority Array Tracking System (PATS) A centralized database that allows tracking of highway needs and their solutions. The system is designed to ensure that WSDOT addresses the highest ranked transportation needs. Deficiencies are tracked for each strategy in the HSP.

project control and reporting (PC&R) The Project Control and Reporting office is responsible for monitoring, tracking, and reporting the delivery of the Highway Capital Program in coordination with the Program Management Offices in each of the six WSDOT regions and the Urban Corridors Office.

project summary A document that comprises the project definition, design decisions, and environmental review summary. The document replaces the project prospectus, design report, and environmental database. The project summary ensures that the project scope addresses the need identified in the HSP.

Regional Transportation Planning Organization (RTPO) A planning organization authorized by the Legislature in 1990 as part of the Growth Management Act. The RTPO is a voluntary organization with representatives from state and local governments and is responsible for coordinating transportation planning activities within a region.

Statewide Transportation Improvement Program (STIP) A planning document that includes all federally funded projects and other regionally significant projects for a three-year period. The STIP is a compilation of all projects that are in the TIPs, developed by the regional planning organizations (MPOs and RTPOs). A new STIP must be developed every two years or less, and is approved jointly by the FHWA and FTA for compliance with statutory requirements and financial feasibility.

Surface Transportation Program (STP) A federal program established by Congress in 1991 that provides a source of federal funding for highway and bridge projects.

Transportation Improvement Program (TIP) A three-year transportation improvement strategy required from MPOs by Congress. It includes all projects in the three-year period expected to be financed by federal funds. All federally funded or regionally significant projects must be included in the TIP.

Transportation Information and Planning Support (TRIPS) A mainframe computer system designed to provide engineering, maintenance, planning, and accounting staff with highway inventory, traffic, and accident data.

Washington State Pavement Management System (WSPMS) A computer system that stores data about the condition of all the highways in the state. Information available includes the latest field review, and past contracts for every main line mile of state highway. Calculations are used to determine whether a given section of pavement is a "past due," "due," or "future due" preservation need.

Washington's Transportation Plan (WTP) A WSDOT planning document developed for the Transportation Commission in coordination with local governments, regional agencies, and private transportation providers. It addresses the future of transportation facilities owned and operated by the state and those that the state does not own, but in which it has an interest. It identifies significant transportation investments that are needed. These transportation needs are defined by service objectives and specific desired outcomes for each transportation mode.

150.04 Project Development Sequence

The project development sequence is composed of the following:

(1) Washington State Highway System Plan (HSP)

The HSP is the element of *Washington's Transportation Plan* that addresses the state's highway system. The HSP forecasts transportation needs, provides objectives and action strategies to improve and preserve the highway system, and serves as the basis for the department's capital investment strategies. (To view the *Highway System Plan,* see http://www.wsdot.wa.gov/ppsc/hsp/HSPPlan.htm)

(2) Highway Construction Program

In every odd-numbered year, the Washington State Legislature meets to consider and pass a transportation budget. One piece of this budget is funding for the highway construction program. In order to control expenditures and track budget dollars and commitments, the department groups capital projects into programs, subprograms, and categories based on the action strategies, objectives, and goals in the *Highway System Plan*. The department has identified three subprograms within the preservation program and six subprograms within the improvement program, four of which are discussed in the Improvement Program section.

(a) Prioritizing Project Needs and Solutions

Each category of work within the highway construction program has a set of needs that are identified by comparing a specific action strategy in the *Washington Transportation Plan* to the existing highway system. These needs are met by developing projects to program. The Legislature has directed the department to prioritize (select) projects for each category based on the benefits returned to the transportation user. State law in Priority Programming for State Highways (RCW 47.05) directs WSDOT to identify transportation needs, determine the benefit/cost (b/c) of the solutions, and prioritize the solutions based on the b/c.

(b) Background Information

WSDOT HQ Systems Analysis and Program Development begins the prioritization process for a category of work by identifying the potential benefit(s) associated with solving the need. There are not sufficient resources to analyze the benefits and costs of all needs in each category of the program each biennium, so a prioritization scheme is used to reduce the effort. Because the primary objective of the department's prioritization process is to provide the largest improvement for the least possible cost, needs in each category are ranked based on their potential to provide a benefit. The process includes these steps:

- The regions scope projects to address the needs in rank order. The biennial programming instructions provide guidance to the regions on how far down the ranked "needs lists" to go. To ensure a consistent approach to scoping a project, WSDOT has developed a set of design matrices. Each design matrix sets forth the level of development for a given type of need that would be automatically approved by the department and FHWA. (See Chapters 325 and 340.)
- The regions prepare a cost estimate for the approved scope of work and compare the cost to the potential benefit in order to determine which projects are the most beneficial to construct.

In order to minimize disruptions to the public and take advantage of cost savings, the department may adjust priorities by up to six years.

(c) Building the Program

The basic building blocks for the highway construction program are the project phases in the Capital Improvement and Preservation Program (CIPP). Carryforward project commitments represent job phases that will continue into the next biennium. The book building process starts with these carryforward projects. The regions need to review the carryforward projects and determine the potential for project delays and cost overruns in the current biennium that might affect the next biennium. Maintaining close coordination between the region, HQ Programming, the Project Development Engineer, and the Construction Engineer is necessary to ensure that projects under development and under construction are accomplished as planned.

Building on this foundation, new improvement project phase starts are added based on department policy and Transportation Commission direction. These new project starts represent needs that are identified in the *Highway System Plan*. The first step in adding new projects to the CIPP for the next biennium is to establish a funding target for each category of work within each subprogram. Once HQ has provided the target funding levels, the regions begin to assemble the highway construction program. It is important to remember that regions can't propose a project unless a need has been identified in the HSP.

After the new projects have been selected and the carryforward projects identified (and their planned expenditures and schedules verified), the program of projects is developed and the project data is input into CPMS for balancing to the target allocations for both dollars and workforce (FTEs). Project summaries are then developed. The program of projects is shared with region executives, and their input is incorporated. Adjustments are made to ensure that the program can be accomplished within the constraints of available workforce and facilities in the region.

(d) Roles and Responsibilities Within WSDOT for Delivering the Highway Construction Program

The WSDOT Budget Office, along with various offices in the Strategic Planning and Programming Division, share responsibility for developing a ten-year capital investment plan for the Commission, including a forecast of available revenue by fund source, and recommend investment levels based on the WTP. Program Development issues programming instructions, based on the preliminary budget targets, which assist the regions as they begin scoping highway projects.

Once a ten-year plan has been determined, and proposed projects scoped, Program Development finalizes a budget request, including a project list that is presented to the Commission for review and submittal to the Legislature. The Legislature sets funding levels for the different programs within the department that will deliver the project list for the funding amount identified in the scoping document.

WSDOT regions, working with support offices, such as Environmental, Utilities, Right of Way, and Construction, design and build the projects that deliver the transportation program.

(e) Categories of Work

The HSP presents the budgets for the Maintenance (M), Operations (Q), Preservation (P), and Improvement (I) programs. Strategies and conceptual solutions are limited to the P & I programs. Each of these programs are broken into sub-programs:

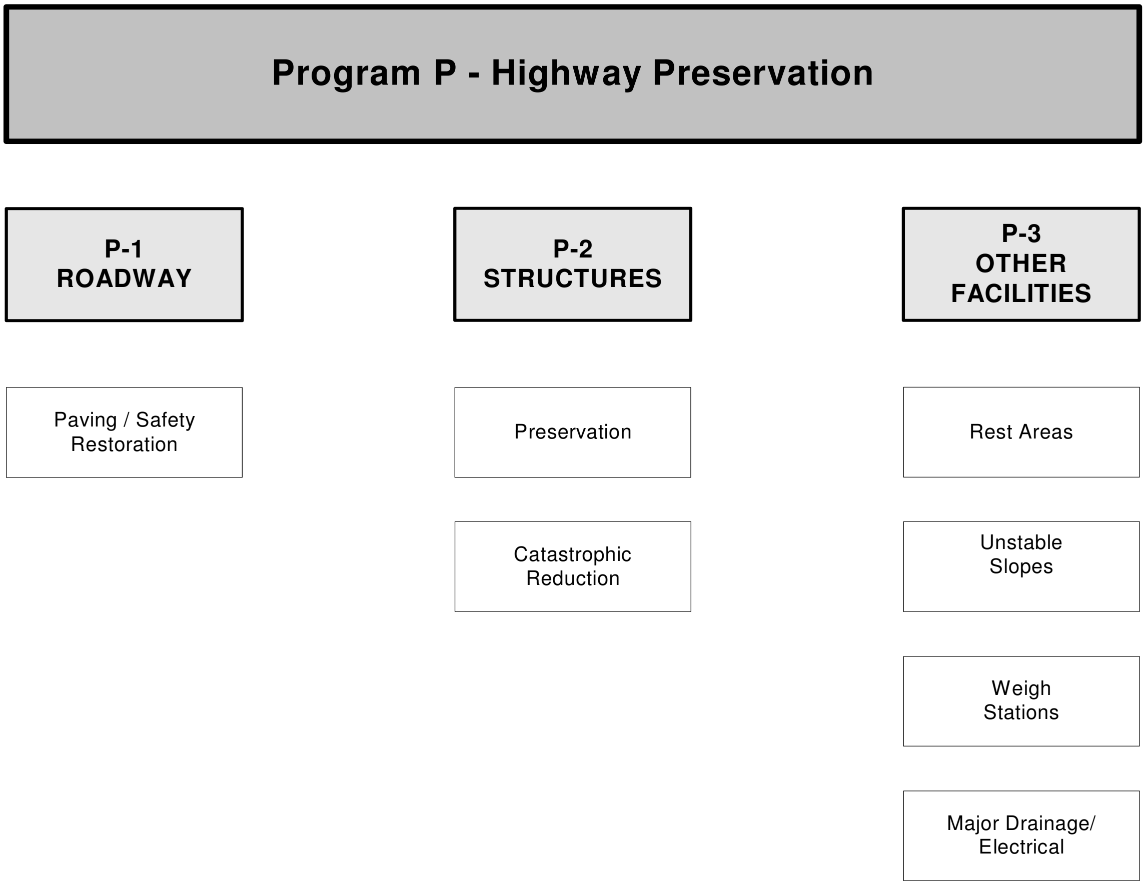


Figure Notes:

Preservation Program (P): Preserve the highway infrastructure cost to effectively protect the public investment.

- **P–1 Paving**

  Repave highways at regular intervals for lowest life cycle cost.

  Restore existing safety features.

- **P–2 Structures**

  Preserve existing structures for operational and structural integrity through rehabilitation or replacement of bridges or other structures.

  Reduce catastrophic failure from naturally occurring events.

- **P–3 Other Facilities**

  Refurbish rest areas to extend service life and improve safety.

  Stabilize known unstable slopes.

  Construct weigh stations to ensure enforcement across the entire highway system.

  Refurbish electrical systems, electronics, and mechanical systems to extend service life and improve safety.

  Rehabilitate or replace existing major drainage features to preserve operational and structural integrity.

Program Elements
Figure 150-1

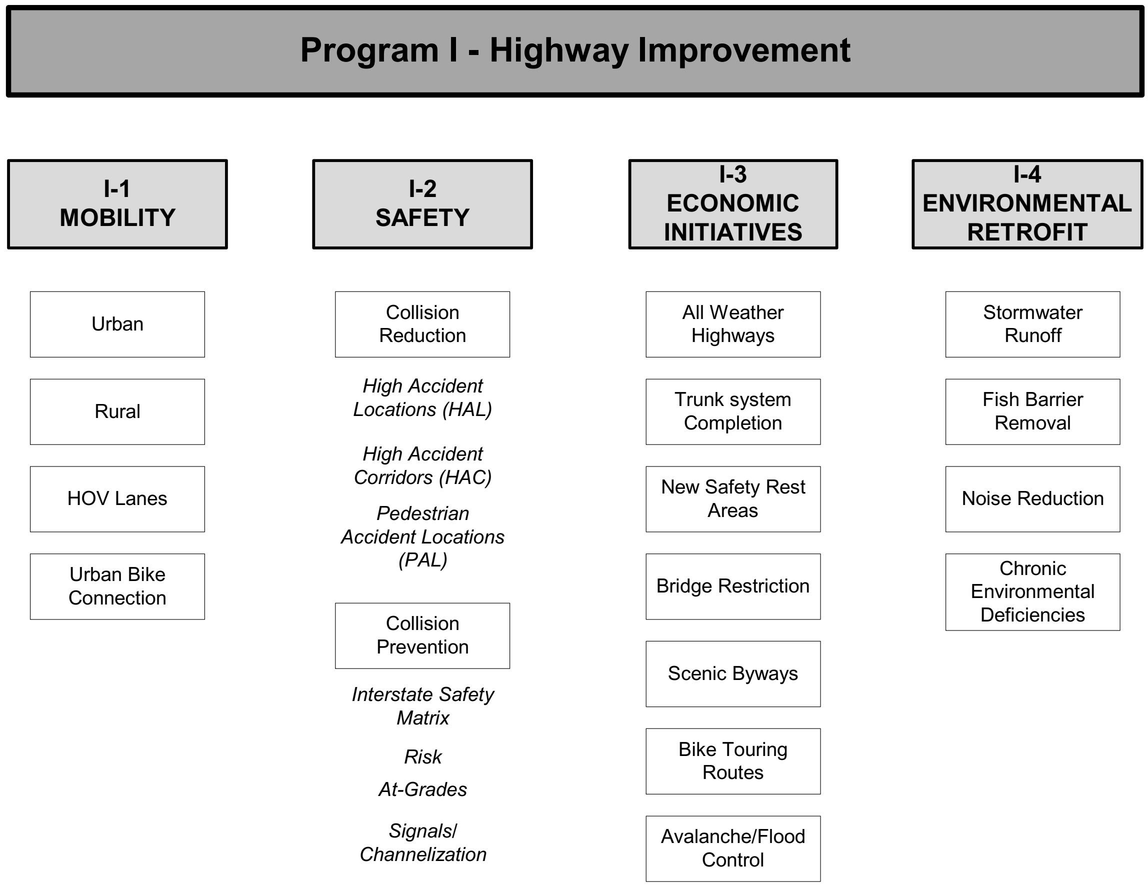


Figure Notes:

Improvement Program (I): Identifies deficiencies in the state highway system and develops solutions for those deficiencies through capital improvement projects.

- **I–1 Mobility**

  Mitigate congestion on urban highways when peak period level of service (LOS) falls below D (Congestion Index 10). For further information, see the *Highway System Plan*, http://www.wsdot.wa.gov/ppsc/hsp/HSPPlan.htm

  Provide uncongested conditions (LOS C-Congestion Index 6) on rural highways.

  Provide bicycle connections on state highways within urban growth areas.

  Complete the Freeway Core HOV Lane system in the Puget Sound region.

- **I–2 Safety**

  Collision Reduction needs include HALs, HACs, and PALs. Needs are ranked based on the societal cost of the accident history. If the Collision Reduction project is programmed within the next six years, regions may combine it with another project to minimize disruption to traffic.

  The needs in Collision Prevention consist of four types: Interstate safety matrix, risk (run off roadway), at-grade intersections, and signals and channelization.

  The needs are prioritized based on the cost benefit of reducing the potential societal cost of accidents, except as noted below.

  The needs in the Interstate safety matrix group are identified by the regions and include any design feature that does not meet the standard specified in the Interstate design matrices. This work is usually done at the same time other work is programmed, such as paving. The needs in the risk (run off roadway) group are identified by HQ Systems Analysis and Program Development, based on roadway and roadside data from the Transportation Data Office. The needs are ranked based on the potential cost of accidents as a result of the existing conditions.

Program Elements
Figure 150-2

At-grade intersections on multilaned, high-speed, access-controlled highways that have a history or the potential for serious accidents are identified by HQ Systems Analysis and Program Development.

The region identifies the needs in the signals and channelization group. Each region is responsible for preparing a prioritized list of needs for locations that meet traffic volume and signal warrants, as detailed in the WSDOT *Traffic Manual*.

Special safety initiative projects are narrowly focused, stand-alone risk reduction projects, such as cable median cross-over barriers and rumble strips.

- **I–3 Economic Initiatives**

  All weather highway needs are identified as those sections of highway that are susceptible to damage by heavy loads when the roadway thaws after a freeze.

  Trunk system completion needs include the state's T-1 freight corridors (highways that carry ten million tons or more of freight each year) identified by HQ Systems Analysis and Program Development and the Transportation Data Office. The Transportation Commission prioritizes these routes.

  The Safety Rest Area Office in the HQ Maintenance and Operations Division works with the regions, specialty groups, and other government agencies to identify locations for new rest areas on state highways and to look for partnership opportunities.

  The Restricted Bridges needs are made up of two types of work: low vertical clearance under-crossings on the Interstate (clearance less than 15 feet 6 inches) and load restricted bridges (licensed legal overloads). The Bridge Planning Section identifies these needs with the technical assistance of the Bridge Condition Section. The low vertical clearance structures on the Interstate have been given priority over the load-restricted structures.

  The Highways and Local Programs Division and the Transportation Data Office have identified where 4-foot bike shoulders do not exist on the state's six rural bicycle-touring routes. The regions look for opportunities to solve these rural bike needs by combining them with programmed work in other categories. This approach minimizes traffic disruption and reduces contract costs.

  HQ Systems Analysis and Program Development has identified roadway segments on T-1 freight corridors (highways that carry ten million tons or more of freight each year) where travelers have experienced delays due to avalanche and flood closures.

- **I–4 Environmental Retrofit**

  Environmental Services (ES) surveys all storm water outfalls that flow into a water body. Each of these storm drains is identified as a need and is further rated from high to low.

  Fish Barrier Removal needs are identified by the Washington State Department of Fish and Wildlife (WDFW). WDFW has surveyed culverts on the state's highway system and identified those that impede the migration of fish. The WDFW is conducting habitat surveys to determine the potential for migratory fish recovery and is prioritizing the culverts based on the results.

  Since 1977, FHWA has funded a program for noise retrofit and made states responsible for mitigating noise-sensitive locations in conjunction with new construction projects. WSDOT's retrofit locations are prioritized based on a b/c ratio.

  The Chronic Environmental Deficiency (CED) Program is a statewide program within WSDOT that works with WSDOT's regional staff to identify and fix locations along highways where recent, frequent, and chronic maintenance and/or repairs to the state transportation infrastructure (highway fills, toe slopes, sanding, etc.) are causing impacts to fish and/or fish habitat.

Program Elements

Figure 150-2 (continued)

(3) Project Summary

The project summary is developed in the region when a project is proposed for programming.

The project summary:

- defines the scope of work HQ Systems Analysis and Program Development and the region have agreed to.
- documents the design decisions made while determining the project scope.
- must be as complete and accurate as possible.
- establishes initial preliminary engineering, right of way, and construction cost estimate.
- documents the project delivery schedule.
- requires approval by HQ Systems Analysis and Program Development prior to beginning work on a project.
- documents the potential environmental impacts and permits that may be required.

The intent of this agreement is to identify the need that has generated the project and the proposed solution that will solve that need.

Regions are encouraged to place special emphasis on project scoping, estimating, and scheduling during program development to ensure program delivery stays within appropriated dollars and workforce. Resources available to the regions include the *Highway System Plan*; Route Development Plans; the Design Matrix; the *Roadside Classification Plan*; Environmental Workbench and other planning; and design and environmental documents to ensure that project scoping is consistent.

The environmental section of the project summary establishes the initial environmental classification and documentation required for the project. Environmental classification at the project summary stage has several benefits. It helps in understanding the impacts associated with a project and it helps to establish a realistic schedule and PE cost estimate. All projects require supporting State Environmental Policy Act (SEPA) documentation. National Environmental Policy Act (NEPA) documentation is also required for all projects that are eligible for federal funding.

Regions are encouraged to take full advantage of expertise available from the HQ Systems Analysis and Program Development Branch of the Strategic Planning and Programming Division, FHWA, the Environmental Office, and local agencies when scoping projects to ensure that all aspects are considered, and that the proposed solution is eligible for available funding. These resources can help the regions evaluate a project's impacts and provide the appropriate project direction.

HQ Systems Analysis and Program Development coordinates review of the project summary and forwards any comments to the regions for resolution prior to approval. Once all comments and outstanding issues are resolved, the project summary can be approved and copies distributed.

(4) Environmental Document

The Environmental Document is a statement identifying impacts to the natural and manmade environment as a result of a project. The statement may consist of one or two pages for categorically exempted projects, a SEPA checklist, or an environmental impact statement (EIS) for major projects. (See Chapter 220.)

(5) Design Documentation Package (DDP)

The DDP is a formal document of design considerations and conclusions reached in the development of a project. The Project File records various design recommendations that are reviewed within the department and, when approved, become the project design. (See Chapter 330.)

(6) Right of Way/Access Plans

Right of Way/Access Plans are the official state documents used to acquire real estate, property, and access rights. These plans determine rights of access from abutting property owners, interchange or intersection spacing, access points per mile, or other selective approaches to a highway facility. Right of way plans are used to obtain the "Order of Public Use and Necessity," which is the authority to acquire real property and property rights under eminent domain.

The establishment of access control is considered whenever major improvements, reconstruction, relocation, significant new rights of way, or new facilities are required. Projects not requiring right of way or other property interests skip this phase of project development. (See Chapters 1420, 1430, 1435 and the *Plans Preparation Manual*, M 22-31.)

(7) Contract Document

The contract Plans, Specifications, and Estimates (PS&E) are the final documents required for the advertisement of a construction contract. Contract plans must conform to the basic design features approved in the project summary, environmental documents, and the DDP. The plans and contract specifications must set forth the work in a clear and concise manner to avoid misinterpretation. A tool available to the designer to ensure that required items are addressed during the PS&E preparation is the "PS&E Review Checklist," available on the WSDOT intranet. Projects may go through PS&E preparation, but will not be advertised for construction until all previous phases are complete. (See the *Plans Preparation Manual,* M 22-31.)

210.01 General

It is the goal of the Washington State Department of Transportation (WSDOT) that decisions be made in the best overall public interest and that other agencies and the public be involved early enough to ensure that the decisions that are made are responsive to the public's interests.

Public involvement is used to place issues before the public; to gather, and assimilate comments; and to inform the public of the final decisions, construction schedules, and project results. As part of the public involvement activities, hearings are held when major decisions are being made. Other, less formal methods are also used because they are the best way to elicit comments and communicate proposals.

Current laws and regulations provide general guidelines that allow considerable flexibility. The environmental policies and procedures (SEPA and NEPA) are intended to ensure that environmental information is available to public officials, agencies, and citizens and that public input is considered before decisions are made.

The role of local elected officials in the project development process is emphasized, and consistency with community planning goals and objectives is required.

210.02 References

USC Title 23 — Highways, Sec. 128 Public Hearings

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

RCW 47.50, Highway Access Management

RCW 47.52, Limited Access Facilities

Design Manual Chapter 220 for environmental references

Improving the Effectiveness of Public Meetings and Hearings, FHWA Guidebook

Public Involvement Techniques for Transportation Decision-Making, FHWA September 1996

210.03 Definitions

hearing An assembly to which the public is invited — to attend and to be heard.

> **formal hearing** A hearing that is conducted by a moderator using a formal agenda, overseen by a hearing examiner, and recorded by a court reporter, as required by law.
>
> **informal hearing** A hearing that is recorded by a court reporter, as required by law. An open format hearing is an informal hearing. The hearing examiner and formal agenda are optional.
>
> **access hearing** A formal hearing that gives local public officials, owners of abutting property, and other interested citizens an opportunity to be heard concerning any plan that proposes the limitation of access to the highway system.
>
> **administrative appeal hearing** A formal process whereby a property owner may appeal the department's implementation of access management legislation. The appeal is heard by an Administrative Law Judge who renders a decision. See 210.11 for the administrative appeal hearing procedures. They differ from those for the other, more public, hearings.

combined hearing A hearing that is held when there are public benefits to be gained by any combination of the environmental, corridor, design, and access hearings.

corridor hearing A formal or informal hearing that presents the corridor alternatives to the public for review and comment before a commitment is made to any one route or location.

design hearing A formal or informal hearing that presents the design alternatives to the public for review and comment before a commitment is made to any one alternative.

environmental hearing A formal or informal hearing that ensures that social, economic, and environmental impacts have been considered.

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

findings and order A document containing the findings and conclusions of a limited access hearing that is approved by the Assistant Secretary for the Environmental and Engineering Service Center.

Hearing Coordinator The Access and Hearings Specialist within the Olympia Service Center (OSC), Design Office, Access and Hearings Unit, who is assigned the responsibility for coordination of all functions relating to hearings.

hearing examiner An Administrative Law Judge (ALJ) from the Office of Administrative Hearings, or a WSDOT designee, appointed to moderate a hearing.

NHS projects Projects on the National Highway System for which FHWA has delegated approval authority for design, contract administration, and construction to WSDOT. (See Chapter 330.)

opportunity for a hearing An advertised offer to hold a hearing if so requested.

resumé An official notification of action taken by WSDOT following adoption of a findings and order.

210.04 Public Involvement

Developing an effective public involvement program is a strategic effort that involves selecting techniques that will meet the unique needs of a given transportation plan, program, or project. An effective public involvement program:

- Informs the public of the need or proposed action.
- Informs the public about the process that will be used to make decisions.
- Ensures that the public has ready access to relevent and understandable information.
- Identifies and resolves issues early in the process.
- Gains public support.
- Assists the project development process.

Public involvement begins during the system planning phase when the public is given opportunities to help solve short and long term transportation problems.

The public involvement effort continues into the project definition phase when a project is proposed to fulfill an identified need. When the study area for a project is identified, the region frequently notifies the public that the department is initiating a project and invites them to participate in a project definition or environmental evaluation meeting.

The region develops a public involvement plan that identifies all the methods proposed for the project. Methods are selected to ensure that public opinion is considered throughout the planning, environmental, location, and design phases of the project. Follow-up activities sometimes continue through construction, and even after completion, to provide ongoing public outreach or notifications.

For simple projects, the region develops a public involvement plan for their own use and guidance. To inform the public, communicate the decision-making process, identify the issues, and possibly resolve concerns, the region communicates with the affected community through newspaper articles, fliers, community group presentations, open house meetings, or other methods. Public involvement on minor projects is not intended to be an open forum on the proposed design; however, public comments received during project development are evaluated and, if appropriate, included in the project.

It may become necessary to revise the public involvement plan as the project evolves, the community changes, or new issues arise.

(1) Public Involvement Plan

The regions develop the public involvement plans for WSDOT projects. For projects requiring an environmental impact statement (EIS), a public involvement plan and OSC approval are required as part of the preparation of the Study Plan. (See Chapter 220.) For all other projects, the region may consult the Access and Hearings Unit for assistance or concurrence.

The public involvement plan includes:

- List of proposed activities.
- Time schedule to do each task keyed to the environmental process schedule, if applicable.
- Methods to be used in considering comments in the decision-making process, including follow-up procedures.
- Personnel, time, and funds needed to carry out the plan.
- Identification of the project stakeholders as the *public* to be involved.

The *public* to be involved (affected directly or indirectly) might include any or all of the following:

- Staff and elected officials of local governments
- Other state and federal agencies and officials
- Indian tribes
- Adjacent property owners and tenants
- Adjacent billboard owners and clients
- Community groups; clubs, civic groups, churches
- Special interest groups
- Environmental Justice stakeholders (low income and minority groups)
- Service providers; emergency, utility
- Others expressing interest
- Others known to be affected
- The general public

The department recognizes the role of local, state, and federal staff and elected officials as active sponsors of proposed projects who might effectively assist in developing and implementing the public involvement plan. Early and continued contact with these resources is a key to the success of the project.

(2) Public Involvement Methods

Effective public involvement is flexible, innovative, multifaceted, and ongoing. There are many methods available to gain public participation. Any of the following methods might be appropriate to a project.

- Formal hearings (210.04(2)(a))
- Informal hearings (open format hearings) (210.04(2)(b))
- Public meetings and open house meetings (210.04(2)(c))
- Prehearing presentations
- Drop-in information centers or booths
- Advisory committee meetings
- Design workshops
- Meetings with public officials
- Individual (one-on-one) meetings
- Meetings with special interest groups
- Presentations at local group meetings
- Surveys and questionnaires/paper or electronic mail
- Hot lines
- Follow-up procedures (210.04(2)(d))

There are many communication tools available for use when announcing and holding public involvement events. See the following for lists of ideas.

- Notification techniques (210.04(2)(e))
- Handouts 210.04(2)(f)
- Graphics and Audio-Visual Aids 210.04(2)(g)

Agency representatives are conveying the department's image. They should be conscious of their roles, be well informed and confident, and communicate skillfully. When the event is well planned and the conductor is sensitive to the needs of the audience and objective about the needs of the project, meetings and hearings are usually productive efforts. See the FHWA publication *Public Involvement Techniques for Transportation Decision-Making.*

(a) **Formal Hearings.** The following are required of all formal hearings.

- Prehearing packet(210.05(5)(a))
- A hearing notice with a fixed time and date (210.05(2))
- Fixed agenda
- Hearing moderator (may be the hearing examiner)
- Hearing examiner
- Comment period
- Summary (210.05(6))

In addition to the oral comment period, people can write opinions on comment forms at the time of, or after, the hearing and submit them before the announced deadline.

See 210.06, 7, 8, and 9 for specifics related to the various types of hearings.

(b) **Informal Hearings (Open Format Hearings).**

An informal hearing must have the characteristics of a formal hearing listed in (a) above except for the fixed agenda. These events are usually scheduled for substantial portions of an afternoon or evening so people can drop in at their convenience and fully participate. People are directed to attend a presentation, visit the exhibits, and then submit their comments.

The following items are features of an open format hearing, which is the most common format for an informal hearing.

- In areas where people work in shifts, open format hearings can be scheduled to overlap the shift changes.
- Brief presentations about the project and hearing process, at preset times, are advertised in the hearing notice. They can be live, videotape, or computerized.
- Agency or technical staff are present to answer questions and provide details of the project.
- Information is presented buffet style and participants shop for information.
- Graphics, maps, photos, models, videos, and related documents are frequently used.
- People get information informally from exhibits, presentations, and staff.
- People have a chance to clarify their comments by reviewing materials and asking questions before commenting.
- People can comment formally before a court reporter, or they can write opinions on comment forms and submit them before the announced deadline.
- People are encouraged to give opinions, comments, and preferences to the examiner in the presence of a court reporter.

(c) **Public Meetings and Open House Meetings.** Meetings are less formal than hearings. Public meetings range from large informational and workshop meetings to small groups and one-on-one meetings with individuals. The region evaluates what is desired from a meeting, and how the input will be tracked, and then plans accordingly.

- Open house meetings are very effective for introducing a project to the public and stimulating the exchange of ideas.

- Small meetings are useful for gaining information from special interest groups, neighborhood groups, and advisory committees.
- Workshop formats, where large groups are organized into small discussion groups, serve to maximize participation of all attendees while discouraging domination by a few individuals.

(d) **Follow-Up Procedures.** Effective public involvement is an on-going two-way exchange and it may be necessary to provide follow-up information several times during a large project to maintain a continuing exchange of information with the community.

At significant stages, the region responds to input with general information about the project. Follow-up information conveys, as accurately as possible, how public input was used to develop the project. Follow-up for larger projects might include newsletters, reports, individual contacts, or other activities related to the public's contribution to the project.

Follow-up measures can continue through construction and after project completion. The construction schedule is useful information and project accomplishments (such as noise abatement) are of interest.

Follow-up for smaller projects or for specific comments might simply be timely responses to individual requests.

(e) **Notification Techniques.** For hearings, see 210.05 for requirements regarding advertising for hearing interest and hearing advertisements. For other public involvement methods, develop notification techniques to attract a cross-section of the public. Provide special notices to those directly affected. Design the notifications to catch the public's attention and encourage people to attend or become involved. Consider the following techniques:

- Handouts
- News Releases — TV or newspapers
- Display ads in newspapers
- Web sites
- Electronic mail
- Faxboards
- Fact sheets
- Billboards
- Project notebooks at public places
- Project display boards at public places
- Fliers
- Newsletters
- Posters
- Local bulletin board announcements
- Personal contacts
- Radio announcements — AM, FM, CB
- On-site tours.
- Project office located close to the project

(f) **Handouts.** A well designed and informative handout can serve as an ongoing link between the department and the public.

Handouts have no set format. Make them as clear, relevant, up-to-date, easily understood, and self-explanatory as possible. Use handouts in foreign languages when appropriate. The following are handout possibilities:

- Special project newspapers
- Pamphlets
- Brochures
- Booklets (large, complicated projects)
- Charts
- Tables
- Graphs
- Project maps (aerial photographs or line drawings)
- Project development schedules
- Reports
- Right-of-way brochures (or other general information)

- Questionnaires
- Surveys

(g) **Graphics and Audio-Visual Aids.** The department normally uses slide shows or graphic exhibits to present project information. These presentations are informal and responsive to questions and concerns. Consider the following presentation techniques:

- Slide, slide-tape presentation
- Videotape
- Models
- Maps — large, simple
- Artistic renderings
- Photomontage
- Aerial photographs
- Computer visualizations

210.05 Hearings

Environmental documents address the social, economic, and environmental effects as described in Chapter 220. The project environmental documentation is the first step in the hearing procedures sequence. Each step of the hearing procedures is dovetailed into the environmental process and is important in achieving the appropriate project documentation. Corridor and design hearings are not normally required for Environmental Assessment, SEPA Checklist, and categorically excluded projects, but the opportunity for an environmental hearing might be required. When environmental hearings are not required, an informational meeting may serve as a useful forum for public involvement in the environmental process.

For all projects, the region reviews the requirements for a hearing or notice of opportunity for a hearing during the early stages of project development and before completion of the draft environmental documents.

If a hearing or notice of opportunity for a hearing is required, see Figure 210-1 for a summary of the event and timing requirements.

(1) Hearing Requirements

A hearing or notice of opportunity for a hearing is required by federal and state law (USC Title 23 §771.111 and RCW 47.52) and by WSDOT policy if one or more of the following occurs. (When in doubt, consult the Hearing Coordinator.)

(a) **Corridor Hearing**

- The proposed route is on a new location.
- There will be substantial social, economic, or environmental impacts.
- There will be a significant change in the layout or function of connecting roads or streets.

(b) **Design Hearing**

- Acquisition of a significant amount of right of way will result in relocation of individuals, groups, or institutions.
- There will be substantial social, economic, or environmental impacts.
- There will be a significant change in the layout or function of connecting roads or streets or of the facility being improved.

(c) **Access Hearing**

- Access control is established or revised

(d) **Environmental Hearing**

- An EIS is required for the project or a hearing is requested for an EA.
- There will be substantial social, economic, or environmental impacts.
- There will be a significant adverse impact upon abutting real property.
- There is significant public interest or controversy regarding the project.
- Other agencies (Coast Guard or Corps of Engineers, for example) have hearing requirements that could be consolidated into one hearing process.

(c) **Follow-up Hearings**

A new hearing or the opportunity for a hearing is required for any previously held hearing when any one of the following occurs. (See USC 23, §771.111.)

- Corridor or design approvals have not been requested within three years after the date the last hearing was held or the opportunity for a hearing was afforded.
- An unusually long time elapsed since the last hearing or opportunity for a hearing.
- A substantial change occurs in the area affected by the proposal (due to unanticipated development, for example).
- A substantial change occurs in a proposal for which an opportunity for a hearing was previously advertised or a hearing was held.
- A significant social, economic, or environmental effect is identified that was not considered at earlier hearings.

(2) Hearing Notice

The OSC Access and Hearings Unit provides sample hearing notices to the regions upon request. These include items that are required by state and federal statutes. Some important elements of a notice are:

- To promote public understanding, the inclusion of a map or drawing is encouraged.
- For a notice of an opportunity for a hearing, include the procedures for requesting a hearing and the deadline, and note the existence of the relocation assistance program for persons or businesses displaced by the project.
- For a corridor, design, or combined corridor-design hearing or a notice of an opportunity for a hearing, announce the availability of the environmental document and where it may be obtained and/or reviewed.
- If there is involvement in wetlands, flood plains, prime and unique farmlands, Section 4(f) lands, or endangered species, include this information in the notice.
- Include information on any associated prehearing presentation (210.05(5)(d)).

Hearing notices and notices of opportunity for a hearing are advertised as described in 210.05(3) and Chapter 220. Hearing notices are also circulated as described in 210.05(5)(b)

(3) Advertise a Hearing or the Opportunity for a Hearing

To advertise a legal notice of a hearing or a notice of an opportunity to request a hearing, use the following procedure:

- The region transmits the proposed notice, and a list of the newspapers in which the notice will appear, to the OSC Hearing Coordinator for concurrence prior to advertisement.
- Upon receiving concurrence, the region advertises the notice.
- Advertisement must be published in a newspaper having general circulation in the vicinity of the proposed project or the impacted population and in any newspaper having a substantial circulation in the area concerned, such as foreign language newspapers and local newspapers.
- The advertisement may be in the legal notices section or, preferably, as a paid advertisement in a prominent location.
- Additional means (such as display ads, direct mail, fliers, posters, or telephoning) may also be used to better reach interested or affected groups or individuals.
- A copy of the published hearing notice is sent to the Hearing Coordinator at the time of the publication.
- For access and environmental hearings, the notice must be published at least 15 days prior to the hearing. The timing of additional publications is optional.
- For corridor and design hearings, the first-notice publication must occur at least 30 days before the date of the hearing. The second publication must be 5 to 12 days before the date of the hearing.

- In no case shall a first notice for a corridor or design hearing be advertised prior to public availability of the draft environmental document.
- For a notice of opportunity for a hearing, the notice must be published once each week for two weeks. The deadline for requesting a hearing must be at least 21 days after the first date of publication and at least 14 days after the second date of publication.

(4) No Hearing Interest

When the region is not aware of specific hearing interest, the region can satisfy project hearing requirements by advertising a notice of opportunity for a hearing.

If no requests are received for a corridor or design hearing, the region transmits a package (which contains the notice of opportunity for a hearing, the Affidavit of Publication of the hearing notice, and a letter stating that there were no requests for a hearing) to the OSC Access and Hearings Unit.

When a notice of opportunity for a hearing is used to fulfill the requirements for a limited access hearing and there are no requests for a hearing, the region must secure waivers from every abutting property owner and affected local agency.

- The region obtains sample waiver forms from the OSC Access and Hearings Unit.
- The Project Engineer must contact every affected property owner of record (not tenant) and local agency to explain the plan and project to them. This explanation must include access features, right of way take (if any), and the right to a hearing.
- The region transmits the original signed waivers to OSC Access and Hearings Unit for processing.
- The Access and Hearings Unit prepares a package for review and approval by the State Design Engineer. This package consists of the signed waivers and Affidavit of Publication of the access hearing notice of opportunity for a hearing along with a recommendation for approval of the right of way plan.

(5) Hearing Preparation

The Deputy State Design Engineer sets the hearing date. Final arrangements for the hearing date can be handled by telephone between the Hearing Coordinator and the region.

The region proposes a hearing date based on the following considerations:

- Convenient for community participation. Contact local community and government representatives to avoid conflict with local activities.
- When Commission members can attend if they so desire. Check with the Hearing Coordinator to avoid conflict with other commission business if possible.
- For corridor and design hearings, at least 30 days after circulation of the DEIS or the published notice of availability of any other environmental document.
- In most cases, more than 45 days after submittal of the prehearing packet.

The region makes other arrangements as follows:

- The location of the hearing hall is to be accessible from public transportation if possible, convenient for community participation, and accessible to the disabled.
- Arranges for a court reporter.
- Arranges for a the Hearing Coordinator to provide a hearing examiner for all access hearings and for other hearings if desired.
- Develops a hearing agenda for all access hearings and for other hearings if desired.
- If requested in response to the hearing notice, interpreters for the deaf, audio equipment for the hearing impaired, language interpreters, and Braille or taped information for people with visual impairments are required.

(a) **Prehearing Packet.** When it is determined that a hearing must be held, the region prepares a prehearing packet.

Include the following in the prehearing packet:

- Vicinity map
- Capsule project description
- Brief project history
- Public support or opposition to the project
- Plans for corridor and design alternatives with descriptions
- Hearing plans (access hearing only)
- News release
- Hearing notice tailored to the needs of the project. (For access hearing, indicate number of notices, plans, and Notices of Appearance needed for mailing.) See 210.05(2).
- List of legislators
- List of government agencies
- List of property owners (access hearing only)
- List of newspapers
- Hearing agenda if applicable
- Hearing arrangements, date, time, place
- Hearing format: formal or open format

Three copies of the prehearing packet are furnished to the OSC Access and Hearings Unit at least 45 days before the proposed hearing date. Concurrence with the prehearing packet takes about two weeks after receipt of the information. This assumes that all necessary information has been submitted to the Access and Hearings Unit.

(b) **Circulate Hearing Notice.** The Hearing Coordinator sends a copy of the notice of hearing to the Commission, the Attorney General's Office, the Public Affairs Office, and the FHWA (if applicable).

The region circulates copies of the hearing notice as follows:

- Send a copy of the hearing notice and a capsule description to the appropriate legislators and local officials about one week before the first publication of a hearing notice.
- Include in the cover letter to the news media a statement such as: "This material may have been released by a local legislator. If not, we will appreciate any coverage you care to give the project at any time prior to the hearing."
- Distribute the news release to all reasonable news media, as well as the newspapers that will carry the formal advertisement of the hearing notice, about 3 days before the first publication of a hearing notice.
- Advertise the hearing notice in the appropriate papers as described in 210.05(3) within a week of the mailing to the legislators.

(c) **Presentation of Material for Inspection and Copying.** The information outlined in the hearing notice, other engineering studies, and information that will be presented at the hearing is made available for inspection and copying throughout the period between the first advertisement and approval of the hearing summary or findings and order. The information need not be in final form, but must include every item that is included in the hearing presentation. The environmental document must also be available for public review.

The information presented for inspection and copying is made available in the general locality of the project. The region reviews the variables (locations of the regional office, the project office, the project site, and the interested individuals, and the probability of requests for review) and selects a mutually convenient site for the presentation of the information. The region keeps a record of who came in, when, and what data they reviewed and copied.

(d) **Hearing Briefing.** On controversial projects, the Hearing Coordinator arranges for a briefing (held before the hearing) for those interested in the project. Attendants include appropriate OSC, regional, and FHWA personnel, with special notice to the Secretary of Transportation. Regional personnel present the briefing.

(e) **Prehearing Presentations.** The region is encouraged to hold an informal presentation to the public for display and discussion of the project and plans. Holding this presentation on projects where local feeling runs high promotes rapport, brings out community reaction to the project, and identifies trouble spots prior to the hearing.

A prehearing presentation is informal, with ample opportunity for exchange of information between the department and the public. Prehearing presentations can be open house meetings, drop-in centers, workshops, or other formats that promote public participation.

The prehearing presentation is usually held approximately one week before the hearing for the more controversial projects. Other dates may be used depending on the desires of the region and the nature of the project.

Include notice of the date, time, and place in the hearing notice and ensure that the hearing notices are mailed in time to give adequate notice of the prehearing presentation.

(f) **The Hearing.** The hearing is moderated by the Regional Administrator or his designee. Normally, a hearing examiner is used when significant controversy or significant public involvement is anticipated. A hearing examiner is required for access hearings.

A word-for-word transcript of the proceedings is made by a court reporter.

Hearings are generally more informative and gain more public participation when an informal format is used so the public's views and opinions are openly sought in a casual and personal way. The open format hearing may be used for all hearings except access hearings. At least one court reporter is required to take testimony on a one-on-one basis. Use display tables and enough knowledgeable staff to answer specific questions about the project.

It is the responsibility of the hearing moderator and other department representatives to be responsive to all reasonable and appropriate questions, if possible. If a question or proposal is presented at the access hearing, which necessitates an answer at a later date, the region reserves an exhibit to respond to the comment. The hearing moderator must not allow any person to be harassed or subjected to unreasonable cross-examination.

(g) **Hearing Agenda Items.** For all access hearings and for other hearings, as desired, the region prepares a hearing agenda to ensure that all significant items are included. A hearing agenda includes:

1. Opening Statement:
    - Highway and project name
    - Purpose of hearing
    - Introduction of elected officials
    - Federal/State/County/City relationship
    - Statutory requirements being fulfilled by the hearing
    - Status of the project with regard to NEPA/SEPA documents
    - Description of information available for inspection and copying
    - For an environmental, corridor, design, or corridor-design hearing, statement that written statements and other exhibits can be submitted during the open record period following the hearing.
    - Statement that all who want to receive written notification of the department's action as a result of the hearing may add their names to the interest list or file a Notice of Appearance for access hearings.
    - Description of how the hearing will be conducted

2. Project History. Present a brief project history, including need for the project, public involvement program, hearing opportunities afforded, and hearings held.

3. Presentation of Plans. Develop alternatives studied to comparable levels of detail and present them equally. Include the no-action alternative. Refer to any supporting studies that are publicly available.

Advise if one corridor or design is preferred by the department for more detailed development. When a preferred alternative exists, stress that it is subject to revision and re-evaluation both during and after the hearing, based on public comments, additional studies, and other information that may become available.

4. Social, Economic, and Environmental Discussion. Discuss all social, economic, and environmental effects or summarize the major impacts and refer to the environmental document.

5. Statements, Plans, or Counter-Proposals from the Public. Accept public views or statements regarding the plans presented, the alternatives to those plans, and the social, economic, and environmental effects of any plan.

6. Relocation Assistance Program. Explain the relocation assistance program and relocation assistance payments available. The Relocation Assistance brochure must be available for free distribution at all hearings. Right of way and relocation personnel should be available.

If the project does not require any relocations, the relocation assistance discussion may be omitted. Make a simple statement to the effect that relocation assistance is provided when needed but that no relocation is required by the project under discussion. The brochure and personnel should still be available to the public at the hearing.

7. Acquisition. Discuss right of way acquisition, estimated cost, and construction schedules. Discuss current schedules of critical activities that may involve or affect the public.

8. Closing. Summarize the hearing and what will follow.

9. Adjournment. Adjourn a hearing with sincere gratitude for the public's valuable participation.

(6) Hearing Summary Contents

The hearing summary includes the following elements:

1. Transcript.

2. Copy of the Affidavit of Publication of the hearing notice.

3. Hearing material:

   - Copies of the letters received before and after the hearing
   - Copies or photographs of, or references to, every exhibit used in the hearing.

4. Summary and analysis of all oral and written comments. Include consideration of the social, economic, and environmental effect of these comments.

210.06 Environmental Hearing

Projects requiring an EIS must use an evaluation process (called *scoping* in the NEPA and SEPA requirements) to identify the significant issues and alternatives to be studied in the DEIS and must follow the public involvement plan included in the Study Plan for the project. After the project has been thoroughly discussed within the community through the environmental evaluation process and informal public involvement methods, a hearing is held to present and gather testimony. The hearing is timed to fall within the comment period of the draft EIS for the project.

Responses to comments on the DEIS must be addressed in the FEIS. See Chapter 220 for the approval process.

The environmental hearing summary includes the items outlined in 210.05(6) above.

210.07 Corridor Hearing

When a Corridor hearing is held, the region must provide enough design detail on the proposed alignment(s) within the corridor(s) so that an informed presentation can be made at the hearing. Justification must also be presented to abandon an existing corridor.

After the hearing, the region reviews the hearing transcript, responds to all questions or proposals submitted at or subsequent to the hearing, compiles a hearing summary, and transmits three copies (four copies for Interstate projects) to the Access and Hearings Unit. When appropriate, the hearing summary may be included in the final EIS.

The corridor hearing summary includes the items outlined in 210.05(6) above.

The Access and Hearings Unit prepares a package that contains the corridor summary and a formal document that identifies and describes the project, and forwards it to the Assistant Secretary for Environmental and Engineering Service Center for adoption.

Federal approval of a corridor on existing alignment is not required unless a substantial social, economic, or environmental impact is involved or unless the project substantially changes the layout or function of connecting roads or streets.

Submit the complete corridor hearing summary to the Access and Hearings Unit within approximately two months following the hearing if it is not part of an EIS.

210.08 Design Hearing

When a design hearing is held for an improvement on existing alignment, and no other corridors are being considered, sufficient data must be presented to clearly document the decision to retain the existing corridor.

(1) Design Hearing Summary

The design hearing summary includes the items outlined in 210.05(6) above.

Submit the complete hearing summary to the Access and Hearings Unit within approximately two months following the hearing.

If new studies or additional data are required subsequent to the hearing, the region compiles the data in coordination with the OSC Design Office.

(a) **NHS Projects.** After the hearing, the region reviews the hearing transcript, responds to all questions or proposals submitted at or subsequent to the hearing, compiles a hearing summary, and transmits three copies (four copies for Interstate projects) to the Access and Hearings Unit. When appropriate, the design hearing summary may be included in the final environmental document. The Access and Hearings Unit prepares a formal document that identifies and describes the project and submits it to the State Design Engineer for approval. One approved copy is returned to the region. The Hearing Coordinator notifies the region that adoption has occurred.

(b) **Interstate Projects.** Following the design hearing summary approval, the Deputy State Design Engineer submits the approved design hearing summary to FHWA for approval. If possible, this submittal is timed to coincide with the submittal of the Design Decision Summary to the FHWA.

(2) Public Notification of Action Taken

The region prepares a formal response to the individuals who had questions not answered at the hearing. The region keeps the public advised as to the eventual result of the hearing process (project adoption, revision to the plan, or project cancellation, for example). A region newsletter sent to those on the interest list is an effective method of notification.

210.09 Access Hearing

Access hearings are required by law (RCW 47.52) whenever limited access is established or revised on new or existing highways. Decisions concerning access hearings are made on a project by project basis by the State Design Engineer based on information that includes the recommendations submitted by the region. (See Chapters 1410, 1420, 1430, and 1435.) Access hearing procedures generally follow the procedures identified in 210.05.

Prior to the access hearing as per RCW 47.52.131, conferences with the local jurisdictions shall be held on the merits of the access report and the plans.

The following supplemental information applies only to access hearings and procedures for approval of the Findings and Order.

(1) Hearing Examiner

The OSC Access and Hearings Unit hires an Administrative Law Judge from the Office of Administrative Hearings to conduct the access hearing.

(2) Order of Hearing

The Order of Hearing officially establishes the hearing date. The Hearing Coordinator calendars the Order of Hearing on the same calendar as the access hearing plan. The Hearing Coordinator then notifies the region, the Attorney General's Office, and the hearing examiner of the official hearing date.

(3) Access Hearing Information to Abutters

The region prepares an information packet for mailing that must be mailed at least 15 days before the hearing (concurrent with advertisement of the hearing notice). If some of the access hearing packets are returned as undeliverable, the region must make every effort to locate the addressees.

The access hearing packet consists of:

- The Access Hearing Plan
- The Access Hearing Notice
- The Notice of Appearance

The region sends the access hearing packet to the following:

- The county and/or city
- The owners of property listed on the county tax rolls as abutting the section of highway, road, or street being considered at the hearing as a limited access facility.
- Local public officials and agencies who have requested a notice of hearing or who, by the nature of their function, interest, or responsibility, are interested in or affected by the proposal
- Every agency, organization, official, or individual on the interest list

And, if applicable, to the following:

- State resource, recreation, and planning agencies
- Tribal governments
- Appropriate representatives of the Department of Interior and the Department of Housing and Urban Development
- Other federal agencies
- Public advisory groups

The region prepares an Affidavit of Service by Mailing. This affidavit states that the access hearing packet was mailed at least 15 days prior to the hearing and that it will be entered into the record at the hearing.

(4) Access Hearing Plan

The region prepares an Access Hearing Plan to be used as an exhibit at the formal hearing and forwards it to the OSC Plans Engineer for review and approval about 45 days before the hearing. This can be a Phase 2 or Phase 2A plan. (See Chapter 1410.) The OSC Plans Engineer puts the Access Hearing Plan on the Deputy State Design Engineer's calendar for approval.

(5) Access Hearing Plan Revisions

The Access Hearing Plan cannot be revised after the Deputy State Design Engineer approves the plan without rescheduling the hearing. If significant revisions to the plan become necessary during the period between approval and the hearing, they can be made and must be entered into the record as a revised (red and green) plan at the hearing.

(6) Access Hearing Notice

The hearing notice must be published at least 15 calendar days before the hearing. This is a legal requirement and the hearing must be rescheduled if the advertising deadline is not met. Publication and notice requirements are the same as those required in 210.05 except that the statutory abutter mailing must be mailed after notification of the appropriate legislators.

(7) Notice of Appearance

The Hearing Coordinator transmits the Notice of Appearance to the region. Anyone wanting to receive a copy of the Findings and Order and the adopted Limited Access Plan must complete a Notice of Appearance form and return it to the department either at the hearing or by mail.

(8) Reproduction of Plans

The Hearing Coordinator submits the hearing plans for reproduction at least 24 days prior to the hearing. The reproduced plans are sent to the region, at least 17 days before the hearing, for mailing to the abutters at least 15 days before the hearing. (See 210.09(3) above.)

(9) Access Hearing Exhibits

The region retains the access hearing exhibits until preparation of the draft Findings and Order is complete. Then the region submits all the original hearing exhibits, and three copies, to the Access and Hearings Unit as part of the Findings and Order package (210.09(11)). Any exhibits submitted directly to OSC are sent to the region for inclusion with the region's submittal.

(10) Access Hearing Transcript

The court reporter furnishes the original access hearing transcript to the region. The region forwards the transcript to the hearing examiner, or presiding authority, for signature certifying that the transcript is complete. The signed original is returned to the region for inclusion in the Findings and Order package.

(11) Findings and Order

The Findings and Order is based entirely on the evidence in the hearing record. The region reviews a copy of the transcript and prepares a Findings and Order package. The package is sent to the Access and Hearings Unit.

A Findings and Order package contains:

- The draft Findings and Order
- Draft responses to comments (reserved exhibits)
- A draft Findings and Order Plan (as modified from the hearing plan)
- All access hearing exhibits (originals and 3 copies)
- The access hearing transcript (original and 3 copies)
- The Notice of Appearance forms
- A number indicating how many copies of the final Findings and Order Plan and text that the region will need for the mailing.

(12) Adoption of Findings and Order

The Assistant Secretary for Environmental and Engineering Service Center adopts the Findings and Order, or refers it to the Commission for adoption, based on the evidence introduced at the hearing and on any supplemental exhibits.

Following adoption of the Findings and Order, the OSC Plans Section makes the necessary revisions to the Access Hearing Plan, which then becomes the Findings and Order Plan.

The Access and Hearings Unit arranges for reproduction of the Findings and Order Plan and the Findings and Order text and transmits them to the region.

The region mails a copy of the Findings and Order Plan and the Findings and Order text to all parties filing a Notice of Appearance and to all local governmental officials. Subsequent to this mailing, the region prepares an Affidavit of Service by Mailing and transmits it to the Access and Hearings Unit.

At the time of mailing, but before publication of the resumé, the region notifies the appropriate legislators of the department's action.

(13) Resumé

The Access and Hearings Unit provides the resumé to the region. The region must publish the resumé once each week for two weeks not to begin until at least 10 days after the mailing of the Findings and Order.

(14) Final Establishment of Access Control

When the Findings and Order is adopted, the Findings and Order Plan becomes a Phase 4 plan. (See Chapter 1410.) The establishment of access control becomes final 30 days from the date the Findings and Order is mailed by the region as documented by the Affidavit of Service by Mailing.

An appeal from the county or city must be in the form of a written disapproval, and request for a hearing before a board of review, submitted to the Secretary of Transportation.

An appeal from abutting property owners must be filed in the Superior Court of the state of Washington, in the county where the limited access facility is to be located, and shall affect only those specific ownerships. The plan is final for all other ownerships.

210.10 Combined Hearings

When deciding whether to combine hearings, consider:

- Whether there is controversy.
- Whether alternative corridors are proposed.
- The nature of the environmental concerns.
- The benefits to the public of a combined hearing.

A combined hearing often alleviates the need to schedule separate hearings close together to cover the same material. A combined EIS-corridor-design hearing is desirable only when the timing for circulation of the draft environmental document is simultaneous with the timing for corridor and design hearings and all alternative designs are available for every alternative corridor.

210.11 Administrative Appeal Hearing

When implementing access management statutes, the region is required to use the public involvement process to communicate the principles and standards of access management to the abutting property owners, business owners, and emergency services providers that might access the affected properties.

The department, as applicable, applies the Highway Access Management statutes to control access to the state highway system in order to avoid congestion and functional deterioration of the system. (See Chapters 1420 and 1430.)

After the public involvement process, if a decision has been made to restrict or delete access to a specific property, the property owner may appeal the decision by requesting a hearing.

(1) Hearing Procedure

An administrative appeal hearing does not follow the hearing procedures described earlier in this chapter. The procedure is as follows:

- The department notifies the property owner, in writing, that an access management action has been taken. The letter explains the appeal process.
- The property owner may write a letter to the department requesting an administrative appeal hearing.
- OSC hires an Administrative Law Judge and sets the hearing date, time, and place.
- The department notifies the property owner of the date, time, and place (in writing).
- Testimony is given.
- The ALJ renders a decision.

(2) Further appeals.

- The property owner may appeal the ALJ’s decision by writing the State Design Engineer.
- The State Design Engineer reviews the appeal and renders a decision (in writing, to the property owner).
- The property owner may appeal the State Design Engineer’s decision to the Superior Court of the state of Washington.

210.12 Documentation

All documents generated by hearings are retained in Archives by the Office of the Secretary of State.

P65:DM

Min. From Hearing	Sequence for a Hearing		
	Determine need for a hearing or an opportunity for a hearing 210.05(1)		
	Develop hearing notice 210.05(2) + exhibits, develop Access Hearing Plan 210.09(4)		
45 days	Send prehearing packet 210.05(5)(a), send Access Hearing Plan 210.09(4)		
	Calendar Order of Hearing & Access Hearing Plan for access hearings 210.09(2)		
30 days	Draft EIS becomes available and its comment period begins for corridor and design hearings		
	Send notice to legislators and local officials within a week of first ad 210.05(5)(b)		
	Send letter with news release to media about 3 days before ad 210.05(5)(b)		
For Access Hearings		**For Corridor, Design, and Environmental Hearings**	
24 days	Reproduction of plans 210.09(8)	30 days 15 days	Advertise a hearing * 210.05(3) Environmental hearing
15 days	Mail information packet 210.09(3) and advertise a hearing * 210.09(6)	5-12 days	Presentation of material to copy, hearing briefing, prehearing presentations 210.05(5)(c) - (e)
	Confer with local jurisdictions 210.09		Second ad 210.05(3) for corridor and design hearings
	Hearing 210.05(5)(f)		Hearing 210.05(5)(f)
	Access Hearing Transcript 210.09(10)		Address comments
	Final Access Hearing Plan 210.09(11)		Summary 210.05(6) within two months of the hearing
	Findings and Order and Resumé 210.09(11) - (13)		

*If the advertisement is for the opportunity for a hearing, the deadline for requests must be at least 21 days after the first ad. If there are no requests, see 210.05(4).

Sequence for a Hearing
Figure 210-1

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 design 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*.)

For most WSDOT projects, the Federal Highway Administration (FHWA) is the lead agency for NEPA. Other federal lead agencies on WSDOT projects are the Federal Aviation Administration, Federal Rail Administration, and the Federal Transit Administration (FTA).

220.05 Identifying the Project Classification

Based on the environmental considerations identified during preparation of the ERS, WSDOT projects are classified for NEPA/SEPA purposes to determine the type of environmental documentation that will be required. Projects with a federal nexus (using federal funds, involving federal lands, or requiring federal approvals or permits) are subject to NEPA and SEPA. Projects that are state funded only, with no federal nexus including federal permits, follow SEPA guidelines. Since many WSDOT projects are prepared with the intent of obtaining federal funding, NEPA guidelines are usually followed. The *Environmental Procedures Manual* provides detailed definitions of the classes of projects and lists types of work typically found in each class; FHWA/federal agency concurrence requirements; and procedures for classifying and, if necessary, reclassifying the type of environmental documentation for projects.

Projects subject to NEPA are classified as either Class I, II, or III. Class I projects require preparation of an EIS because the action is likely to have significant adverse environmental impacts. Class II projects are Categorical Exclusions or Documented Categorical Exclusions that meet the definitions contained in 40 CFR 1508.4 and 23 CFR 771.117. These are actions that are not likely to cause significant adverse environmental impacts. Class III projects require an Environmental Assessment (EA) because the significance of the impact on the environment is not clearly established.

SEPA has a similar, but not identical system. SEPA recognizes projects that are categorically exempt, projects that require an EIS, and projects that do not. WSDOT projects that are CEs under NEPA (Class II) may not be categorically exempt under SEPA.

If the project is not exempt under SEPA, WSDOT must issue a threshold determination and then prepare a SEPA Checklist or EIS. The threshold determination may be a determination of non-significance (DNS) or a determination of significance (DS) requiring an EIS. WSDOT may adopt a NEPA EA FONSI to satisfy the requirements for a DNS.

220.06 Environmental Impact Statements – Class I Projects

Class I projects are actions that are likely to have significant impact on the environment because of their effects on land use, planned growth, development patterns, traffic volumes, travel patterns, transportation services, natural resources, or because they are apt to create substantial public controversy. An EIS may follow an EA if significant impacts are discovered during preparation of an EA. The *Environmental Procedures Manual* has details on EIS documents and procedures. WSDOT typically prepares a joint NEPA/SEPA EIS to satisfy both statutes.

Examples of projects that usually require an EIS, as referenced in 23 CFR 771.115, are:

- New controlled-access freeway
- Highway projects of four or more lanes on a new location
- New construction or extension of fixed rail transit facilities (e.g., rapid rail, light rail, commuter rail, automated guideway transit)
- New construction or extension of a separate roadway for buses or high-occupancy vehicles not located within an existing highway facility
- Construction of a new ferry terminal or large-scale changes to existing terminal facilities

Although examples are given, it is important to remember that it is the size and significance of the potential impacts that determines the need for an EIS, not the size of the project. “Significance” is not always clearly defined but is generally determined by the impact’s “context” and “intensity.” Having a significant impact in just one area is sufficient to warrant preparation of an EIS.

Only about three percent of WSDOT's projects go through the EIS process. Typically these are the larger, more complicated projects often in urban areas or involving new right of way and important natural or cultural resources. The process takes from two to five years or longer depending on the issues and stakeholders. EISs are expensive because of the amount of information produced, the level of design required, the frequency of redesign to address issues that are discovered, and the higher level of agency and public involvement. WSDOT is preparing an 'EIS Reader-Friendly Tool Kit' to simplify the content of EISs and to improve them as a communication tool to inform the public and decision-makers. Both federal and state initiatives exist to streamline the EIS process and reduce the costs.

220.07 Categorical Exclusions – Class II Projects

The FHWA NEPA Regulations identify project types that qualify as CEs (see 23 CFR 771.117). In general, CEs are actions that, based on past experience with similar projects, do not have significant environmental impacts. CEs are subject to reevaluation by FHWA where there are unusual circumstances, such as new environmental impacts; controversy on environmental grounds; unforeseen impacts to cultural, historic or recreational resources (Section 4(f) or Section 106); or inconsistencies with federal, state, or local laws.

CEs are defined further by two subcategories: CEs not requiring FHWA concurrence and Documented Categorical Exclusions (DCE). Projects defined as CEs not requiring FHWA concurrence must meet the requirements of the Memorandum of Understanding Between WSDOT and FHWA on Programmatic Categorical Exclusion Approvals, signed May 25, 1999 (see *Environmental Procedures Manual*). This may include preparation of a Biological Assessment (BA) to document effects to endangered and threatened species. If a "no effects" determination is the outcome of the BA, then the only NEPA documentation required is a signed ERS that is included in the Project Summary package sent to HQ Systems Analysis and Program Development. No other NEPA documentation or approval by FHWA is required.

For DCEs, additional environmental documentation is required and FHWA approval must be obtained before the Project File can be approved. All environmental documentation must be completed before finalizing the PS&E package and going to ad. The ERS is then renamed the Environmental Classification Summary (ECS), signed by the WSDOT Regional Environmental Manager, and sent with federal permits and/or documentation to FHWA for approval.

After obligation of project design funds, detailed environmental studies for CE documentation may be required for DCE projects to determine the environmental, economic, and social impacts. WSDOT then finalizes the ECS and submits it to FHWA for final approval.

220.08 Environmental Assessment – Class III Projects

Under NEPA, when the significance of the impact of a proposed project on the environment is not clearly established, an Environmental Assessment (EA) is prepared to determine the extent of environmental impact and to determine whether an EIS is needed. WSDOT may adopt the EA to satisfy requirements for a SEPA DNS, but the EA will not satisfy the EIS requirement under SEPA. No EIS is required when the EA supports a NEPA Finding of No Significant Impact (FONSI). Issuance of a FONSI (normally by the FHWA) is the final step in the EA process. (See Section 411.04 of the *Environmental Procedures Manual* for details on EA documentation and procedure.)

220.09 Reevaluations

Both NEPA and SEPA allow for reevaluating the project classification or environmental document. In general, reevaluations are required when there are substantial changes to the scope of a project, such that the project is likely to have significant adverse environmental impacts, or if there is new information that increases the likelihood that a project will have significant adverse environmental impacts. Reevaluations are also required if project construction has not begun within 5 years of completing the NEPA process.

As FHWA must concur with the NEPA classification, any major change in a project classification for a project involving federal funds requires the processing of a revised ECS form. Minor changes may be handled informally, if FHWA concurs.

For SEPA, when the scope of a project is changed, a revised ERS is normally required with some exceptions. As part of that revision process, the environmental classification needs to be reassessed. The decision on whether or not to revise the ERS is made by the regional Environmental Office in coordination with the region Program Management Office. For many minor scope changes, a new ERS is not required. A note to the file or a follow-up memo is then prepared to document the revision.

In some cases, new circumstances may cause a change in the environmental classification but not a change in scope. A note to the file or a follow-up memo documents any changes in classification.

220.10 Commitment File

As an initial part of project development, the region establishes a project commitment file. Establishment of this file generally coincides with preparation of the environmental document or might be at later stages as required. The file consists of proposed mitigating measures, commitments made to resource or other agencies with permitting authority, and other documented commitments made on the project. Also included in the file are design and environmental commitments. Other commitments types (ROW, Maintenance, etc.) may be added at the region's discretion.

The region continues to maintain the commitment file as a project progresses through its development process. Whenever commitments are made, they are incorporated into project documents and transferred from one phase of the project to the next. Commitments are normally included or identified in the following documents or actions:

- Environmental documents and consultations
- Design Documentation Package (DDP)
- Environmental permits
- MOUs/ Letters to stakeholders
- Right of way plans
- Access plans
- Findings and order from access hearings
- Contract document
- Preconstruction conference
- Change orders
- End of project report
- Maintenance

To organize and track commitments made during the development and implementation of a project, WSDOT has established a Commitment Tracking System (CTS). This system provides easy access and retrieval of commitment information. Reports from the system establish the commitment record for the project file. When a commitment is made, log it in the CTS. The entry requires sufficient detail necessary to document the commitment, including references to correspondence, agreement numbers, etc. A commitment may be revised when WSDOT and the organization or individual involved agree to the revision.

When commitments are completed, the CTS is updated with the date the commitment was finished and appropriate comments. Commitments requiring ongoing maintenance need to be formally passed off to Maintenance and Operations for incorporation into the Maintenance Program.

220.11 Documentation

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

Chapter 240 Environmental Permits and Approvals

240.01 Introduction

Washington State Department of Transportation (WSDOT) projects are subject to a variety of federal, state, and local environmental permits and approvals. The *Environmental Procedures Manual,* M 31-11, provides detailed guidance on the applicability of each permit and approval. Because the facts of each project vary and the environmental regulations are complex, reliance on either the *Design Manual* or the *Environmental Procedures Manual* is insufficient. Region and Headquarters (HQ) environmental staff should be consulted.

240.02 Permits and Approvals

The Environmental Review Summary (ERS) prepared as part of the Project Summary identifies some of the most common environmental permits that might be required based on the information known at that stage. As the project design develops, additional permits and approvals can be identified. Conducting project site visits for engineering and environmental features may reduce project delays due to late discoveries. Coordination with region and HQ environmental staff is recommended.

Figures 240-1a through 1e provide a comprehensive list of the environmental permits and approvals required by WSDOT projects. For each permit or approval, the responsible agency is identified, the conditions that trigger the permit are listed, the relevant sections of the *Environmental Procedures Manual* are provided, and the statutory authority is cited.

The conditions that trigger a permit or approval are discussed in detail in the *Environmental Procedures Manual*. The permit triggers are subject to interpretation and change as new regulations are developed or court decisions are rendered that alter their applicability. Determining which permits and approvals apply and how they apply is dependent on the facts of each project. Consult environmental staff at each stage of the project design to review the permits and approvals that might be required based on the project design.

Permit or Approval	Responsible Agency	Conditions Requiring	Environmental Procedures	Statutory Authority
National Environmental Policy Act (NEPA)	FHWA and WSDOT	Activities that require federal permits, approvals, or funding trigger NEPA procedural and documentation requirements.	320, 410-480	42 USC 4321 23 CFR 771 40 CFR 1500-1508
State Environmental Policy Act (SEPA)	Ecology	Any activity not categorically exempt triggers SEPA procedural and documentation requirements.	410-480	RCW 43.21C WAC 197-11, WAC 468-12
Corps of Engineers Section 404 Individual Permits (Uses Joint Aquatic Resource Permits Application [JARPA])	COE	Any discharging, dredging, or placing of fill material in waters of the U.S. and adjacent wetlands	431, 432, 437, 452, 510	Section 404 of the Clean Water Act (CWA); 33 USC 1344, 33 CFR 330.5 and 330.6
Corps of Engineers Section 404 Nationwide Permits (NWP) (Uses JARPA)	COE	NWP information is presented in a 2002 special public notice issued by the COE. A total of 44 NWPs for a range of activities in waters of the US are described in the public notice.	431, 432, 437, 452, 510	Section 404 of the CWA; 33 USC 1344, 33 CFR 330.5 and 330.6
Water Quality 401 Certification (Uses JARPA)	Ecology Headquarters, Shorelands and Environmental Assistance Program, Coordination Section; US EPA on Tribal and Federal land	Any activity requiring a federal permit for discharging into waters must receive certification from the state that the discharge complies with that state's water quality standards.	431, 432, 437, 452, 453	33 USC 1341, 33 CFR 320.4; RCW 90.48, WAC 173-225
Coastal Zone Management (CZM) Certification (Uses JARPA)	Ecology Headquarters, Shorelands and Environmental Assistance Program	Any activity requiring a federal permit/license must certify that the activity will comply with the State's Coastal Zone Management Program (Shoreline Management Act).	431, 432, 437, 452, 520	16 USC 1456, 33 CFR 320.3, RCW 90.58
Coast Guard Section 9 Bridge Permit (Uses JARPA)	U.S. Coast Guard	Any work on bridges and causeways in navigable waters or waters that are susceptible to improvement for transporting interstate or foreign commerce, or waters that are used by boats 21 feet or more in length.	431, 432, 452, 453	Section 9 of the Rivers and Harbors Act; 33 USC 401; 33 CFR 114 and 115; Federal Aid Highway Act of 1987. Section 123(b)
Corps of Engineers Section 10 Permit (Uses JARPA)	COE	Any obstruction, alteration, or improvement of any navigable water, including rechanneling, piers, wharfs, dolphins, bulkheads, and buoys.	431, 432, 452	Section 10 of the Rivers and Harbors Act; 33 USC 401; 33 CFR 330.5 and 330.6
Threatened and Endangered Species	USFWS and NMFS	Projects affecting critical habitat of species listed under the ESA may be subject to water quality and wetland permits listed in Section 431.06 and Section 437.06.	436, 447, 510, 520	16 USC 1531-1543

Permits and Approvals
Figure 240-1a

Permit or Approval	Responsible Agency	Conditions Requiring	Environmental Procedures	Statutory Authority
Historic Preservations Act - Section 106	OAHP SHPO	Potential impacts to historic or archaeological properties trigger Section 106 procedural and documentation requirements.	411, 456	16 USC 470 Sec.106 36 CFR 800 RCW 43.51.750
Land and Water Conservations Act - Section 6(f)	FHWA and Affected Agency (WSDOT)	Use of lands purchased with LWCA funds triggers Section 6(f) procedural and documentation requirements.	411, 455	LWCA, 16 USC
U.S. Dept of Transportation Act - Section 4(f)	FHWA and Affected Agency (WSDOT)	Use of park and recreation lands, wildlife and waterfowl refuges, and historic sites of national, state, or local significance triggers Section 4(f) procedural and documentation requirements.	411, 455	49 USC 1651 Sec. 4 (f) 23 CFR 138
Wild and Scenic Rivers	FHWA and Affected Agency	No specific permits are required for projects in wild and/or scenic river corridors, but water quality permits may apply.	453	16 USC 1271
Farmland Conversion	NRCS Counties/Cities	NRCS Form AD1006 approval may be required if project entails conversion of farmlands. Local grading permits may also be required.	454	7 USC 4201 7 CFR 650
Airport/Highway Clearance	FAA (Federal)	Airspace intrusion by a highway facility (i.e. proposed construction in the vicinity of public use or military airports) may require FAA notification.	460	FHPM 6-1-1-2 FAA Regs. Part .77
(NPDES Municipal Stormwater Discharge General Permit	Ecology	WSDOT projects that discharge stormwater. There are four geographical areas covered by separate general permits that are based on watershed boundaries: Island, Snohomish, South Puget Sound, and Cedar/Green.	431, 433	33 USC 1342, RCW 90.48, WAC 173-226
NPDES Stormwater Construction Permit	Ecology	WSDOT construction activities disturbing more than 5 acres.	431, 433	33 USC 1342, RCW 90.48, WAC 173-226
NPDES Sand and Gravel General Permit	Ecology	Discharges of process water and stormwater associated with sand and gravel operations and rock quarries.	431, 433	33 USC 1342, RCW 90.48; WAC 173-226
NPDES Stormwater Industrial Permit	Ecology	Ferry-related activities that discharge stormwater to waters of the state.	431, 433	33 USC 1342, RCW 90.48; WAC 173-226
Underground Injection Control	Ecology	Injection well that may contaminate drinking water.	433	40 CFR 144 RCW 43-21A.44 , WAC 173-218

Permits and Approvals
Figure 240-1b

Permit or Approval	Responsible Agency	Conditions Requiring	Environmental Procedures	Statutory Authority
Hazardous Waste Tracking Form	Ecology	A WAD tracking number from Ecology is required for transport, storage, or disposal of dangerous waste.	447	WAC 173-303
Water Quality Permit. Use of Herbicides to Control Noxious Weeds on WSDOT Properties and Projects within the State of Washington	Ecology, Environmental Coordination Section, Federal Permit Manager for WSDOT	Application of herbicides to waters of the state at WSDOT-owned or –managed sites to control noxious weeds.	431	RCW 90.48.445, and WAC 173-201A-110
Administrative Order # DE99WQ-003. WSDOT Use of Herbicides to Control Non-noxious Weeds on WSDOT Properties and Projects within the State of Washington	Ecology, Environmental Coordination Section, Federal Permit Manager for WSDOT	Approved methods of application must be followed and careful record keeping must be documented. WDFW must be consulted for identification of salmonid bearing waters and special seasonal timing restrictions. Restrictions and public notice requirements are placed on herbicide application within 0.5 mile of areas of potential public use.	431	RCW 90.48, and WAC 173-201A-110
Water Right Permit	Ecology, Water Resources Program	Any withdrawal of surface or groundwater for a WSDOT activity or project.	431, 433	RCW 90.03; 90.44; 90.54
State Waste Discharge (SWD) Permit	Ecology	Any activity that will discharge or dispose of municipal and industrial wastewater into groundwaters of the state, or discharge industrial wastewater to a NPDES-permitted wastewater treatment plant. SWD permits are different from NPDES permits because NPDES permits regulate discharges directly to water or stormwater systems.	433	RCW 90.48; WAC 173-226
Water System Project Approvals	Washington State Department of Health or County/City Department of Health	Any project in which there are two or more water service connections for human consumption and domestic use.	431, 433	RCW 43.20A; WAC 246-290 through 293
Hydraulic Project Approval (HPA)	WDFW	Any project that will use, cross, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state. Regulated activities include culvert work, stream realignment, and bridge replacement.	431, 432, 436, 447, 452, 453, 510, 520	RCW 75.20.100; WAC 220-110;

Permits and Approvals
Figure 240-1c

Permit or Approval	Responsible Agency	Conditions Requiring	Environmental Procedures	Statutory Authority
Fish Habitat Enhancement Project Application	WDFW	Streamlined process for projects designed to enhance fish habitat. Application is in addition to JARPA.	436	
Aquatic Resource Use Authorization (Uses JARPA)	DNR	Included in JARPA.	436, 437, 520	RCW 79.90 WAC 332-30
Easements	DNR	Any activity that fills, crosses over, bridges, or is on the beds of navigable waters of the state.	436, 437, 520	RCW 47.12
Monument Removal	DNR	Removal or destruction of a monument.	451	
Operating Permit for Surface Mining	DNR, USFS, BLM	Surface mining (pit and quarry sites); more than 3 acres disturbed at one time or pit walls more than 30 feet high and steeper than 1:1; pit site reclamation (WDNR). Borrow pits on federal land may require a permit or easement from the land-management agency.	420, 510	RCW 78.44
Forest Practices Application	DNR	Road construction, pits, pesticide use, and other specified activities on public or private forest land (i.e., land capable of supporting merchantable timber).	455	RCW 76.09 WAC 222
Shoreline Substantial Development Permit (Uses JARPA)	Counties or Cities	Qualified activities within shoreline jurisdiction – lakes/reservoirs 20 acres or greater, streams with 20 cfs annual flow, marine water, and all areas landward for 200 feet of OHWM.	431, 432, 437, 452, 520	RCW 90.48, WAC 173-10 through 173-28
Flood Plain Development Permit (Uses JARPA)	Counties or Cities	Any structure or activity that may adversely affect the flood regime of a stream within the flood zone.	432	RCW 86.16; WAC 173-158
Critical Areas Ordinance (Uses JARPA)	Counties and Cities	Any activity involving critical areas as regulated by the local jurisdiction. Critical areas include wetlands, critical recharge areas to aquifers, fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas.	420, 431, 436, 437, 451, 520	RCW 36.70A

Permits and Approvals
Figure 240-1d

Permit or Approval	Responsible Agency	Conditions Requiring	Environmental Procedures	Statutory Authority
Clearing, Grading, and Building Permits	Counties / Cities	Clearing and grading of land for development with impacts outside WSDOT right of way (includes connecting streets, frontage roads, etc.). Construction of any building for human habitation.	420, 451, 454, 460, 520	RCW 36.21.080
Temporary Air Pollution	Ecology, Local Clean Air Agencies, Fire Protection Agencies	Pollutants above allowed levels for temporary periods; includes building demolition and brush burning. Regulations may limit the type, size, or timing of brush burning.	425	RCW 70.94
New Source Construction	Ecology, Local Clean Air Agencies	Air pollution from a point source (e.g., asphalt plants, rock crushers).	425	RCW 70.94.152
Noise Variance	Counties / Cities	Construction and maintenance activities during nighttime hours may require a variance from local noise ordinances. Daytime noise from construction is usually exempt.	446	WAC 173-60
Archaeological Resources Protection Permit	Tribes Federal Landowners, (e.g. BLM, COE, NPS)	Excavation or removal of archaeological resources from tribal or federal land.	456	43 CFR 7.6 – 7.11

BLM – Bureau of Land Management
CFR – Code of Federal Regulations
COE – Corps of Engineers
CWA – Clean Water Act
CZMA – Coastal Zone Management Act
DNR – Department of Natural Resources
DOE – Department of Ecology
EPA – Environmental Protection Agency
ESA – Endangered Species Act
FERC – Federal Energy Regulatory Commission
LWCA – Land and Water Conservation Act
NMFS – National Marine Fisheries Service
NPDES – National Pollution Discharge Elimination System
NPS – National Park Service
NRCS – Natural Resources Conservation Service
OAHP – Office of Archaeology and Historic Preservation
OHWM – Ordinary High Water Mark
RCW – Revised Code of Washington
SHPO – State Historic Preservation Officer
USFS – U.S. Forest Service
USFWS – U.S. Fish and Wildlife Service
WAC – Washington Administrative Code
WAD – EPA, Washington State waste ID tracking number
WDFW – Washington State Department of Fish and Wildlife

Permits and Approvals
Figure 240-1e

240.03 Project Types and Permits

Understanding and anticipating what permits and approvals may be required for a particular project type will assist the designer in project delivery. This section provides information on what project types are likely to trigger which permits. The purpose of this section is to inform designers of the potential for permits and does not substitute for the information developed in the Environmental Review Summary prepared during the Project Summary or more specific permit information developed during design. The intent is to provide a familiar and reasonably quick method for gauging the relative complexity of the permit process. Designers are encouraged to use the expertise in the region environmental office and the HQ Environmental Services Office.

To make the evaluation familiar, this chapter uses the design matrices developed in Chapter 325, as a template. The project types and definitions are found in Chapter 325 with the exception of some additional project types for bridge work. These additional bridge projects are defined below. Rather than identify levels of design for each project type, the matrices identify permits and approvals. While every project is unique to some degree, there are common facts associated with project types that allow for a level of predictability. As the project type gets more complex, the predictability of which environmental permits and approvals may be triggered decreases.

Figures 240-2 through 240-7b use the predictability about project types and combine that with assumptions on environmental conditions to generate probabilities about required permits and approvals. The probabilities cannot be substituted for a fact-based analysis of the project and the applicability of any particular environmental permit or approval. Contact region or HQ environmental staff before decisions are made about whether a permit or approval applies. Coordination with the HQ Bridge and Structures Office and the HQ Environmental Services Office is recommended for bridge projects.

The probabilities for needing a permit are divided into low, medium, and high. A low probability generally means that the thresholds for triggering an environmental permit or approval may not be reached under the assumptions behind the project type. A medium probability means that there is the potential to trigger the application of the permit or approval. A high probability means that there is a likelihood of triggering the permit or approval.

The assumptions underlying the project types and probabilities are shown as endnotes following the matrices (Figures 7a – 7c). Some general assumptions were made regarding the project types; for main line projects on the Interstate, National Highway System main line (except Interstate), or non-National Highway System, all bridgework is assumed to be over water. For interchange projects on the Interstate and non-Interstate, all bridgework is assumed to be over roads. (See Chapter 325.)

The environmental permits and approvals selected for inclusion in the matrices represent the ones that are most frequently triggered. The other permits and approvals listed in Figure 240-1a through 1e are more limited in their application and often require very specific fact situations. They are discussed in more detail in the *Environmental Procedures Manual*.

The additional bridge projects are as follows:

- **Bridge Replacement (Obsolete, Structural):** Projects to replace or rehabilitate state-owned bridges when continued maintenance and preservation strategies can no longer accommodate safe, continuous movement of people and goods. Includes new or replacement bridge (on or over, main line, interchange ramp, or water body), and repair or replacement of reinforced concrete, steel, and/or timber bridges. Obsolete replacement typically includes bridges that have a narrow width or low vertical clearance or a restrictive waterway opening. Structural replacement is a replacement of a bridge that has a structural deficiency in a superstructure or substructure element.

- **Existing Bridge Widening:** Widening an existing bridge for an existing highway.
- **Bridge Deck Rehabilitation:** Structures preservation projects that repair delaminated concrete bridge deck and add a protective overlay that will provide a sound, smooth surface; prevent further corrosion of the reinforcing steel; and preserve operational and structural capacity. The goal is to ensure safe, long-lasting riding surfaces on all reinforced concrete bridges.
- **Bridge Scour Countermeasures:** Measures undertaken to reduce the risk of bridge foundation scour damage and stream bank erosive forces that increase the potential of bridge collapse due to flooding and long-term waterway changes. The goal is to maintain the structural integrity of the roadway prism and highway structures. Bridge scour repair can include repair to the streambed around a bridge column or repairs to stream banks near a bridge. This category typically involves an in-depth engineering and environmental review for site and/or reach processes. Extensive documentation and permitting are typically needed. Early and close coordination with the permit agency representatives through Regional environmental staff is essential. Close coordination with the HQ Bridge Preservation Office, Hydraulics Branch, and Environmental Services Office (watershed, permit program) are useful to ensure a one-WSDOT project approach is established early in the design phase.
- **Steel Bridge Painting:** Measures undertaken to preserve the load-carrying capacity of steel bridges by maintaining properly functioning paint systems to provide protection against corrosion. These measures include high-pressure washing and spot abrasive blasting to prepare steel surfaces for painting. This category typically involves discharge of wastewater into waters of the state and the decisions surrounding the need for full or partial containment of the wash water and blast media used for preparing the steel surfaces. Early and close coordination with the Bridge Management Engineer is necessary. A thorough review of the Standard Specifications current Water Quality Implementing Agreement (WQIA), and available Programmatic Permits, such as the General Hydraulic Project Approval (GHPA) and National Pollution Discharge Elimination System (NPDES) permits, is also recommended. Early project scoping for determination of wildlife usage is another factor for early coordination with all departments.
- **Bridge Seismic Retrofit:** Seismic retrofit of a bridge element (typically bridge columns). Measures undertaken to reduce the vulnerability of existing Washington State-owned bridges in the high to moderate seismic risk areas to earthquake damage that could cause collapse, excessive repair costs, or lengthy closures to traffic. This includes Phase 1 repairs (prevent span separation), Phase 2 repairs (retrofit single-column supports) and Final Phase (retrofit multiple-column supports).
- **Special Bridge Repair (Electrical/ Mechanical Retrofit):** Rehabilitating a major portion of an existing bridge to include electrical and mechanical repairs, such as for a movable bridge, a bridge over navigable water, or sign support structures.
- **Other Bridge Structures:** Major repair or replacement of Sign Bridges, Cantilever Sign Supports, Bridge Mounted Sign Supports, Tunnels, and High Mast Luminaire Poles.
- **New Special Structures:** Measures taken to build a new floating, movable, suspension, or cable stayed bridge for new or existing roadway.

⇩ Project Type / Permit or Approval[***] ⇨	Section 404 Individual Permits	Section 404 Nationwide Permits (NWP)[(1)]	Water Quality 401 Certification	Coastal Zone Management (CZM) Certification	Threatened and Endangered Species	Hydraulic Project Approval (HPA)	Shoreline Substantial Development Permit	Flood Plain Development Permit	Aquatic Resource Use Authorization	NPDES Municipal Stormwater Permit	NPDES Stormwater Construction Permit	NPDES Industrial Discharge Permit	State Waste Discharge (SWD) Permit	Section 9 Bridge Permit	Section 10 Permit	Section 106	Section 4(f) 6(f)	Critical/Sensitive Areas Ordinances	Noise Variance
(1-1) Preventive Maintenance																			
Pavement Restoration																			
(1-2) Diamond Grinding	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(1-3) Milling with HMA Inlays	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(1-4) Nonstructural Overlay	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
Pavement Rehab./Resurf.																			
(1-5) HMA Structural Overlays	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(1-6) PCCP Overlays	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(1-7) Dowel Bar Retrofit	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
Bridge Rehabilitation																			
(1-8) Bridge Widening	M	M	M	M	M	H	H	M	L	L	L	L	L	M	M	M	L	M	L**
(1-8a) Existing Bridge Replacement	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	H	M	M	M
(1-8b) Bridge Deck Rehabilitation	M	L	L	H	M	M	H	L	L	H	L	L	L	M	L	M	L	L	M
(1-8c) Bridge Scour Countermeasures	M	H	H	H	H	H	H	L	M	L	L	L	L	M	M	M	L	H	L
(1-8d) Steel Bridge Painting	L	L	H	H	M	H	L	L	L	L	L	L*	L	M	L	L	L	L	M**
(1-8e) Bridge Seismic Retrofit	L	M	M	M	M	H	L	L	L	L	L	L	L	M	L	L	L	L	L
(1-8f) Special Bridge Repair	L	M	M	M	M	M	L	L	L	L	L	L	L	M	L	L	L	L	M
Safety																			
(1-9) Median Barrier	L	M	M	L	L	L	L	L	L	H	M	L	L	L	L	L	L	L	L
(1-10) Guardrail Upgrades	L	M	M	L	L	L	M	L	L	H	M	L	L	L	L	L	L	L	L
(1-11) Bridge Rail Upgrades	L	L	L	H	L	L	H	L	L	H	L	L	L	L	L	M	L	L	L
Reconstruction																			
(1-12) New/Reconstruction	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	H	M	M	M

(See endnotes for explanation of matrices)

Project Environmental Matrix 1
Permit Probabilities for Interstate Routes (Main Line)
Figure 240-2

⇩ Project Type / Permit or Approval ⇨	Section 404 Individual Permits	Section 404 Nationwide Permits (NWP)	Water Quality 401 Certification	Coastal Zone Management (CZM) Certification	Threatened and Endangered Species	Hydraulic Project Approval (HPA)	Shoreline Substantial Development Permit	Flood Plain Development Permit	Aquatic Resource Use Authorization	NPDES Municipal Stormwater Permit	NPDES Stormwater Construction Permit	NPDES Industrial Discharge Permit	State Waste Discharge (SWD) Permit	Section 9 Bridge Permit	Section 10 Permit	Section 106	Section 4(f) 6(f)	Critical/Sensitive Areas Ordinances	Noise Permit
(2-1) Preventive Maintenance																			
Pavement Restoration																			
(2-2) Diamond Grinding	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
(2-3) Milling with HMA Inlays	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
(2-4) Nonstructural Overlay	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
Pavement Rehab./Resurf.																			
(2-5) HMA Structural Overlays	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
(2-6) PCCP Overlays	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
(2-7) Dowel Bar Retrofit	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
Bridge Rehabilitation																			
(2-8) Bridge Deck Rehabilitation	M	L	L	H	M	M	H	L	L	H	L	L	L	M	L	M	L	L	M**
(2-8a) Steel Bridge Painting	L	L	H	H	M	H	L	L	L	L	L	H	L	M	L	L	L	L	L
(2-8b) Bridge Seismic Retrofit	L	M	M	M	M	H	L	L	L	L	L	L	L	M	L	L	L	L	L
Safety																			
(2-9) Guard Rail Upgrades	L	M	M	L	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
(2-10) Bridge Rail Upgrades	L	L	L	M	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
Reconstruction																			
(2-11) New/Reconstruction	M/H	H	H	H	H	H	H	M	L	H	H	L	L	L	L	H	M	M	M

Project Environmental Matrix 2
Permit Probabilitiy for Interstate Interchange Areas
Figure 240-3

⇩ Project Type / Permit or Approval ⇨	Section 404 Individual Permits	Section 404 Nationwide Permits (NWP)	Water Quality 401 Certification	Coastal Zone Management (CZM) Certification[2]	Threatened and Endangered Species	Hydraulic Project Approval (HPA)	Shoreline Substantial Development Permit[3]	Flood Plain Development Permit	Aquatic Resource Use Authorization	NPDES Municipal Stormwater Permit	NPDES Stormwater Construction Permit	NPDES Industrial Discharge Permit	State Waste Discharge (SWD) Permit[4]	Section 9 Bridge Permit[5]	Section 10 Permit[6]	Section 106	Section 4(f) 6(F)	Critical/Sensitive Areas Ordinances[7]	Noise Permit
Preservation																			
Roadway																			
(3-1) Non-Interstate Freeway	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(3-2) HMA/PCCP/BST Overlays	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(3-3) Replace HMA w/ PCCP at I/S	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
Structures																			
(3-4) Bridge Replacement	H	H	H	H	H		H	H	M	H	H	L	L	M	M	M	M	M	L
(3-5) Bridge Deck Rehab.	M	L	L	H	M	M	H	L	L	H	L	L	L	M	L	M	L	L	M
(3-5a) Bridge Scour	M	H	H	H	H	H	H	L	M	L	L	L	L	M	M	M	L	H	L
(3-5b) Steel Bridge Painting	L	L	H	H	M	H	L	L	L	L	L	H	L	M	L	L	L	L	L
(3-5c) Bridge Seismic Retrofit	L	M	M	M	M	H	L	L	L	L	L	L	L	M	L	L	L	L	L
(3-5d) Special Bridge Repair	L	M	M	M	M	M	L	L	L	L	L	L	L	M	L	L	L	L	M
Improvements																			
(3-6) Non-Interstate Freeway	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M**
(3-7) Urban	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M**
(3-8) Rural	M	H	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-9) HOV	M	M	M	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	M
(3-10) Bike/Ped. Connectivity	M	H	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
Safety																			
(3-11) Non-Interstate Freeway	L	L	L	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-12) Intersection	L	L	L	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(3-13) Corridor	L	L	L	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-14) Median Barrier	L	M	M	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(3-15) Guardrail Upgrades	L	M	M	L	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
(3-16) Bridge Rail Upgrades	L	L	L	M	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
(3-17) Risk: Roadside	L	H	H	L	L	L	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-18) Risk: Sight Distance	L	L	L	L	L	L	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-19) Risk: Roadway Width	L	H	H	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-20) Risk: Realignment	M	H	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
Economic Development																			
(3-21) Freight and Goods (Frost Free)	M	H	H	M	M	M	M	M	L	H	H	L	L	L	L	M	M	M	M
(3-22) Four-Lane Trunk System	M	H	H	M	M	M	M	M	M	H	H	L	L	L	L	H	H	H	M
(3-23) Rest Areas (New)	M	H	H	L	M	M	M	L	L	H	H	L	M	L	L	H	H	H	L
(3-24) Bridge Restrictions	M	H	H	H	M	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(3-25) Bike Routes (Shldrs)	L	M	M	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L

Project Environmemtal Matrix 3
Permit Probability for NHS Routes Non-Interstate (Main Line)
Figure 240-4

⇩ Project Type / Permit or Approval ⇨	Section 404 Individual Permits	Section 404 Nationwide Permits (NWP)	Water Quality 401 Certification[1]	Coastal Zone Management (CZM) Certification[2]	Threatened and Endangered Species	Hydraulic Project Approval (HPA)	Shoreline Substantial Development Permit	Flood Plain Development Permit	Aquatic Resource Use Authorization	NPDES Municipal Stormwater Permit	NPDES Stormwater Construction Permit	NPDES Industrial Discharge Permit	State Waste Discharge (SWD) Permit[4]	Section 9 Bridge Permit[5]	Section 10 Permit	Section 106	Section 4(f) 6(F)	Critical/Sensitive Areas Ordinances[7]	Noise Permit
Preservation																			
Roadway																			
(4-1) Non-Interstate Freeway	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
(4-2) HMA/PCCP/BST	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
Overlays Ramps	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	
Structures																			
(4-3) Bridge Replacement	M	H	H	M	L	L	M	M	L	H	H	L	L	L	L	M	L	L	M
(4-4) Bridge Deck Rehab.	M	L	L	H	M	M	H	L	L	H	L	L	L	M	L	M	L	L	L
(4-5) Steel Bridge Painting	L	L	H	H	M	H	L	L	L	L	L	H	L	M	L	L	L	L	L
(4-6) Bridge Seismic Retrofit	L	M	M	M	M	H	L	L	L	L	L	L	L	M	L	L	L	L	L
Improvements																			
Mobility																			
(4-6) Non-Interstate Freeway	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M**
(4-7) Urban	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M**
(4-7) Rural	M	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
(4-8) HOV By Pass	M	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	M
(4-9) Bike/Ped. Connectivity	M	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
Safety																			
(4-10) Non-Interstate Freeway	L	L	L	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
(4-11) At Grade	L	L	L	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(4-12) Intersection	L	L	L	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(4-13) Guardrail Upgrades	L	M	M	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(4-14) Bridge Rail Upgrades	L	L	L	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(4-15) Risk: Roadside	L	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
(4-16) Risk: Sight Distance	L	L	L	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
(4-17) Risk: Roadway Width	L	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
(4-18) Risk: Realignment	M	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
Economic Development																			
(4-19) Four-Lane Trunk System	M	H	H	M	M	M	M	M	M	H	H	L	L	L	L	H	H	H	M

Project Environmental Matrix 4
Interchange Areas, NHS (Except Interstate) and Non-NHS
Figure 240-5

⇩ Project Type / Permit or Approval ⇨	Section 404 Individual Permits	Section 404 Nationwide Permits (NWP)	Water Quality 401 Certification(1)	Coastal Zone Management (CZM) Certification(2)	Threatened and Endangered Species	Hydraulic Project Approval (HPA)	Shoreline Substantial Development Permit	Flood Plain Development Permit	Aquatic Resource Use Authorization	NPDES Municipal Stormwater Permit	NPDES Stormwater Construction Permit	NPDES Industrial Discharge Permit	State Waste Discharge (SWD) Permit(4)	Section 9 Bridge Permit(5)	Section 10 Permit	Section 106	Section 4(f) 6(F)	Critical/Sensitive Areas Ordinances(7)	Noise Permit
Roadway																			
(5-1) HMA/PCCP	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(5-2) BST	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(5-3) BST Routes/Basic Safety	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(5-4) Replace HMA with PCCP at I/S	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	
Structures																			
(5-5) Bridge Replacement	H	H	H	H	H	H	H	H	M	H	H	L	L	M	M	M	M	M	M
(5-6) Bridge Repl. (Multilane)	H	H	H	H	H	H	H	H	M	H	H	L	L	M	M	M	M	M	M
(5-7) Bridge Deck Rehab	M	L	L	H	M	M	H	L	L	H	L	L	L	M	L	M	L	L	M
(5-7a) Bridge Scour Countermeasures	M	H	H	H	H	H	H	L	M	L	L	L	L	M	M	M	L	H	L
(5-7b) Steel Bridge Painting	L	L	H	H	M	H	L	L	L	L	L	H	L	M	L	L	L	L	L
(5-7c) Bridge Seismic Retrofit	L	M	M	M	M	H	L	L	L	L	L	L	L	M	L	L	L	L	L
(5-7d) Special Bridge Repair	L	M	M	M	M	M	L	L	L	L	L	L	L	M	L	L	L	L	M
Improvements																			
(5-8) Non-Interstate Freeway	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M	M**
(5-9) Urban	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M	M**
(5-10) Rural	M	H	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-11) HOV	M	M	M	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	M
(5-12) Bike/Ped. Connectivity	M	M	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
Safety																			
(5-13) Non-Interstate Freeway	L	L	L	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-14) Intersection	L	L	L	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(5-15) Corridor	L	L	L	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-16) Median Barrier	L	M	M	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(5-17) Guardrail Upgrades	L	M	M	L	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
(5-18) Bridge Rail Upgrades	L	L	L	M	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
(5-19) Risk: Roadside	L	H	H	L	L	L	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-20) Risk: Sight Distance	L	L	L	L	L	L	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-21) Risk: Roadway Width	L	H	H	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-22) Risk: Realignment	M	H	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
Economic Development																			
(5-23) Freight and Goods (Frost Free)	M	H	H	M	M	M	M	M	L	H	H	L	L	L	L	M	M	M	M
(5-24) Rest Areas (New)	M	H	H	M	M	M	M	L	L	H	H	L	M	L	L	H	H	H	L
(5-25) Bridge Restrictions	M	H	H	H	M	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(5-26) Bike Routes (Shldrs)	L	M	M	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L

Project Environmental Matrix 5
Non-NHS Routes (Main Line)
Figure 240-6

NOTES

For Figures 240-2 through 240-6.

For main line projects on the Interstate, National Highway System main line (except Interstate), or non-National Highway System, all bridgework is assumed to be over water. For interchange projects on the Interstate and non-Interstate, all bridgework is assumed to be over roads. (See Chapter 325.)

NEPA/SEPA Endnotes

(*) Programmatic permits may apply

(**) Night work may require variance

(***) NEPA/SEPA compliance is required on all projects. The level of documentation will correspond to the complexity of the project and the potential environmental impacts anticipated. (See region or HQ environmental staff.)

Section 404 IP Endnotes

L= Low probability assumes the work is covered by an NWP.

M= Medium probability assumes the potential for impacts beyond the thresholds for an NWP.

H= High probability assumes a likelihood for impacts beyond the thresholds for an NWP.

Section 404 NWP Endnotes

L= Low probability assumes no work and/or fill below the OHWM or wetlands in waters of the US.

M= Medium probability assumes potential for work and/or fill below the OHWM in waters of the US and/or minimal wetland fill.

H= High probability assumes likelihood for work and/or fill in waters of the U.S. below the OHWM or wetland fills below 1/3 acre (tidal) or 1/2 acre (non-tidal).

Section 401 Endnotes

(1) Parallels probability of Section 404 IP/NWP. Includes reference to Corps/Ecology/Tribes Regional General Conditions.

CZM Endnotes

(2) Parallels probability of Section 401 within 15 coastal counties only and involving waters of the state subject to Shoreline Management Act.

ESA Endnotes

L= Low probability assumes either applicable programmatic BA or individual BA and No Effect Determination.

M= Medium probability assumes either applicable programmatic or individual BA and Not Likely to Adversely Effect Determination.

H= High probability assumes either applicable programmatic or individual BA and adverse effect determination (Biological Opinion).

HPA Endnotes

L= Low probability assumes no work within or over waters of the state subject to HPA.

M= Medium probability assumes potential for limited work within or over waters of the state.

H= High probability assumes likelihood for work within or over waters of the state.

Shoreline Endnotes

L= Low probability assumes no work within shorelines of the state.

M= Medium probability assumes potential for work within shorelines of the state.

H= High probability assumes likelihood for work within shorelines of the state.

Endnotes for Project Environmental Matrices

Figure 240-7a

Floodplain Endnotes

L= Low probability assumes no fill in the 100-year floodplain.

M= Medium probability assumes potential for fill in the 100-year floodplain.

H= High probability assumes likelihood for fill in the 100-year floodplain.

Aquatic Resource Use Authorization Endnotes (DNR)

L= Low probability assumes no new structures or use of aquatic lands. ("Use" is subject to interpretation by DNR.)

M= Medium probability assumes potential for new structures or use of aquatic lands.

H= High probability assumes likelihood for new structures or use of aquatic lands. May need to define USE and include Easement over Navigable Water.

Section 402 NPDES Municipal Stormwater General Permit Endnotes

(3) Applies to construction, operation, and maintenance activities in four watersheds - Island/ Snohomish, Cedar/Green, South Puget Sound, and Columbia Gorge.

L= Low probability assumes project exempt from NPDES Municipal Stormwater Permit.

H= High probability assumes project subject to NPDES Municipal Stormwater Permit.

Section 402 NPDES Stormwater Construction General Permit Endnotes

L= Low probability assumes ground disturbance of less that one acre.

M= Medium probability assumes ground disturbance of one acre or more.

H= High probability assumes likelihood of ground disturbance of one acre or more.

Section 402 NPDES Industrial Discharge General Permit Endnotes

L= Low probability assumes no bridge or ferry terminal washing over waters of the state.

M= Medium probability assumes potential for bridge or ferry terminal washing over waters of the state.

H= High probability assumes likelihood for bridge or ferry terminal washing over waters of the state.

State Waste Discharge Permit Endnotes

(4) Applies to discharges of commercial or industrial wastewater into waters of the state - does not cover stormwater discharges under NPDES program.

L= Low probability assumes SWD permit does not apply.

M= Medium probability assumes potential for SWD permit.

Section 9 Bridge Permit Endnotes

(5) Applies to work on bridges across navigable waters of the U.S.

L= Low probability assumes no bridgework.

M= Medium probability assumes potential for work on a bridge across navigable water.

H= High probability assumes likelihood for work on a bridge across navigable water.

Section 10 Permit Endnotes

(6) Applies to obstruction, alteration, or improvement of navigable waters of the U.S.

L= Low probability assumes no obstructions, alterations, or improvements to navigable waters.

M= Medium probability assumes potential for obstructions, alterations, or improvements to navigable waters.

H= High probability assumes likelihood for obstructions, alterations, or improvements to navigable waters.

Endnotes for Project Environmental Matrices

Figure 240-7b

Section 106 Endnotes

L= Low probability assumes no federal nexus and/or activities exempted per the statewide Programmatic Agreement on Section 106 signed by FHWA, WSDOT, OAHP and ACHP.

M= Medium probability assumes a federal nexus; therefore, Section 106 federal regulations apply.

H= High probability assumes a federal nexus and/or the likelihood for discovery of historic or culturally significant artifacts. See 36 CFR part 800, *Environmental Procedures Manual*, (Current DOT Policy and the Section 106 Programmatic Agreement).

Section 4(f)/6(f) Endnotes

L= Low probability assumes no use of or acquisition of new right-of-way.

M= Medium probability assumes potential use of or acquiring of new right of way.

H= High probability assumes likelihood for use of or acquiring of new right of way.
Review Triggers: http://www.wsdot.wa.gov/environment/compliance/Section4f_guidance.htm

Critical/Sensitive Areas Endnotes

(7) The mechanism for critical/sensitive areas review varies by jurisdiction.

L= Low probability assumes no work inside or outside of right of way in critical/sensitive areas.

M= Medium probability assumes potential for work inside or outside of right of way in critical/sensitive areas.

H= High probability assumes likelihood for work inside or outside of right of way in critical/sensitive areas.

Noise Variance Endnotes

L= Low probability assumes no night work.

M= Medium probability assumes potential for night work.

H= High probability assumes likelihood for night work.

Endnotes for Project Environmental Matrices

Figure 240-7c

240.04 Design Process and Permit Interaction

Environmental permits require information prepared during the design phase to demonstrate compliance with environmental rules, regulations, and policies. To avoid delays in project delivery, it is necessary for the designer to understand and anticipate this exchange of information. The timing of this exchange often affects design schedules, while the permit requirements can affect the design itself. In complex cases, the negotiations over permit conditions can result in iterative designs as issues are raised and resolved.

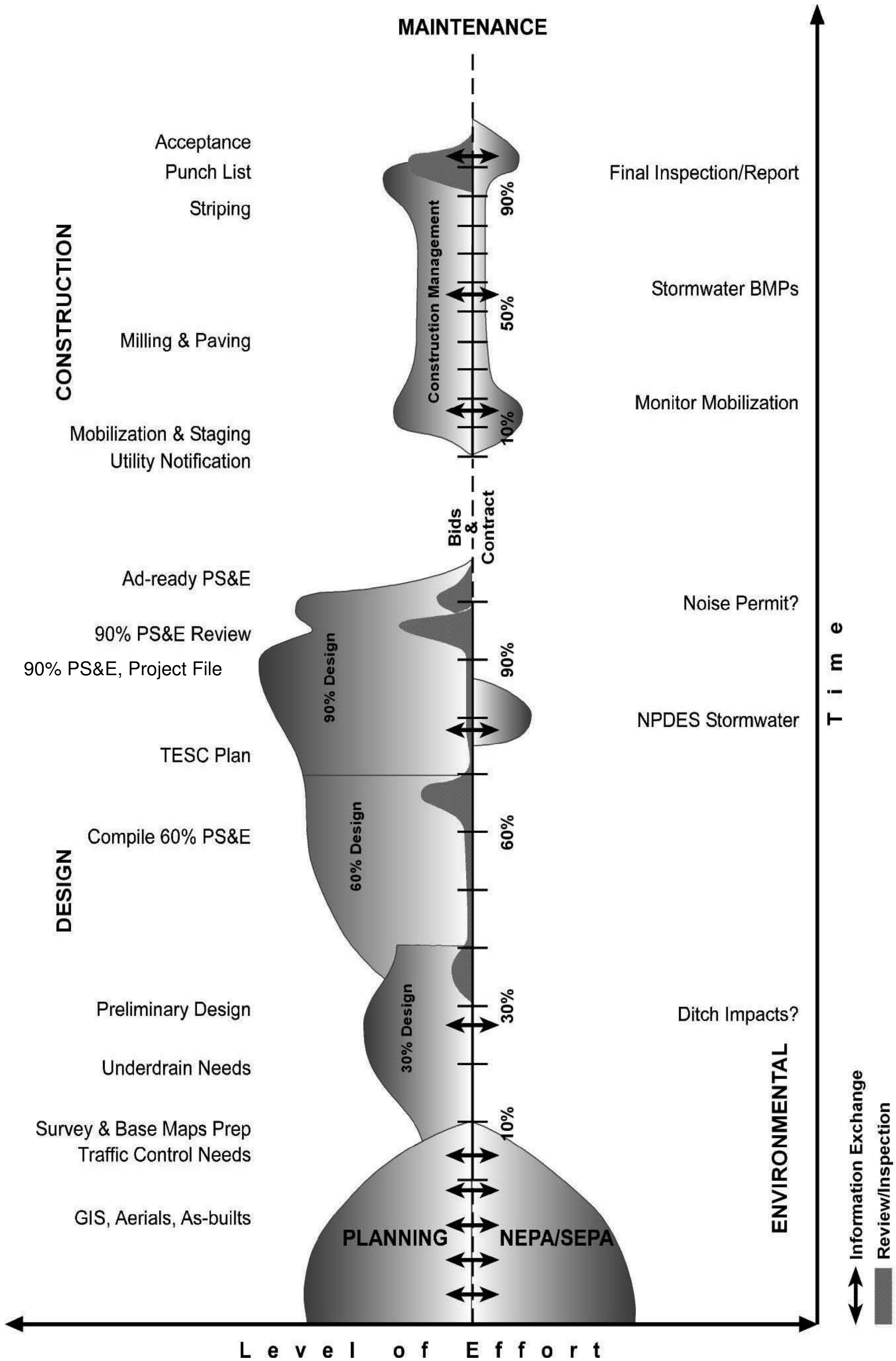
The permit process begins well in advance of the actual permit application. For some permits, WSDOT has already negotiated permit conditions through the use of programmatic and general permits. These permits typically apply to repetitive, relatively simple projects and the permit conditions apply regardless of the actual facts of the project type. For complex projects, the negotiations with permit agencies often begin during the environmental documentation phase for compliance with NEPA and SEPA. The mitigation measures developed for the NEPA/SEPA documents are captured as permit conditions on the subsequent permits.

For many other project types, the permit process begins during the design phase. This section illustrates the interaction between design and permitting for two relatively uncomplicated projects. Figures 240-8 and 240-9 illustrate project timelines for two project types and the interaction of typical permits for those project types. The project types are an overlay project and a channelization project. The figures illustrate the level of effort over time for both design components and environmental permits.

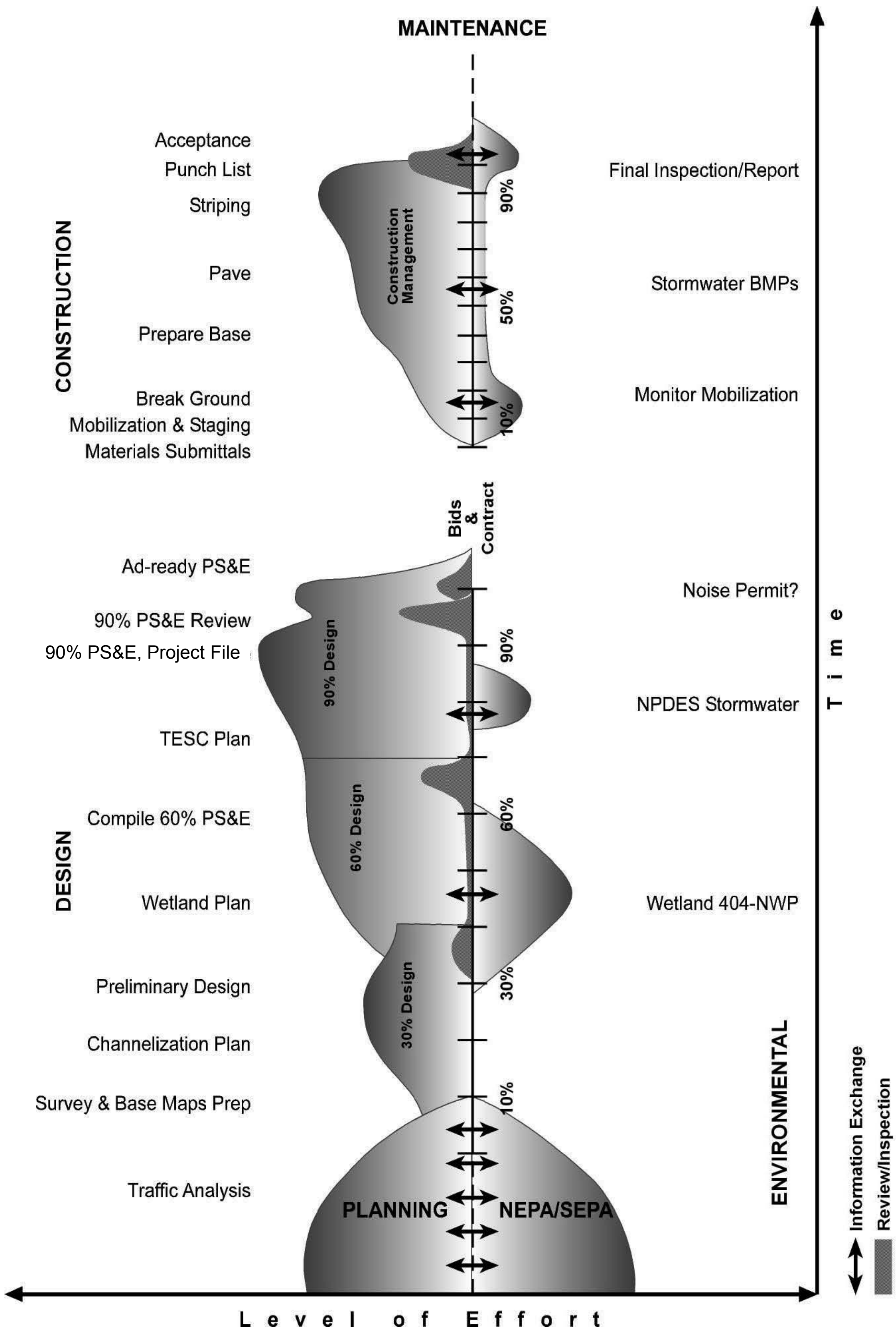
The overlay project assumes that only an NPDES Municipal Stormwater General Permit is required. Compliance with this permit is through application of WSDOT's *Highway Runoff Manual,* M 31-16 and the implementation of WSDOT's 1997 *Stormwater Management Plan*. The possibility for a noise variance exists because of the potential for night work.

The channelization project assumes minor amounts of new right of way are required. Because roadside ditches are often at the edge of the right of way, it was assumed that the potential for impacting wetlands exists. Usually the amount of fill is minor and the project may qualify for a Corps of Engineers Section 404 Nationwide Permit. A wetland mitigation plan is required to meet permit requirements, and the plan's elements have the potential to affect design, including stormwater facilities.

The interaction of design and permitting increases in complexity as the project type becomes more complex. More detailed analysis of environmental permits and their requirements is available in the *Environmental Procedures Manual* and through consultation with region and HQ environmental staff.



Environmental Interrelationship: HMA/PCCP/BST Main Line Overlay
Figure 240-8



Environmental Interrelationship: Safety Corridor Channelization Main Line
Figure 240-9

315.01 General

Value Engineering is a systematic process designed to focus on the major issues of a complex project or process. It uses a multidisciplined team to develop recommendations for the important decisions that must be made. The primary objective of a Value Engineering study is *Value Improvement*.

For projects, the value improvements might be improvements in scope definition, functional design, constructibility, coordination (both internal and external), or the schedule for project development. Other possible value improvements are reduced environmental impact, reduced public (traffic) inconvenience, or reduced project cost. The Value Engineering process incorporates, to the extent possible, the values of the design engineer, construction engineer, maintenance engineer, contractor, state and federal approval agencies, local agencies, other stakeholders, and the public. Important design decisions are formulated from the recommendations of the Value Engineering team.

315.02 References

CFR 23 Part 627 Value Engineering

Value Engineering for Highways, Study Workbook, U. S. Department of Transportation, FHWA

Introduction To Value Engineering Principles and Practices, Transportation Partnership in Engineering Education Development (TRANSPEED), University of Washington.

315.03 Definitions

Value Engineering (VE) A systematic application of recognized techniques by a multidisiplined team to identify the function of a product or service, establish a worth for that function, generate alternatives through the use of creative thinking, and provide the needed functions to accomplish the original purpose; thus assuring the lowest life cycle cost without sacrificing safety, necessary quality, or environmental attributes. Value Engineering is sometimes referred to as Value Analysis (VA) or Value Management (VM).

Project The portion of a transportation facility that WSDOT proposes to construct, reconstruct, or improve as described in the *State Highway System Plan* or applicable environmental documents. A project may consist of several contracts or phases over several years that are studied together as one *project*.

315.04 Procedure

The VE process uses the Eight-Phase Job Plan in Figure 315-1. Only the phases 1 and 7 are discussed in this chapter. A detailed discussion of phases 2 through 6 is in the VE training manual entitled *Introduction To Value Engineering Principles and Practices*.

(1) Selection Phase

(a) Project Selection

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

A VE study is required for any federally funded NHS project with an estimated cost of $25 million or more (CFR 23 Part 627). Other types of projects that usually provide the highest potential for value improvement have a preliminary estimate exceeding $2 million and include one or more of the following:

- Projects with alternative solutions that vary the scope and cost
- New alignment or bypass sections
- Capacity improvements that widen an existing highway
- Major structures
- Interchanges on multilane facilities
- Projects with extensive or expensive environmental or geotechnical requirements
- Materials that are difficult to acquire or require special efforts
- Inferior materials sources
- Major reconstruction
- Projects requiring major traffic control
- Projects with multiple stages

(b) Statewide VE Study Plan

On a biennial basis, the state VE manager coordinates with the region VE coordinators to prepare the two-Year VE Study Plan with specific projects scheduled by quarter. The VE Study Plan is the basis for determining the projected VE program needs including team members, team leaders, and training. The Statewide VE Study Plan is a working document and close coordination is necessary between the Olympia Service Center (OSC) and the regions to keep it current.

The regional VE coordinator:

- Identifies potential projects for VE studies from the Project Summaries and the available planning documents for future work.
- Makes recommendations for the VE study timing
- Presents a list of the identified projects to regional management to prioritize into a regional Two-Year VE Study Plan. (VE studies other than projects are also included in the plan.)

The State Design Engineer:

- Reviews the regional Two-Year VE Study Plan regarding the content and schedule of the plan.

The state VE Manager:

- Incorporates the regional Two-Year VE Study Plans and the OSC Study Plans to create the Statewide VE Study Plan.

(c) VE Study Timing

Selecting the project at the appropriate stage of development (the timing of the study) is very important to the success of the VE program. Value can be added by performing a VE study any time during project development; however, the WSDOT VE program identifies three windows of opportunity for performing a VE study.

1. **Problem Definition Stage**

   As soon as preliminary engineering information is available and the specific deficiencies or “drivers” are identified, the project scope and preliminary cost are under consideration. This is the best time to consider the various alternatives or design solutions and there is the highest potential that the related recommendations of the VE team can be implemented. At the conclusion of the VE study, the project scope, preliminary cost, and major design decisions can be based on the recommendations.

   When conducting a study in the problem definition stage, the VE study focuses on issues affecting project “drivers.” This stage often provides an opportunity for building consensus with stakeholders.

2. **Conceptual Design Stage**

   At the conceptual design stage, the project scope and preliminary cost have already been established and the major design decisions have been made. Some PS&E activities might have begun and coordination has been initiated with the various service units that will be involved with the design. At this stage, the established project scope, preliminary cost, and schedule will define the limits of the VE study. There is still opportunity for a VE study to focus on the technical issues for each of the specific design elements.

3. 30 % Development Stage

At the 30% stage, most of the important project decisions have been made and the opportunity to affect the project design is limited. The VE study focuses on constructibility, construction sequencing, staging, traffic control elements, and any significant design issues that have been identified during design development.

(d) Study Preparation

To initiate a VE study, the project manager submits a Request for Value Engineering Study form (shown in Figure 315-2) to the regional VE coordinator at leastone month before the proposed study date.

The regional VE coordinator then works with the state VE Manager to determine the team leader and team members.

The design team prepares a study package that includes project information for each of the team members. A list of potential items is shown in Figure 315-3.

The region provides a facility and the equipment for the study (Figure 315-3).

(e) Team Leader

The quality of the VE study is dependent on the skills of the VE team leader. This individual guides the team efforts and is responsible for its actions during the study. The best VE team leader is knowledgeable and proficient in transportation design and construction and in the VE study process for transportation projects.

For best results, the team leader should be certified by the Society of American Value (SAVE) as a Certified Value Specialist (CVS) or as a Value Methodology Practitioner (VMP).

Team leadership can be supplied from within the region or from other regions, OSC, consultants, or other qualified leaders outside the department. The state VE Manager coordinates with the regional VE coordinator to select the team leader. A statewide pool of qualified team leaders is maintained by the state VE Manager.

(f) Team Members

The VE team is usually composed of five to eight persons with diverse backgrounds that are relevant to the specific study. The team members may be selected from the regions, OSC, other state and federal agencies, local agencies, and the private sector.

The team members are selected on the basis of the kinds of expertise needed to address the major functional areas and critical high-cost issues of the study. All team members must be committed to the time required for the study. For best results, the team members have had VE training before participating in a VE study.

(g) VE Study Requirements

The time required to conduct a VE study varies with the complexity and size of the project, but typically ranges from three to five days.

The VE study Final Report and Workbook include a narrative description of project input information, background and history, constraints and drivers, VE team focus areas, and a discussion of the team speculation, evaluation, and recommendations. All of the team's evaluation documentation (including sketches, calculations, analysis, and rationale for recommendations) is included in the Workbook as part of the Final Report. The number of copies of the Final Report and Workbook is specified by the project manager.

(2) Implementation Phase

The VE team's recommendations are included in the Final Report and Workbook. The project manager reviews and evaluates the recommendations and prepare a VE Decision Document. This document has a specific response for each of the VE team recommendations and a summary statement containing the managers' decisions and schedule for implementation regarding further project development.

The VE Decision Document also includes estimated costs or savings of the recommendations as well as the estimated cost to implement the recommendations. A copy of this document is sent to the state VE Manager so the results can be included in the annual VE report to FHWA.

The VE Decision Document is submitted to the State Design Engineer and a copy becomes a vital element in the design file for the project. Project development then continues based on the decisions developed from the preliminary engineering and the VE study recommendations (barring participation agreements funded by other agencies, utilities, developers, and so forth).

315.05 Documentation

The following documents are to be preserved in the project file.

- ❏ Value Engineering Study Final Report and Workbook
- ❏ VE Decision Document

P:DM3

1. Selection Phase 315.04(1)	Select the right projects, timing, team, and project processes and elements.
2. Investigation Phase	Investigate the background information, technical input reports, field data, function analysis, and team focus and objectives.
3. Speculation Phase	Be creative and brainstorm alternative proposals and solutions.
4. Evaluation Phase	Analyze design alternatives, technical processes, life cycle costs, documentation of logic, and rationale.
5. Development Phase	Develop technical and economic supporting data to prove the feasibility of the desirable concepts. Develop team recommendations. Recommend long term as well as interim solutions.
6. Presentation Phase	Present the recommendations of the VE team in an oral presentation, and in a written report and workbook
7. Implementation Phase 315.04(2)	Evaluate the recommendations. Prepare an implementation plan (VE Decision Document) including the response of the managers and a schedule for accomplishing the decisions based on the recommendations.
8. Audit Phase	Maintain a records system to track the results and accomplishments of the VE program on a statewide basis. Compile appropriate statistical analyses as requested.

Steps 2-6 are performed during the study, see *Introduction To Value Engineering Principles and Practices* for procedure's during these steps.

Eight-Phase Job Plan for VE Studies
Figure 315-1

Project Title:				
SR No.	MP to MP		Length	Subprogram
PIN		WIN		
Assigned Project Engineer				
Proposed Advertising Date				
Estimated Right of Way Costs		Estimated Construction Costs		
Design Speed		Projected ADT		
Route Conditions/Geometry: Adjacent Segments Overall Route				
Major Project Elements				
Environmental Issues				
Construction Issues				
Suggested Value Team Composition:				
	Architecture	Hydraulics		
	Bridge	Landscape Architecture		
	Construction	Maintenance		
	Design	Planning/Programming		
	Environmental	Traffic		
	Other ______________	Real Estate Services		
Region Contact Person		Date’s requested for VE study		

Request for Value Engineering Study
Figure 315-2

Project Related Input* (Study Package)	**Study Related Facilities and Equipment**
Design File	Room w/ large table
Quantities	Phone
Estimates	Photo/Video log access/SRView
R/W Plans	Van for Field Trip **
Soils Reports	Easel(s)
Plan Sheets	Large Tablet Paper (2x2 squares)
Environmental Documents	Colored Marking Pens
X-sections and Profiles	Masking and Clear Adhesive Tape
Land Use Maps	Workbook(s)
Contour Maps	Polaroid Camera
Quadrant Maps	*Design Manual*
Accident Data	“Green Book”
Traffic Data	Standard Plans
Up to Date Large Scale Aerial Photographs	Standard Specifications
Vicinity Map	M.P. Log
Hydraulics Report	Bridge List
Aerial Photos	WSDOT Phone Book
Existing As-Built Plans	Scales and Straight Edge
	Red Book - Field Tables
	Unit Bid Prices
	Calculators
	Scissors

* Not all information listed may be available to the team depending on the stage of the project.
** If field trip is not possible, provide video of project.

VE Study Team Tools
Figure 315-3

325.01 General

This *Design Manual* provides guidance for three levels of design for highway projects: the basic, modified, and full design levels. The design matrices in this chapter are used to identify the design level(s) for a project and the associated processes for allowing design variances. The matrices address the majority of preservation and improvement projects and focus on those design elements that are of greatest concern in project development.

The design matrices are five tables that are identified by route type. Two of the matrices apply to Interstate highways. The other three matrices apply to non-Interstate highways and address preservation and improvement projects.

A design matrix is used to determine the design level for the Design Elements of a project. Apply the appropriate design levels and document the design decisions as required by this chapter and Chapter 330.

325.02 Selecting a Design Matrix

Selection of a design matrix is based on highway system (Interstate, NHS excluding Interstate, and non-NHS) and location (main line, interchange). (See Figure 325-1.)

Highway System	Location	
	Main Line	Interchange Area
Interstate	Matrix 1	Matrix 2
NHS(1)	Matrix 3	Matrix 4
Non-NHS	Matrix 5	Matrix 4

(1) Except Interstate.

Design Matrix Selection Guide
Figure 325-1

The **Interstate System** (Matrices 1 and 2) is a network of routes selected by the state and the FHWA under terms of the federal aid acts. These routes are principal arterials that are the most important to the economic welfare and defense of the United States. They connect, as directly as practicable:

- Principal metropolitan areas and cities.
- Industrial centers.
- International border crossings.

The Interstate System also includes important routes into, through, and around urban areas, serves the national defense, and, where possible, connects with routes of continental importance. It serves international and interstate travel and military movements.

The Interstate System is represented on the list of NHS highways, Figures 325-2a and 2b, with the letter "I" before the route number.

The **National Highway System (NHS)** (Matrices 3 and 4) is an interconnected system of principal arterial routes and highways (including toll facilities) that serve:

- Major population centers.
- International border crossings.
- Industrial centers.
- Ports.
- Airports.
- Public transportation facilities.
- Other intermodal transportation facilities.
- Other major travel destinations.

The NHS includes the Interstate System and the Strategic Highway Corridor Network (STRAHNET) and its highway connectors to major military installations (Interstate and non-Interstate).

The NHS meets national defense requirements and serves international, interstate, and interregional travel.

See Figures 325-2a and 2b.

The **Non-NHS** highways (Matrices 4 and 5) are state routes that form a network of highways that supplement the NHS system by providing for freight mobility and, mainly, regional and interregional travel. Non-NHS highways are not shown on Figures 325-2a and 2b. They are shown on WSDOT's (free) Official State Highway Map of Washington.

325.03 Using a Design Matrix

The design matrices are shown in Figures 325-3 through 325-7. Follow *Design Manual* guidance for all projects except as noted in the design matrices and elsewhere as applicable. The definitions presented in this chapter are meant to provide clarification for terminology used in the *Design Manual*. There is no assurance that these terms are used consistently in references outside of the *Design Manual*.

(1) Project Type

For project types not listed in the design matrices (such as unstable slopes), consult the Headquarters Design Office for guidance.

In the design matrices, row selection is based on Project Type. The Project Summary defines and describes the project. (Project Summary is discussed in Chapter 330.) For NHS and non-NHS routes (Matrices 3, 4, and 5), the project's program/subprogram might be sufficient information for identifying Project Type. See the *Programming Manual* for details about funding programs and subprograms.

The various sources of funds for these subprograms carry eligibility requirements that the designers and Project Development must identify and monitor throughout project development — this is especially important to ensure accuracy when writing agreements and to avoid delaying advertisement for bids if the Project Type changes.

Some projects involve work from several subprograms. In such cases, identify the various limits of the project that apply to each subprogram. Where the project limits overlap, apply the higher design level to the overlapping portion.

Project Types (in alphabetical order) are:

At Grade projects are safety improvements on NHS highways (45 mph or greater) to build grade separation facilities that replace the existing intersections.

Bike Routes (Shldrs) are main line economic development improvements to provide a statewide network of rural bicycle touring routes with shoulders a minimum of four feet wide.

Bike/Ped. Connectivity projects are mobility improvements to provide bicycle/pedestrian connections, along or across state highways within urban growth areas, to complete local networks.

Bridge Deck Rehabilitation projects are structures preservation, which repair delaminated bridge decks and add protective overlays that will provide a sound, smooth surface; prevent further corrosion of the reinforcing steel; and preserve operational and structural integrity.

Bridge Rail Upgrades are safety improvements to update older bridge rails to improve strength and redirectional capabilities.

Bridge Repl. (Multilane) projects are non-NHS main line structures preservation that replace bridges on multilane highways to improve operational and structural capacity.

Bridge Replacement projects are NHS and two-lane non-NHS (main line and interchange) structures preservation that replace bridges to improve operational and structural capacity.

Bridge Restrictions projects are main line economic development improvements that remove vertical or load capacity restrictions to benefit the movement of commerce.

BST projects are non-NHS roadway preservation to do bituminous surface treatment (BST) work only, to protect the public investment.

BST Routes/Basic Safety projects are non-NHS roadway preservation to resurface highways at regular intervals and restore existing safety features to protect the public investment.

Corridor projects are main line improvements to reduce and prevent collisions (vehicular, nonmotorized, and pedestrian) within available resources.

Diamond Grinding is grinding a concrete pavement, using gang mounted diamond saw blades, to remove surface wear or joint faulting.

Dowel Bar Retrofit is reestablishing the load transfer efficiencies of the existing concrete joints and transverse cracks by cutting slots, placement of epoxy coated dowel bars, and placement of high-early strength, nonshrink concrete.

Four-Lane Trunk System projects are NHS economic development improvements to complete contiguous four-lane limited access facilities on a trunk system consisting of all Freight and Goods Transportation Routes (FGTS) with a classification of 10,000,000 tons/year.

Freight & Goods (Frost Free) projects are main line economic development improvements to reduce delay from weather related closures on high priority freight and goods highways.

Guardrail Upgrades are safety improvement projects limited to the specified roadside Design Elements. These projects focus on W beam with 12'-6" spacing and on guardrail systems with concrete posts. The length of need is examined and minor adjustments are made. Removal is an option if guardrail is no longer needed. For Interstate main line, address length of need as specified in Chapter 710. For non-interstate routes, additional length of more than 5% of the existing length is beyond the intent of this program. In these instances, consider funding in accordance with priority programming instructions, and if the length of need is not met, document to the Design Documentation Package (DDP), that the length of need is not addressed because it is beyond the intent of this program.

HMA/PCCP projects are non-NHS roadway preservation to resurface highways at regular intervals and restore existing safety features to protect the public investment.

HMA/PCCP/BST Overlays are NHS main line roadway preservation projects that resurface the existing surfaces at regular intervals to protect the public investment.

HMA/PCCP/BST Overlays Ramps are NHS and non-NHS ramp roadway preservation projects that resurface the existing surfaces at regular intervals and restore existing safety features to protect the public investment.

HMA Structural Overlays is a hot mix asphalt overlay that is placed to increase the load carrying ability of the pavement structure. Structural overlay thickness is greater than 0.15 ft.

HOV Bypass projects are NHS and non-NHS ramp mobility improvements to improve mobility within congested highway corridors by providing HOV bypass lanes on freeway ramps. Congested highway corridors have high congestion index values as described in the *Highway System Plan* (footnote in text for Improvement/Mobility).

HOV projects are main line mobility improvements completing the freeway Core HOV lane system in the Puget Sound region, and providing level of service C on HOV lanes (including business access transit lanes), within congested highway corridors.

Intersection projects are safety improvements to reduce and prevent collisions, to increase the safety of highways, and to improve pedestrian safety within available resources.

Median Barrier projects are limited safety improvement projects – mainly new median barrier with a focus on cable barrier to reduce median crossover accidents.

Milling with HMA Inlays is removal of a specified thickness of the existing HMA pavement, typically from the traveled lanes, and then overlaying with HMA at the same specified thickness.

New/Reconstruction includes the following types of work:

- Capacity changes: add a through lane, convert a general purpose (GP) lane to a special purpose lane (such as an HOV lane), or convert a high occupancy vehicle (HOV) lane to GP.
- Other lane changes: add or eliminate a collector-distributor or auxiliary lane. (A rural truck climbing lane that, for its entire length, meets the warrants in Chapter 1010 is not considered new/reconstruction.)
- Pavement reconstruction: full depth PCCP or HMA replacement.
- New interchange.
- Changes in interchange type such as diamond to directional or adding a ramp.
- New or replacement bridge (on or over, main line or interchange ramp).

Non-Interstate Freeway (mobility) projects, on non-NHS and NHS interchanges and on NHS main line, are mobility improvements on multilane divided highways, with limited access control, within congested highway corridors.

Non-Interstate Freeway (roadway preservation) projects, on non-NHS and NHS interchanges and on NHS main line, are roadway preservation to overlay or inlay with HMA/PCCP/BST on multilane divided highways, with limited access control, to minimize long-term costs and restore existing safety features.

Non-Interstate Freeway (safety) are NHS and non-NHS (main line and interchanges) safety improvements on multilane divided highways, with limited access control, to increase the safety within available resources.

Nonstructural Overlay is an HMA pavement overlay that is placed to minimize the aging effects and minor surface irregularities of the existing HMA pavement structure. The existing HMA pavement structure is not showing extensive signs of fatigue (longitudinal or alligator cracking in the wheel paths). Nonstructural overlays are less than or equal to 0.15 ft thick, and frequently less than 0.12 ft thick.

PCCP Overlays are Portland cement concrete pavement overlay of an existing PCCP or HMA surface.

Preventive Maintenance includes roadway work such as pavement patching; restoration of drainage system; panel replacement; joint and shoulder repair; and bridge work such as crack sealing, joint repair, slope stabilization, seismic retrofit, scour countermeasures, and painting. Preventive maintenance projects must not degrade any existing safety or geometric aspects of the facility. Any elements that will be reconstructed as part of a preventative maintenance project are to be addressed in accordance with Full Design Level.

Replace HMA w/ PCCP at I/S (intersections) projects are NHS and non-NHS main line roadway preservation that restores existing safety features and replaces existing HMA intersection pavement that has reached the point of lowest lifecycle cost (11-15 years old) with PCCP that has about a 40 year life cycle.

Rest Areas (New) projects are NHS and non-NHS main line economic development and safety improvements to provide rest areas every 60 miles, and some RV dump stations.

Risk, Realignment projects are improvements intended to improve alignment at specific locations where the Risk program has identified a high probability of collisions/accidents.

Risk, Roadside projects are improvements intended to mitigate roadside conditions at specific locations where the Risk program has identified a high probability of vehicular encroachment.

Risk, Roadway Width projects are improvements intended to adjust the roadway width at specific locations where the Risk program has identified a high probability of a vehicle leaving its lane of travel.

Risk, Sight Distance projects are improvements intended to improve sight distance at specific locations where the Risk program has identified a high probability of collisions/accidents.

Rural projects are mobility improvements providing uncongested level of service on rural highways within congested highway corridors. (See HOV Bypass above for cross reference regarding “congested.”)

Urban (Multilane) projects are non-NHS mobility improvements within congested urban multilane highway corridors. (See HOV Bypass above for cross reference regarding “congested.”)

Urban projects are NHS and two-lane non-NHS (main line and interchange) mobility improvements within congested urban highway corridors. (See HOV Bypass above for cross reference regarding “congested.”)

(2) Design Elements

The column headings on a design matrix are **Design Elements.** Not all potential design elements have been included in the matrices.

The Design Elements that are included are based on the following thirteen FHWA controlling design criteria: design speed, lane width, shoulder width, bridge width, structural capacity, horizontal alignment, vertical alignment, grade, stopping sight distance, cross slope, superelevation, vertical clearance, and horizontal clearance. For the column headings, some of these controlling criteria have been combined (for example, design speed is part of horizontal and vertical alignment).

If using a design element that is not on the assigned matrix, use full design level as found elsewhere in this manual.

If using a design element that is not covered in this manual, use an approved manual or guidance on the subject and document the decision and the basis for the decision.

The following elements are shown on the design matrices. If the full design level applies, see the chapters listed below. If basic design level applies, see Chapter 410. If the modified design level applies, see Chapter 430.

Horizontal Alignment is the horizontal attributes of the roadway including horizontal curvature, superelevation, and stopping sight distance; all based on design speed. (See Chapter 620 for horizontal alignment, Chapter 642 for superelevation, Chapter 650 for stopping sight distance, and Chapters 440 or 940 for design speed.)

Vertical Alignment is the vertical attributes of the roadway including vertical curvature, profile grades, and stopping sight distance; all based on design speed. (See Chapter 630 for vertical alignment, Chapters 430, 440, 630, and 940 for grades, Chapters 430 and 650 for stopping sight distance, and Chapter 430, 440, or 940 for design speed.)

Lane Width is defined in Chapter 440. (See also Chapters 430, 640, 641, and 940.)

Shoulder Width is defined in Chapter 440. (See also Chapters 430, 640, and 940.) Also see Chapter 710 for shy distance requirements when barrier is present.

Lane Transitions (pavement transitions) are the rate and length of transition of changes in width of lanes. (See Chapter 620.)

On/Off Connection is the widened portion of pavement at the end of a ramp connecting to a main lane of a freeway. (See Chapter 940.)

Median Width is the distance between inside edge lines. (See Chapters 440 and 640.)

Cross Slope, Lane is the rate of elevation change across a lane. This element includes the algebraic difference in cross slope between adjacent lanes. (See Chapter 430 and Traveled Way Cross Slope in 640.)

Cross Slope, Shoulder is the rate of elevation change across a shoulder. (See Chapters 430 and 640.)

Fill/Ditch Slope is the downward slope from edge of shoulder to bottom of ditch or catch. (See Chapters 430 and 640.)

Access is the means of entering or leaving a public road, street, or highway with respect to abutting private property or another public road, street, or highway. (See Chapter 1420.)

Clear Zone is the total roadside border area, starting at the edge of the traveled way, available for use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a nonrecoverable slope, and/or a clear run-out area. (The median is part of a clear zone.) (See Chapter 700.)

Signing, Delineation, Illumination are signs, guide posts, pavement markings, and lighting. (See Chapter 820 for signing and 1120 for bridge signs, Chapter 830 for delineation, and Chapter 840 for illumination.)

Vertical Clearance - see Chapter 1120.

Basic Safety is the list of safety items in Chapter 410.

Bicycle and Pedestrian See Chapter 1020, Bicycle Facilities, and Chapter 1025, Pedestrian Design Considerations, for definitions.

Bridges: Lane Width is the width of a lane on a structure. (See Chapters 430, 440, 640, 641, 940, and 1120.)

Bridges: Shoulder Width is the distance between the edge of traveled way and the face of curb or barrier, whichever is less. (See Chapters 430, 440, 640, 940, and 1120.) Also see Chapter 710 for shy distance requirements.

Bridges/Roadway: Vertical Clearance is the minimum height between the roadway, including shoulder, and an overhead obstruction. (See Chapter 1120.)

Bridges: Structural Capacity is the load bearing ability of a structure. (See Chapter 1120.)

Intersections/Ramp Terminals: Turn Radii See Chapter 910 for definition.

Intersections/Ramp Terminals: Angle See Chapter 910 for definition.

Intersections/Ramp Terminals: Intersection Sight Distance See Chapters 910 and 940 for definitions.

Barriers: Terminals and Transition Sections — **Terminals** are crashworthy end treatments for longitudinal barriers that are designed to reduce the potential for spearing, vaulting, rolling, or excessive deceleration of impacting vehicles from either direction of travel. Impact attenuators are considered terminals. Beam guardrail terminals include anchorage. — **Transition Sections** are sections of barriers used to produce a gradual stiffening of a flexible or semirigid barrier as it connects to a more rigid barrier or fixed object. (See Chapters 700, 710, and 720.)

Barriers: Standard Run are guardrail and other barriers as found in the *Standard Plans for Road Bridge and Municipal Construction* excluding terminals, transitions, attenuators, and bridge rails. (See Chapter 710.)

Barriers: Bridge Rail is barrier on a bridge excluding transitions. (See Chapter 710.)

(3) Design Level

In the non-Interstate matrices, design levels are noted in the cells by B, M, F, and sometimes with a number corresponding to a footnote on the matrix. For Improvement type projects full design level applies to all design elements except as noted in the design matrices and in other chapters as applicable. In the Interstate matrices, only full design level applies.

The design levels of basic, modified, and full (B, M, and F) were used to develop the design matrices. Each design level is based on the investment intended for the highway system and Project Type. (For example, the investment is higher for an Interstate overlay than for an overlay on a non-NHS route.)

A **blank cell** on a design matrix row signifies that the Design Element will not be addressed because it is beyond the scope of the typical project. In rare instances, a Design Element with a blank cell may be included if that element is linked to the original need that generated the project and is identified in the Project Summary or a Project Control Form.

Basic design level (B) preserves pavement structures, extends pavement service life, and maintains safe operations of the highway. See Chapter 410 for design guidance.

Modified design level (M) preserves and improves existing roadway geometrics, safety, and operational elements. See Chapter 430 for design guidance. Use full design level for design elements or portions of design elements that are not covered in Chapter 430.

Full design level (F) improves roadway geometrics, safety, and operational elements. See Chapter 440 and other applicable *Design Manual* chapters for design guidance.

(4) Design Variances

Types of design variances are design exceptions (DE), evaluate upgrades (EU), and deviations. See Chapter 330 concerning the Design Variance Inventory System (DVIS).

A **design exception (DE)** in a matrix cell indicates that WSDOT has determined that the Design Element is usually outside the scope of the Project Type. Therefore, an existing condition that does not meet or exceed the design level specified in the matrix may remain in place unless a need has been identified in the *Highway System Plan* and prioritized in accordance with the programming process. See Chapter 330 regarding documentation.

An **evaluate upgrade (EU)** in a matrix cell indicates that WSDOT has determined that the Design Element is an item of work that is to be considered for inclusion in the project. For an existing element that does not meet or exceed the specified design level, an analysis is required to determine the impacts and cost effectiveness of including the element in the project. The EU analysis must support the decision regarding whether or not to upgrade that element. See Chapter 330 regarding documentation.

A **deviation** is required when an existing or proposed Design Element differs from the specified design level for the project and neither DE nor EU processing is indicated. See Chapter 330 regarding documentation.

DE or EU with /F or /M in a cell means that the Design Element is to be analyzed with respect to the specified design level. For instance, a DE/F is analyzed with respect to full design level and might be recorded as having an existing Design Element that does not meet or exceed current full design level. An EU/M is analyzed to decide whether or not to upgrade any existing Design Element that does not meet or exceed current modified design level.

(5) Terminology in Notes

F/M Full for freeways/Modified for nonfreeway uses the word **freeway** to mean a divided highway facility that has a minimum of two lanes in each direction, for the exclusive use of traffic, and with full control of access. For matrix cells with an F/M designation, analyze freeway routes at full design level and nonfreeway routes at modified design level.

The **HAL, HAC, and PAL** mentioned in note (1) on Design Matrices 3, 4, and 5 are high accident locations (HAL), high accident corridors (HAC), and pedestrian accident locations (PAL).

The **Access Control Tracking System** mentioned in note (3) on Design Matrices 3, 4, and 5 is a list that is available on the web at http://www.wsdot.wa.gov/eesc/design/access/ under the RELATED SITES heading. See Chapter 1420 for access control basics and 1430 and 1435 for limited and managed access, respectively.

The **corridor or project analysis** mentioned in notes (2) and (4) on Design Matrices 3, 4, and 5 is the justification needed to support a change in design level from the indicated design level. The first step is to check for recommendations for future improvements in an approved Route Development Plan. If none are available, an analysis can be based on route continuity and other existing features. See Chapter 330 regarding documentation.

Note **(21) Analyses required** appears only on Design Elements for Risk projects on Design Matrices 3, 4, and 5. These Design Elements are to be evaluated using benefit/cost (B/C) to compare and rank each occurrence of the Design Elements. The B/C evaluation supports engineering decisions regarding which proposed solutions are included in a Risk project.

Most components of a Risk project will have a B/C of 1.0 or greater. Proposed solutions with a B/C ratio less than 1.0 may be included in the project based on engineering judgment of their significant contribution to corridor continuity. Risk program size, purpose and need, or project prioritization may lead to instances where design elements with a ratio greater than 1.0 are excluded from a project. The analysis, design decisions and program funding decisions are to be documented in the Design Documentation Package. Decisions regarding which design elements to include in a project are authorized at the WSDOT region level.

State Route	NHS Route Description	Beginning SR MP	Begin ARM	Ending SR MP	End ARM
US 2	I-5 to Idaho State Line	0.00	0.00	334.51	326.64
US 2 Couplet	Everett Couplet	0.00	0.00	1.64	0.87
US 2 Couplet	Brown Street Couplet	287.45	0.00	288.08	0.63
US 2 Couplet	Division Street Couplet	289.19	0.00	290.72	1.53
SR 3	US 101 to SR 104	0.00	0.00	60.02	59.81
SR 4	US 101 to I-5	0.00	0.00	62.28	62.27
I-5	Oregon State Line to Canadian Border	0.00	0.00	276.56	276.62
SR 8	US 12 to US 101	0.00	0.00	20.67	20.67
SR 9	SR 546 to Canadian Border	93.61	93.52	98.17	98.08
SR 9 Spur	Sumas Spur	98.00	0.00	98.25	0.24
SR 11	I-5 to Alaskan Ferry Terminal	19.93	19.93	21.28	21.28
US 12	US 101 to Idaho State Line	0.00	0.00	434.19	430.76
US 12 Couplet	Aberdeen Couplet	0.33	0.00	0.68	0.35
SR 14	I-5 to US 97	0.00	0.00	101.02	100.93
SR 14 Spur	Maryhill Spur	100.66	0.00	101.05	0.39
SR 16	I-5 to SR 3	0.00	0.00	29.19	27.01
SR 16 Spur	SR 16 to SR 3	28.74	0.00	29.13	0.39
SR 17	US 395 to I-90	7.43	0.00	50.89	43.40
SR 18	So. Federal Way Park & Ride to I-5	2.20B	0.00	0.00	0.53
SR 18	I-5 to I-90	0.00	0.53	27.91	28.41
SR 20	US 101 to I-5	0.00	0.00	59.54	59.49
SR 20 Spur	SR 20 to San Juan Ferry	47.89	0.00	55.67	7.78
SR 22	US 97 to I-82	0.70	0.00	4.00	3.31
SR 26	I-90 to US 195	0.00	0.00	133.53	133.61
SR 26 Spur	SR 26 to US 195	133.44	0.00	133.51	0.07
SR 28	US 2 to SR 281	0.00B	0.00	29.77	33.91
I-82	I-90 to Oregon State Line	0.00	0.00	132.60	132.57
I-90	I-5 to Idaho State Line	1.94	0.00	299.82	297.52
I-90 Reverse Lane	Reversible lane	1.99	0.00	9.44	7.45
SR 96	McCollum Park and Ride to I-5	0.00	0.00	0.52	0.52
US 97	Oregon State Line to SR 22	0.00B	0.00	61.44	61.30
US 97	I-90 to Canadian Border	133.90	118.80	336.48	321.62
US 97 Couplet	Maryhill Couplet	2.59	0.00	2.68	0.09
US 97 Spur	US 97 to US 2 (Orondo)	213.36	0.00	213.62	0.26
US 97 Y	SR 970 to US 97				
SR 99	188th to SeaTac Airport	18.35	14.70	18.77	15.12
SR 99	SR 509 to SR 104	26.04	22.40	43.60	39.84
US 101	Oregon State Line to SR 401	0.00	0.00	0.46	0.46
US 101	SR 4 to I-5	28.89	28.89	367.41	365.78
US 101 Couplet	Aberdeen Couplet	87.49	0.00	91.66	4.17
US 101 Couplet	Port Angeles Couplet	249.65	0.00	251.32	1.67
SR 104	US 101 to I-5	0.20	0.00	29.67	29.14
SR 109	Pacific Beach Access	0.00	0.00	30.25	30.29
SR 125	Oregon State Line to US 12	0.00	0.00	6.09	6.08
SR 125 Spur	SR 125 to US 12	6.09	0.00	6.76	0.67
SR 127	US 12 to SR 26	0.03	0.00	27.05	27.05
SR 128	US 12 to Idaho State Line	0.00	0.00	2.30	2.30

NHS Highways in Washington
Figure 325-2a

State Route	NHS Route Description	Beginning SR MP	Begin ARM	Ending SR MP	End ARM
SR 166	Naval Fuel Depot	0.02	0.00	3.40	3.38
SR 167	I-5 to I-405	0.00	0.00	27.28	28.60
I-182	I-82 to US 395	0.00	0.00	15.19	15.19
US 195	Idaho State Line to I-90	0.00B	0.00	95.99	93.37
US 195 Spur	US 195 to Idaho State Line	0.06	0.00	0.60	0.54
I-205	Oregon State Line to I-5	26.59	0.00	37.16	10.57
SR 240	Hanford Access	30.63	28.86	34.87	33.10
SR 270	US 195 to Idaho	0.00	0.00	9.89	9.89
SR 270	Pullman Couplet	2.67	0.00	2.90	0.23
SR 270	US 195 Y Connection	0.00	0.00	0.38	0.38
SR 281	SR 28 to I-90	0.00	0.00	10.55	10.55
SR 281 Spur	SR 281 to I-90	2.65	0.00	4.34	1.69
SR 303	SR 3 to SR 304	0.00B	0.00	8.73	8.89
SR 304	SR 16 to Bremerton Ferry	0.00	0.00	3.51	3.24
SR 305	SR 3 to Winslow Ferry	0.02	0.00	13.52	13.50
SR 307	SR 305 to SR 104	0.00	0.00	5.25	5.25
SR 310	SR 3 to SR 304	0.00	0.00	1.84	1.84
US 395	Congressional High Priority Route	13.05	13.05	270.26	275.09
SR 401	US 101 to SR 4	0.00	0.00	12.13	12.13
I-405	I-5 to I-5	0.00	0.00	30.32	30.30
SR 432	SR 4 to I-5	0.00	0.00	10.33	10.32
SR 433	Oregon State Line to SR 432	0.00	0.00	0.94	0.94
SR 500	I-5 to SR 503	0.00	0.00	5.96	5.96
SR 501	I-5 to Port of Vancouver	0.00	0.00	3.83	3.42
SR 502	I-5 to SR 503	0.00B	0.00	7.56	7.58
SR 503	SR 500 to SR 502	0.00	0.00	8.09	8.09
SR 509	SR 99 to 12th Place S	24.35B	26.13	29.83	33.11
SR 509	Pacific Ave. to Marine View Drive	0.22	1.44	3.20	4.42
SR 512	I-5 to SR 167	0.00	0.00	12.06	12.06
SR 513	Sandpoint Naval Air Station	0.00	0.00	3.35	3.35
SR 516	I-5 to SR 167	2.03	2.02	4.72	4.99
SR 518	I-5 to SR 509	0.00	0.00	3.81	3.42
SR 519	I-5 to Seattle Ferry Terminal	0.00	0.00	1.14	1.14
SR 520	I-5 to SR 202	0.00	0.00	12.83	12.82
SR 522	I-5 to US 2	0.00	0.00	24.68	24.68
SR 524	Lynnwood Park and Ride to I-5	4.64	4.76	5.20	5.32
SR 524 Spur	Cedar Way Spur - Lynnwood Park and Ride to I-5	4.64	0.00	5.14	0.50
SR 525	I-5 to SR 20	0.00	0.00	30.49	30.72
SR 526	SR 525 to I-5	0.00	0.00	4.52	4.52
SR 529	Everett Homeport	0.00	0.00	2.20	2.20
SR 539	I-5 to Canadian Border	0.00	0.00	15.16	15.16
SR 543	I-5 to Canadian Border	0.00	0.00	1.09	1.09
SR 546	SR 539 to SR 9	0.00	0.00	8.02	8.02
I-705	I-5 to Schuster Parkway	0.00	0.00	1.50	1.50
SR 970	I-90 to US 97	0.00	0.00	10.31	10.31
SR 970 Y	Y connection to US 97	0.00	0.00	0.10	0.10

NHS Highways in Washington

Figure 325-2b

⇩ Project Type																Bridges			Barriers		
Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width (13)	On/Off Conn.	Median Width	Cross Slope Lane	Cross Slope Shldr	Fill/Ditch Slopes	Clear Zone	Sign. (10)	Delini. (9)	Illumin.	Vert. Clear. (11)	Bike & Ped.	Lane Width	Shldr Width	Structural Capacity	Term. & Trans. Section (12)	Std Run	Bridge Rail (14)(19)
(1-1) Preventive Maintenance																					
Pavement Restoration																					
(1-2) Diamond Grinding										EU	EU	F		DE					F	EU	F
(1-3) Milling with HMA Inlays									EU	F	EU	F		DE					F	EU	F
(1-4) Nonstructural Overlay				DE			EU	EU	EU	F	EU	F		EU					F	F	F
Pavement Rehab./Resurf.																					
(1-5) HMA Structural Overlays	EU	DE	F	F	F(17)	DE	F	EU	F	F	EU	F	F	F		F	DE		F	F	F
(1-6) PCCP Overlays	EU	DE	F	F	F(17)	DE	F	EU	F	F	EU	F	F	F		F	DE		F	F	F
(1-7) Dowel Bar Retrofit	EU	DE	F	F	F(17)	DE	DE		F	F	EU	F	F	DE			DE		F	F	F
Bridge Rehabilitation																					
(1-8) Bridge Deck Rehabilitation												F		F		F	DE	(11)	F(6)	F(22)	F
Safety																					
(1-9) Median Barrier				DE															F(20)	F(20)	
(1-10) Guardrail Upgrades				DE						F									F	F(23)	
(1-11) Bridge Rail Upgrades																			F	F(22)	F
Reconstruction (16)																					
(1-12) New/Reconstruction	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

☐ Not Applicable
F Full design level. See Chapter 440.
DE Design Exception to full design level.
EU Evaluate Upgrade to full design level.

(6) Applies only to bridge end terminals and transition sections.
(9) Continuous shoulder rumble strips required in rural areas. See Chapter 700.
(10) See Chapter 820.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(13) See Chapters 440 and 640.
(14) Includes crossroad bridge rail. See Chapter 710.
(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters and see 325.03(2).
(17) DE for existing acceleration/deceleration lanes when length meets posted freeway speed and no significant accidents. See Chapter 940.
(19) The funding sources for bridge rail are a function of the length of the bridge. Consult programming personnel.
(20) Applies to median elements only.
(22) Upgrade barrier, if necessary, within 200 ft of the end of the bridge.
(23) See description of Guardrail Upgrades Project Type, 325.03(1) regarding length of need.

Design Matrix 1
Interstate Routes (Main Line)
Figure 325-3

⇩ Project Type	Ramps and Collector Distributors																				Cross Road										
															Ramp Terminals			Barriers											Barriers		
Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	On/Off Conn.	Cross Slope Lane	Cross Slope Shldr	Fill/ Ditch Slopes	Limited Access	Clear Zone	Sign., Del., Illumin. (9)(10)	Vertical Clear. (11)	Bike & Ped.	Turn Radii	Angle	I/S Sight Dist.	Term. & Trans. Section (12)	Std Run	Bridge Rail (14)(19)	Lane Width	Shldr Width	Fill/ Ditch Slopes	Limited Access	Clear Zone	Sign., Del., Illumin. (10)	Vert. Clear. (11)	Ped. & Bike	Term. & Trans. Section (12)	Std Run	Bridge Rail (14)(19)
(2-1) Preventive Maintenance																															
Pavement Restoration																															
(2-2) Diamond Grinding											EU	F(15)						F	EU	F					EU	F(15)			F	EU	F
(2-3) Milling with HMA Inlays									EU		F	F(15)	F	M				F	F	F			EU		F	F(15)		M	F	F	F
(2-4) Nonstructural Overlay							EU	EU	EU		F	F(15)	F	M				F	F	F			EU		F	F(15)		M	F	F	F
Pavement Rehab./Resurf.																															
(2-5) HMA Structural Overlays	EU	DE	F	F	F	F(17)	F	EU	F	F	F	F(15)	F	M	F	F	F	F	F	F	DE	DE	DE	F	F	F(15)	F	M	F	F	F
(2-6) PCCP Overlays	EU	DE	F	F	F	F(17)	F	EU	F	F	F	F(15)	F	M	F	F	F	F	F	F	DE	DE	DE	F	F	F(15)	F	M	F	F	F
(2-7) Dowel Bar Retrofit	DE		DE	DE	F	F(17)	DE		F	F	F	F(15)	DE		F	F	F	F	F	F				F		F(15)			F	F	F
Bridge Rehabilitation																															
(2-8) Bridge Deck Rehabilitation													F	M				F(6)	F(22)	F							F	M	F(6)	F(22)	F
Safety																															
(2-9) Intersection			F	F	F				F	F	F	F		M	F	F	F	F	F	F			F	F	F	F	F	M	F	F	F
(2-10) Guardrail Upgrades				DE							F							F	F(23)										F	F(23)	
(2-11) Bridge Rail Upgrades																		F	F(22)	F									F	F(22)	F
Reconstruction (16)																															
(2-12) New/Reconstruction	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

☐ Not Applicable
F Full design level. See Chapter 440.
M Modified design level. See Chapter 430.
DE Design Exception to full design level.
EU Evaluate Upgrade to full design level.

(6) Applies only to bridge end terminals and transition sections.
(9) Continuous shoulder rumble strips required in rural areas. See Chapter 700.
(10) See Chapter 820.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(14) Includes crossroad bridge rail. See Chapter 710.
(15) EU for signing and illumination.

(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters and see 325.03(2).
(17) DE for existing acceleration/deceleration lanes when length meets posted freeway speed and no significant accidents. See Chapter 940.
(19) The funding sources for bridge rail are a function of the length of the bridge. Consult programming personnel.
(22) Upgrade barrier, if necessary, within 200 ft of the end of the bridge.
(23) See description of Guardrail Upgrades Project Type, 325.03(1) regarding length of need.

Design Matrix 2
Interstate Interchange Areas
Figure 325-4

⇩ Project Type																Bridges (11)				Intersections			Barriers		
Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	On/Off Conn.	Median Width	Cross Slope Lane	Cross Slope Shldr	Fill/ Ditch Slopes	Access (3)	Clear Zone (18)	Sign., Del., Illumin.	Basic Safety	Bike & Ped.	Lane Width	Shldr Width	Vertical Clear-ance	Structural Capacity	Turn Radii	Angle	I/S Sight Dist.	Term. & Trans. Section (12)	Std Run	Bridge Rail (14)(19)
Preservation																									
Roadway																									
(3-1) Non-Interstate Freeway	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F		B	B		DE/F	DE/F	F					F	B	F
(3-2) HMA/PCCP/BST Overlays	DE/M	DE/M	DE/M	DE/M	DE/F	DE/F	DE/M	DE/M	DE/M	DE/M			B	B	M	DE/M	DE/M	F				B	F	B	F
(3-3) Replace HMA w/ PCCP at I/S	DE/M	DE/M	EU/M	EU/M	DE/F		DE/M	EU/M	DE/M	DE/M			B	B	M	DE/M	DE/M	F				B	F	B	F
Structures																									
(3-4) Bridge Replacement	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)		F	F		F	F(2)	F(2)	F	F	F(2)	F(2)	F	F	F	F
(3-5) Bridge Deck Rehab.													B	B	M			F					F(6)	F(22)	F
Improvements (16)																									
Mobility																									
(3-6) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F	F	F	F	F
(3-7) Urban	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F (2)	F	F	F (2)	F (2)	F	F	F	F
(3-8) Rural	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F (2)	F	F	F (2)	F (2)	F	F	F	F
(3-9) HOV	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F (2)	F	F	F (2)	F (2)	F	F	F	F
(3-10) Bike/Ped. Connectivity	(5)	(5)	(5)	(5)	(5)			(5)	(5)	(5)	(5)	(5)	(5)		F	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)
Safety																									
(3-11) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F		F	F	F	F	F	F
(3-12) Intersection (1)			F(2)	F(2)	F					F (2)	F	F	F		M					F	F	F	F	F	F
(3-13) Corridor (1)(24)	M(4)	M(4)	M(4)	M(4)	F	F(17)	M(4)	M(4)	M(4)	M(4)	F	F	F		F	M(4)	M(4)	F		M(4)	M(4)	F	F	F	F
(3-14) Median Barrier				DE/F																			F(20)	F(20)	
(3-15) Guardrail Upgrades				DE/F																			F	F(23)	
(3-16) Bridge Rail Upgrades																							F	F(22)	F
(3-17) Risk: Roadside										F	EU/F	F	F										F	F	F
(3-18) Risk: Sight Distance	F/M(21)	F/M(21)	F/M(21)	F/M(21)						F/M(21)	F(21)	F(21)	F		F	F(21)	F(21)	F(21)		F/M(21)	F/M(21)	F(21)	F	F	F
(3-19) Risk: Roadway Width			F/M(21)	F/M(21)	F(21)	F(21)	F/M(21)	F/M(21)	F/M(21)	F/M(21)	F	F	F		F	F(21)	F(21)	F(21)		F/M(21)	F/M(21)	F(21)	F	F	F
(3-20) Risk: Realignment	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F		F(2)	F(2)	F(2)	F	F	F
Economic Development																									
(3-21) Freight & Goods (Frost Free)(8)	F(2)	F(2)	F(2)	F(2)	F	F (2)	F(2)	F(2)	F(2)	F(2)	EU/F	F	B		EU/F(26)	DE/F	DE/F	F	F	EU/F	EU/F	EU/F	F	F	F
(3-22) Four-Lane Trunk System	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F	F	F	F	F
(3-23) Rest Areas (New)	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F		F	F	F	F	F	F
(3-24) Bridge Restrictions	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)		F	F		EU/F(26)	F(2)	F(2)	F	F	F(2)	F(2)	F	F	F	F
(3-25) Bike Routes (Shldrs)			EU/M	(7)	EU/F				EU/M	EU/M			B	B	F	EU/M	EU/M	F				B	F	B	EU/F

☐ Not Applicable
F Full design level. See Chapter 440.
M Modified design level. See Chapter 430.
B Basic design level. See Chapter 410.
F/M Full for freeways/Modified for nonfreeway
DE Design Exception
EU Evaluate Upgrade

(1) Collision Reduction (HAL, HAC, PAL), or Collision Prevention (At-Grade Removal, Signalization & Channelization). Specific deficiencies that created the project must be upgraded to design level as stated in the matrix.
(2) Modified design level may apply based on a corridor or project analysis. See 325.03(5).
(3) If designated as L/A acquired in the Access Control Tracking System, limited access requirements apply. If not, managed access applies. See 325.03(5).
(4) Full design level may apply based on a corridor or project analysis. See 325.03(5).
(5) For bike/pedestrian design see Chapters 1020 and 1025.
(6) Applies only to bridge end terminals and transition sections.
(7) 4 ft minimum shoulders.
(8) If all weather structure can be achieved with spot digouts and overlay, modified design level applies to NHS highways and basic design level applies to non-NHS highways.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(14) Includes crossroad bridge rail. See Chapter 710.
(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters and see 325.03(2).
(17) DE for existing acceleration/deceleration lanes when length meets posted freeway speed and no significant accidents. See Chapter 940.
(18) On managed access highways within the limits of incorporated cities and towns, City and County Design Standards apply to areas outside the curb or outside the paved shoulder where no curb exists.
(19) The funding sources for bridge rail are a function of the length of the bridge. Consult programming personnel.
(20) Applies to median elements only.
(21) Analyses required. See 325.03(5) for details.
(22) Upgrade barrier, if necessary, within 200 ft of the end of the bridge.
(23) See description of Guardrail Upgrades Project Type, 325.03(1) regarding length of need.
(24) Apply Full design level to projects that realign or reconstruct significant portions of the alignment.
(26) Sidewalk ramps must be addressed for ADA compliance. See Chapter 1025.

Design Matrix 3
Main Line NHS Routes (Except Interstate)
Figure 325-5

⇩ Project Type	Ramps and Collector Distributors														Ramp Terminals			Barriers			Cross Road									Barriers		
Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	On/Off Conn.	Cross Slope Lane	Cross Slope Shldr	Fill/ Ditch Slopes	Access (3)	Clear Zone	Sign, Del., Illumin.	Basic Safety	Bike & Ped.	Turn Radii	Angle	I/S Sight Dist.	Term. & Trans. Section (12)	Std Run	Bridge Rail (14)(19)	Lane Width	Shldr Width	Fill/ Ditch Slopes	Access (3)	Clear Zone	Sign., Del., Illumin.	Basic Safety	Vert. Clear. (11)	Ped. & Bike	Term. & Trans. Section (12)	Std . Run	Bridge Rail (14)(19)
Preservation																																
Roadway																																
(4-1) Non-Interstate Freeway	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F		B	B	M	DE/F	DE/F	DE/F	F	B	F	DE/F	DE/F	DE/F			B	B	F	M	F	B	F
(4-2) HMA/PCCP/BST Overlays Ramps												B	B	M			B	F	B	F						B	B	F	M	F	B	F
Structures																																
(4-3) Bridge Replacement	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F	F	F	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F
(4-4) Bridge Deck Rehab.												B	B	M				F(6)	F(22)	F						B	B	F	M	F(6)	F(22)	F
Improvements (16)																																
Mobility																																
(4-5) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F
(4-6) Urban	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F	F	F	F	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F
(4-7) Rural	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F	F	F	F	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F
(4-8) HOV By Pass	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F	F	F	F	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F
(4-9) Bike/Ped. Connectivity	(5)	(5)	(5)	(5)	(5)		(5)	(5)	(5)	(5)	(5)	(5)		F	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)			(5)		(5)	F	(5)	(5)	(5)
Safety																																
(4-10) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F		M	F	F	F	F	F	F	F	F	F	F	F	F		F	M	F	F	F
(4-11) At Grade (1)(25)	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F	F	F	F	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F
(4-12) Intersection (1)			F(2)	F(2)	F				F(2)	F	F	F		M	F	F	F	F	F	F			F(2)	F	F	F		F	M	F	F	F
(4-13) Guardrail Upgrades				DE/F														F	F(23)											F	F(23)	
(4-14) Bridge Rail Upgrades																														F	F(22)	F
(4-15) Risk: Roadside									F	EU/F	F	F											F	EU/F	F	F				F	F	F
(4-16) Risk: Sight Distance	F/M(21)	F/M(21)	F/M(21)	F/M(21)					F/M(21)	F(21)	F(21)	F		F	F/M(21)	F/M(21)	F	F	F	F			F/M(21)	F(21)	F(21)			F(21)	F			
(4-17) Risk: Roadway Width			F/M(21)	F/M(21)	F	F(21)	F/M(21)	F/M(21)	F/M(21)	F	F	F		F	F/M(21)	F/M(21)	F	F	F	F	F/M(21)	F/M(21)	F/M(21)	F	F			F(21)	F	F	F	F
(4-18) Risk: Realignment	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F/M(21)	F/M(21)	F	F	F	F	F(2)	F(2)	F(2)	F	F			F(21)	F	F	F	F
Economic Development																																
(4-19) Four-Lane Trunk System	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F	F	F	F	F	F	F		F		F	F	F

☐ Not Applicable
F Full design level. See Chapter 440.
M Modified design level. See Chapter 430.
B Basic design level. See Chapter 410.
F/M Full for freeways/Modified for nonfreeway
DE Design Exception
EU Evaluate Upgrade

(1) Collision Reduction (HAL, HAC, PAL), or Collision Prevention (At-Grade Removal, Signalization & Channelization). Specific deficiencies that created the project must be upgraded to design level as stated in the matrix.
(2) Modified design level may apply based on a corridor or project analysis. See 325.03(5).
(3) If designated as L/A acquired in the Access Control Tracking System, limited access requirements apply. If not, managed access applies. See 325.03(5).
(4) Full design level may apply based on a corridor or project analysis. See 325.03(5).
(5) For bike/pedestrian design see Chapters 1020 and 1025.
(6) Applies only to bridge end terminals and transition sections.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(14) Includes crossroad bridge rail. See Chapter 710.
(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters and see 325.03(2).
(19) The funding sources for bridge rail are a function of the length of the bridge. Consult programming personnel.
(21) Analyses required. See 325.03(5) for details.
(22) Upgrade barrier, if necessary, within 200 ft of the end of the bridge.
(23) See description of Guardrail Upgrades Project Type, 325.03(1) regarding length of need.
(25) For main line, use the Project Type row for Safety, Non-Interstate Freeway on Matrix 3 for NHS and on Matrix 5 for non-NHS.

Design Matrix 4
Interchange Areas, NHS (Except Interstate) and Non-NHS
Figure 325-6

⇩ Project Type / Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	Median Width	Cross Slope Lane	Cross Slope Shldr	Fill/ Ditch Slopes	Access (3)	Clear Zone (18)	Sign, Del., Illumin.	Basic Safety	Bike & Ped.	Bridges (11) Lane Width	Bridges (11) Shldr Width	Bridges (11) Vertical Clear.	Bridges (11) Structural Capacity	Intersections Turn Radii	Intersections Angle	Intersections I/S Sight Dist.	Barriers Term. & Trans. Section (12)	Barriers Std Run	Barriers Bridge Rail (19)
Preservation																								
Roadway																								
(5-1) HMA/PCCP												B	B	M			F				B	F	B	F
(5-2) BST																								
(5-3) BST Routes/Basic Safety												B	B								B	F	B	F
(5-4) Replace HMA with PCCP at I/S			EU/M	EU/M		DE/M	EU/M					B	B	M			F					F	B	F
Structures																								
(5-5) Bridge Replacement	M	F	M	M	F		M	M	M		F	F		F	F(2)	F(2)	F	F	M	M	F	F	F	F
(5-6) Bridge Repl. (Multilane)	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)		F	F		F	F(2)	F(2)	F	F	F(2)	F(2)	F	F	F	F
(5-7) Bridge Deck Rehab												B	B	M								F(6)	F(22)	F
Improvements (16)																								
Mobility																								
(5-8) Urban (Multilane)	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	(2)	F	F	F		F	F(2)	F(2)	F	F	EU/F	EU/F	F	F	F	F
(5-9) Urban	M	M	M	M	F		M	M	M	F	F	F		F	M	M	F	F	EU/M	EU/M	F	F	F	F
(5-10) Rural	M	M	M	M	F	M	M	M	M	F	F	F		F	M	M	F	F	EU/M	EU/M	F	F	F	F
(5-11) HOV	M	M	M	M	F	M	M	M	M	F	F	F		F	M	M	F	F	EU/M	EU/M	F	F	F	F
(5-12) Bike/Ped. Connectivity	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)		F	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)
Safety																								
(5-13) Non-Interstate Freeway	F(2)	F(2)	F(2)	F(2)	F(2)	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F		F(2)	F(2)	F	F	F	F
(5-14) Intersection (1)			M(4)	M(4)	F				M(4)	F	F	F		M					M(4)	M(4)	F	F	F	F
(5-15) Corridor (1)	M(4)	M(4)	M(4)	M(4)	F	M(4)	M(4)	M (4)	M(4)	F	F	F		M	M(4)	M(4)	F		M(4)	M(4)	F	F	F	F
(5-16) Median Barrier				DE/F																		F(20)	F(20)	
(5-17) Guardrail Upgrades				DE/F																		F	F(23)	
(5-18) Bridge Rail Upgrades																						F	F(22)	F
(5-19) Risk: Roadside									M(4)	EU/F	F	F										F	F	F
(5-20) Risk: Sight Distance	F/M(21)	F/M(21)	F/M(21)	F/M(21)					F/M(21)	F(21)	F(21)	F		F	F(21)	F(21)	F(21)		F/M(21)	F/M(21)	F(21)	F	F	F
(5-21) Risk: Roadway Width			F/M(21)	F/M(21)	F	F/M(21)	F/M(21)	F/M(21)	F/M(21)	F	F	F		F	F(21)	F(21)	F(21)		F/M(21)	F/M(21)	F(21)	F	F	F
(5-22) Risk: Realignment	F/M	F/M	F/M	F/M	F	F/M	F(2)	F(2)	F/M	F	F	F		F	F(21)	F(21)	F(21)		F/M(21)	F/M(21)	F(21)	F	F	F
Economic Development																								
(5-23) Freight & Goods (Frost Free) (8)	EU/M	EU/M	EU/M	EU/M	EU/F	EU/M	M	M	EU/M		F	B	B	EU/F(26)	DE/M	DE/M	F		EU/M	EU/M	EU/F	F	B	F
(5-24) Rest Areas (New)	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F			F	F	F	F	F	F
(5-25) Bridge Restrictions	M	F	M	M	F	M	M	M	M		F	F		EU/F(26)	M	M	F	F	M	M	F	F	F	F
(5-26) Bike Routes (Shldrs)			EU/M	(7)	EU/F			EU/M	EU/M			B	B	F	EU/M	EU/M					B	F	B	EU/F

☐ Not Applicable
F Full design level. See Chapter 440.
M Modified design level. See Chapter 430.
F/M Full for freeways/Modified for nonfreeway
B Basic design level. See Chapter 410.
DE Design Exception
EU Evaluate Upgrade

(1) Collision Reduction (HAL, HAC, PAL), or Collision Prevention (At Grade Removal, Signalization & Channelization). Specific deficiencies that created the project must be upgraded to design level as stated in the matrix.
(2) Modified design level may apply based on a corridor or project analysis. See 325.03(5).
(3) If designated as L/A acquired in the Access Control Tracking System, limited access requirements apply. If not, managed access applies. See 325.03(5).
(4) Full design level may apply based on a corridor or project analysis. See 325.03(5).
(5) For bike/pedestrian design see Chapters 1020 and 1025.
(6) Applies only to bridge end terminals and transition sections.
(7) 4 ft minimum shoulders.
(8) If all weather structure can be achieved with spot digouts and overlay, modified design level applies to NHS highways and basic design level applies to non-NHS highways.

(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters and see 325.03(2).
(18) On managed access highways within the limits of incorporated cities and towns, City and County Design Standards apply to areas outside the curb or outside the paved shoulder where no curb exists.
(19) The funding sources for bridge rail are a function of the length of the bridge. Consult programming personnel.
(20) Applies to median elements only.
(21) Analyses required. See 325.03(5) for details.
(22) Upgrade barrier, if necessary, within 200 ft of the end of the bridge.
(23) See description of Guardrail Upgrades Project Type, 325.03(1) regarding length of need.
(26) Sidewalk ramps must be addressed for ADA compliance. See Chapter 1025.

Design Matrix 5
Main Line Non-NHS Routes
Figure 325-7

Chapter 330 Design Documentation, Approval, and Process Review

330.01 General

The project file contains the documentation of 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 will shift from one office to another during the life of a project. The project file follows the project, as the project responsibility shifts from office to office. Portions of the project file that are not designated as components of the Design Documentation Package 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 followed. The Design Documentation Package is retained in a permanent, retrievable file for a period of 75 years, in accordance with 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

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)

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

Directional Documents Index, D 00-00, WSDOT

Advertisement and Award Manual, M 27-02, WSDOT

Hydraulics Manual, M 23-03, WSDOT

Master Plan for Limited Access Highways, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Route Development Plan, WSDOT

Washington State Highway System Plan, WSDOT

330.03 Definitions

Design Approval Documented approval of the Design Documentation Package through signature of a designated representative of the approving organization as shown in Figures 330-2a and 330-2b. This documentation becomes part of the Design Documentation Package. If federal funds are involved, Design Approval is required in order to begin right of way acquisition.

Design Concurrence An incremental Design Approval by the designated representative of the approving organization shown in Figures 330-2a and 330-2b. The Project Summary documents must be submitted to the designated approval authority before Design Concurrence can be granted. The primary purpose of Design Concurrence is for work order authorization to establish funding for preliminary engineering.

DE A design exception. 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 providing designers an opportunity to search for previously granted variances. The DVIS application can be accessed at 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 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

EU An evaluate upgrade. A decision making process, requiring evaluation and documentation of whether or not to correct an existing design element as designated in the design matrices. 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. There are two versions of the Project Control Form. One version of the form is specifically for projects included in the Nickel Funding Package enacted by the 2003 legislature. The other version of the form is for projects that are not included in the Nickel Funding Package. The form is available at wwwi.wsdot.wa.gov/ppsc/pgmmgt/dpsb/

project file 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 required project approvals, that will be retained long-term, in accordance with the 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 plus technical reports, calculations (quantity calculations are part of the project file, but are not designated as components of the DDP), estimates, justifications for decisions made, and any applicable documents listed in the Design Documentation Check List on the web.

See 330.04(2). The Design Documentation Package explains how and why the design was chosen, and documents approvals. See 330.01.

Project Summary A set of electronic documents consisting of the Environmental Review Summary (ERS), Design Decisions Summary (DDS), and Project Definition (PD). The Project Summary is part of the design documentation required to obtain Design Concurrence and ultimately is part of the design documentation required for Design Approval. See 330.06.

Environmental Review Summary (ERS) An electronic document that records the environmental requirements and considerations for a specific project.

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.

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. This 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 (such as geotechnical, surfacing, bridge condition, etc.) are developed during this phase.

330.04 Design Documentation

(1) Purpose

Design documentation is prepared to record the evaluations 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. Justifications and approvals, if required, are also included.

The Design Documentation Package identifies the purpose and need of the project and documents how the project addresses the purpose and need. The required content of the Design Documentation Package is identified in the Design Documentation Check List at www.wsdot.wa.gov/eesc/design/projectdev/

(2) Design Documents

The Design Documentation Package portion of the project file 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 project file and Design Documentation Package for all but the simplest projects are listed in Figure 330-5. For project-specific components, provide documentation in the project file and Design Documentation Package as detailed in the Design Documentation Check List at www.wsdot.wa.gov/eesc/design/projectdev/

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

The Design Variance Inventory is required for all projects on NHS highways having design variances and is recommended for all projects having design variances. This form lists all evaluate upgrades (EU) not upgraded to the applicable design level, design exceptions (DE), and deviations as indicated by the design matrices. Also, record variances resulting from a project or corridor analysis in the DVI. Use the Design Variance Inventory System (DVIS) database application to record and manage design variances. The DVIS is available at www.wsdot.wa.gov/eesc/design/projectdev/

The Project Definition (PD) and Environmental Review Summary (ERS) are required for most projects. Exceptions will be identified by the Project Control and Reporting office.

The Design Decisions Summary (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 Project Control and Reporting office for projects not included in the list.

- Bridge painting
- Crushing and stockpiling
- Pit site reclamation
- Lane marker replacement
- Guide post 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, Evaluate Upgrade, and Deviation Documentation

DEs, EUs, and deviations are introduced in Chapter 325. See Figure 330-1 for design matrices documentation requirements.

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	No
Blank cell in design matrix [3]		DDP	No
Cell Entry			
Full (F), Modified (M), 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] May be included in the project in special cases, if identified in the Project Summary or Project Control Form
[4] Nonconformance with specified design level (Chapter 325) requires an approved deviation
[5] Requires supporting justification. (See 330.04(4).)

Design Matrix Documentation Requirements
Figure 330- 1

In special cases, projects may need to address design elements which are shown as blank cells in a design matrix. These special cases must be coordinated with the appropriate Assistant State Design Engineer, 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 Design Variance Inventory is required for the project, the DE locations must be recorded in the inventory.

All EU decisions must be documented. 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. Documentation requirements for an EU decision are similar to, but less demanding than, documentation requirements for a deviation. 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 330-2b.

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 330-2b. Submit the request as early as possible because approved deviations are needed prior to Design 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

An element of engineering judgment might be a reference to another publication, with an explanation of why that reference is applicable to the situation encountered on the project. 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 Design Documentation Package for the new project. Check the Design Variance Inventory System for previously granted deviations.

A change in a design level resulting from an approved Route Development Plan or corridor or project analysis, as specified in design matrix notes, is documented similar to an EU. 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, or to document an EU decision, use the list in Figure 330-6 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 are on the Internet at 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 Bridge Office or the Traffic Office, rather than the region. The project coordination with other disciplines (such as Real Estate Services, 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 as listed in D 00-00; the Master Plan for Limited Access Highways; *Washington State Highway System Plan; Route Development Plan;* Washington Federal-Aid Stewardship Agreement as implemented in the design matrices (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, 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 Environmental Classification Summary (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 instituting public involvement methods that are appropriate to the magnitude and type of the project. (See Chapter 210.)

The Assistant State Design Engineers work with the regions on project development and conduct process reviews on projects as described in 330.09.

330.06 Scoping Phase

Development of the project scope is the initial phase of project development for a specific project. 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.

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 Design Concurrence is granted before the project is funded for design and construction. The Project Summary consists of ERS, DDS, and PD documents, which are electronic forms. Specific on-line instructions for filling them out are contained in the Project Summary database.

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 Project Summary, the information in the ERS must be reviewed and revised to match the new Project Summary. The ERS is prepared during the scoping phase and is approved by the region.

Design Decisions Summary (DDS) states the design matrix used to develop the project, the roadway geometrics, design deviations, evaluate upgrades (EUs), other roadway features, and any design decisions made during 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 Project Definition and the ERS. Design decisions may be revised throughout the project development process based on continuing evaluations.

The DDS is approved by the appropriate Assistant State Design Engineer 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 comfortable that there will be no significant change in the Project Definition or estimated cost. If, however, 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.

Project Definition (PD) identifies the various disciplines and design elements that will be encountered in project development. The PD states the needs, the purpose of the project, program categories, and the recommendations for project phasing. This information determines the level of documentation and evaluation that is needed for Design 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 330-2b. 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 and Design Approval are submitted through the Headquarters (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 Concurrence may be entered into the Project File. (See Design Concurrence definition for purpose.)

When the Design Documentation Package is complete, Design Approval is granted by the approval authority designated in Figures 330-2a and 330-2b. The Design Approval becomes part of the DDP. See 330.04 and Figure 330-5 for design documents that may lead to Design Approval. Figures 330-2a through 330-4 present approval levels for project design and PS&E documents.

The following items must be approved prior to Design Approval:

- Required Environmental Documents
- Project Summary Documents
- Design Variance Inventory as required
- Cost Estimate

At the time of Design Approval, the Design Documentation Package addresses all guidance currently implemented in the *Design Manual*. If a project is delayed but is advertised within three years of the Design Approval, discuss *Design Manual* revisions with your Project Development Engineer, who will discuss the revisions with the appropriate Assistant State Design Engineer (ASDE) to determine if there is a need to redesign any portion of the project. If the ASDE determines that a redesign is not necessary, the ASDE will confirm with an e-mail. Place a copy of the e-mail confirmation in the Design Documentation Package to document that the current design criteria was evaluated and the ASDE agreed that a redesign is unnecessary.

Address new design policy for projects to be advertised more than three years after Design Approval, redesign as appropriate, and update the Design Documentation Package and the Design Approval to reflect the revisions. Consult the Detailed Chronology of Design Policy Changes Affecting Shelved Projects at www.wsdot.wa.gov/eesc/design/policy/designpolicy.htm for an overview of design policy changes.

330.09 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: the Design Documentation Check List, PS&E Review Check List, and 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. HQ Design Office, Project Development Branch maintains current copies on the Internet at 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 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 check lists.
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 regional 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 check lists 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
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 on a 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

(a) These approval levels also apply to deviation processing for local agency work on a state highway.
(b) See 330.04(4)
(c) See Chapter 325 for definition.
(d) Requires FHWA review and approval (full oversight) of design and PS&E submitted by HQ Design
(e) To determine the appropriate oversight level, FHWA reviews the Project Summary (or other programming document) submitted by HQ Design, or by WSDOT Highways and Local Programs through HQ Design
(f) FHWA oversight is accomplished by process review. (See 330.09)
(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

Design Approval Level
Figure 330-2a

Project Design	FHWA Oversight Level	Deviation and Corridor/Project Approval[a][b]	EU Approval[b]	Design 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 a 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 a 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

(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) See Chapters 1430 & 1435 for guidance on access deviations

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 *Programmatical 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]	
Access Point Decision Report		[7]	**X**
Non-Interstate Interchange Access Point 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]	
Project Design 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]	**X** [16]	
Preliminary Signalization Plans		**X** [6]	
Rest Area Plans		**X**	
Roadside Restoration Plans	**X** [18]	**X** [19]	
Structures Requiring TS&L's		**X**	**X**
Wetland Mitigation Plans	**X**	**X**	
Wetland Mitigation 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]	

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 & 330-2b for design approval level
[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 Branch for review and approval
[14] Approved by region's Administrator
[15] See 23 CFR 635.111
[16] See M 23-03, *Hydraulics Manua*l for additional guidance
[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

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)	[3](c)(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 $50,000 limitation 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
(c) Design Office
(d) Project Control & Reporting Office
(e) Construction Office
(f) Transportation Data Office

References:

****Advertisement and Award Manual*
**Plans Preparation 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
Access Point Decision 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	

Notes:

(1) See Design Documentation Check List at www.wsdot.wa.gov/eesc/design/projectdev/ for a complete list of project documentation requirements.

(2) Required for NHS highways, recommended for all highways.

Common Components of Design Documentation Package

Figure 330-5

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
    (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
        - Justification - see 330.04(4)
3. Concurrences, Approvals, and Professional Seals

Deviation and Evaluate Upgrade Request/Documentation Content List
Figure 330-6

Chapter 340 Minor Operational Enhancement Projects

340.01 General

This chapter complements Chapter 325 by providing guidance for development of minor operational enhancement projects. Do not use this chapter to develop preservation or improvement projects. Refer to Chapter 325 for guidance in development of preservation and improvement projects and also for projects initiated by local agencies or developers. The minor operational enhancement matrices contained in this chapter identify the design level(s) for a project, the associated approval level, and the documentation requirements for the most common minor operational enhancement projects and focus on the various elements of greatest concern during project development.

Minor enhancement projects are categorized as low-cost enhancements, to improve the operational safety and efficiency of the highway system. These enhancements are most often installed by state forces through work orders, but may be accomplished through: a stand-alone state contract funded entirely through the Q Program, a Q Program funded bid item within a larger improvement project, a change order to an existing state contract, or agreements with local agencies. An important characteristic of these projects is the ability to quickly develop and implement them without a cumbersome approval process. Balanced with that is a need to apply consistency in design policies and guidelines in the development and approval processes. Therefore, the intent of this chapter is to clarify the design guidelines and documentation requirements for minor operational enhancement projects without unduly impeding the process.

The objective of the Q Program is to maximize highway transportation system safety and efficiency through a statewide program focused on the WSDOT business function for "Traffic Operations." It is the smallest of the four major highway programs that comprise the Highway System Plan (i.e. Improvement, Maintenance, Preservation, and Traffic Operations). Elements within the Q Program include: Q1 – Traffic Operations Program Management, Q2 – Traffic Operations Program Operations, and Q3 - Special Advanced Technology Projects. This chapter is intended to guide the development of projects in the Low Cost Enhancements subcategory within the Q2 program. Large capital improvement projects developed for the Q3 subprogram are beyond the scope and intent of this chapter. Normally, these projects are developed using *Design Manual* guidelines for Preservation and Improvement Program projects. Consult the Headquarters Traffic Office for guidance when designing Q3 subprogram projects.

The minor operational enhancement matrices consisting of three tables are identified by route type. One of the matrices applies to Interstate and NHS freeways, one applies to NHS Non-freeway routes, and the third matrix applies to non-NHS routes.

340.02 References

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

Chart of Accounts, M 13-02, WSDOT

340.03 Definitions

The **National Highway System (NHS)** See Chapter 325 for definition and a list of specific routes on the NHS.

The term **freeway** applies to multilane, divided highways with full access control.

The **minor operational enhancement projects** usually originate from the Q2 component of the Q Program and are quick responses to implement low cost improvements.

Projects are typically narrow in scope, and focus on improvements to traffic operations, and modifications to traffic control devices. Guidance on the type of work included in the Q subprograms is in the *Chart of Accounts* (M 13-02).

(1) Project Types

Regulatory projects include actions undertaken to manage or regulate traffic conflict, movements, and use of the roadway. Potential projects in this category include revisions to speed limits, parking restrictions, turn restrictions, truck restrictions, signal operations, unsignalized intersection control, intersection lane use control, ramp meters, no passing zones, crosswalks, special traffic control schemes, and lane use restrictions.

Driver guidance projects are actions to improve driver guidance, clarify options, or reduce hazard in the roadway setting. Potential projects include revisions to, informational signs, warning signs, lighting and supplemental illumination, supplemental delineation, glare screen, signals, roadside guidance, and intelligent transportation systems (ITS).

Pavement widening projects are expansion of the roadway surface for vehicular use and may involve earthwork, drainage, and paving elements. Consult with the regional bicycle/pedestrian coordinator to ensure that the concerns of bicyclists and pedestrians are given adequate consideration. These projects are considered alterations of the roadway and must address Americans with Disabilities Act (ADA) accessibility for pedestrians. See Chapter 1025 for guidance on pedestrian facilities. Potential projects are:

- Turn lane — Addition of a new channelized turn bay at an intersection.
- Pullout — Pavement widening to provide auxiliary highway uses including transit stops, Washington State Patrol (WSP) enforcement pullouts, snow chain-up areas, and maintenance vehicle turnouts.
- Expansion — Widen at intersection corners, lengthen existing channelized turn bay, widening shoulders, and flattening approach taper. This type of work is not anticipated for main line sections on Interstate freeways.
- Median crossover — Restricted-use median crossover on separated highways for emergency or maintenance use. See Chapter 960 for design of median crossovers.

Rechannelize existing pavement projects alter the use of the roadway without additional widening. These projects may add, delete, or modify channelization features, and may include reduction of existing shoulder or lane widths. Consult with the regional bicycle/pedestrian coordinator to ensure that the concerns of bicyclists and pedestrians are given adequate consideration. Projects that change the traffic configuration by reducing shoulders to add turn lanes are considered an alteration of the existing roadway and have the same requirements for preservation projects as it relates to pedestrian facilities for ADA accessibility. See Chapter 1025 for guidance on pedestrian facilities.

Potential projects are:

- Pavement markings — Develop added storage, additional lanes, or altered lane alignment. This work may modify tapers or radii, modify painted islands, channelize bicycle lanes, preferential-use lanes or shoulders.
- Raised channelization — New or altered raised curbing to channelization islands to enhance guidance, curtail violation or misuse, or introduce access control.
- Left-Turn Channelization (2-Lane Highways) – Restriping two-lane highways with a minimum pavement width of 39 feet, to provide left-turn channelization at existing intersections. Restripe to provide a minimum of 11-foot lanes and 3-foot shoulders. Ensure that the pavement is structurally adequate for the anticipated traffic loads. Within this configuration at T-Intersections, a reduced

length refuge lane may be provided for traffic entering the main line from the intersecting roadway. See Figure 340-6 for minimum dimensional characteristics of the refuge lane.

Nonmotorized facilities projects add adjacent roadside features for bicycle or pedestrian use. Involve the regional bicycle/pedestrian coordinator in the project development process.

Potential projects are:

- Sidewalk — Installation of sidewalks, which might involve preserving existing shoulder, or converting some portion of existing shoulder for use as a new sidewalk.
- Walkway — Adds to the existing roadway's overall width to provide a wider walkable shoulder.
- Separated Trails — Class 1 separated bike lane or pedestrian paths on independent alignment or parallel to the highway.
- Spot Improvement — Installation of ADA sidewalk curb cuts, new pedestrian landings, sidewalk bulbouts at intersections, or new or revised trailhead features.

Roadside projects are modifications to roadside features for safety purposes. Potential projects are:

- Cross section — Altering roadway cross sections to address clear zone hazard or sight distance concern such as slope flattening, recontouring a ditch, closing a ditch with culvert, or removal of hazard.
- Protection — Installation of hazard protection for clear zone mitigation including guardrail, barrier, and impact attenuator.
- New object — Placement of new hardware or fixed object within clear zone unable to meet breakaway criteria.

(2) Design Elements

The following elements are shown on the minor operational enhancement matrices. If full design level applies see the chapters listed below. If modified design level applies, see Chapter 430.

Sight Distance refers to any combination of horizontal and vertical stopping sight distance, decision sight distance, passing sight distance, and intersection sight distance. See Chapters 650 and 910 for definitions and guidance.

Lane Width See Chapter 325 for definition.

Lane Transition See Chapter 325 for definition.

Shoulder Width See Chapter 325 for definition.

Fill/Ditch Slope See Chapter 325 for definition.

Clear Zone See Chapter 325 for definition.

Ramp Sight Distance refers to any combination of horizontal and vertical stopping sight distance, decision sight distance, and intersection sight distance. See Chapters 650 and 910 for definitions and guidance.

Ramp Lane Width is the lane width for ramp alignments. See Lane Width definition in Chapter 325.

Ramp Lane Transition is the lane transition applied to a ramp alignment. See definition for Lane Transition in Chapter 325. Also see Chapter 940.

Ramp Shoulder Width is the shoulder width for a ramp alignment. See Shoulder Width definition in Chapter 325.

Ramp Fill/Ditch Slopes is the fill/ditch slope along a ramp alignment. See Fill/Ditch Slope definition in Chapter 325.

Ramp Clear Zone is the clear zone along a ramp alignment. See Clear Zone definition in Chapter 325.

Ramp Terminals or Intersection Turn Radii See Chapter 910 for definition.

Ramp Terminals or Intersection Angle See Chapter 910 for definition.

Ramp Terminals or Intersection Sight Distance See Chapter 910 for definition.

Pedestrian and Bike refers to the facilities along a route for accommodation of pedestrians and/or bicycles. See Chapter 1020 for bicycles and Chapter 1025 for pedestrians.

Crossroads at Ramps Lane Width is the lane width on a crossing alignment intersected by a ramp. See Lane Width definition in Chapter 325.

Crossroads at Ramps Shoulder Width is the shoulder width on a crossing alignment intersected by a ramp. See Shoulder Width definition in Chapter 325.

Crossroads at Ramps Pedestrian and Bike refers to the facilities on a crossing alignment intersected by a ramp, for accommodation of pedestrians and/or bicycles. See Pedestrian and Bike definition.

Crossroads at Ramps Fill/Ditch Slopes is the fill/ditch slope along a crossroad intersected by a ramp. See Fill/Ditch Slope definition in Chapter 325.

Crossroads at Ramps Clear Zone is the clear zone along a crossroad intersected by a ramp. See Clear Zone definition in Chapter 325.

Barriers Terminal and Transition Section See Chapter 325 for definition.

Barriers Standard Run See Chapter 325 for definition.

340.04 Minor Operational Enhancement Matrix Procedures

During project definition and design, the following steps are used to select and apply the appropriate minor operational enhancement matrix. Each step is further explained in this chapter.

- *Select a minor operational enhancement matrix* by identifying the route: Interstate/NHS Freeway, NHS non-freeway, or non-NHS.
- Within the minor operational enhancement matrix, *select the row* by the type of work.
- Use the minor operational enhancement matrix to *determine the documentation and approval levels for the various design elements* in the project. Apply the appropriate design levels and document the design decisions as required by this chapter and Chapter 330.

340.05 Selecting a Minor Operational Enhancement Matrix

Selection of a minor operational enhancement matrix is based on highway system (Interstate/NHS Freeway, NHS non-freeway, non-NHS). (See Figure 340-1.) Figures 325-2a and 2b provide a list of the NHS and the Interstate routes in Washington. The minor operational enhancement matrices are shown in Figures 340-2 through 340-4. Follow *Design Manual* guidance for all projects except as noted in the minor operational enhancement matrices.

Route	Project	
	Freeway	Non-freeway
Interstate	Matrix 1	
NHS	Matrix 1	Matrix 2
Non-NHS	Matrix 1	Matrix 3

Minor Operational Enhancement Matrix Selection Guide
Figure 340-1

340.06 Project Type

Row selection in the design matrices is based on project type or type of work. See 340.03(1). For projects not listed in the matrices, consult the Headquarters Traffic Office and the Headquarters Design Office.

Some projects might include work from several project types. In such cases, identify the design and approval level for each project element. In all cases, select the higher design level and approval level where overlaps are found.

340.07 Using a Minor Operational Enhancement Matrix

The column headings on a minor operational enhancement matrix are design elements. They are based on the following thirteen Federal Highway Administration (FHWA) controlling design criteria: design speed, lane width, shoulder width, bridge width, structural capacity, horizontal alignment, vertical alignment, grade, stopping sight distance, cross slope, superelevation, vertical clearance, and horizontal clearance. For the column headings, some of the controlling criteria are combined (for example design speed is part of horizontal and vertical alignment).

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. Design approval 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

Development Engineer. At the time the work order is approved, the Assistant State Design engineer is to be sent an informational copy of the Level 2 documentation to provide an opportunity to communicate concerns. Comment on the informational copy is not mandatory, and progress toward project implementation does not wait on a response.

Level 3 documentation requirements include the level 2 requirements, however the approval process is through the region's Traffic Engineer, and region's Project Development Engineer with final approval from the Assistant State Design Engineer.

Level 4 documentation requirements include the level 3 requirements, however the approval process is through region's Traffic Engineer, region's Project Development Engineer, and the Assistant State Design Engineer with final approval from the Federal Highway Administration on Interstate routes.

Level 2, 3, and 4 design deviation requests are intended to be stand-alone documentation describing the project, design criteria, proposed element(s), why the desired design level was not or can not be used, alternatives evaluated, and a request for approval. Include funding source(s), type of route, project limits, design classification, posted speed, current ADT, and percent truck traffic in the project description. Justification for the design deviation can include project costs, but must be supported by at least two of the following:

- Accident history or potential.
- Engineering judgment.
- Environmental issues.
- Route continuity (consistency with adjoining route sections).
- The project is an interim solution (covering a 4 to 6 year time horizon).

⇩ Project Type	Main Line						Ramps <u>(1)</u>						Ramp Terminals or Intersections			Crossroads at Ramps					Barriers All		Doc. Level
Design Elements ⇨	Sight Dist.	Lane Width	Lane Tran-sition	Shldr Width	Fill/ Ditch Slopes	Clear Zone	Sight Dist.	Lane Width	Lane Tran-sition	Shldr Width	Fill/ Ditch Slopes	Clear Zone	Turn Radii	Angle	Sight Dist.	Lane Width	Shldr Width	Ped & Bike	Fill/ Ditch Slopes	Clear Zone	Term. & Trans. Section	<u>(2)</u> Std Run	
Regulatory - (Traffic Office Authority)																							**BD**
Driver Guidance - (Traffic Office Authority)																							**BD**
Pavement Widening																							
<u>(1-1Q)</u> Turn Lane								**F/DJ**	**F/DJ**	**F/DJ**			**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
<u>(1-2Q)</u> Pullout							**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**	**M/DJ**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
<u>(1-3Q)</u> Expansion	**F/3**	**F/4**	**F/3**	**F/4**	**F/3**	**F/3**		**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**	**M/DJ**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
<u>(1-4Q)</u> Median Crossover	**F/3**	**F/4**	**F/3**	**F/4**	**F/3**	**F/3**															**F/3**	**F/3**	**BD+**
Rechannelize Existing Pavement																							
<u>(1-5Q)</u> Pavement Markings	**F/3**	**F/4**	**F/3**	**F/4**		**F/3**	**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**		**F/DJ**	**F/3**	**F/3**	**BD+**
<u>(1-6Q)</u> Raised Channelization							**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**		**F/DJ**	**F/3**	**F/3**	**BD+**
<u>(1-7Q)</u> <u>Left-Turn Channelization 2-Lane Hwys (3)</u>																<u>**DJ**</u>	<u>**DJ**</u>	<u>**M**</u>					
Nonmotorized Facilities																							
<u>(1-8Q)</u> Sidewalk/Walkway													**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
<u>(1-9Q)</u> Separated Trails																		**F/DJ**			**F/3**	**F/3**	**BD+**
<u>(1-10Q)</u> Spot Improvement													**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**		**F/DJ**			**BD+**
Roadside																							
<u>(1-11Q)</u> Cross Section	**F/3**				**F/3**	**F/3**	**F/DJ**				**F/DJ**	**F/DJ**			**F/DJ**				**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
<u>(1-12Q)</u> Protection	**F/3**			**F/4**	**F/3**	**F/3**	**F/DJ**			**F/DJ**	**F/DJ**	**F/DJ**			**F/DJ**		**M/DJ**		**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
<u>(1-13Q)</u> New Object	**F/3**					**F/3**	**F/DJ**					**F/DJ**			**F/DJ**					**F/DJ**	**F/3**	**F/3**	**BD+**

□ Not Applicable
F Full design level
M Modified design level. See Chapter 430.
DJ Design Justification required and Project Approval by region Traffic, with notification to Headquarters Design.
2 Deviation approval through the region<u>'s</u> Traffic and Project Development Engineers, with notification to Headquarters Design.
3 Deviation approval through level 2 and the Assistant State Design Engineer.
4 Deviation approval through level 3, and FHWA on Interstate routes.
BD Basic Documentation required.
BD+ Basic Documentation plus supplemental coordination required.

If a project impacts any design element, the impacted elements are addressed. Elements not impacted, are not addressed.

For items not meeting the <u>design level</u> provided in the matrix, justification or deviation is required and is processed through the designated approval level, DJ, 2, 3, or 4

For at-grade intersections on NHS routes, apply Matrix 2.

<u>(1)</u> Documentation must provide assurance of no adverse effect to main line flow. Otherwise process a deviation through level 4

<u>(2)</u> If existing shoulder width is decreased below minimum values, when placing new guardrail or concrete barrier, a deviation request justifying the proposal is required.

<u>(3)</u> <u>Where existing pavement width is 39 feet or greater.</u>

Minor Operational Enhancement Matrix 1
Interstate & NHS Freeway Routes
Figure 340-2

⇩ Project Type	Main Line						Intersections				Barriers All		Doc. Level
Design Elements ⇨	Sight Dist.	Lane Width	Lane Tran-sition	Shldr Width	Fill/ Ditch Slopes	Clear Zone	Turn Radii	Angle	Sight Dist.	Ped & Bike	Term. & Trans. Section	(2) Std Run	
Regulatory - (Traffic Office Authority)													**BD**
Driver Guidance - (Traffic Office Authority)													**BD**
Pavement Widening													
(2-1Q) Turn Lane	**M/2**	**M/3**	**F/2**	**M/3**	**M/2**	**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
(2-2Q) Pullout	**M/2**	**M/3**	**F/2**	**M/3**	**M/2**	**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
(2-3Q) Expansion	**M/2**	**M/3**	**F/2**	**M/3**	**M/2**	**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
Rechannelize Existing Pavement													
(2-4Q) Pavement Markings	**M/2**	**M/3**	**F/2**	**M/3**		**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
(2-5Q) Raised Channelization	**M/2**	**M/3**	**F/2**	**M/3**		**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
(2-6Q) Left-Turn Channelization 2-Lane Hwys (3)		**DJ**		**DJ**						**M**			
Nonmotorized Facilities													
(2-7Q) Sidewalk/Walkway	**M/2**	**M/3**	**F/2**	**M/3**	**M/2**	**F/2**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
(2-8Q) Separated Trails	M/2				M/2	F/2				F/DJ	F/3	F/3	BD+
(2-9Q) Spot Improvement	M/2	M/3	F/2	M/3	M/2	F/2	M/DJ	M/DJ	F/DJ	F/DJ	F/3	F/3	BD+
Roadside													
(2-10Q) Cross Section	**M/2**				**M/2**	**F/2**			**F/DJ**		**F/3**	**F/3**	**BD+**
(2-11Q) Protection	**M/2**				**M/2**	**F/2**			**F/DJ**		**F/3**	**F/3**	**BD+**
(2-12Q) New Object	**M/2**				**M/2**	**F/2**			**F/DJ**		**F/3**	**F/3**	**BD+**

□ Not Applicable
F Full design level
M Modified design level. See Chapter 430.
DJ Design Justification required and Project Approval by region Traffic, with notification to Headquarters Design.
2 Deviation approval through the region's Traffic and Project Development Engineers, with notification to Headquarters Design.
3 Deviation approval through level 2 and the Assistant State Design Engineer.
BD Basic Documentation required.
BD+ Basic Documentation plus supplemental coordination required.

If a project impacts any design element, the impacted elements are addressed. Elements not impacted, are not addressed.

For items not meeting the design level provided in the matrix, justification or deviation is required and is processed through the designated approval level, DJ, 2 or 3.

For interchange features, apply Matrix 1.

(2) If existing shoulder width is decreased below minimum values, when placing new guardrail or concrete barrier, a deviation request justifying the proposal is required.

(3) Where existing pavement width is 39 feet or greater.

Minor Operational Enhancement Matrix 2
NHS Non-freeway Routes
Figure 340-3

⇩ Project Type	Main Line						Intersections				Barriers All		Doc. Level
Design Elements ⇨	Sight Dist.	Lane Width	Lane Tran-sition	Shldr Width	Fill/ Ditch Slopes	Clear Zone	Turn Radii	Angle	Sight Dist.	Ped & Bike	Term. & Trans. Section	(2) Std Run	
Regulatory - (Traffic Office Authority)													**BD**
Driver Guidance - (Traffic Office Authority)													**BD**
Pavement Widening													
(3-1Q) Turn Lane	**M/DJ**	**M/2**	**F/DJ**	**M/2**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
(3-2Q) Pullout	**M/DJ**	**M/2**	**F/DJ**	**M/2**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
(3-3Q) Expansion	**M/DJ**	**M/2**	**F/DJ**	**M/2**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
Rechannelize Existing Pavement													
(3-4Q) Pavement Markings	**M/DJ**	**M/2**	**F/DJ**	**M/2**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
(3-5Q) Raised Channelization	**M/DJ**	**M/2**	**F/DJ**	**M/2**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
(3-6Q) Left-Turn Channelization 2-Lane Hwys (3)		**DJ**		**DJ**						**M**			
Nonmotorized Facilities													
(3-7Q) Sidewalk/Walkway	**M/DJ**	**M/2**	**F/DJ**	**M/2**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
(3-8Q) Separated Trails	**M/DJ**				**M/DJ**	**F/DJ**				**F/DJ**	**F/2**	**F/2**	**BD+**
(3-9Q) Spot Improvement	**M/DJ**	**M/2**	**F/DJ**	**M/2**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**F/DJ**	**F/2**	**F/2**	**BD+**
Roadside													
(3-10Q) Cross Section	**M/DJ**				**M/DJ**	**F/DJ**			**F/DJ**		**F/2**	**F/2**	**BD+**
(3-11Q) Protection	**M/DJ**				**M/DJ**	**F/DJ**			**F/DJ**		**F/2**	**F/2**	**BD+**
(3-12Q) New Object	**M/DJ**				**M/DJ**	**F/DJ**			**F/DJ**		**F/2**	**F/2**	**BD+**

□ Not Applicable
F Full design level
M Modified design level. See Chapter 430.
DJ Design Justification required and Project Approval by region Traffic, with notification to Headquarters Design.
2 Deviation approval through the region's Traffic and Project Development Engineers, with notification to Headquarters Design.
3 Deviation approval through level 2 and the Assistant State Design Engineer.
BD Basic Documentation required.
BD+ Basic Documentation plus supplemental coordination required.

If a project impacts any design element, the impacted elements are addressed. Elements not impacted, are not addressed.

For items not meeting the design level provided in the matrix, justification or deviation is required and is processed through the designated approval level, DJ, 2 or 3.

For interchange features, apply Matrix 1.

(2) If existing shoulder width is decreased below minimum values, when placing new guardrail or concrete barrier, a deviation request justifying the proposal is required.

(3) Where existing pavement width is 39 feet or greater.

Minor Operational Enhancement Matrix 3
Non-NHS Routes
Figure 340-4

Date Placeholder

TO: (Specify) Region Traffic Engineer[1]

THRU:

FROM:

SUBJECT:

Design Approved By:

____

(Specify) Region Traffic Engineer[1]

____

Date

General Information

SR ___________ is a (*NHS or Non-NHS*) route, and classified as a (*Urban or Rural*) (*Interstate, Principal Arterial, Minor Arterial, Collector or Urban Managed Access Roadway*) in ___________ County. The posted speed limit is ____ mph. The ADT is, ___________ with ________ percent trucks. The project is within a (*full, partial, or modified limited access control, or Class 1 - 5 managed access controlled*) area.

Project Initiation

How did the project get started? Accident history, constituent call, e-mail, or letter?

Existing Geometrics

What is out there today? Lane, shoulder, sidewalk widths? Turn pockets, etc.?

Project Description

How did you come to the design decision being proposed? What does it resolve for the situation at hand? What options have you looked at? Why were other options not selected?

Proposed Geometrics

What will be out there when you are through? Lane, shoulder, sidewalk widths? Turn pockets, etc.?

[1] For example "Eastern Region Traffic Engineer"

Q Project Design Summary/Approval Template

Figure 340-5a

Resurfacing

If pavement is involved what does the resurfacing report say to use?

Pavement Marking/Traffic Control Devices

What happens with the pavement markings? Signing? Illumination? Signals? Etc.?

Environmental Approval

Did you check with the Environmental Services Office? Are there any issues or permits that need to be addressed? Hydraulics?

Deviations

Are there any deviations? Describe briefly what features are deviated and the date of approval.

Permits

Are there any permits or easements needed? Construction permits? Noise variances? Utility relocations? Detours? Signal? Others?

Project Cost and Schedule

How much do you anticipate spending? When is the project scheduled for advertisement? When do you anticipate the project will be completed?

Sole Source Justification

Some traffic items are sole source and require justification. Have you completed the process?

Work Zone Traffic Control

What happens to traffic, pedestrians, and bicyclists during construction? Is a lane taken or reduced in width? Night work? Shoulder work? Duration? Does Washington State Patrol (WSP) need to be involved?

Local Agency Coordination

Do we need to coordinate with, or notify the city or county? WSP?

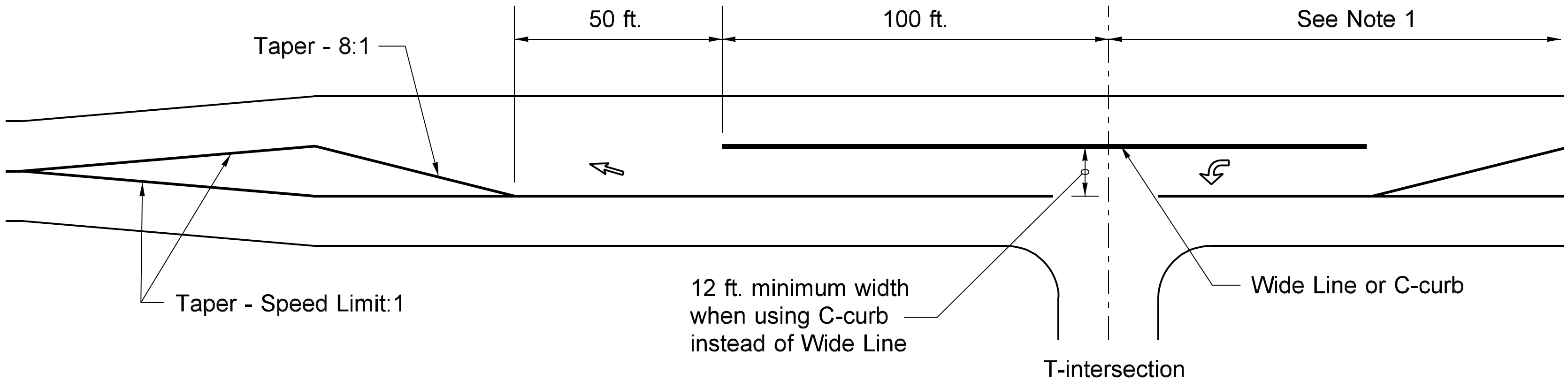
We are requesting approval for the Subject project. This project was designed in accordance with Q Program guidelines for Minor Operational Enhancements, Matrix ___________ *note matrix title and project type line.*

Typist's Initials Placeholder

Attachments: Channelization Plan?
Permits?
Deviations?

cc: Headquarters Design 47329

Q Project Design Summary/Approval Template (continued)
Figure 340-5b



Notes:

1. See Chapter 910 for left-turn channelization.

Refuge Lane for T-Intersections on 2-Lane Highways
Figure 340-6

410.01 General

Basic design level (B) preserves pavement structures, extends pavement service life, and maintains safe operations of the highway. The basic design level includes restoring the roadway for safe operations and, where needed, may include safety enhancement. Flexibility is provided so that other conditions can be enhanced while remaining within the scope of pavement preservation work.

The required safety items of work listed below may be programmed under a separate project from the paving project as long as there is some benefit to the delay, the safety features remain functional, and the work is completed within two years after the completion of the paving project. If some of the required items are separated from the paving project, maintain a separate documentation file that addresses the separation of work during the two-year time period.

For bituminous surface treatment projects on non-NHS routes, the separation of required safety items is not limited to the two years stated above. The safety work can be accomplished separately using a corridor-by-corridor approach.

410.02 Required Basic Safety Items of Work

For basic design level (B), the following items of work are required:

- Install and replace delineation in accordance with Chapter 830
- Install and replace rumble strips in accordance with the matrices and Chapter 700
- Adjust existing features that are affected by resurfacing, such as monuments, catch basins, and access covers
- Adjust guardrail height in accordance with Chapter 710
- Replace deficient signing, as needed, using current standards. This does not include replacement of sign bridges or cantilever supports
- Relocate, protect, or provide breakaway features for sign supports, luminaires, and WSDOT electrical service poles inside the design clear zone
- Restore sight distance at public road intersections and the inside of curves through low cost measures if they are available such as removal or relocation of signs and other obstructions, and cutting of vegetative matter
- Upgrade nonstandard bridge rail in accordance with the matrices and Chapter 710
- Upgrade barrier terminals and bridge end protection, including transitions, in accordance with Chapter 710
- Restore the cross slope to 1.5 percent when the existing cross slope is flatter than 1.5percent and, in the engineer's judgment, the steeper slope is needed to solve highway runoff problems in areas of intense rainfall

410.03 Minor Safety and Minor Preservation Work

Consider the following items, where appropriate, within the limits of a paving project:

- Spot safety enhancements. These are modifications to isolated roadway or roadsidefeatures that, in the engineer's judgment, reduce potential accident frequency or severity
- Striping changes that will provide additional or improved channelization for intersections where sufficient pavement width and structural adequacy exist
- Roadside safety hardware (such as guardrail, signposts, impact attenuators)

- Addressing Location 1 Utility Objects in accordance with the *Utilities Accommodation Policy*, M 22-86

Consider the following items when restoration, replacement, or completion is necessary to assure that an existing system can function as intended:

- Right of way fencing
- Drainage
- Illumination
- Electrical
- Pedestrian and bicycle use

Examples of the above include, but are not limited to, the following: installing short sections of fence needed to control access, replacing grates that are a hazard to bicycles, upgrading electrical system components that require excessive maintenance, and beveling culverts.

P65:DP/DME

430.01 General

Modified design level (M) preserves and improves existing roadway geometrics, safety, and operational elements. This chapter provides the design guidance that is unique to the modified design level.

Design elements that do not have modified design level guidance include:

- Access control, see Chapter 1420
- Basic safety, see Chapter 410
- Clear zone, see Chapter 700
- Traffic barriers, see Chapter 710
- Gore area lighting, see Chapter 840
- Interchange areas, see Chapter 940

Design elements that have both modified and full design level components include:

- Horizontal alignment, see Chapter 620
- Superelevation see Chapter 642
- Vertical alignment, see Chapter 630

430.02 Design Speed

When applying modified design level to a project, select a design speed for use in the design process that reflects the character of the terrain and the type of highway. Select a speed that is not less than the posted speed, the proposed posted speed, or the operating speed, whichever is higher. Document which speed was used, include any supporting studies and data.

430.03 Roadway Widths

The design of a project must not decrease the existing roadway width.

Lane and shoulder widths are shown in Figures 430-3 and 4. Consider joint use with other modes of transportation in shoulder design.

Review route continuity and roadway widths. Select widths on the tangents to be consistent throughout a given section of the route. Make any changes where the route characteristics change.

(1) Turning Roadway Widths

It may be necessary to widen the roadway on curves to accommodate large vehicles. The total two-lane roadway width of a curve may not be less than that shown in Figure 430-5 or, if the internal angle (delta) is less than 90 degrees, Figure 430-6. The proposed roadway width for a curve may not be less than that of the adjacent tangent sections.

The total roadway width from Figure 430-5 or Figure 430-6 may include the shoulder. When the shoulder is included, full-depth pavement is required.

Widening of the total roadway width of a curve by less than 2 ft is not required for existing two-lane roadways that are to remain in place.

(2) Median Width

See Figure 430-3.

430.04 Ramp Lane Widths

Ramp lane widths are shown in Figure 430-1 and in Figure 430-10. For ramps with radii less than 300 ft apply full design level. See Chapter 641.

Curve Radius (ft)	Lane Width (ft)
Tangent - 4,000	13
3,000 - 2,000	14
1,000 - 300	15

Turning Ramp Lane Widths
Modified Design Level
Figure 430-1

430.05 Stopping Sight Distance

(1) Existing Stopping Sight Distance for Vertical Curves

For crest vertical curves use the existing algebraic difference in grades and the length of curve to compare the existing condition to Figure 430-7. If corrective action is required by Figure 430-7, apply full design level and see Chapter 650.

When modified design level is being applied, sag vertical curves are not normally addressed.

(2) Stopping Sight Distance for Horizontal Curves

For modified design level, use the existing lateral clearance to the sight obstruction and the curve radius to compare the existing condition to Figure 430-8. If corrective action is required by Figure 430-8, apply full design level and see Chapter 650.

For Figure 430-8, an obstruction is any object with a height of 2 ft or more above the roadway surface on the inside of a curve. Examples of possible obstructions are median barrier, guardrail, bridges, walls, cut slopes, wooded areas, and buildings.

430.06 Profile Grades

When applying modified design level, profile grades generally are not flattened. However, corrective action may be justified for combinations of steep grades and restricted horizontal or vertical curvature. Identify major modifications to horizontal and vertical alignment in the Project Decisions Summary. Total removal of pavement and reconstruction of the subgrade are examples of major modifications.

430.07 Cross Slope

On all tangent sections, the normal cross slopes of the traveled way are 2 percent. Cross slopes up to 2 percent have a barely perceptible effect on vehicle steering, but cross slopes steeper than 2 percent can be noticeable.

The algebraic difference in cross slopes is an operational factor during a passing maneuver on a two-lane road. Its influence increases when increased traffic volumes decrease the number and size of available passing opportunities.

If a longitudinal contiguous section of pavement is to be removed or is on a reconstructed alignment, or if a top course is to be placed over existing pavement, design the restored pavement to a cross slope of 2 percent.

A somewhat steeper cross slope may be necessary to facilitate pavement drainage in areas of intense rainfall, even though this might be less desirable from the operational point of view. In such areas, the design cross slopes may be increased to 2.5 percent with an algebraic difference of 5 percent.

For existing pavements, cross slopes within a range of 1 to 3 percent may remain if there are no operational or drainage problems and— on a two-way, two-lane road — the following conditions are met:

- The algebraic difference is not greater than 4 percent where the ADT is greater than 2000.
- The algebraic difference is not greater than 5 percent where the ADT is 2000 or less.
- The algebraic difference is not greater than 6 percent and the road is striped or signed for no passing.

If the existing pavement does not meet the conditions above, correct the cross slope(s) to be within the range of 1.5 to 2.5 percent. For a two-way, two-lane road, provide an algebraic difference to meet the appropriate conditions stated above except when facilitating drainage in areas of intense rainfall. When applying modified design level to a road with bituminous surface treatment (BST), cross slope correction is not required on the basis of algebraic differences alone.

To maintain or restore curb height, consider lowering the existing pavement level and correcting cross slope by grinding before an asphalt overlay. On urban highways, the cross slope of the outside shoulder may be steepened to minimize curb height and other related impacts. The shoulder may be up to 6 percent with a rollover between the traveled way and the shoulder of no more than 8 percent.

430.08 Fill Slopes and Ditch Inslopes

Foreslopes (fill slopes and ditch inslopes) and cut slopes are designed as shown in Figure 430-9 for modified design level main line roadway sections. After the foreslope has been determined, use the guidance in Chapter 700 to determine the need for a traffic barrier.

When a crossroad or road approach has steep foreslopes, there is the possibility that an errant vehicle might become airborne. Therefore, flatten crossroad and road approach foreslopes to 6H:1V where practical and at least to 4H:1V. Provide smooth transitions between the main line foreslopes and the crossroad or road approach foreslopes. Where possible, move the crossroad or road approach drainage away from the main line. This can locate the pipe outside the design clear zone and reduce the length of pipe required.

430.09 Intersections

(1) General

Except as given below, design intersections to meet the requirements in Chapter 910.

(2) Design Vehicle

Figure 430-2 is a guide for determining the design vehicle. Perform a field review to determine intersection type, type of vehicle that use the intersection, and adequacy of the existing geometrics.

(3) Angle

The allowable angle between any two respective legs is between 60° and 120°. When realignment is required to meet this angle requirement, consider realigning to an angle between 75° and 105°.

430.10 Bridges

Design all new and replacement bridges to full design level (Chapter 440) unless a corridor or project analysis justifies the use of modified design level lane and shoulder widths. Evaluate bridges to remain in place using Figures 430-3 and 4. Whenever possible, continue the roadway lane widths across the bridge and adjust the shoulder widths.

Intersection Type	Design Vehicle
Junction of Major Truck Routes	WB-67
Junction of State Routes	WB-40
Ramp Terminals	WB-40
Other Rural	SU(1)
Urban Industrial	SU(1)
Urban Commercial	P(1)
Residential	P(1)

(1) When the intersection is on a transit or school bus route, use the BUS design vehicle. See Chapter 1060 for additional guidance for transit facilities and for the BUS turning path templates.

Design Vehicles
Modified Design Level
Figure 430-2

Consider joint use with other modes of transportation in lane and shoulder design. See Chapters 1020, 1050, and 1060.

430.11 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 website: http://www.wsdot.wa.gov/eesc/design/projectdev/

	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	The posted speed, the proposed posted speed, or the operating speed, whichever is higher.							
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 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)(12)(8)	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	Full Design Level Applies (14)							
Access Control	See Chapter 1420 and the Master Plan for Limited Access Highways, or WAC 468-52 and the region's Highway Access Management Classification Report							

(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 ft. In urban areas, see Chapter 440. On designated bicycle routes, the minimum shoulder width is 4 ft. (See Chapter 1020.)

(4) For lanes 11 ft or more in width, the minimum shoulder width to the face of the curb is 1 ft on the left.

(5) May be reduced by 2 ft 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 ft or less, see Chapter 1120.

(9) Add 11 ft for each additional lane.

(10) Add 12 ft for each additional lane.

(11) Includes a 4 ft median which may be reduced by 2 ft 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 ft shoulders — may be reduced by 2 ft 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.

Modified Design Level for Multilane Highways and Bridges

Figure 430-3

	Two-Lane Highways					
	Trucks Under 10%			Trucks 10% and Over		
Design Class	MDL-9	MDL-10	MDL-11	MDL-12	MDL-13	MDL-14
Current ADT(1)	Under 1000	1000-4000	Over 4000	Under 1000	1000-4000	Over 4000
Design Speed	The posted speed, the proposed posted speed, or the operating speed, whichever is higher.					
Traffic Lane(2) Width	11 ft	11 ft	11 ft	11 ft	12 ft	12 ft
Parking Lanes Urban	8 ft	8 ft	8 ft (3)	8 ft	8 ft	8 ft (3)
Shoulder Width(4)	2 ft	3 ft (5)	4 ft	2 ft	3 ft (5)	4 ft
Minimum Width for Bridges to Remain in Place (6)(7)	22 ft (8)	24 ft	28 ft	22 ft (8)	24 ft	28 ft
Minimum Width for Rehabilitation of Bridges to Remain in Place (7)(9)	28 ft (10)	32 ft	32 ft	28 ft (10)	32 ft	32 ft
Minimum Width for Replacement	Full Design Level Applies (11)					
Access Control	See Chapter 1420 and the Master Plan for Limited Access Highways, or WAC 468-52 and the region's Highway Management Classification Report.					

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

(2) See Figures 430-5 and 430-6 for turning roadways.

(3) Parking restriction recommended when ADT exceeds 7,500.

(4) When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 ft. On designated bicycle routes the minimum shoulder width is 4 ft (See Chapter 1020).

(5) For design speeds of 50 mph or less on roads of 2,000 ADT or less, width may be reduced by 1 ft, with justification.

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

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

(8) 20 ft when ADT 250 or less.

(9) 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.

(10) 26 when ADT 250 or less.

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

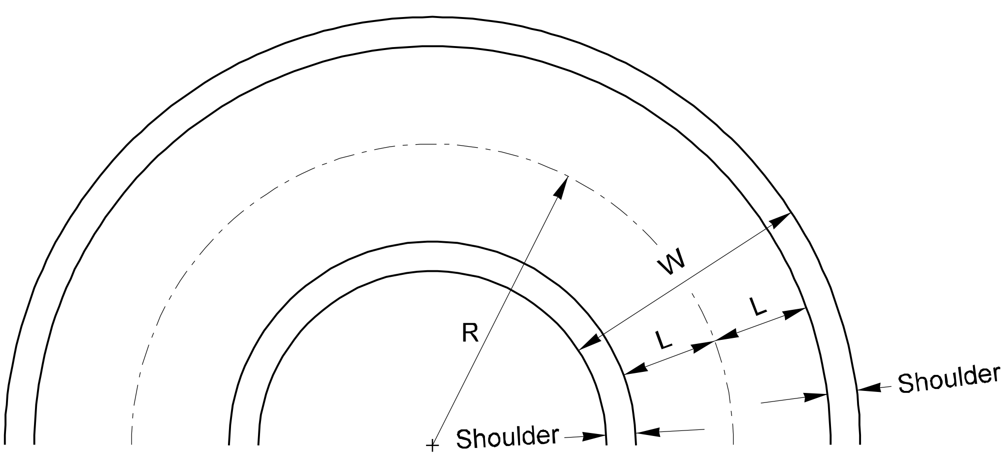
Modified Design Level for Two-Lane Highways and Bridges

Figure 430-4

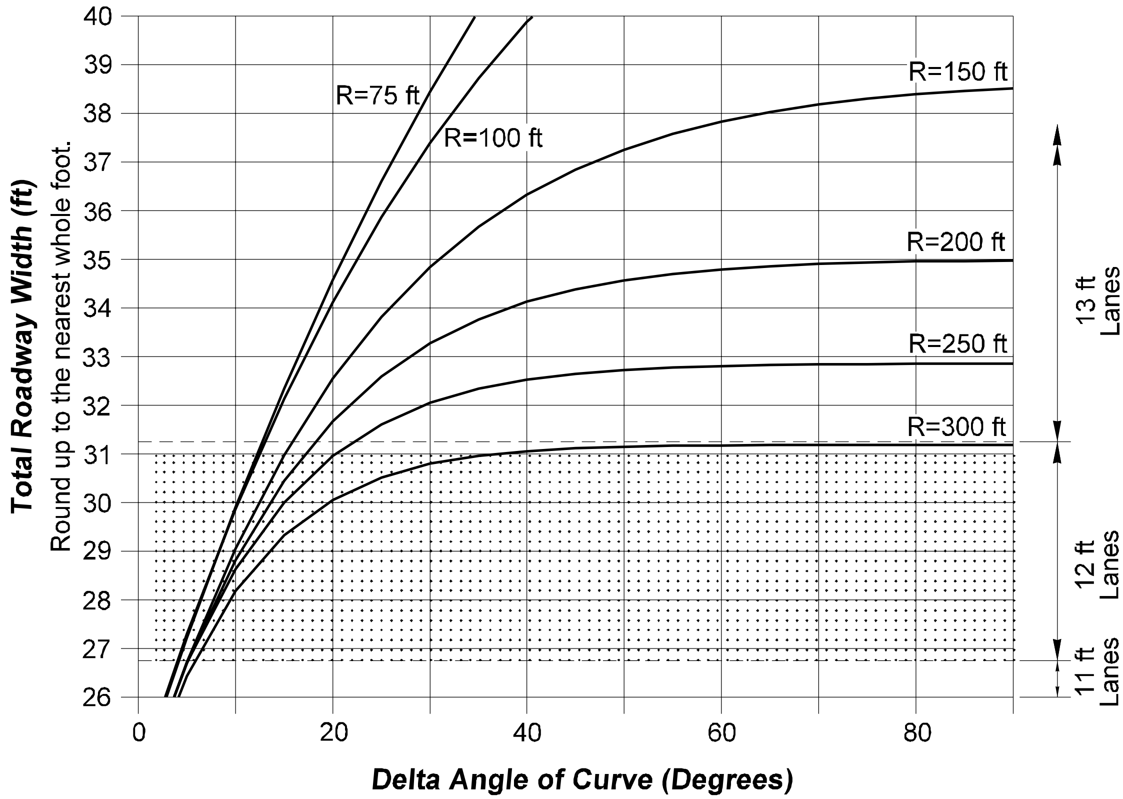
Radius of Center Line R (ft)	Minimum Total Roadway Width W (ft)	Minimum Lane Width L (ft)
Tangent	26	11
900	26	11
800	27	12
700	27	12
600	28	12
500	28	12
400	29	12
350	30	12
300	31	12
250	33	13
200	35	13
150	39	13

Notes: Also see minimums from Figure 430-4.

If the minimum total roadway width is greater than the sum of the shoulders and lane widths, apply the extra width to the inside of the curve.

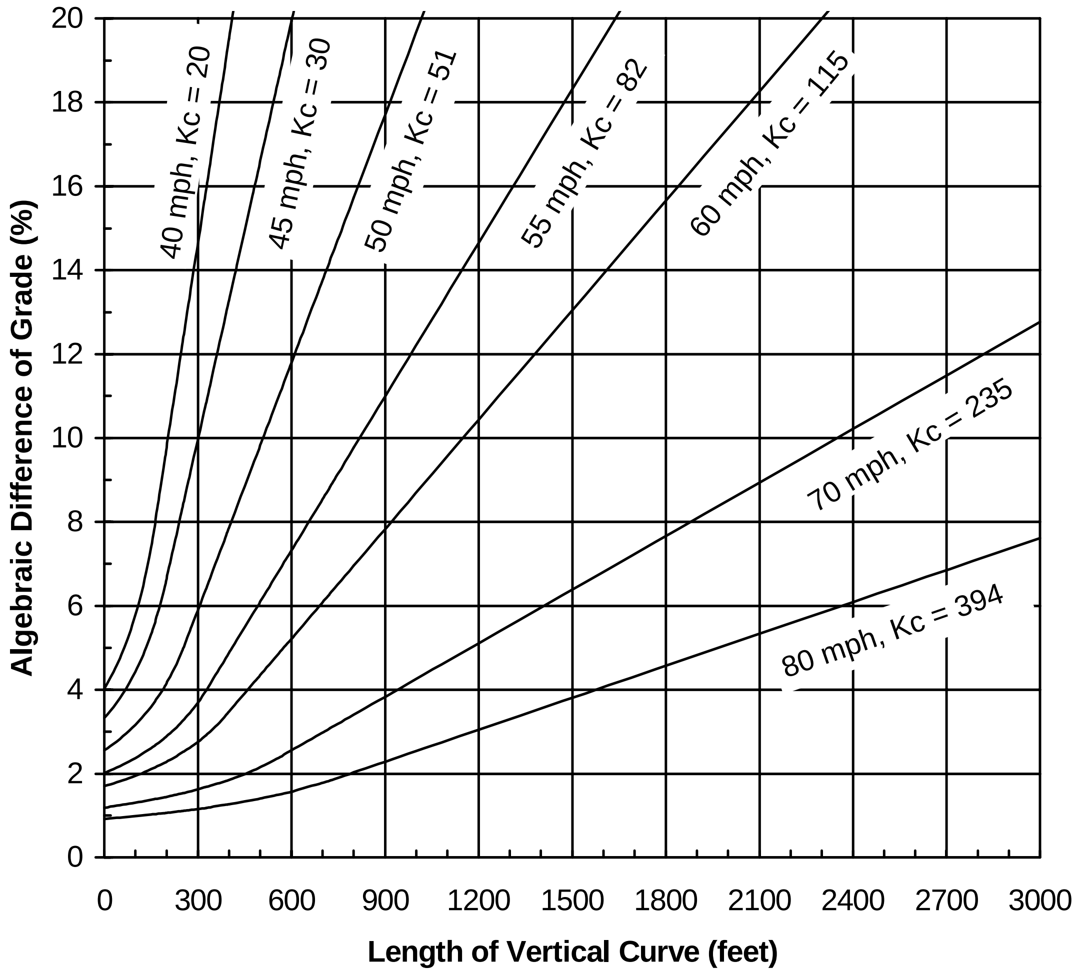


Minimum Total Roadway Widths for Two-Lane Highway Curves
Modified Design Level
Figure 430-5



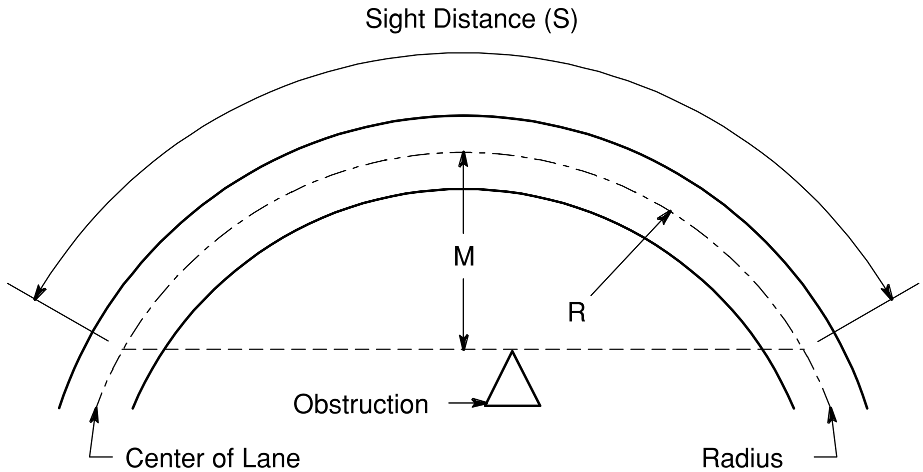
If result is less than the total roadway width
from Figure 430 - 4, use the greater.

Minimum Total Roadway Widths for Two-Lane Highway Curves, D<90°
Modified Design Level
Figure 430-6

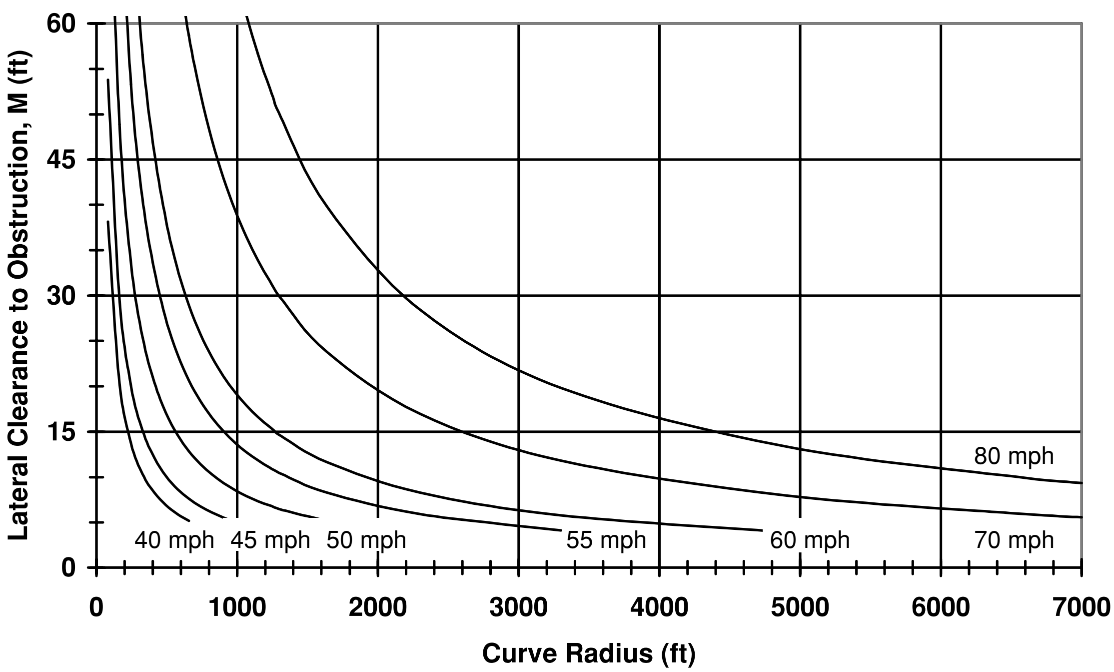


When the intersection of the algebraic difference of grade with the length of vertical curve is above the selected design speed line, corrective action must be considered.
Kc see Chapter 650

Evaluation for Stopping Sight Distance for Crest Vertical Curves
Modified Design Level
Figure 430-7

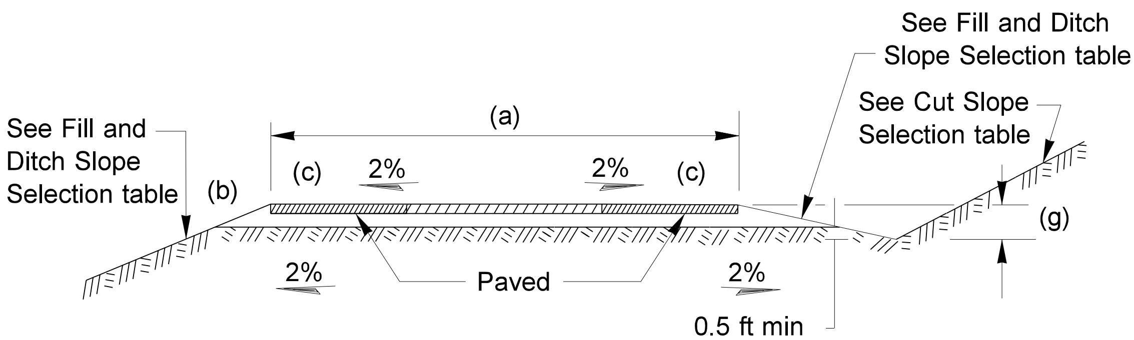


M is the distance in feet from the center line
of the inside lane to the obstruction.
Obstruction is a cut slope or other object
2 ft or more above the inside lane.



When the intersection of the lateral clearance (M) with the
curve radius (R) falls below the curve for the selected
design speed, corrective action must be considered.

Evaluation for Stopping Sight Distance for Horizontal Curves
Modified Design Level
Figure 430-8



Height of Cut (ft)	Slope not Steeper than (d)
0 - 5	4H:1V
5 - 20	3H:1V
over 20	2H:1V

Cut Slope Selection

Height of Fill/Depth of Ditch (ft)	Slope not Steeper than
0 - 20	4H:1V
20- 30	3H:1V
over 30	2H:1V (e)(f)

Fill and Ditch Slope Selection

Notes:

(a) See Figures 430-3 and 4 for minimum roadway widths and Figures 430-5 and 6 for turning roadway widths.

(b) Widen and round embankments steeper than 4H:1V.

(c) See Chapter 640 for shoulder slope requirements.

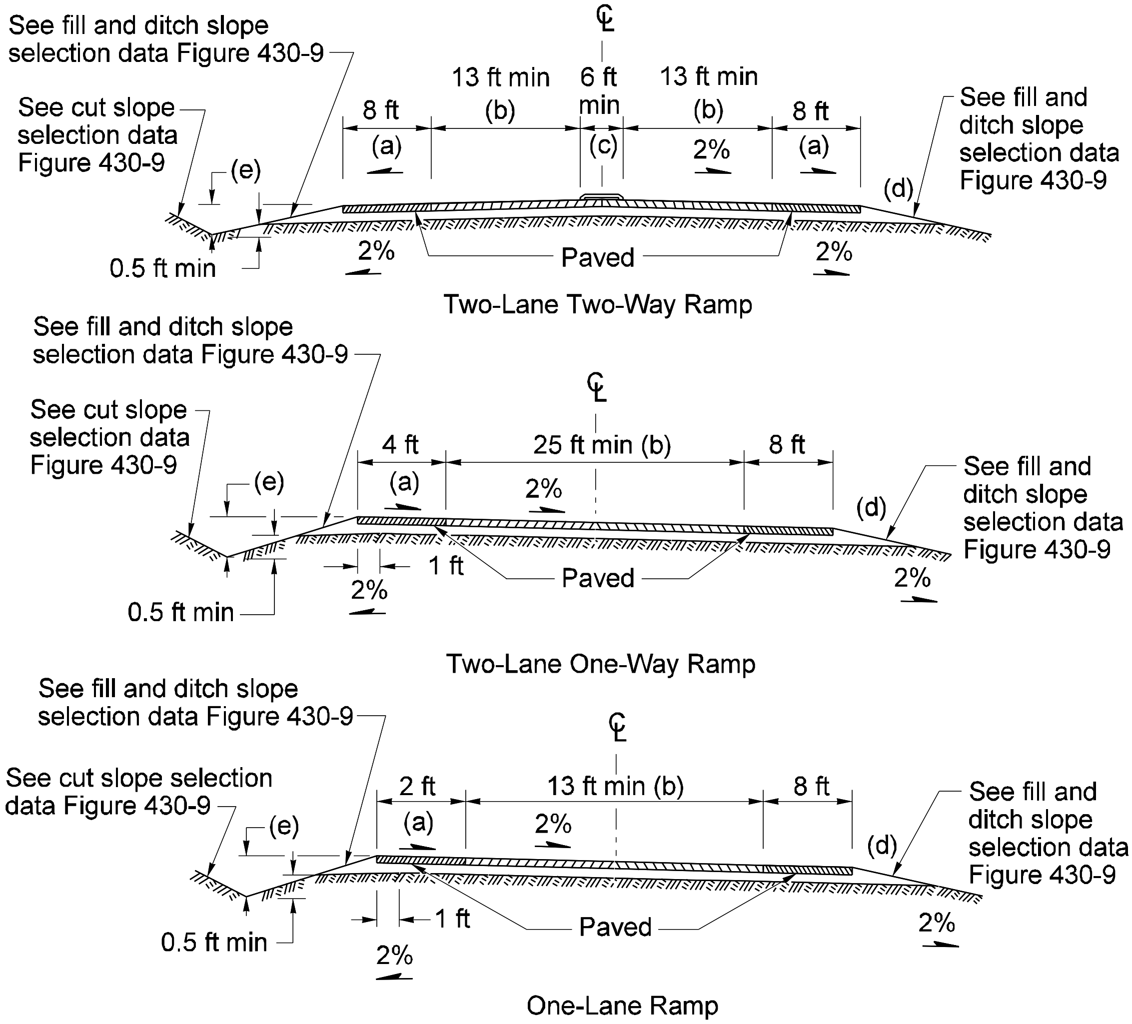
(d) Or as recommended by the soils or geotechnical report. Refer to Chapter 700 for clear zone and barrier requirements.

(e) Consider flatter slopes for the greater fill heights and ditch depths where practical.

(f) Fill slopes up to 1 1/2H:1V may be used where favorable soil conditions exist. Refer to Chapter 640 for additional details and Chapter 700 for clear zone and barrier requirements.

(g) Minimum ditch depth is 2 ft for design speeds over 40 mph or 1.5 ft for design speeds 40 mph or less.

Main Line Roadway Sections
Modified Design Level
Figure 430-9



(a) See Chapter 640 for shoulder slope requirements.

(b) See text 430.04 for minimum ramp width.

(c) 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.

(d) Widen and round embankments steeper than 4H : 1V.

(e) Minimum ditch depth is 2 ft for design speeds over 40 mph and 1.5 ft for design speeds at and under 40 mph.

Ramp Roadway Sections
Modified Design Level
Figure 430-10

440.01 General

Full design level is the highest level of design and is used on new and reconstructed highways. These projects are designed to provide optimum mobility, safety, and efficiency of traffic movement. The overall objective is to move the greatest number of vehicles, at the highest allowable speed, and at optimum safety. Major design controls are functional classification, terrain classification, urban or rural surroundings, traffic volume, traffic character and composition, design speed, and access control.

440.02 References

Revised Code of Washington (RCW) 46.61.575, Additional parking regulations

RCW 47.05.021, Functional classification of highways.

RCW 47.24, City Streets as Part of State Highways

Washington Administrative Code (WAC) 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings"

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.

Plans Preparation Manual, WSDOT, M 22-31

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

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

A Policy on Design Standards - Interstate System, 1991, AASHTO

440.03 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.

bikeway Any trail, path, part of a highway or shoulder, sidewalk, or any other traveled way specifically signed and/or marked for bicycle travel.

collector system Routes that primarily serve the more important intercounty, intracounty, and intraurban travel corridors, collect traffic from the system of local access roads and convey it to the arterial system, and on which, regardless of traffic volume, the predominant travel distances are shorter than on arterial routes (RCW 47.05.021).

design speed The speed used to determine the various geometric design features of the roadway.

divided multilane A roadway with 2 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.

frontage road An auxiliary road that is a local road or street located on the side of a highway for service to abutting property and adjacent areas and for control of access.

functional classification The grouping of streets and highways according to the character of the service they are intended to provide.

high pavement type Portland cement concrete pavement or hot mix asphalt pavement on treated base.

incorporated city or town A city or town operating under either Title 35 or 35A RCW.

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

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 system. The Interstate System is part of the principal arterial system.

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 Standard Specifications. The width of an existing lane is measured from the edge of traveled way to the center of the lane line or between the centers of adjacent lane lines.

limited access highway All highways where the rights of direct access to or from abutting lands have been acquired from the abutting landowners.

low pavement type Bituminous surface treatment (BST).

managed access highway All highways where the rights of direct access to or from abutting lands have not been acquired from the abutting landowners.

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

minor arterial system A rural network of arterial routes linking cities and other activity centers that generate long distance travel and, with appropriate extensions into and through urban areas, form an integrated network providing interstate and interregional service (RCW 47.05.021).

***National Highway System* (NHS)** An interconnected system of principal arterial routes that serves interstate and interregional travel; meets national defense requirements; and serves major population centers, international border crossings, ports, airports, public transportation facilities, other intermodal transportation facilities, and other major travel destinations. The Interstate System is a part of the NHS.

operating speed The speed at which drivers are observed operating their vehicles during free-flow conditions. The 85th percentile of the distribution of observed speeds is most frequently used.

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

posted speed The maximum legal speed as posted on a section of highway using regulatory signs.

principal arterial system A connected network of rural arterial routes with appropriate extensions into and through urban areas, including all routes designated as part of the Interstate System, that serve corridor movements having travel characteristics indicative of substantial statewide and interstate travel (RCW 47.05.021).

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

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

shoulder width The lateral width of the shoulder, measured from the edge of traveled way to the edge of the roadway or face of curb.

suburban area A term for the area at the boundary of an urban area. Suburban settings may combine higher speeds common in rural areas with activities that are more similar to urban settings. Separate design values are not given for suburban areas, classify suburban areas as either urban or rural as best fits the existing or design year conditions.

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.

two-way left-turn lanes (TWLTL) A lane, located between opposing lanes of traffic, to be used by vehicles making left turns from either direction, either from or onto the roadway.

undivided multilane A roadway with 2 or more through lanes in each direction on which left-turns are not controlled.

urban area An area defined by one or more of the following:

- An area including and adjacent to a municipality or other urban place having a population of five thousand or more, as determined by the latest available published official Federal census, decennial or special, within boundaries to be fixed by a State highway department, subject to the approval of the FHWA.
- Within the limits of an incorporated city or town
- Characterized by intensive use of the land for the location of structures and receiving such urban services as sewer, water, and other public utilities and services normally associated with an incorporated city or town.
- With not more than twenty-five percent undeveloped land.

urbanized area An urban area with a population of 50,000 or more.

usable shoulder The width of the shoulder that can be used by a vehicle for stopping.

440.04 Functional Classification

As provided in RCW 47.05.021, the state highway system is divided and classified according to the character and volume of traffic carried by the routes and distinguished by specific geometric design <u>criteria</u>. The functional classifications used on highways, from highest to lowest classification, are Interstate, principal arterial, minor arterial, and collector. The higher functional classes give more priority to through traffic and less to local access.

The criteria used <u>to determine</u> the functional classification consider the following:

- Urban population centers <u>inside</u> and <u>outside</u> the state stratified and ranked according to size.
- Important traffic generating economic activities, including but not limited to recreation, agriculture, government, business, and industry.
- Feasibility of the route, including availability of alternate routes <u>inside</u> and <u>outside</u> the state.
- Directness of travel and distance between points of economic importance.
- Length of trips.
- Character and volume of traffic.
- Preferential consideration for multiple service which shall include public transportation.
- Reasonable spacing depending upon population density.
- System continuity.

440.05 Terrain Classification

To provide a general basis of reference between terrain and geometric design, three classifications of terrain have been established.

Level. Level to moderately rolling. This terrain offers few or no obstacles to the construction of a highway having continuously unrestricted horizontal and vertical alignment.

Rolling. Hills and foothills. Slopes rise and fall gently but occasional steep slopes might offer some restriction to horizontal and vertical alignment.

Mountainous. Rugged foothills, high steep drainage divides, and mountain ranges.

Terrain classification pertains to the general character of the specific route corridor. Roads in valleys or passes of mountainous areas might have all the characteristics of roads traversing level or rolling terrain and are usually classified as level or rolling rather than mountainous.

440.06 Geometric Design Data

(1) State Highway System

For projects designed to full design level, all highways in rural areas and limited access highways in urban areas the geometric design data is controlled by the functional class (Figures 440-4 through 7b). The urban managed access highway design class (Figure 440-8) may be used on managed access highways in urban areas, regardless of the functional class.

(2) State Highways as City Streets

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. For facilities on the NHS, use the *Design Manual* criteria as the minimum for the functional class of the route. For facilities not on the NHS, the *Local Agency Guidelines* may be used as the minimum design criteria; however, the use of *Design Manual* criteria is encouraged where feasible. On managed access highways within the limits of incorporated cities and towns, the cities or towns have full responsibility for design elements outside of curb, or outside the paved shoulder where no curb exists, using the *Local Agency Guidelines.*

(3) City Streets and County Roads

Plan and design facilities that cities or counties will be requested to accept as city streets or county roads according to the applicable design criteria shown in:

- WAC 468-18-040.
- *Local Agency Guidelines*.
- The standards of the local agency that will be requested to accept the facility.

440.07 Design Speed

Vertical and horizontal alignment, sight distance, and superelevation will vary appreciably with design speed. Such features as traveled way width, shoulder width, and lateral clearances are usually not affected. See Chapters 620, 630, 642, and 650 for the relationships between design speed, geometric plan elements, geometric profile elements, superelevation, and sight distance.

The choice of a design speed is influenced principally by functional classification, posted speed, operating speed, terrain classification, traffic volumes, accident history, access control, and economic factors. However, a geometric design that adequately allows for future improvement is the major criterion, rather than strictly economics. Categorizing a highway by a terrain classification often results in arbitrary reductions of the design speed when, in fact, the terrain would allow a higher design speed without materially affecting the cost of construction. Savings in vehicle operation and other costs alone might be sufficient to offset the increased cost of right of way and construction.

It is important to consider the geometric conditions of adjacent sections. Maintain a uniform design speed for a significant segment of highway.

For all rural highways and limited access highways in urban areas, the design speed is given for each design class in Figures 440-4 through 7b.

When terrain or existing development limit the ability to achieve the design speed for the functional class, use a corridor analysis to determine the appropriate design speed. The desirable design speed is not less than given in Figure 440-1. Do not select a design speed less than the posted speed.

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 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 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, 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 in 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 in 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. Submit Form 223-528, Pavement Type Determination to the HQ Materials Laboratory for a final determination of the pavement type to use. 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. 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/

Design Class	Divided Multilane 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)		
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) Submit Form 223-528, 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.

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)												
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) Submit Form 223-528, 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.

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) 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) Submit Form 223-528, 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.

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)	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)	

Type of Terrain	Rural — Design Speed (mph)										Urban — Design Speed (mph)								
	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) Submit Form 223-528, 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.

Geometric Design Data, Collector
Figure 440-7b

Design Class	Divided Multilane		Undivided Multilane		Two-Lane	
	$U_{M/A}$-1	$U_{M/A}$-2	$U_{M/A}$-3	$U_{M/A}$-4	$U_{M/A}$-5	$U_{M/A}$-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)						
Right of Traffic	10	10 (8)	8 (8)	8 (8)	8 (9) (8)	4 (8)
Left of Traffic	4	4 (8)				
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.

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

510.01 General

It is the responsibility of the Washington State Department of Transportation (WSDOT) to understand the characteristics of the soil and rock materials that support or are adjacent to the transportation facility to ensure that the facility, when designed, will be adequate to safely carry the estimated traffic. It is also the responsibility of WSDOT to ensure the quality and quantity of all borrow materials used in the construction of transportation facilities.

The following information serves as guidance in the above areas. Where a project consists of a surface overlay of an existing highway, requirements as set forth in *WSDOT Pavement Guide for Design, Evaluation and Rehabilitation* are used.

To identify the extent and estimated cost for a project, it is necessary to obtain and use an adequate base data. In recognition of this need, preliminary soils investigation work begins during project definition. This allows early investigative work and provides necessary data in a timely manner for use in project definition and design. More detailed subsurface investigation follows during the project design and plan, specification, and estimate (PS&E) phases.

It is essential to get the region's Materials Engineer (RME) and the Headquarters (HQ) Geotechnical Services Division involved in the project design as soon as possible once the need for geotechnical work is identified. See 510.04(3) for time-estimate information. Furthermore, if major changes occur as the project is developed, inform the RME and HQ Geotechnical Services Division as soon as possible so that the geotechnical design can be adapted to the changes without significant delay to the project.

510.02 References

Construction Manual, M 41-01, WSDOT

Hydraulics Manual, M 23-03, 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

WSDOT Pavement Guide Interactive

510.03 Materials Sources

(1) General

The region's Project Development Engineer (RPDE) determines when a materials source is needed. The region's Materials Engineer (RME) determines the best materials source for the project. (See Figure 510-1.) It is preferred that existing approved materials source sites be used when there are suitable sites available. When there are no approved sites available, the RME conducts a site investigation. The HQ Geotechnical Services Division provides assistance upon request.

The RME selects sources for gravel base, borrow excavation and gravel borrow, crushed surfacing materials, mineral and concrete aggregates, riprap, and filler only after careful investigation of:

- The site. (Consider the adequacy of the work area.)
- The quality of the material.
- The quantity of the material. (Consider the needs of the immediate project and the needs to support future maintenance and construction work in the area.)

- Reclamation requirements.
- Aesthetic considerations.
- Economic factors.
- Ability to preserve or enhance the visual quality of the highway and local surroundings.

Once the materials source investigation and laboratory testing have been completed the RME prepares a materials source report. The materials source report summarizes the site geology, site investigation (including boring and test pit logs), source description, quality and quantity of material available, and other aspects of the materials sources that are relevant.

(2) Materials Source Approval

The RME submits the materials source report to the HQ Geotechnical Services Division for review and approval.

The HQ Materials Office and the HQ Design Office must approve each pit or quarry site before it is purchased, leased, or acquired on a royalty basis. Until the approval process is complete, the project cannot be advertised for bids. Local and state permits are required for materials sources. To avoid delay in advertising the project, begin the site investigations and permitting process in the early stages of project definition.

510.04 Geotechnical Investigation, Design, and Reporting

(1) General

A geotechnical investigation is conducted on all projects that involve significant grading quantities, unstable ground, or foundations for structures in a manner that preserves the safety of the public who use the facility, as well as preserving the economic investment by the state of Washington. Geotechnical engineering must be conducted by engineers or engineering geologists who possess adequate geotechnical training and experience, and must be conducted in accordance with regionally or nationally accepted geotechnical practice. Where required by law, geotechnical engineering must be performed by, or under the direct supervision of, a person licensed to perform such work in the state of Washington.

(2) Key Contacts for Initiating Geotechnical Work

In general, the RME functions as the clearing house for all geotechnical work, with the exception of structural projects and Washington State Ferries (WSF) projects. The RME takes the lead in conducting the geotechnical work if the geotechnical work required is such that the ground is stable and relatively firm, bedrock is not involved, and the design of the project geotechnical elements does not require specialized geotechnical design expertise. If this is not the case, the RME asks for the involvement and services of the HQ Geotechnical Services Division. They respond to and provide recommendations directly to the region's project design office (or the HQ Facilities Office in the case of Facilities projects), but always keeping the RME "in the loop."

For structural projects (bridges and tunnels, for example), the HQ Bridge and Structures Office works directly with the HQ Geotechnical Services Division.

For WSF projects, the Terminal Engineering Office works directly with the RME or the HQ Geotechnical Services Division, depending on the nature of the project.

For walls and noise walls, see Chapters 1130 and 1140, respectively. For geosynthetic design, see Chapter 530.

(3) Scheduling Considerations for Geotechnical Work

The region's Design Office, HQ Bridge and Structures Office, WSF, and the HQ Facilities Office are responsible for identifying the potential need for geotechnical work, and requesting time and budget estimates from the RME or the HQ Geotechnical Services Division, as early as practical to prevent delays to the project.

Once the geotechnical design request and the site data are received by the RME or the HQ Geotechnical Services Division, it can take anywhere from two to six months, or more, to complete the geotechnical design, depending on the complexity of the project, whether or not test holes are needed, current workload, the need to give the work to consultants, and how long it takes to obtain environmental permits and rights of entry (ROE).

If a consultant must be used, the minimum time required to complete a design (for even a simple project) is typically 2.5 months.

In true emergency situations (a highway blocked by a landslide or a collapsed bridge, for example), it is possible to get geotechnical design work completed (in house or by consultants) more rapidly to at least provide a design for temporary mitigation.

Consider all of these factors when deciding how soon to initiate the geotechnical work for a project but, in general, the sooner, the better.

(4) Site Data and Permits Needed to Initiate Geotechnical Work

To initiate geotechnical work on a project during the design and PS&E phases, provide the following information:

(a) Project description.

(b) Plan sheets showing the following:

- Station and location of cuts, fills, walls, bridges, retention/detention ponds, or other geotechnical features to be designed.
- Existing utilities (as-built plans are acceptable).
- Right of way limits.
- Wetlands.
- Drainage features.
- Existing structures.
- Other features or constraints that could affect the geotechnical design or investigation.

(c) Electronic files, or cross sections every 50 ft to 65 ft or as appropriate, to define existing and new ground line above and below the wall, cut, fill, and other pertinent information.

- Show stationing.
- Show locations of existing utilities, right of way lines, wetlands, and other constraints.
- Show locations of existing structures that might contribute load to the cut or fill.

(d) Right of entry agreements and permits required for geotechnical investigation.

(e) Due date and work order number.

(f) Contact person.

When the alignment and any constraints as noted above are staked, the stationing on the plans and in the field must be in the same units. Physical surveys are preferred to photogrammetric surveys to ensure adequate accuracy of the site data.

Permits and agreements to be supplied by the region might include:

- HPA
- Shoreline permits
- Tribal lands and waters
- Railroad easement and right of way
- City, county, or local agency use permits
- Sensitive area ordinance permits

The region's project office is also responsible for providing the stations, offsets, and elevations of test holes to the nearest 1 ft once the test holes have been drilled. Provide test hole locations using state plane coordinates as well, if available.

(5) Overview of Geotechnical Design Objectives for the Various Project Stages

(a) **Project Definition.** The project design office uses the geotechnical investigation results obtained during the project definition phase to develop the project delivery cost and schedule. Geotechnical recommendations provided for this phase will be at the conceptual/feasibility level. The investigation for this phase usually consists of a visual project walk-through and a review of the existing records, geologic maps, and so forth.

For projects of significant geotechnical scope and complexity, and if soil borings are not available at critical locations within the project, some soil borings might be drilled at this time. Potential geotechnical hazards (earthquake faults, liquefaction, landslides, rockfall, soft ground, for example) are identified during project definition, and conceptual hazard avoidance or mitigation plans are developed. Future geotechnical design services needed in terms of time and cost, including the need for special permits to perform the geotechnical exploration (critical areas ordinances), are determined at this time.

(b) **Project Design.** Once the roadway geometry is established, detailed design of cut and fill slopes, adequate to establish the right of way needs, is accomplished. Once approximate wall locations and heights are known, preliminary design of walls is performed to establish feasibility, primarily to establish right of way needs (as is true for slopes) and likely wall types. A similar level of design is applied to hydraulic structures, and to determine overall construction staging and constructibility requirements to address the geotechnical issues at the site. Conceptual and/or more detailed preliminary bridge foundation design is conducted during this phase if it was not conducted during project definition. Before the end of this phase, the geotechnical data necessary to allow future completion of the PS&E level design work is gathered (final geometric data, test hole data, and so forth.).

(c) **PS&E Development.** Final design of all geotechnical project features is accomplished. Recommendations for these designs, as well as special provisions and plan details to incorporate the geotechnical design recommendations in the PS&E, are provided in the geotechnical report. Minor geotechnical features such as signal/sign foundations and small detention/retention ponds are likely to be addressed at this stage, as the project details become clearer. Detailed recommendations for the constructibility of the project geotechnical features are also provided.

(6) Earthwork

(a) **Project Definition.** The project designer contacts and meets with the RME, and the HQ Geotechnical Services Division as needed, at the project site to conduct a field review to help identify the geotechnical issues for the project.

In general, if soil/rock conditions are poor and/or large cuts or fills are anticipated, the RME requests that the HQ Geotechnical Services Division participate in the field review and reporting efforts.

The designer provides a description and location of the proposed earthwork to the RME.

- For widening of existing facilities, the anticipated width, length, and location of the widening, relative to the current facility, are provided.
- For realignments, the approximate new location proposed for the facility is provided.
- Locations in terms of length can be by mile post or stations.

A brief conceptual level report is provided to the designer that summarizes the results of the investigation.

(b) **Project Design.** Geotechnical data necessary to allow completion of the PS&E level design is compiled during the design phase. This includes soils borings, testing, and final geometric data. Detailed design of cut and fill slopes can be done once the roadway geometry is established and geotechnical data is available. The purpose of this design effort is to determine the maximum stable cut or fill slope and, for fills, potential for short and long term settlement. Also, the usability of the cut materials and the type of borrow needed for the project, if any, is evaluated. Evaluate the use of soil bioengineering as an option for building steeper slopes or to prevent surface erosion. See the Chapter 1350 "Soil Bioengineering," for more information.

The designer requests a geotechnical report from the RME. The site data indicated in 510.04(4), as applicable, is provided. It is important that the request for the geotechnical report be made as early in the design phase as practical. Cost and schedule requirements to generate the report are project specific and can vary widely. The time required to obtain permits and rights of entry must be considered when establishing schedule requirements.

The RME, in conjunction with the HQ Geotechnical Services Division, provides the following information as part of the geotechnical report (as applicable):

1. General description of the regional and site geology

2. Summary of the investigation

3. Boring logs
4. Laboratory tests and results
5. Soil/rock unit descriptions
6. Ground water conditions
7. Embankment design recommendations
    - The slope required for stability
    - Estimated amount and rate of settlement
    - Stability and settlement mitigation requirements
    - Construction staging requirements
    - Effects of site constraints
    - Monitoring needs
    - Material and compaction requirements
    - Subgrade preparation
8. Cut design recommendations
    - The slope required for stability
    - Stability mitigation requirements (deep seated stability and erosion)
    - Identification of seepage areas and how to mitigate them
    - Effects of site constraints
    - Monitoring requirements
    - Usability of excavated cut material, including gradation, moisture conditions and need for aeration, and shrink/swell characteristics

The recommendations include the background regarding analysis approach and any agreements with the region or other customers regarding the definition of acceptable level of risk.

The project office uses the report to finalize design decisions for the project. To meet slope stability requirements, additional right of way might be required or a wall might be needed. Wall design is covered in Chapter 1130. Construction timing might require importing material rather than using cut materials. The report is used to address this and other constructibility issues. The report is also used to proceed with completion of the project PS&E design.

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

Special provisions and plan details, if not received as part of the report provided during project design, are developed with the assistance of the RME or the HQ Geotechnical Services Division. The project designer uses this information, as well as the design phase report, to complete the PS&E documents. Both the region's Materials Section and the HQ Geotechnical Services Division can review the contract plans before the PS&E review process begins, if requested. Otherwise, they will review the contract plans during the normal PS&E review process.

(7) Hydraulic Structures and Environmental Mitigation

(a) **Project Definition.** The designer provides a description and location of the proposed hydraulic/environmental improvements and other pertinent site information, and discusses the extent of the hydraulics and environmental improvements, with both the RME and the HQ Hydraulics Branch, to identify the geotechnical issues to be investigated. At this stage, only the identification and feasibility of the proposed hydraulic structures or environmental mitigation are investigated. The cost and schedule requirements for the geotechnical investigation are also determined at this time.

Examples of hydraulic structures include, but are not limited to, large culverts, pipe arches, underground detention vaults, and fish passage structures. Examples of environmental mitigation include, but are not limited to, detention/retention ponds and wetland creation.

(b) **Project Design.** The designer requests a geotechnical report from the RME. The site data indicated in 510.04(4), as applicable, is provided along with the following information:

- Pertinent field observations (such as unstable slopes, existing soft soils or boulders, or erosion around and damage to existing culverts or other drainage structures).
- Jurisdictional requirements for geotechnical design of berms/dams.

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

The RME, with support from the HQ Geotechnical Services Division as needed, provides the following information, when requested and where applicable, as part of the project geotechnical report:

- Soil boring logs.
- Soil pH and resistivity.
- Water table elevation.
- Soil infiltration rates (highest rate for assessing spill containment/aquifer protection and long-term rate for determining pond capacity).
- Bearing capacity and settlement for hydraulic structure foundations.
- Slope stability for ponds.
- Retention berm/dam design.
- Potential for and amount of differential settlement along culverts and pipe arches and the estimated time required for settlement to occur.
- Soil pressures and properties (primarily for underground detention vaults).
- Erosion potential.
- Geosynthetic design per Chapter 530.
- Recommendations for mitigation of the effect of soft or unstable soil on the hydraulic structures.
- Recommendations for construction.

Note that retaining walls that are part of a pond, fish passage, and the like, are designed per Chapter 1130.

The project designer uses the geotechnical information to:

- Finalize design decisions.
- Evaluate and mitigate environmental issues.
- Proceed with completion of the PS&E design (includes determining the most cost effective hydraulic structure/pond to meet the desired objectives, locating and sizing ponds and foundations for hydraulic structures, structural design, mitigating the effects of settlement, satisfying local jurisdictional requirements for design, and so forth).

(c) **PS&E Development.** During PS&E development, the designer uses the information provided in the geotechnical report as follows:

- Select pipe materials in accordance with corrosion, resistivity, and abrasion guidelines in the *Hydraulics Manual*.
- Consider and include construction recommendations.

Additional design and specification guidance and support from the RME or the HQ Geotechnical Services Division are sought as needed. Both sections provide careful review of the contract plans before the PS&E review process begins, if requested. Otherwise, they will review the contract plans during the normal PS&E review process.

(8) Signals, Sign Bridges, Cantilever Signs, and Luminaire Foundations

(a) **Project Definition and Design.** Geotechnical information is usually not required for signals, sign bridges, cantilever signs, and luminaires during project definition.

The region’s Traffic Office contacts the RME for conceptual foundation recommendations. The conceptual recommendations are based on existing information in the area, and identify if Standard Plan foundations are feasible or if special design foundations are required. If good soils are anticipated or the foundations will be placed in fill, Standard Plan foundations can be assumed. If special design foundations are required, additional time and money can be included in the project to accommodate increased field exploration for foundation design, HQ Geotechnical Services Division involvement, and structural design by the HQ Bridge and Structures Office.

(b) **PS&E Development.** Foundation recommendations are made by either the RME or the HQ Geotechnical Services Division. The recommendations provide all necessary geotechnical information to complete the PS&E.

The region's Traffic Office (or region's Project Engineer in some cases) is responsible for delivering the following project information to the region's Materials Engineer:

- Plan sheet showing the location of the structures (station and offset) and the planned structure type.
- Applicable values for: XYZ, strain pole class, sign bridge span length, luminaire height, variable message sign weight, wind load, CCTV pole height, and known utility information in the area.

The RME provides the following information to the requester if Standard Plan foundation types can be used:

- Allowable lateral bearing capacity of the soil.
- Results of all field explorations.
- Groundwater elevation.
- Foundation constructibility.

The region uses this information to complete the plan sheets and prepare any special provisions. If utilities are identified during the field investigation that could conflict with the foundations, the region's project office pursues moving or accommodating the utility. Accommodation could require special foundation designs.

If special designs are required, the RME notifies the requester that special designs are required and forwards the information received from the region to the HQ Geotechnical Services Division. The HQ Geotechnical Services Division provides the HQ Bridge and Structures Office with the necessary geotechnical recommendations to complete the foundation designs. The region coordinates with the HQ Bridge and Structures Office to ensure that they have all the information necessary to complete the design. Depending on the structure type and complexity, the HQ Bridge and Structures Office might produce the plan sheets and special provisions for the foundations, or they might provide the region with information so that the region can complete the plan sheets and special provisions.

(9) Buildings, Park and Ride Lots, Rest Areas, and Communication Towers

In general, the RME functions as the clearing house for the geotechnical work to be conducted in each of the phases for technical review of the work if the work is performed by consultants, or for getting the work done in-house. For sites and designs that are more geotechnically complex, the RME contacts the HQ Geotechnical Services Division for assistance.

Detailed geotechnical investigation guidance is provided in Facilities Operating Procedure 9-18, "Site Development." In summary, this guidance addresses the following phases of design:

(a) **Site Selection.** Conceptual geotechnical investigation (based on historical data and minimal subsurface investigation) of several alternative sites is performed in which the geotechnical feasibility of each site for the intended use is evaluated, allowing the sites to be ranked. In this phase, geological hazards (landslides, rockfall, compressible soils, liquefaction, and so forth) are identified, and geotechnical data adequate to determine a preliminary cost to develop and build on the site is gathered.

(b) **Schematic Design.** For the selected site, the best locations for structures, utilities, and other elements of the project are determined based on site constraints and ground conditions. In this phase, the site is characterized more thoroughly than in the site selection phase, but subsurface exploration is not structure specific.

(c) **Design Development.** The final locations of each of the project structures, utilities, and other project elements determined from the schematic design phase are identified. Once these final locations are available, a geotechnical investigation adequate to complete the final design of each of the project elements (structure foundations, detention/retention facilities, utilities, parking lots, roadways, site grading, and so forth) is conducted. From this investigation and design, the final PS&E is developed.

(10) Retaining Walls, Reinforced Slopes, and Noise Walls

(a) **Project Definition.** The designer provides a description and location of the proposed walls or reinforced slopes, including the potential size of the proposed structures and other pertinent site information, to the RME. At this stage, only the identification and feasibility of the proposed walls or reinforced slopes are investigated. A field review may also be conducted at this time as part of the investigation effort. In general, if soil/rock conditions are poor and/or large walls or reinforced slopes are anticipated, the RME requests that the HQ Geotechnical Services Division participate in the field review and reporting efforts. The cost and schedule requirements for the geotechnical investigation are also determined at this time.

A brief conceptual level report that summarizes the results of the investigation may be provided to the designer at this time, depending on the complexity of the geotechnical issues.

(b) **Project Design and PS&E Development**. Geotechnical data necessary to allow completion of the PS&E level design for walls and reinforced slopes are compiled during the design and PS&E development phases. This includes soils borings, testing, and final geometric data. Detailed design of walls and reinforced slopes can be done once the roadway geometry is established and geotechnical data are available. The purpose of this design effort is to determine the wall and slope geometry needed for stability, noise wall and retaining wall foundation requirements, and the potential for short- and long-term settlement.

The designer requests a geotechnical report from the RME for retaining walls, noise walls, and reinforced slopes that are not part of the bridge preliminary plan. For walls that are part of the bridge preliminary plan, the HQ Bridge and Structures Office requests the geotechnical report for the walls from the HQ Geotechnical Services Division. For both cases, see Chapter 1130 for the detailed design process for retaining walls and reinforced slopes and Chapter 1140 for the detailed design process for noise walls. It is important that requests for a geotechnical report be made as early in the design phase as practical. The time required to obtain permits and rights of entry must be considered when establishing schedule requirements.

For retaining walls and reinforced slopes, the site data to be provided with the request for a geotechnical report are as indicated in Chapter 1130. Also supply right of entry agreements and permits required for the geotechnical investigation. The site data indicated in 510.04(4), as applicable, are provided for noise walls.

The RME or the HQ Geotechnical Services Division (see Chapter 1130 or 1140 for specific responsibilities for design), provides the following information as part of the geotechnical report (as applicable):

1. General description of the regional and site geology
2. Summary of the investigation
3. Boring logs
4. Laboratory tests and results
5. Soil/rock unit descriptions
6. Ground water conditions
7. Retaining wall/reinforced slope and noise wall recommendations
    - Recommended geometry for stability
    - Stability and settlement mitigation requirements, if needed
    - Foundation type and capacity
    - Estimated amount and rate of settlement

- Design soil parameters
- Construction staging requirements
- Effects of site constraints
- Monitoring needs
- Material and compaction requirements
- Subgrade preparation

The recommendations may also include the background regarding analysis approach and any agreements with the region or other customers regarding the definition of acceptable level of risk. Additional details and design issues to be considered in the geotechnical report are as provided in Chapter 1130 for retaining walls and reinforced slopes and in Chapter 1140 for noise walls. The project designer uses this information for final wall/reinforced slope selection and to complete the PS&E.

For final PS&E preparation, special provisions and plan details (if not received as part of the report provided during project design) are developed with the assistance of the region Materials Section or the HQ Geotechnical Services Division. Both the region Materials Section and the HQ Geotechnical Services Division can review the contract plans before the PS&E review process begins, if requested. Otherwise, they will review the contract plans during the normal PS&E review process.

(11) Unstable Slopes

Unstable slope mitigation includes the stabilization of known landslides and rockfall that occur on slopes adjacent to the WSDOT transportation system, and that have been programmed under the P3 unstable slope program.

(a) **Project Definition.** The region's project office provides a description and location of the proposed unstable slope mitigation work to the RME. Location of the proposed work can be mile post limits or stationing. The region's project designer meets at the project site with the RME and HQ Geotechnical Services Division to conduct a field review, discuss project requirements, and identify geotechnical issues associated with the unstable slope project. The RME requests that the HQ Geotechnical Services Division participate in the field review and project definition reporting.

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

(b) **Project Design.** Geotechnical information and field data necessary to complete the unstable slope mitigation design is compiled during this design phase. This work includes, depending on the nature of the unstable slope problem, test borings, rock structure mapping, geotechnical field instrumentation, laboratory testing, and slope stability analysis. The purpose of this design effort is to determine the most appropriate method(s) to stabilize the known unstable slope.

The designer requests a geotechnical report from the HQ Geotechnical Services Division through the RME. The site data indicated in 510.04(4), as applicable, is provided along with the following information:

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

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

The HQ Geotechnical Services Division provides the following information as part of the project geotechnical report (as applicable):

- General site description and summary of site geology.
- Summary of the field investigation.
- Boring logs.
- Laboratory tests and results.
- Geotechnical field instrumentation results.
- Summary of the engineering geology of the site including geologic units encountered.
- Unstable slope design analysis and mitigation recommendations.
- Constructibility issues associated with the unstable slope mitigation.
- Appropriate special provisions for inclusion in the contact plans.

The region's project design office uses the geotechnical report to finalize the design decisions for the project and the completion of the PS&E design.

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

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

(12) Rockslope Design

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

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

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

The designer requests a geotechnical report from the HQ Geotechnical Services Division through the RME. The site data indicated in 510.04(4), as applicable, is provided.

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

The HQ Geotechnical Services Division provides the following information as part of the project geotechnical report (as applicable):

1. General site description and summary of site geology.

2. Summary of the field investigation.

3. Boring logs.

4. Laboratory tests and results.

5. Rock units encountered within the project limits.

6. Rock slope design analysis and recommendations.

- Type of rockslope design analysis conducted and limitation of the analysis. Also included will be any agreements with the region and other customers regarding the definition of acceptable risk
- The slope(s) required for stability
- Additional slope stabilization requirements (rock bolts, rock dowels, and so forth.)
- Rockslope ditch criteria (See Chapter 640)
- Assessment of rippability
- Blasting requirements including limitations on peak ground vibrations and air blast over-pressure, if required
- Usability of the excavated material including estimates of shrink and swell
- Constructibility issues associated with the rock excavation

The project office uses the geotechnical report to finalize the design decisions for the project, and the completion of the PS&E design for the rockslope elements of the project.

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

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

(13) Bridge Foundations

(a) **Project Definition.** The HQ Geotechnical Services Division supports the project definition process to develop reasonably accurate estimates of bridge substructure costs. For major projects and for projects that are located in areas with little or no existing geotechnical information, a field review is recommended. The region's office responsible for project definition coordinates field reviews. Subsurface exploration (drilling) is usually not required at this time, but might be needed if cost estimates cannot be prepared within an acceptable range of certainty.

The HQ Bridge and Structures Office, once they have received the necessary site data from the region's project office, is responsible for delivering the following project information to the HQ Geotechnical Services Division:

- Alternative alignments and/or locations of bridge structures.
- A preliminary estimate of channelization (structure width).

- Known environmental constraints.

The Bridge and Structures and region offices can expect to receive the following from the HQ Geotechnical Services Division:

- Summary or copies of existing geotechnical information.
- Identification of geotechnical hazards (slides, liquefiable soils, soft soil deposits, and so forth.).
- Identification of permits that might be required for subsurface exploration (drilling).
- Conceptual foundation types and depths.
- If requested, an estimated cost and time to complete a geotechnical foundation report.

The HQ Bridge and Structures Office uses this information to refine preliminary bridge costs. The region's project office uses the estimated cost and time to complete a geotechnical foundation report to develop the project delivery cost and schedule.

(b) **Project Design.** The HQ Geotechnical Services Division assists the HQ Bridge and Structures Office with preparation of the bridge Preliminary Plan. Geotechnical information gathered for project definition will normally be adequate for this phase, as test holes for the final bridge design cannot be drilled until accurate pier location information is available. For selected major projects, a type, size, and location (TS&L) report might be prepared which usually requires some subsurface exploration to provide a more detailed, though not final, estimate of foundation requirements.

The HQ Bridge and Structures Office is responsible for delivering the following project information, based on bridge site data received from the region's project office, to the HQ Geotechnical Services Division:

- Anticipated pier locations
- Approach fill heights
- For TS&L, alternate locations/alignments/ structure types

The HQ Bridge and Structures Office can expect to receive:

- Conceptual foundation types, depths and capacities
- Permissible slopes for bridge approaches
- For TS&L, a summary of site geology and subsurface conditions, and more detailed preliminary foundation design parameters and needs
- If applicable or requested, erosion or scour potential

The HQ Bridge and Structures Office uses this information to complete the bridge preliminary plan. The region's project office confirms right of way needs for approach embankments. For TS&L, the geotechnical information provided is used for cost estimating and preferred alternate selection. The preliminary plans are used by the HQ Geotechnical Services Division to develop the site subsurface exploration plan.

(c) **PS&E Development.** During this phase, or as soon as a 95 percent preliminary plan is available, subsurface exploration (drilling) is performed and a geotechnical foundation report is prepared to provide all necessary geotechnical recommendations needed to complete the bridge PS&E.

The HQ Bridge and Structures Office is responsible for delivering the following project information to the HQ Geotechnical Services Division:

- 95 percent preliminary plans (concurrent with distribution for region approval)
- Estimated foundation loads and allowable settlement criteria for the structure, when requested

The HQ Bridge and Structures Office can expect to receive:

- Bridge geotechnical foundation report

The HQ Bridge and Structures Office uses this information to complete the bridge PS&E. The region's project office reviews the geotechnical foundation report for construction considerations and recommendations that might affect region items, estimates, staging, construction schedule, or other items.

Upon receipt of the structure PS&E review set, the HQ Geotechnical Services Division provides the HQ Bridge and Structures Office with a Summary of Geotechnical Conditions for inclusion in Appendix B of the contract.

(14) Geosynthetics

See Chapter 530 for geosynthetic design guidance.

(15) Washington State Ferries Projects

(a) **Project Design.** The HQ Geotechnical Services Division assists the Washington State Ferries (WSF) division with determining the geotechnical feasibility of all offshore facilities, terminal facility foundations, and bulkhead walls. For upland retaining walls and grading, utility trenches, and pavement design, the RME assists WSF with determining geotechnical feasibility.

In addition to the site data identified in Section 510.04(4), as applicable, the following information is supplied by WSF to the HQ Geotechnical Services Division or the RME, as appropriate, with the request for the project geotechnical report::

- A plan showing anticipated structure locations as well as existing structures.
- Relevant historical data for the site.
- A plan showing utility trench locations.
- Anticipated utility trench depths.
- Proposed roadway profiles.

WSF can expect to receive:

- Results of any borings or laboratory tests conducted.
- A description of geotechnical site conditions.
- Conceptual foundation types, depths and capacities.
- Conceptual wall types.
- Assessment of constructibility issues that affect feasibility.
- Surfacing depths and/or pavement repair and drainage schemes.
- If applicable or requested, erosion or scour potential.

WSF uses this information to complete the project design report, design decisions, and estimated project budget and schedule.

WSF is responsible for obtaining any necessary permits or right of entry agreements needed to access structure locations for the purpose of subsurface exploration (for example, test hole drilling). The time required for obtaining permits and rights of entry must be considered when developing project schedules. Possible permits and agreements might include but are not limited to:

- City, county, or local agency use permits.
- Sensitive area ordinance permits.

(b) **PS&E Development**

Subsurface exploration (drilling) is performed and a geotechnical foundation report is prepared to provide all necessary geotechnical recommendations needed to complete the PS&E.

The designer requests a geotechnical report from the HQ Geotechnical Services Division or the RME, as appropriate. The site data indicated in 510.04(4), as applicable, is provided along with the following information:

- A plan showing final structure locations as well as existing structures.
- Proposed structure loadings.

WSF can expect to receive:

- Results of any borings or laboratory tests conducted.
- A description of geotechnical site conditions.
- Final foundation types, depths, and capacities.
- Final wall types and geotechnical designs/parameters for each wall.
- Assessment of constructibility issues to be considered in foundation selection and when assembling the PS&E.
- Pile driving information - driving resistance and estimated overdrive.

- Surfacing depths and/or pavement repair and drainage schemes.

WSF uses this information to complete the PS&E.

Upon receipt of the WSF PS&E review set, the HQ Geotechnical Services Division provides WSF with a Summary of Geotechnical Conditions for inclusion in Appendix B of the Contract. A Final Geotechnical Project Documentation package is assembled by the HQ Geotechnical Services Division and sent to WSF or the Plans Branch, as appropriate, for reproduction and sale to prospective bidders.

510.05 Use of Geotechnical Consultants

The HQ Geotechnical Services Division or the RME assists in developing the geotechnical scope and estimate for the project, so that the consultant contract is appropriate. (Consultant Services assists in this process.) A team meeting between the consultant team, the region or Washington State Ferries (depending on whose project it is), and the HQ Geotechnical Services Division/RME is conducted early in the project to develop technical communication lines and relationships. Good proactive communication between all members of the project team is crucial to the success of the project due to the complex supplier-client relationships.

510.06 Geotechnical Work by Others

Geotechnical design work conducted for the design of structures or other engineering works by other agencies or private developers within the right of way is subject to the same geotechnical engineering requirements as for engineering works performed by WSDOT. Therefore, the provisions contained within this chapter also apply in principle to such work. All geotechnical work conducted for engineering works within the WSDOT right of way or that otherwise directly impacts WSDOT facilities must be reviewed and approved by the HQ Geotechnical Services Division or the RME.

510.07 Surfacing Report

Detailed criteria and methods that govern pavement rehabilitation can be found in WSDOT Pavement Guide Interactive. The RME provides the surfacing report to the region's project office. This report provides recommended pavement types, surfacing depths, pavement drainage recommendations, and pavement repair recommendations.

510.08 Documentation

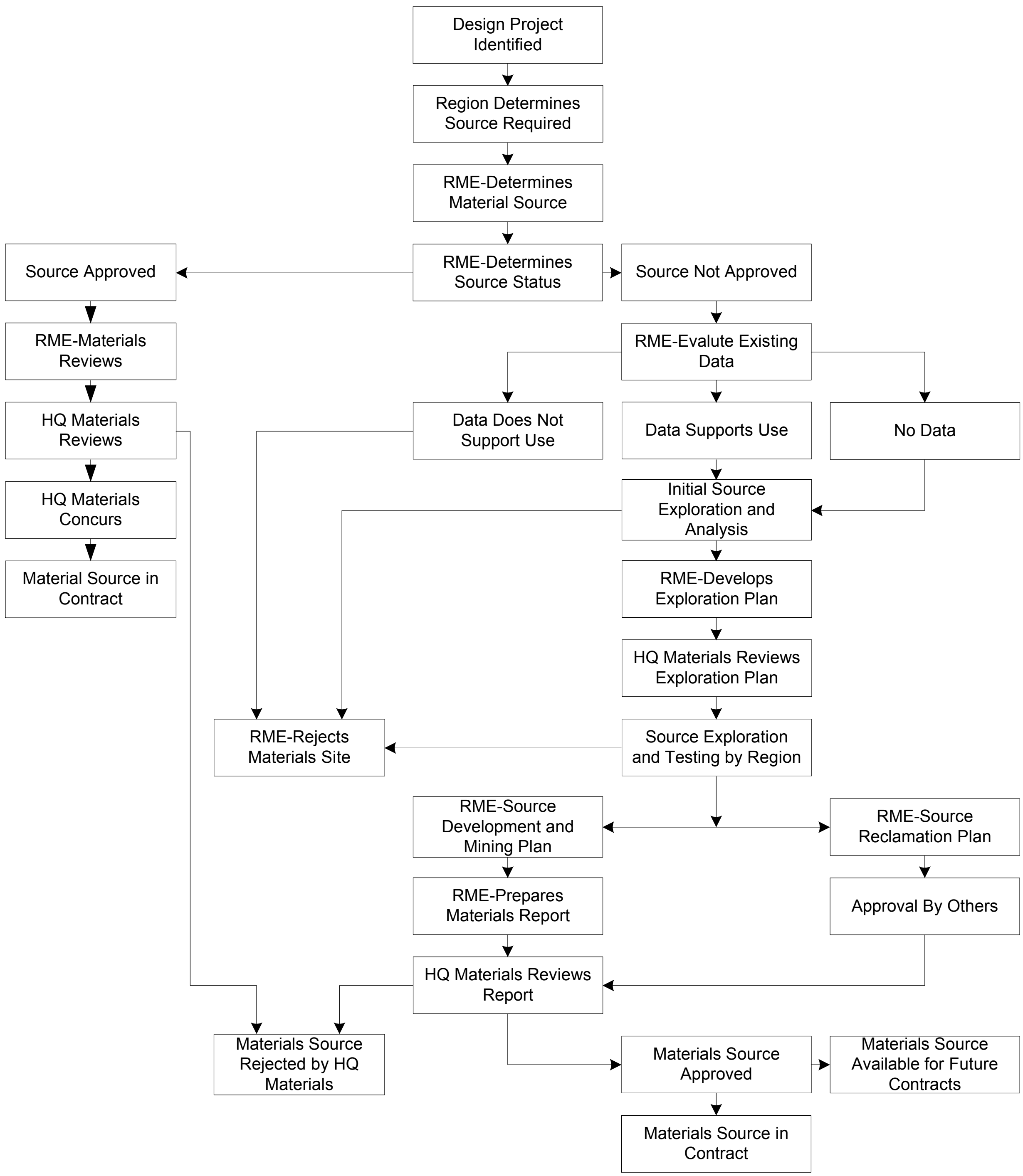
(1) Design Documentation

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

(2) Final Geotechnical Project Documentation and Geotechnical Information Included as Part of the Construction Contract

Once a project PS&E is near completion, all of the geotechnical design memorandums and reports are compiled together to form the Final Geotechnical Project Documentation, to be published for the use of prospective bidders. The detailed process for this is located in the *Plans Preparation Manual*.

Geotechnical information included as part of the contract generally consists of the final project boring logs, and, as appropriate for the project, a Summary of Geotechnical Conditions. Both of these items are provided by the HQ Geotechnical Services Division.



Material Source Development Plan
Figure 510-1

520.01 Introduction

Detailed criteria and methods that govern pavement design are in the *WSDOT Pavement Guide – Interactive*.

520.02 Estimating Tables

Figures 520-1 through 520-5b are to be used when detailed estimates are required. They are for pavement sections, shoulder sections, stockpiles, and asphalt distribution. Prime coats and fog seal are in Figure 520-2a.

Type of Material	Unit Dry Weight			
	Truck Measure		Compacted on Roadway	
	lb/cy	T/cy	lb/cy	T/cy
Ballast	3100	1.55	3900	1.95
Crushed Surfacing Top Course	2850	1.43	3700	1.85
Crushed Surfacing Base Course	2950	1.48	3700	1.85
Screened Gravel Surfacing			3700	1.85
**Gravel Base			3400 – 3800	1.70 – 1.90
Shoulder Ballast			2800	1.40
Maintenance Sand 3/8” – 0	2900	1.45		
Mineral Aggregate 2” – 1”	2600	1.30		
Mineral Aggregate 1 3/4” – 3/4”	2600	1.30		
Mineral Aggregate 1 1/2” – 3/4”	2550	1.28		
Mineral Aggregate 1” – 3/4”	2500	1.25		
Mineral Aggregate 3/4” – 1/2”	2400	1.20		
Mineral Aggregate 1 1/4” – 1/4’”	2600	1.30		
Mineral Aggregate 1” – 1/4”	2600	1.30		
Mineral Aggregate 7/8” – 1/4”	2550	1.28		
Mineral Aggregate 3/4” – 1/4”	2500	1.25		
Mineral Aggregate 5/8” – 1/4”	2650	1.33		
Mineral Aggregate 1/2” – 1/4” or #4	2600	1.30		
Mineral Aggregate 1/4” or #4 – 0	2900	1.45		
Concrete Aggr. No. 2 (1 1/4” - #4)	3000	1.50		
Concrete Sand (Fine Aggregate)	2900	1.45		
Crushed Cover Stone	2850	1.43		

** 3,700 lb/cy (1.85 tons/cy) is recommended as the most suitable factor; however, if the grading approaches the coarseness of ballast, the factor would approach 3,800 lb/cy (1.90 tons/cy), and if the grading contains more than 45% sand, the factor would decrease, approaching 3,400 lb/cy (1.70 tons/cy) for material that is essentially all sand.

General Notes:

Weights shown are dry weights and corrections are required for water contents.

The tabulated weights for the materials are reasonably close; however, apply corrections in the following order:

For specific gravity:

$$\text{Wt.} = \frac{\text{tabular wt. x specific gravity on surface report}}{2.65}$$

For water content:

Wt. = tabular wt. x (1 + free water % in decimals)

If they are to be stockpiled, increase required quantities by 10 percent to allow for waste.

Direct attention to the inclusion of crushed surfacing top course material that may be required for keystone when estimating quantities for projects having ballast course.

Estimating – Miscellaneous Tables

Figure 520-1

General Data [1, 2, 3]							
Hot Mix Asphalt Pavement							
Complete Mix							
Class of Mix	Depth (ft)	Spread per sy		sy per ton	Tons/Mile Width (ft)		
		lb	ton		10	11	12
HMA	0.10	137	0.0685	14.60	402	442	482

Prime Coats and Fog Seal															
Asphalt							Aggregate								
Application	Type of Asphalt[4]	Application gal[5] per sy	Tons[5] per sy	Tons/Mile Width (ft)			Application lb per sy	Tons/Mile Width (ft)			cy per sy	cy/Mile Width (ft)			
				10	11	12		10	11	12		10	11	12	
Prime Coat	MC-250	0.25	0.001004	5.9	6.5	7.1	30	88	97	106	0.0105	62	68	74	
Fog Seal	CSS-1	0.04	0.000167	1.0	1.1	1.2									

Specific Data [1 2 3]														
Hot Mix Asphalt Paving Quantities (tons/mile)*														
Width (ft)	Depth of Pavement (ft)													
	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
4	161	241	321	402	482	563	643	723	804	884	964	1045	1125	1206
6	241	362	482	603	723	844	964	1085	1206	1326	1447	1567	1688	1808
8	321	482	643	804	964	1125	1286	1447	1607	1768	1929	2090	2250	2411
10	402	603	804	1005	1206	1407	1607	1808	2009	2210	2411	2612	2813	3014
11	442	663	884	1105	1326	1547	1768	1989	2210	2431	2652	2873	3094	3315
12	482	723	964	1206	1447	1688	1929	2170	2411	2652	2893	3135	3376	3617
22	884	1326	1768	2210	2652	3094	3536	3978	4421	4863	5305	5747	6189	6631
24	964	1447	1929	2411	2893	3376	3858	4340	4822	5305	5787	6269	6751	7234
* Based on 137 lbs/sy of 0.10 ft compacted depth = 2.05 tons/cy														

1 The specific gravity of the aggregate will affect the weight of aggregate in the completed mix.

2 The percentage of fine mineral in the coarse aggregate will affect the ratio of coarse to fine. If the coarse aggregate produced contains an excessive amount of fines (1/4” to 0), increase the percentage of coarse aggregate and decrease the fines accordingly.

3 Quantities shown do not provide for widening, waste from stockpile, or thickened edges.

4 The column “Type of Asphalt” is shown for the purpose of conversion to proper weights for the asphalt being used and does not imply that the particular grade shown is required for the respective treatment.

5 Quantities shown are retained (residual) asphalt.

Estimating – Hot Mix Asphalt Pavement and Asphalt Distribution Tables
Figure 520-2a

Asphalt Distribution (tons/mile) [1]																						
Asphalt Grade	Gal/ ton @ 60° F	Width (ft)	Rate of Application (Gal./cy)																			
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
SC, MC, RC 70	253	10	1.16	2.32	3.48	4.64	5.80	6.96	8.12	9.28	10.46	11.59	12.79	13.91	15.07	16.23	17.39	18.55	19.71	20.87	22.03	23.19
		11	1.28	2.55	3.83	5.10	6.38	7.65	8.93	10.20	11.48	12.75	14.03	15.30	16.58	17.86	19.13	20.41	21.68	22.96	24.23	25.51
		12	1.39	2.78	4.17	5.57	6.96	8.35	9.74	11.13	12.52	13.91	15.30	16.70	18.09	19.48	20.87	22.26	23.65	25.04	26.43	27.83
SC,MC,RC 250	249	10	1.18	2.36	3.53	4.71	5.89	7.07	8.25	9.42	10.60	11.78	12.96	14.14	15.31	16.49	17.67	18.85	20.03	21.20	22.38	23.56
		11	1.30	2.59	3.89	5.18	6.48	7.78	9.07	10.37	11.66	12.96	14.25	15.55	16.85	18.14	19.44	20.73	22.03	23.33	24.62	25.92
		12	1.41	2.83	4.24	5.65	7.07	8.48	9.90	11.31	12.72	14.14	15.55	16.96	18.38	19.79	21.20	22.62	24.03	25.45	26.86	28.27
SC,MC,RC 800	245	10	1.20	2.39	3.59	4.79	5.99	7.18	8.38	9.58	10.78	11.97	13.17	14.37	15.56	16.76	17.96	19.16	20.35	21.55	22.75	23.95
		11	1.30	2.63	3.95	5.27	6.59	7.90	9.22	10.54	11.85	13.17	14.49	15.80	17.12	18.44	19.79	21.07	22.39	23.71	25.02	26.34
		12	1.44	2.87	4.31	5.75	7.18	8.62	10.06	11.49	12.93	14.37	15.80	17.24	18.68	20.11	21.55	22.99	24.42	25.86	27.30	28.73
SC,MC,RC 3000	241	10	1.22	2.44	3.66	4.87	6.09	7.31	8.53	9.75	10.97	12.19	13.41	14.62	15.84	17.06	18.28	19.50	20.72	21.94	23.15	24.37
		11	1.34	2.68	4.02	5.36	6.69	8.03	9.37	10.71	12.05	13.39	14.73	16.07	17.41	18.74	20.08	21.42	22.76	24.10	25.44	26.78
		12	1.46	2.92	4.38	5.84	7.30	8.76	10.22	11.68	13.15	14.61	16.07	17.53	18.99	20.45	21.91	23.37	24.83	26.29	27.75	29.21
Paving Asphalt 200-300 PEN.	239	10	1.23	2.45	3.68	4.91	6.14	7.36	8.59	9.82	11.05	12.27	13.50	14.73	15.96	17.18	18.41	19.64	20.86	22.09	23.32	24.55
		11	1.35	2.70	4.05	5.40	6.75	8.10	9.45	10.80	12.15	13.50	14.85	16.20	17.55	18.90	20.25	21.60	22.95	24.30	25.65	27.00
		12	1.47	2.95	4.42	5.89	7.36	8.84	10.31	11.78	13.26	14.73	16.20	17.67	19.15	20.62	22.09	23.56	25.04	26.51	27.98	29.46
Emulsified Asphalt	240	10	1.22	2.44	3.67	4.89	6.11	7.33	8.56	9.77	11.00	12.22	13.44	14.67	15.89	17.11	18.33	19.56	20.78	22.00	23.22	24.44
		11	1.34	2.67	4.03	5.38	6.72	8.07	9.41	10.76	12.10	13.45	14.79	16.13	17.48	18.82	20.17	21.51	22.86	24.20	25.54	26.89
		12	1.47	2.93	4.40	5.87	7.33	8.80	10.27	11.73	13.20	14.67	16.13	17.60	19.07	20.53	22.00	23.47	24.93	26.40	27.87	29.33

1 Quantities of asphalt shown are based on 60° F temperature. Recompute to the application temperature for the particular grade.

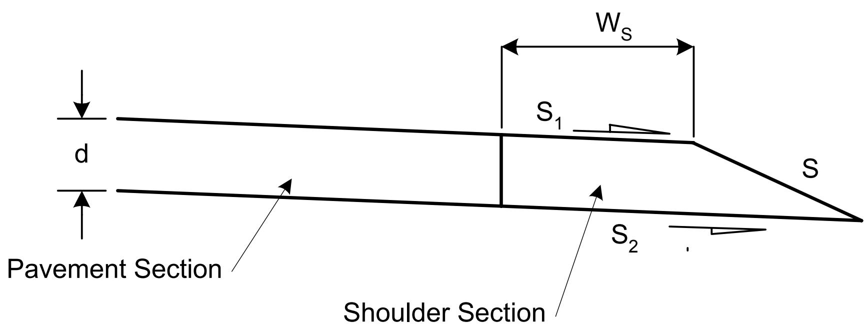
Estimating –Asphalt Distribution Tables

Figure 520-2b

Bituminous Surface Treatment [1]																		
Class of Mix	Type of Application	Average Application		Mineral Aggregate						Average Spread	Asphalt [2, 4, 5]						Basic [3] Asphalt Used
				10 ft		11 ft		12 ft			10 ft		11 ft		12 ft		
		lb/sy	cy/sy	T/mi	cy/mi	T/mi	cy/mi	T/mi	cy/mi	gal/sy	gal/mi	T/mi	gal/mi	T/mi	gal/mi	T/mi	
	Prime Coat									0.48	2787	11.2	3065	12.3	3344	13.4	MC-250
	Crushed Screenings 3/4” – 1/2”	35	0.0146	103	86	113	94	123	103								
	Tack Coat									0.43	2493	10.4	2743	11.4	2992	12.5	CRS-2
	Crushed Screenings 1/2” – 1/4”	28	0.0106	81	62	89	68	97	74								
	Crushed Screenings 1/4” – 0”	5	0.0017	15	10	16	11	18	12								
	Totals	68	0.0269	199	158	218	173	238	189	0.91	5280	21.6	5808	23.7	6336	25.9	
B	Seal Coat									0.50	2933	12.2	3227	13.4	3520	14.7	CRS-2
	Crushed Screenings 5/8” – 1/4”	33	0.0123	95	72	105	79	114	86								
	Crushed Screenings 1/4” – 0”	5	0.0017	15	10	16	11	18	12								
	Totals	38	0.0140	110	82	121	90	132	98	0.50	2933	12.2	3227	13.4	3520	14.7	
C	Seal Coat									0.45	2640	11.0	2904	12.1	3168	13.2	CRS-2
	Crushed Screenings 1/2” – 1/4”	28	0.0106	81	62	89	68	97	74								
	Crushed Screenings 1/4” – 0”	5	0.0017	15	10	16	11	18	12								
	Totals	33	0.0123	96	72	105	79	115	86	0.45	2640	11.0	2904	12.1	3168	13.2	
D	Seal Coat									0.43	2493	10.4	2743	11.4	2992	12.5	CRS-2
	Crushed Screenings 3/8” - #10	25	0.0088	73	51	81	57	88	62								
Preseal for B, C & D	Preseal									0.18	1027	4.3	1129	4.7	1232	5.1	CRS-2
	Crushed Screenings 1/4” – 0”	12	0.0040	34	23	37	26	40	28								

1 Quantities shown do not provide for widening, waste from stockpile, or thickened edges.
2 Quantities of asphalt shown are based on 60°F temperature. Recompute to the application temperature for the particular grade.
3 The column “Basic Asphalt Used” is shown for the purpose of conversion to proper weights for the asphalt being used and does not imply that the particular grade shown is required for the respective treatment.
4 For cutbacks, decrease asphalt by 25 percent.
5 For stress absorbing membrane (rubberized asphalt), increase asphalt by 25 percent.

Estimating – Bituminous Surface Treatment
Figure 520-3



W_S = Shoulder Width – (Varies 4 ft, 6 ft, 8 ft, 10 ft, 12 ft)
d = Depth of Section – (Varies 0.05 ft to 2 ft)
S = Side Slope (H:V) – (Varies 2:1, 3:1, 4:1, and 6:1)
S_1 = Top Shoulder Slope – (Varies –0.02 ft/ft or –0.05 ft/ft)
S_2 = Bottom Shoulder Slope – (Varies –0.02 ft/ft or –0.05 ft/ft)

Formula for Shoulder Section		
Tons/mile = (A)(K) K=(5280/27)(1.85 tons/cy) $A = \frac{[d + W_S(1/S - S_1)]^2 S}{2(1 - SS_2)} - \frac{W_S^2}{2}(1/S - S_1)$		
Case 1	$S_1 = S_2$ = -0.02 ft/ft	$A = \frac{[d + W_S(1/S - 0.02)]^2 S}{2(1 - 0.02S)} - \frac{W_S^2}{2}(1/S - 0.02)$
Case 2	S_1 = -0.02 ft/ft, S_2 = -0.05 ft/ft	$A = \frac{[d + W_S(1/S - 0.02)]^2 S}{2(1 - 0.05S)} - \frac{W_S^2}{2}(1/S - 0.02)$
Case 3	S_1 = -0.05 ft/ft, S_2 = -0.02 ft/ft	$A = \frac{[d + W_S(1/S - 0.05)]^2 S}{2(1 - 0.02S)} - \frac{W_S^2}{2}(1/S - 0.05)$ *
Case 4	$S_1 = S_2$ = -0.05 ft/ft	$A = \frac{[d + W_S(1/S - 0.05)]^2 S}{2(1 - 0.05S)} - \frac{W_S^2}{2}(1/S - 0.05)$
*Limit: Positive Values of A only when d = W_S(0.03)		

EXAMPLE: Shoulder Section

Given –		Shoulder Width 8 ft
	Top Course	0.25 ft
	Base Course	0.80 ft
	Total Depth	1.05 ft
	Side Slope	3:1
	Shoulder Slope	-0.05
	Subgrade Slope	-0.02

Depth	1.05 ft (Case 3) =	3070 tons/mile
Top Course	0.25 ft (Case 4) =	763 tons/mile
Base Course	=	2307 tons/mile

Top Course = 763 tons/mile
Base Course = 2307 tons/mile

Estimating – Base and Surfacing Typical Section
Formulae and Example
Figure 520-4

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
4	2	1	73	148	226	304	385	468	553	639	728	818
		2	171	251	333	417	504	592	682	774	869	965
		3	N/A	N/A	131	205	281	360	440	522	605	691
		4	73	149	226	306	387	470	556	643	733	824
	3	1	74	150	230	313	398	486	577	671	768	868
		2	178	262	350	442	536	634	734	838	945	1056
		3	N/A	N/A	131	206	285	366	450	537	627	720
		4	74	151	231	315	402	492	585	681	780	883
	4	1	74	153	235	321	411	505	603	705	810	920
		2	185	275	370	469	572	681	793	910	1032	1158
		3	N/A	N/A	131	208	288	373	461	554	650	750
		4	75	154	237	326	418	516	617	724	834	950
	6	1	75	157	245	339	439	545	658	776	901	1032
		2	204	307	417	535	661	794	936	1085	1242	1406
		3	N/A	N/A	131	210	296	387	485	589	699	815
		4	76	160	252	351	459	574	696	827	965	1111
6	2	1	109	221	334	449	566	685	806	929	1053	1180
		2	325	444	565	688	812	939	1068	1199	1332	1467
		3	N/A	N/A	N/A	239	349	461	575	691	809	929
		4	110	221	335	450	568	687	809	933	1058	1186
	3	1	110	223	339	457	579	703	830	961	1094	1230
		2	338	462	590	722	856	994	1134	1278	1426	1576
		3	N/A	N/A	N/A	239	350	464	581	701	824	949
		4	110	223	340	460	583	709	838	970	1106	1245
	4	1	110	225	343	466	592	722	856	994	1136	1282
		2	352	483	619	760	905	1055	1209	1368	1531	1699
		3	N/A	N/A	N/A	239	351	467	587	711	839	971
		4	111	226	346	470	599	733	871	1013	1160	1311
	6	1	112	229	353	483	620	762	911	1066	1227	1394
		2	386	534	690	853	1025	1204	1391	1585	1788	1998
		3	N/A	N/A	N/A	239	353	474	600	733	871	1016
		4	112	233	360	496	640	791	950	1116	1291	1473
8	2	1	146	293	443	594	747	902	1059	1218	1379	1541
		2	526	683	843	1004	1167	1333	1500	1670	1841	2015
		3	N/A	N/A	N/A	N/A	376	522	670	820	972	1125
		4	146	293	443	595	749	904	1062	1222	1384	1548
	3	1	146	295	447	602	760	920	1084	1250	1419	1591
		2	546	711	879	1050	1224	1402	1583	1766	1954	2144
		3	N/A	N/A	N/A	N/A	376	523	673	825	981	1139
		4	146	296	448	604	763	926	1091	1260	1432	1607
	4	1	147	297	452	610	773	939	1109	1284	1462	1644
		2	568	741	919	1101	1288	1479	1675	1875	2080	2290
		3	N/A	N/A	N/A	N/A	376	524	675	831	990	1153
		4	147	298	454	615	780	950	1124	1302	1486	1673
	6	1	148	302	462	628	801	979	1164	1355	1552	1755
		2	622	816	1017	1226	1443	1668	1900	2140	2388	2643
		3	N/A	N/A	N/A	N/A	376	525	681	842	1009	1183
		4	149	305	469	641	820	1008	1203	1406	1616	1835

Estimating - Base and Surfacing Quantities
Figure 520-5a

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
4	2	1	910	1004	1100	1198	1297	1399	1502	1608	1715	1824
		2	1063	1163	1266	1370	1476	1585	1695	1807	1922	2038
		3	779	868	960	1053	1148	1245	1344	1445	1548	1652
		4	918	1013	1110	1210	1311	1415	1520	1628	1738	1849
	3	1	971	1076	1185	1296	1410	1527	1647	1770	1896	2024
		2	1169	1286	1406	1529	1655	1785	1918	2053	2193	2335
		3	816	914	1016	1120	1228	1338	1451	1567	1686	1807
		4	989	1098	1210	1326	1444	1566	1691	1820	1951	2086
	4	1	1034	1151	1273	1398	1528	1661	1798	1939	2085	2234
		2	1289	1424	1564	1708	1857	2010	2168	2330	2497	2668
		3	855	963	1075	1191	1311	1435	1562	1694	1830	1969
		4	1070	1194	1323	1456	1594	1737	1884	2035	2191	2352
	6	1	1169	1312	1462	1617	1779	1947	2121	2301	2488	2680
		2	1579	1759	1947	2142	2346	2557	2776	3002	3237	3479
		3	937	1066	1200	1341	1488	1641	1800	1966	2138	2315
		4	1265	1426	1596	1773	1957	2150	2350	2558	2774	2998
6	2	1	1308	1438	1570	1704	1840	1978	2117	2259	2402	2548
		2	1603	1742	1883	2026	2171	2318	2467	2618	2771	2926
		3	1050	1174	1299	1426	1555	1686	1819	1954	2090	2229
		4	1315	1447	1581	1716	1854	1994	2135	2279	2425	2573
	3	1	1369	1510	1655	1802	1953	2106	2262	2421	2583	2748
		2	1729	1886	2046	2209	2376	2545	2718	2894	3073	3255
		3	1078	1209	1343	1480	1620	1763	1909	2058	2209	2363
		4	1387	1532	1681	1832	1987	2145	2306	2471	2638	2809
	4	1	1432	1586	1743	1905	2070	2240	2413	2591	2772	2957
		2	1871	2048	2229	2415	2606	2801	3000	3204	3412	3625
		3	1106	1246	1389	1537	1688	1843	2003	2166	2333	2504
		4	1467	1628	1793	1963	2137	2315	2499	2686	2878	3075
	6	1	1567	1746	1932	2124	2322	2526	2736	2953	3175	3404
		2	2215	2441	2674	2916	3164	3421	3685	3957	4237	4525
		3	1167	1325	1488	1658	1833	2015	2203	2398	2598	2805
		4	1663	1861	2066	2279	2500	2729	2965	3209	3461	3721
8	2	1	1706	1872	2040	2211	2383	2557	2732	2910	3090	3271
		2	2190	2367	2547	2728	2912	3097	3285	3475	3666	3860
		3	1281	1438	1597	1758	1921	2086	2253	2422	2592	2765
		4	1713	1881	2051	2223	2397	2573	2751	2930	3112	3296
	3	1	1766	1944	2125	2309	2495	2685	2877	3072	3271	3472
		2	2338	2534	2734	2937	3144	3353	3566	3782	4001	4223
		3	1300	1464	1631	1801	1974	2149	2328	2509	2693	2880
		4	1785	1966	2151	2339	2530	2724	2921	3122	3326	3533
	4	1	1830	2020	2214	2411	2613	2819	3028	3242	3459	3681
		2	2504	2722	2945	3172	3404	3641	3882	4128	4378	4632
		3	1320	1491	1666	1845	2028	2215	2405	2600	2799	3001
		4	1865	2062	2263	2469	2679	2894	3114	3337	3566	3799
	6	1	1965	2181	2402	2630	2864	3105	3351	3604	3863	4128
		2	2907	3178	3457	3743	4038	4340	4650	4967	5292	5626
		3	1363	1549	1741	1940	2144	2355	2572	2795	3024	3259
		4	2061	2295	2536	2786	3043	3308	3580	3861	4149	4445

Estimating - Base and Surfacing Quantities

Figure 520-5b

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
10	2	1	182	366	551	739	928	1119	1312	1507	1704	1903
		2	773	969	1167	1367	1569	1773	1979	2187	2397	2609
		3	N/A	N/A	N/A	N/A	N/A	543	724	908	1094	1281
		4	182	366	552	740	930	1122	1315	1511	1709	1909
	3	1	182	368	556	747	941	1137	1337	1539	1745	1953
		2	802	1007	1215	1426	1640	1858	2079	2303	2530	2760
		3	N/A	N/A	N/A	N/A	N/A	543	725	910	1098	1289
		4	182	368	557	749	944	1143	1344	1549	1757	1968
	4	1	183	370	560	755	954	1156	1363	1573	1787	2006
		2	834	1049	1268	1492	1721	1954	2191	2433	2679	2930
		3	N/A	N/A	N/A	N/A	N/A	543	726	912	1103	1298
		4	183	371	563	760	961	1167	1377	1592	1811	2035
	6	1	184	374	570	773	982	1196	1417	1644	1878	2117
		2	913	1153	1399	1654	1916	2186	2464	2750	3043	3344
		3	N/A	N/A	N/A	N/A	N/A	543	727	917	1113	1316
		4	185	377	578	786	1001	1225	1456	1695	1942	2197
12	2	1	218	438	660	883	1109	1336	1566	1797	2030	2265
		2	1066	1301	1537	1776	2016	2259	2504	2750	2999	3249
		3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	956	1175	1397
		4	218	438	660	884	1110	1339	1569	1801	2035	2271
	3	1	219	440	664	891	1121	1354	1590	1829	2071	2315
		2	1106	1351	1599	1850	2104	2362	2623	2887	3154	3424
		3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	956	1177	1401
		4	219	441	666	894	1125	1360	1598	1839	2083	2330
	4	1	219	442	669	900	1134	1373	1616	1862	2113	2367
		2	1151	1407	1668	1933	2203	2478	2757	3040	3328	3621
		3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	956	1179	1405
		4	219	443	672	904	1142	1384	1630	1881	2137	2397
	6	1	220	446	679	918	1162	1413	1671	1934	2203	2479
		2	1259	1544	1836	2136	2444	2759	3083	3414	3752	4099
		3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	957	1182	1413
		4	221	450	686	930	1182	1442	1709	1985	2268	2558

Pavement Section										
Width W_P (ft)	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
11	199	398	597	796	995	1194	1393	1592	1791	1990
12	217	434	651	868	1085	1302	1519	1737	1954	2171
22	398	796	1194	1592	1990	2388	2786	3184	3582	3980
24	434	868	1302	1737	2171	2605	3039	3473	3907	4341

*Tabulated quantities are based on compacted weight of 1.85 tons/yd^3

Estimating - Base and Surfacing Quantities

Figure 520-5c

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
10	2	1	2104	2306	2511	2717	2925	3135	3347	3561	3777	3995
		2	2823	3039	3257	3477	3699	3923	4149	4378	4608	4840
		3	1471	1662	1855	2050	2247	2446	2646	2849	3053	3260
		4	2111	2315	2521	2729	2939	3151	3366	3582	3800	4020
	3	1	2164	2378	2595	2815	3038	3264	3492	3724	3958	4195
		2	2994	3230	3470	3714	3960	4209	4462	4718	4977	5239
		3	1483	1680	1880	2082	2288	2496	2707	2921	3138	3358
		4	2183	2401	2621	2845	3072	3303	3536	3773	4013	4256
	4	1	2228	2454	2684	2918	3156	3398	3643	3893	4147	4404
		2	3186	3446	3710	3980	4253	4531	4814	5101	5393	5689
		3	1496	1699	1905	2116	2330	2548	2770	2996	3227	3460
		4	2263	2496	2734	2976	3222	3473	3729	3989	4253	4522
	6	1	2363	2615	2873	3137	3407	3684	3966	4255	4550	4851
		2	3653	3969	4294	4626	4965	5313	5668	6031	6402	6781
		3	1524	1739	1960	2187	2420	2660	2906	3157	3415	3679
		4	2459	2729	3007	3292	3585	3887	4195	4512	4836	5168
12	2	1	2502	2740	2981	3224	3468	3714	3962	4212	4464	4718
		2	3502	3757	4013	4272	4533	4795	5060	5327	5596	5866
		3	1620	1845	2072	2301	2532	2765	2999	3236	3474	3714
		4	2509	2750	2992	3236	3482	3730	3981	4233	4487	4743
	3	1	2562	2813	3066	3322	3581	3843	4107	4375	4645	4919
		2	3698	3975	4255	4538	4824	5114	5406	5702	6001	6304
		3	1627	1857	2089	2324	2562	2803	3047	3294	3544	3796
		4	2581	2835	3092	3352	3615	3882	4151	4424	4700	4980
	4	1	2626	2888	3154	3424	3698	3976	4258	4544	4834	5128
		2	3918	4220	4526	4837	5152	5472	5796	6125	6458	6796
		3	1635	1869	2107	2348	2594	2844	3098	3355	3617	3882
		4	2661	2930	3204	3482	3765	4052	4344	4640	4941	5246
	6	1	2761	3049	3343	3643	3950	4262	4581	4906	5237	5575
		2	4453	4815	5185	5562	5948	6341	6742	7150	7566	7991
		3	1651	1894	2144	2400	2662	2930	3205	3485	3772	4065
		4	2857	3163	3477	3799	4128	4465	4810	5163	5524	5892
Pavement Section												
Width W_P (ft)			0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
11			2189	2388	2587	2786	2985	3184	3383	3582	3781	3980
12			2388	2605	2822	3039	3256	3473	3690	3907	4124	4341
22			4378	4775	5173	5571	5969	6367	6765	7163	7561	7959
24			4775	5210	5644	6078	6512	6946	7380	7814	8249	8683
*Tabulated quantities are based on compacted weight of 1.85 tons/yd^3												

Estimating - Base and Surfacing Quantities

Figure 520-5d

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50
4	2	1	1935	2048	2163	2279	2398	2518	2640	2765	2891	3019
		2	2157	2277	2399	2524	2650	2779	2909	3042	3176	3312
		3	1759	1867	1977	2089	2203	2319	2437	2557	2678	2802
		4	1963	2078	2196	2315	2437	2561	2686	2814	2943	3075
	3	1	2156	2290	2428	2568	2711	2857	3006	3157	3312	3470
		2	2480	2629	2781	2936	3094	3255	3420	3588	3759	3933
		3	1932	2059	2190	2323	2459	2598	2740	2885	3033	3183
		4	2223	2364	2509	2656	2806	2960	3117	3277	3441	3607
	4	1	2387	2543	2704	2869	3038	3210	3387	3567	3752	3940
		2	2844	3025	3210	3399	3593	3792	3995	4202	4415	4631
		3	2113	2260	2412	2567	2726	2890	3057	3228	3403	3582
		4	2517	2686	2860	3039	3222	3410	3602	3799	4000	4206
	6	1	2879	3084	3295	3513	3736	3966	4201	4443	4691	4946
		2	3729	3986	4252	4525	4806	5094	5391	5695	6007	6327
		3	2499	2689	2886	3088	3297	3512	3733	3960	4193	4433
		4	3229	3468	3715	3969	4232	4502	4779	5065	5358	5659
6	2	1	2695	2844	2995	3147	3302	3459	3617	3778	3940	4104
		2	3083	3242	3403	3566	3731	3898	4067	4238	4411	4586
		3	2369	2511	2655	2802	2949	3099	3251	3404	3560	3717
		4	2722	2874	3028	3184	3341	3501	3663	3827	3993	4160
	3	1	2916	3086	3260	3436	3615	3798	3983	4170	4361	4555
		2	3440	3629	3821	4016	4214	4416	4620	4828	5039	5253
		3	2521	2681	2844	3010	3179	3351	3525	3703	3883	4067
		4	2983	3160	3341	3524	3711	3901	4094	4290	4490	4692
	4	1	3146	3339	3536	3737	3942	4151	4364	4580	4801	5026
		2	3843	4065	4291	4523	4758	4998	5243	5492	5746	6004
		3	2679	2858	3041	3228	3418	3613	3812	4014	4221	4431
		4	3276	3482	3692	3907	4127	4350	4579	4812	5049	5291
	6	1	3639	3880	4127	4381	4640	4906	5178	5456	5741	6031
		2	4820	5123	5434	5753	6079	6413	6755	7105	7462	7827
		3	3017	3236	3461	3693	3930	4174	4423	4679	4941	5210
		4	3989	4264	4547	4837	5136	5442	5756	6078	6407	6745
8	2	1	3454	3640	3827	4016	4207	4399	4594	4791	4989	5189
		2	4055	4253	4452	4654	4858	5063	5271	5480	5692	5906
		3	2939	3115	3293	3473	3655	3839	4024	4212	4401	4592
		4	3482	3670	3860	4052	4246	4442	4640	4840	5042	5246
	3	1	3675	3882	4092	4304	4520	4738	4959	5183	5410	5640
		2	4449	4677	4909	5144	5382	5624	5869	6116	6367	6622
		3	3070	3263	3459	3658	3859	4064	4271	4481	4695	4911
		4	3743	3956	4173	4392	4615	4841	5071	5303	5539	5778
	4	1	3906	4135	4368	4606	4847	5092	5341	5593	5850	6111
		2	4891	5155	5423	5696	5973	6255	6541	6832	7127	7427
		3	3208	3418	3632	3851	4073	4299	4529	4763	5001	5243
		4	4036	4278	4524	4775	5031	5291	5556	5825	6098	6376
	6	1	4399	4676	4959	5249	5545	5847	6155	6469	6790	7116
		2	5966	6315	6671	7035	7407	7787	8174	8569	8972	9383
		3	3501	3749	4002	4262	4529	4801	5079	5364	5655	5952
		4	4748	5060	5379	5706	6040	6383	6733	7091	7456	7830

Estimating - Base and Surfacing Quantities

Figure 520-5e

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
4	2	1	3148	3280	3414	3549	3687	3826	3967	4110	4255	4402
		2	3451	3591	3734	3878	4025	4173	4324	4477	4631	4788
		3	2927	3054	3183	3314	3447	3582	3718	3857	3997	4139
		4	3209	3344	3482	3622	3763	3907	4053	4201	4350	4502
	3	1	3630	3793	3959	4129	4300	4475	4653	4834	5017	5203
		2	4110	4291	4475	4662	4852	5045	5242	5441	5644	5850
		3	3337	3493	3652	3814	3979	4147	4318	4492	4668	4848
		4	3777	3950	4126	4305	4488	4673	4862	5054	5250	5448
	4	1	4133	4329	4529	4733	4941	5153	5369	5589	5812	6040
		2	4852	5078	5308	5543	5782	6026	6274	6527	6784	7046
		3	3764	3951	4142	4337	4535	4738	4944	5155	5369	5587
		4	4416	4631	4850	5074	5302	5535	5773	6015	6261	6512
	6	1	5206	5473	5745	6024	6310	6601	6898	7202	7512	7828
		2	6654	6989	7332	7683	8041	8407	8781	9163	9552	9950
		3	4678	4930	5188	5452	5722	5999	6282	6570	6865	7166
		4	5968	6285	6609	6941	7281	7628	7984	8347	8718	9096
6	2	1	4270	4438	4608	4779	4953	5128	5306	5485	5666	5849
		2	4763	4942	5123	5306	5491	5678	5868	6059	6252	6447
		3	3876	4038	4201	4365	4532	4701	4871	5044	5218	5394
		4	4330	4502	4676	4852	5030	5210	5391	5575	5761	5949
	3	1	4752	4951	5153	5359	5567	5778	5992	6208	6428	6651
		2	5471	5691	5915	6142	6372	6605	6842	7082	7325	7571
		3	4253	4442	4634	4829	5026	5227	5430	5637	5846	6058
		4	4898	5107	5320	5535	5754	5976	6201	6429	6660	6895
	4	1	5254	5486	5723	5963	6207	6455	6707	6963	7223	7487
		2	6267	6534	6806	7082	7363	7648	7938	8233	8532	8835
		3	4645	4864	5086	5312	5542	5776	6014	6256	6501	6751
		4	5537	5788	6044	6304	6569	6838	7111	7389	7672	7959
	6	1	6328	6630	6939	7254	7576	7903	8237	8577	8923	9275
		2	8200	8581	8969	9365	9769	10181	10600	11028	11463	11905
		3	5484	5765	6051	6344	6643	6949	7260	7578	7901	8231
		4	7090	7442	7803	8171	8547	8931	9322	9721	10128	10543
8	2	1	5391	5595	5801	6009	6219	6431	6644	6859	7077	7296
		2	6121	6339	6559	6780	7004	7230	7457	7687	7919	8153
		3	4785	4980	5177	5376	5577	5779	5984	6190	6398	6608
		4	5452	5660	5870	6082	6296	6512	6730	6950	7172	7396
	3	1	5873	6109	6347	6589	6833	7080	7330	7583	7839	8098
		2	6879	7140	7403	7670	7940	8214	8490	8770	9053	9339
		3	5129	5351	5576	5803	6034	6267	6503	6743	6985	7229
		4	6020	6265	6514	6765	7020	7278	7539	7804	8071	8342
	4	1	6376	6644	6917	7193	7473	7758	8046	8338	8634	8934
		2	7731	8040	8354	8671	8994	9321	9652	9988	10329	10674
		3	5488	5738	5992	6249	6511	6776	7046	7319	7596	7877
		4	6659	6946	7238	7534	7835	8140	8450	8764	9083	9406
	6	1	7449	7788	8133	8485	8842	9206	9575	9951	10333	10722
		2	9801	10227	10661	11103	11552	12009	12474	12947	13427	13915
		3	6255	6565	6880	7202	7530	7864	8204	8550	8903	9262
		4	8211	8600	8997	9401	9813	10233	10661	11096	11539	11990

Estimating - Base and Surfacing Quantities
Figure 520-5f

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50
10	2	1	4214	4436	4659	4884	5111	5340	5571	5804	6038	6275
		2	5074	5310	5548	5788	6031	6275	6521	6769	7019	7272
		3	3468	3678	3890	4104	4320	4537	4757	4978	5201	5427
		4	4242	4466	4692	4920	5150	5382	5617	5853	6091	6331
	3	1	4435	4678	4924	5173	5424	5679	5936	6196	6460	6726
		2	5505	5774	6045	6320	6599	6880	7165	7453	7744	8038
		3	3581	3806	4035	4266	4501	4738	4978	5221	5467	5715
		4	4503	4752	5005	5261	5520	5782	6048	6316	6588	6863
	4	1	4666	4931	5201	5474	5751	6032	6317	6606	6899	7196
		2	5990	6295	6605	6919	7238	7561	7889	8221	8558	8900
		3	3698	3940	4186	4436	4689	4947	5208	5474	5743	6017
		4	4796	5074	5357	5644	5935	6232	6532	6838	7147	7462
	6	1	5158	5472	5792	6117	6449	6787	7132	7482	7839	8202
		2	7167	7561	7963	8373	8790	9215	9648	10088	10537	10993
		3	3950	4226	4509	4798	5093	5394	5701	6015	6334	6660
		4	5508	5856	6211	6574	6945	7323	7710	8104	8506	8915
12	2	1	4974	5231	5491	5752	6015	6281	6548	6816	7087	7360
		2	6139	6414	6691	6969	7250	7533	7818	8104	8393	8684
		3	3956	4200	4446	4694	4944	5195	5449	5704	5961	6220
		4	5002	5262	5524	5788	6055	6323	6593	6866	7140	7416
	3	1	5195	5474	5756	6041	6329	6619	6913	7209	7509	7811
		2	6609	6918	7230	7545	7863	8184	8509	8837	9168	9502
		3	4052	4310	4571	4836	5103	5372	5645	5921	6199	6481
		4	5262	5548	5837	6129	6424	6723	7024	7329	7637	7948
	4	1	5425	5727	6033	6342	6656	6973	7294	7619	7948	8282
		2	7138	7485	7836	8192	8553	8917	9287	9661	10039	10422
		3	4151	4425	4702	4983	5268	5557	5850	6147	6448	6753
		4	5556	5870	6189	6512	6840	7172	7509	7851	8197	8547
	6	1	5918	6268	6624	6986	7354	7728	8109	8495	8888	9287
		2	8422	8862	9309	9764	10227	10698	11176	11662	12156	12657
		3	4364	4669	4981	5298	5622	5952	6288	6630	6979	7333
		4	6268	6652	7043	7442	7849	8264	8687	9117	9555	10001
Pavement Section												
Width W_P (ft)			1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50
11			4179	4378	4576	4775	4974	5173	5372	5571	5770	5969
12			4558	4775	4993	5210	5427	5644	5861	6078	6295	6512
22			8357	8755	9153	9551	9949	10347	10745	11143	11541	11939
24			9117	9551	9985	10419	10853	11287	11722	12156	12590	13024
*Tabulated quantities are based on compacted weight of 1.85 tons/yd^3												

Estimating - Base and Surfacing Quantities

Figure 520-5g

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
10	2	1	6513	6753	6995	7239	7485	7733	7983	8234	8488	8743
		2	7526	7782	8041	8301	8563	8827	9094	9362	9632	9905
		3	5654	5883	6113	6346	6581	6817	7056	7296	7538	7782
		4	6573	6818	7064	7312	7562	7814	8069	8325	8583	8843
	3	1	6995	7266	7541	7819	8099	8382	8669	8958	9250	9545
		2	8335	8636	8940	9247	9557	9870	10187	10506	10829	11156
		3	5967	6221	6479	6739	7002	7268	7537	7809	8084	8361
		4	7141	7423	7707	7995	8286	8581	8878	9179	9482	9789
	4	1	7497	7802	8111	8423	8740	9060	9385	9713	10045	10381
		2	9246	9596	9951	10311	10675	11043	11416	11794	12176	12563
		3	6294	6575	6860	7149	7442	7739	8040	8344	8653	8966
		4	7780	8104	8432	8764	9101	9442	9788	10139	10494	10853
	6	1	8571	8946	9327	9715	10108	10508	10914	11326	11744	12169
		2	11457	11928	12408	12895	13390	13892	14403	14921	15447	15980
		3	6992	7330	7674	8025	8382	8744	9113	9488	9870	10257
		4	9333	9758	10191	10631	11079	11536	11999	12471	12950	13437
12	2	1	7634	7911	8189	8469	8751	9035	9321	9609	9899	10190
		2	8977	9272	9569	9868	10168	10471	10776	11083	11392	11703
		3	6481	6744	7009	7276	7544	7814	8087	8361	8637	8915
		4	7695	7975	8258	8542	8828	9117	9407	9700	9994	10291
	3	1	8116	8424	8735	9049	9365	9685	10007	10333	10661	10992
		2	9840	10180	10524	10871	11221	11575	11931	12291	12654	13020
		3	6765	7052	7342	7635	7931	8230	8532	8836	9144	9454
		4	8263	8581	8901	9225	9553	9883	10216	10553	10893	11236
	4	1	8619	8960	9304	9653	10006	10363	10723	11088	11456	11829
		2	10810	11202	11599	12000	12405	12816	13230	13650	14073	14502
		3	7061	7374	7691	8011	8335	8664	8996	9332	9672	10017
		4	8902	9262	9626	9994	10367	10745	11127	11514	11905	12300
	6	1	9692	10103	10521	10945	11374	11810	12253	12701	13155	13616
		2	13167	13684	14209	14741	15282	15830	16386	16949	17521	18100
		3	7694	8061	8434	8813	9199	9590	9988	10392	10802	11218
		4	10454	10915	11384	11861	12346	12838	13338	13846	14361	14885

Pavement Section										
Width W_P (ft)	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
11	6168	6367	6566	6765	6964	7163	7362	7561	7760	7959
12	6729	6946	7163	7380	7597	7814	8031	8249	8466	8683
22	12337	12735	13133	13530	13928	14326	14724	14122	15520	15918
24	13458	13892	14326	14761	15195	15629	16063	16497	16931	17365

*Tabulated quantities are based on compacted weight of 1.85 tons/yd^3

Estimating - Base and Surfacing Quantities

Figure 520-5h

530 Geosynthetics

530.01 General

Geosynthetics include a variety of manufactured products that are used in drainage, earthwork, erosion control, and soil reinforcement applications.

Several geosynthetic applications are addressed in the *Standard Specifications for Road, Bridge, and Municipal Construction* (Standard Specifications). These applications are as follows:

- Low survivability underground drainage
- Moderate survivability underground drainage
- Separation
- Soil stabilization
- Moderate survivability permanent erosion control
- High survivability permanent erosion control
- Ditch lining
- Temporary silt fence

The Standard Specifications address geosynthetic properties as well as installation requirements and are not site specific. Geosynthetic properties provided in the Standard Specifications are based on the range of soil conditions likely to be encountered in the state of Washington for the applications defined. Other applications, such as prefabricated edge drains, pond liners, and geotextile retaining walls, are currently handled by special provision.

Design responsibilities are discussed in 530.05 below and illustrated in Figures 530-4 and 5.

This chapter does not address applications where geosynthetics are used to help establish vegetation through temporary prevention of erosion (vegetation mats).

530.02 References

Highway Runoff Manual, M 31-15, WSDOT

Hydraulics Manual, M 23-03, WSDOT

Pavement Guide for Design, Evaluation and Rehabilitation, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

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

530.03 Geosynthetic Types and Characteristics

Geosynthetics include woven and nonwoven geotextiles, geogrids, geonets, geomembranes, and geocomposites. Terms used in the past for these construction materials include *fabrics*, *filter fabric*, or *filter cloth* which are for the most part synonymous with the newer term *geotextile*.

Photographs of the various types of geosynthetics are provided in Figure 530-6.

Woven geotextiles consist of slit polymer tapes, monofilament fibers, fibrillated yarns, or multifilament yarns simply woven into a mat. Woven geotextiles generally have relatively high strength and stiffness and, except for the monofilament wovens, relatively poor drainage characteristics.

Nonwoven geotextiles consist of a sheet of continuous or staple fibers entangled randomly into a felt in the case of needle-punched nonwovens, and pressed and melted together at the fiber contact points in the case of heat-bonded nonwovens. Nonwoven geotextiles tend to have low to medium strength and stiffness with high elongation at failure, and relatively good drainage characteristics. The high elongation characteristic gives them superior ability to deform around stones and sticks.

Geogrids consist of a polymer grid mat constructed either of coated yarns or punched and stretched polymer sheet and usually have high strength and stiffness. They are used primarily for soil reinforcement.

Geonets are similar to geogrids but are typically lighter weight, weaker, and have smaller mesh openings. They are used in light reinforcement applications or are combined with drainage geotextiles to form a drainage structure.

Geomembranes consist of impervious polymer sheets that are typically used to line ponds or landfills, or in some cases are placed over moisture sensitive swelling clays to control moisture.

Geocomposites include prefabricated edge drains, wall drains, and sheet drains, that consist typically of a cuspated or dimpled polyethylene drainage core wrapped in a geotextile. The geotextile wrap keeps the core clean so that water can freely flow through the drainage core. The drainage core acts as a conduit. Prefabricated edge drains are used in place of shallow geotextile wrapped trench drains at the edges of the roadway to provide subgrade and base drainage. Wall drains and sheet drains are typically placed between the back of the wall and the soil to drain the soil retained by the wall.

530.04 Geosynthetic Function Definitions and Applications

The function of the geosynthetic varies with the application. See Figure 530-7 for pictorial representations of the various applications. The geosynthetic must be designed with its function(s) in the given application in mind. Typical geosynthetic functions include filtration, drainage, separation, reinforcement, and erosion control. Definitions of these functions and examples of applications where these functions are dominant are as follows:

Geosynthetic filtration is defined as the passage of water through the geosynthetic relatively unimpeded (permeability or permittivity) without allowing passage of soil through the geosynthetic (retention). This is the primary function of geotextiles in underground drainage applications.

Drainage is defined as the carrying of water in the plane of the geosynthetic as a conduit (transmissivity). This is a primary function of geocomposite drains and in some cases thick nonwoven needle-punched geotextiles placed in underground drainage applications where water must be transported away from a given location by the geosynthetic itself.

Separation is defined as the prevention of the mixing of two dissimilar materials. This is a primary function of geotextiles placed between a fine-grained subgrade and a granular base course beneath a roadway.

Reinforcement is defined as the strengthening of a soil mass by the inclusion of elements (geosynthetics) that have tensile strength. This is the primary function of high strength geotextiles and geogrids in geosynthetic reinforced wall or slope applications, or in roadways placed over very soft subgrade soils that are inadequate to support the weight of the construction equipment or even the embankment itself.

Geosynthetic erosion control is defined as the minimizing of surficial soil particle movement due to the flow of water over the surface of bare soil or due to the disturbance of soil caused by construction activities under or near bodies of water. This is the primary function of geotextiles used as silt fences or placed beneath riprap or other stones on soil slopes. Silt fences keep eroded soil particles on the construction site, whereas geotextiles placed beneath riprap or other stones on soil slopes prevent erosion from taking place at all. In general, the permanent erosion control methods described in this chapter are only used where more natural means (such as the use of biodegradable vegetation mats to establish vegetation to prevent erosion) are not feasible.

These functions control some of the geosynthetic properties, such as apparent opening size (AOS) and permittivity, and in some cases load-strain characteristics.

The application will also affect the geosynthetic installation conditions. These installation conditions influence the remaining geosynthetic properties needed, based on the *survivability* level required.

Geosynthetic survivability is defined as the ability of the geosynthetic to resist installation conditions without significant damage, such that the geosynthetic can function as intended. Survivability affects the strength properties of the geosynthetic required.

530.05 Design Approach for Geosynthetics

Four questions must be answered to complete a geosynthetic design:

- Is a geosynthetic really needed?
- What geosynthetic properties will ensure that the geosynthetic functions as intended?
- Where should the geosynthetic be located?
- Will maintenance of the geosynthetic, or the structure of which it is a part, be needed? And, if so, how will it be maintained?

The site conditions and purpose for the geotextile are reviewed to determine whether or not a geotextile is needed.

- For most drainage, separation, soil stabilization, permanent erosion control, and silt fence applications, if a geotextile is needed the geotextile properties in the Standard Specifications can be used.
- In some situations where soil conditions are especially troublesome or in critical or high risk applications, a project specific design may be needed.
- The location of the geosynthetic will depend on how it is intended to function. (See Figure 530-7 for examples.)
- Consider the flow path of any ground water or surface water when locating the geotextile as well as selecting the geotextile to be used. For example, in permanent erosion control applications, water may flow to the geotextile from the existing ground as well as from the surface through wave action, stream flow, or overland sheet flow. For saturated fine sandy or silty subgrades, water must be able to flow from the subgrade through the geotextile soil stabilization layer during the pumping action caused by traffic loads.

Background information and the answers to each of these questions, or at least guidance to obtaining the answers to these questions, are provided for each Standard Specification application as follows:

(1) Underground Drainage, Low and Moderate Survivability

Geotextile used for underground drainage must provide filtration to allow water to reach the drain aggregate without allowing the aggregate to be contaminated by finer soil particles.

Geotextile filtration properties are a function of the soil type. For underground drainage applications, if the subgrade soil is relatively clean gravel or coarse sand, a geotextile is probably not required. At issue is whether or not there are enough fines in the surrounding soil to eventually clog the drain rock or drain pipe if unrestricted flow toward the drain is allowed.

To approximately match the geotextile filtration properties to various soil types, specifications for three classes of Construction Geotextile for Underground Drainage are available in the Standard Specifications. For underground drainage applications, use the gradation of the soil, specifically the percent by weight passing the #200 sieve, to select the drainage geotextile class required. Base selection of the appropriate class of geotextile on the following table:

Percent Passing the #200 Sieve	Geotextile Class
Less than 15%	A
15% to 50%	B
Greater than 50%	C

Selection Criteria for Geotextile Class
Figure 530-1

Obtain soil samples for geotextile underdrain design every 300 ft along the roadway alignment, using hand holes, and at major soil type transitions. This may be spread to every 1,000 ft if the soil conditions appear to be uniform. Use existing soil data where feasible instead of taking new soil samples.

If soil conditions vary widely along the alignment where underground drainage geotextile is anticipated, different classes of drainage geotextile may be required for specific sections of a continuous system.

Strength properties for the underground drainage geotextile depend on the survivability level required to resist installation stresses.

Low survivability designates that the installation stresses placed on the geotextile will be relatively low, requiring only moderate geotextile strength to resist potentially damaging installation conditions. Examples of low survivability level underground drainage applications include:

- Trench drains
- Drains placed behind walls or other structures to drain the backfill
- A geotextile filter sheet placed behind a gabion wall to prevent fines from being washed through the gabion wall face. Trench depths, or the height of the geotextile filter sheet behind gabion walls, must be less than or equal to 6 ft for the low survivability level.

In moderate survivability applications, significant installation stresses may occur, requiring higher geotextile strength. Examples of the moderate survivability application include:

- Trench drains with a depth of greater than 6 ft
- A geotextile filter sheet behind a gabion wall with a height greater than 6 ft
- Any area drain

An area drain is defined as a geotextile placed over or under a horizontal to moderately sloping (1.5H:1V or flatter slope) layer of drainage aggregate. Examples of area drains include:

- Drainage layers over cut-and-cover tunnels
- Rock buttress drainage
- Permeable base beneath highway pavement (see the *Pavement Guide for Design, Evaluation and Rehabilitation* for additional information on permeable bases)
- A parking lot drainage layer

Note that pipe wrapping (the geotextile is wrapped around the surface of the pipe) is not included as an underground drainage application.

Locate the geotextile such that it will function as intended. For example, if the objective is to keep the drainage aggregate surrounding a drain pipe clean, locate the geotextile such that it completely separates the drainage aggregate from more silty surrounding soils, which may include native soils as well as relatively silty roadway base or fill materials.

Consider the flow path of any ground water or surface water when locating the geotextile.

The flow path from the geotextile, as part of the ground water drainage, is typically directed to a surface water conveyance system. Design of surface water conveyance is guided by the *Hydraulics Manual*. The surface water conveyance must be low enough to prevent backflow and charging of the ground water drainage; typically by matching inverts of ground water drainage to crowns of surface water conveyance pipes. A 1 ft allowance is usually applied when connecting to open water or ditches.

(2) Separation

Geotextile used for separation must prevent penetration of relatively fine grained subgrade soil into the ballast or other roadway or parking lot surfacing material to prevent contamination of the surfacing material (the separation function). This application may also apply to situations other than beneath roadway or parking lot surfacing where it is not necessary for water to drain through the geotextile unimpeded (filtration), but where separation of two dissimilar materials is required.

Separation geotextile should only be used in roadway applications where the subgrade is workable such that it can be prepared and compacted as required in Section 2-06.3 of the Standard Specifications, but without removal and replacement of the subgrade soil with granular material. Such removal and replacement defeats the purpose of the geotextile separator.

Separation geotextile placed beneath roadway surfacing is feasible if the subgrade resilient modulus is greater than 5,800 psi and if a saturated fine sandy, silty, or clayey subgrade is not likely to be present. Note that the feasibility of separation geotextile may be dependent on the time of year and weather conditions expected when the geotextile is to be installed.

For separation applications, a geotextile is not needed if the subgrade is dense and granular (silty sands and gravels), but is not saturated fine sands. In general, a separation geotextile is not needed if the subgrade resilient modulus is greater than 15,000 psi.

(3) Soil Stabilization

Geotextile used for soil stabilization must function as a separator, a filtration layer, and to a minor extent as a reinforcement layer. This application is similar to the separation application, except that the subgrade is anticipated to be softer and wetter than in the separation application.

Soil stabilization geotextile is used in roadway applications if the subgrade is too soft and wet to be prepared and compacted as required in Section 2-06.3 of the Standard Specifications. Soil stabilization geotextile is placed directly on the soft subgrade material, even if some overexcavation of the subgrade is performed. Backfill to replace the overexcavated subgrade is not placed below the geotextile soil stabilization layer, as this would defeat the purpose of the geotextile.

The need for soil stabilization geotextile should be anticipated if the subgrade resilient modulus is less than or equal to 5,800 psi, or if a saturated fine sandy, silty, or clayey subgrade is likely to be present.

Consider the flow path of any ground water or surface water when locating the soil stabilization geotextile and when selecting the geotextile to be used. For saturated fine sandy or silty subgrades, water must be able to flow from the subgrade through the geotextile soil stabilization layer during the pumping action caused by traffic loads.

Even if the subgrade is not anticipated to be saturated based on available data, if the subgrade is silty or clayey and it is anticipated that the geotextile will be installed during prolonged wet weather, a soil stabilization geotextile may still be needed.

Soil stabilization geotextile should not be used for roadway fills greater than 5 ft in height or if extremely soft and wet silt, clay, or peat is anticipated at the subgrade level. (Such deposits may be encountered in wetlands, for example.) In such cases the reinforcement function becomes more dominant, requiring that a site-specific design be performed.

(4) Permanent Erosion Control, Moderate and High Survivability

The primary function of geotextile used for permanent erosion control is to protect the soil beneath it from erosion due to water flowing over the protected soil.

The need for a permanent erosion control geotextile depends on the type and magnitude of water flow over the soil being considered for protection, the soil type in terms of its erodability, and the type and amount of vegetative cover present. (See the *Highway Runoff Manual.*)

The source of flowing water could be streams, man-made channels, wave action, or runoff. Water may also flow from the soil behind the geotextile depending on the ground water level.

If ground water cannot escape through the geotextile, an erosion control system failure termed *ballooning* (resulting from water pressure buildup behind the geotextile) or soil piping could occur. Therefore, the geotextile must have good filtration characteristics.

Three classes of permanent erosion control geotextile are available to approximately match geotextile filtration characteristics to the soil. In order to select the drainage geotextile class, determine the gradation of the soil, specifically the percent by weight passing the #200 sieve. Base selection of the appropriate class of geotextile using Figure 530-1.

A minimal amount of soil sampling and testing is needed to determine the geotextile class required. Permanent erosion control geotextile generally does not extend along the roadway alignment for significant distances as does underground drainage geotextile. One soil sample per permanent erosion control location is sufficient. If multiple erosion control locations are anticipated along a roadway alignment, soil sampling requirements for underground drainage can be applied.

If soil conditions vary widely along the alignment where permanent erosion control geotextile is anticipated, different classes of erosion control geotextile may be required for specific sections of a continuous system.

Examples of the permanent erosion control application are the placement of geotextile beneath riprap or gabions along drainage channels, shorelines, waterways, around bridge piers, and under slope protection for highway cut or fill slopes.

If a moderate survivability geotextile is to be used, the geotextile must be protected by a 12 in aggregate cushion and be placed on slopes of 2H:1V or flatter to keep installation stresses to a relatively low level. Large stones can cause significant damage to a moderate survivability geotextile if the geotextile is not protected in this manner. If these conditions are not met, then a high survivability erosion control geotextile must be used.

(5) Ditch Lining

The primary function of the geotextile in a ditch lining application is to protect the soil beneath it from erosion.

This ditch lining application is limited to man-made ditches less than 16 ft wide at the top with side slopes of 2H:1V or flatter. (If the ditch does not meet these requirements, then permanent erosion control, moderate or high survivability geotextile must be used.) It is assumed that only quarry spall sized stones or smaller will be placed on the geotextile so only a moderate survivability geotextile will be required.

Filtration is not a significant function in this application. Since the ditch is relatively shallow, it is expected that the main water source will be the water carried by the ditch, and little water will pass through the geotextile.

Another application with a similar geotextile function is the placement of geotextile below culvert outlets to prevent erosion at the outlet.

(6) Temporary Silt Fence

The primary function of geotextile used in a temporary silt fence is to prevent eroded material from being transported away from the construction site by runoff water. The silt fence acts primarily as a temporary dam and secondarily as a filter.

In some cases, depending on the topography, the silt fence may also function as a barrier to direct flow to low areas at the bottom of swales where the water can be collected and temporarily ponded. It is desirable to avoid the barrier function as much as possible, as silt fences are best suited to intercepting sheet flow rather than concentrated flows as would occur in swales or intermittent drainage channels.

To function as intended, the silt fence should have a low enough permeability to allow the water to be temporarily retained behind the fence allowing suspended soil particles in the water to settle to the ground. If the retention time is too long, or if the flow rate of water is too high, the silt fence could be overtopped thus allowing silt laden water to escape. Therefore, a minimal amount of water must be able to flow through the fence at all times.

Temporary water ponding is considered the primary method of silt removal and the filtration capabilities of the fence are the second line of defense. However, removal of silt sized particles from the water directly by the geotextile creates severe filtration conditions for the geotextile, forcing the geotextile to either blind or allow the fines to pipe through the geotextile. (Blinding is the coating of the geotextile surface with soil particles such that the openings are effectively plugged.) If the geotextile openings (AOS) are designed to be small enough to capture most of the suspended soil particles, the geotextile will likely blind, reducing the permeability enough to allow water to overtop the fence. Therefore, it is best to allow some geotextile openings that are large enough to allow the silt sized particles to easily pass through. Even if some silt particles pass through the fence, the water flow rate below the fence will be decreased and the volume of silt laden water passing through the geotextile is likely to be relatively small and the water is partially filtered.

The geotextile apparent opening size (AOS) and permittivity are typically used to specify the filtration performance of geotextiles. The geotextile function in silt fence applications is more complex than this and AOS and permittivity do not relate directly to how well a silt fence will perform. However, nominal values of AOS and permittivity can be specified such that the types of geotextile products known to perform satisfactorily in this application are selected. Such values are provided in the Standard Specifications.

The source of load on the geotextile is from silt buildup at the fence and water ponding. The amount of strength required to resist this load depends on whether or not the geotextile is supported with a wire or polymer grid mesh between the fence posts. Obviously, unsupported geotextile must have greater strength than supported geotextile. If the strength of the geotextile or its support system is inadequate, the silt fence could fail. Furthermore, unsupported geotextile must have enough stiffness such that it does not deform excessively and allow silt laden water to go over the top of the fence.

The need for a silt fence can be anticipated where construction activities will disturb and expose soil that could erode. The ground surface is considered disturbed if vegetative cover is at least partially removed over a significant area by construction activities. Consider whether or not silt laden runoff water from the disturbed area can reach an environmentally sensitive area or a man-made storm water system. If the exposed soil is a clean sand or gravel or if a significant zone of heavy vegetative cover separates the exposed soil from the environmentally sensitive area, a silt fence may not even be needed. Obtain assistance from the Olympia Service Center (OSC) Hydraulics Section for help in determining whether or not a silt fence is needed in such situations.

The feasibility of a geotextile silt fence depends on the magnitude of water flow to the fence, the steepness of the slope behind the fence and whether or not flow is concentrated at the fence. If the silt fence is not feasible, alternative erosion control methods may be required. (See the *Highway Runoff Manual*.)

Consider all feasible erosion control options in terms of potential effectiveness and economy before making the final decision to use a silt fence. Select the best option for the site conditions, including site geometry and contours, soil type, and rainfall potential. Consider silt fences for temporary erosion control in disturbed areas in the following circumstances:

- Fully covering disturbed areas temporarily with polyethylene sheeting or other temporary covering is not feasible or practical.
- Permanent ground cover for disturbed areas is not yet established.
- Runoff water reaches the silt fence primarily as sheet flow rather than as concentrated flows, with the exception of some ditch and swale applications.
- Slopes above the silt fence are not steeper than 1.5H:1V.
- The sheet flow length (length of slope contributing runoff water to the silt fence) is not too long.

Maximum sheet flow lengths allowed for silt fences are provided in the following table which is based on the typical 2-year 24-hour design storm for Washington resulting in a 24-hour rainfall of 3 in.

Slope	Sheet Flow Length
1.5H:1V	100 ft
2H:1V	115 ft
4H:1V	150 ft
6H:1V	200 ft

Maximum Sheet Flow Lengths for Silt Fences
Figure 530-2

The sheet flow length represents the area contributing runoff water from precipitation. The sheet flow length is defined in Figure 530-8. The sheet flow lengths provided in Figure 530-2 were determined assuming a bare soil condition, with the soil classified as a silt. These are worst case assumptions because less runoff would be expected for sand or gravel soils or if some vegetation is present.

The sheet flow length is usually equal to or greater than the disturbed soil slope length. However, undisturbed sloping ground above the disturbed slope area may also contribute runoff to the silt fence area. The length of undisturbed sloping ground above the disturbed slope to included in the total contributing slope length depends on the amount and type of vegetation present, the slope steepness, and the degree of development above the slope.

If unsure whether the proposed silt fence meets the requirements in Figure 530-2, contact the OSC Hydraulics Section for assistance.

Average or Ditch Swale Grade	Ditch or Swale Storage Length	Allowable Contributing Area per Foot of Ditch or Swale Storage Width
16%	13 ft	200 ft^2
10%	20 ft	250 ft^2
5%	40 ft	300 ft^2
4%	50 ft	400 ft^2
3%	65 ft	500 ft^2
2%	100 ft	600 ft^2
1%	200 ft	1,000 ft^2

Maximum Contributing Area for Ditch and Swale Applications
Figure 530-3

Temporary silt fences may also be used in ditch or swale applications. If the area contributing runoff to the fence exceeds the value determined from Figure 530-3, hydraulic overload will occur. The ditch or swale storage length and width are defined in Figure 530-9. The assumptions used in the development of Figure 530-3 are the same as those used for Figure 530-2 in terms of the design storm and ground conditions.

As an example, if a site has a 13-ft wide ditch with an average slope of 2%, the fence can be located such that 7,800 ft^2 of area drain to it. If it appears that the area draining to the fence will be larger than the allowable, it may be possible to divide the contributing area into smaller areas and add a silt fence for each smaller area as shown in Figure 530-10.

The minimum storage length for the ditch behind each silt fence must be maintained. If this is not possible, it may be necessary to use an alternate erosion control structure as described in the *Highway Runoff Manual* or to develop a special silt fence design.

Figure 530-3 was developed with the assumption that water will be able to pond to a depth of at least 2 ft behind the fence. If this is not the case (the ditch or swale depth is less than 2 ft), the table cannot be used. Furthermore, the ditch depth must be greater than the height of the silt fence at its lowest point within the ditch. Otherwise, there will not be enough storage available behind the fence and water will circumvent the fence by flowing around it.

Locate silt fences on contour as much as possible. At the ends of the fence turn it up hill such that it captures the runoff water and prevents water from flowing around the end of the fence. This is illustrated in Figure 530-11.

Silt fences are designed to capture up to a 2 ft depth of water behind the fence. Therefore, the ground line at the ends of the fence must be at least 2 ft above the ground line at the lowest part of the fence. This 2 ft requirement applies to ditches as well as to general slope erosion control.

If the fence must cross contours (except for the ends of the fence) use gravel check dams placed perpendicular to the back of the fence to minimize concentrated flow and erosion along the back of the fence. (See Figure 530-12.)

- The gravel check dams are approximately 1 ft high at the back of the fence and be continued perpendicular to the fence at the same elevation until the top of the dam intercepts the ground surface behind the fence.
- Locate the gravel check dams every 10 ft along the fence.
- In general, the slope of the fence line is not be steeper than 3H:1V.
- For the gravel check dams, use Crushed Surfacing Base Course Section 9-03.9(3)), Gravel Backfill for Walls Section 9-03.12(2), or Shoulder Ballast Section 9-03.9(2)).

If the silt fence application is considered critical (such as when the fence is placed immediately adjacent to environmentally sensitive areas such as streams, lakes, or wetlands) place a second silt fence below the first silt fence to capture any silt that passes through the first fence and/or place straw bails behind the silt fence. Locate silt fences at least 7 ft from an environmentally sensitive area. Where this is impossible, and a silt fence must be used, a special design may be necessary.

Temporary silt fences are sometimes used to completely encircle underground drainage inlets or other similar features to prevent silt from entering the drainage system. This is acceptable, but the silt fence functions primarily as a barrier, and not as a ponding or filtering mechanism, unless the drainage inlet is in a depression that is large enough to allow water to pond behind the silt fence.

- If the drainage inlet and silt fence are not in a large enough depression, silt laden water will simply be directed around the fence and must be captured by another fence or sedimentation pond downslope.
- If the depression is deep, locate the silt fence no more than 2 ft below the top of the depression to prevent overtopping. A site-specific design may be needed if the silt fence is located deeper than 2 ft within the depression.

It may be necessary to relocate silt fences during the course of a construction project as cuts and fills are built or as disturbed areas change. An erosion control/silt fence plan that accounts for the anticipated construction stages (and eventual removal) should be developed. Do not assume that one silt fence location can routinely be used for the entire life of the contract. Periodically check the locations in the field during the construction project and field-adjust the silt fence locations as necessary to ensure that the silt fence functions as intended.

(7) Standard Specification Geotextile Application Identification in the Plans

Identify the geotextile in the contract plan detail in a way that ties it to the appropriate Standard Specification application. For example:

- If a geotextile is to be used to line an underground trench drain 3 ft in depth and the native soil has less than 15% passing the #200 sieve, identify the geotextile on the plan sheet as “Construction Geotextile for Underground Drainage, Low Survivability, Class A.”

- If the geotextile is to be placed beneath riprap on a slope without a cushion layer between the geotextile and the riprap and the native soil contains 35% passing the #200 sieve, identify the geotextile on the plan sheet as “Construction Geotextile for Permanent Erosion Control, High Survivability, Class B.”
- If the geotextile is to be placed between the roadway base course and a moist silt subgrade with a resilient modulus of 6,500 psi, and the roadway is planned to be constructed during the dry summer and early fall months, identify the geotextile on the plan sheet as “Construction Geotextile for Separation.”

(8) Site-Specific Designs (All Applications)

A site-specific design is required:

- For all reinforcement applications
- For applications not covered by the Standard Specifications

Consider a site-specific design:

- For high risk applications
- For exceptionally large geotextile projects: if the geotextile quantity in a single application is over 35,000 yd^2, or over 85,000 yd^2 for the separation application
- For severe or unusual soil or ground water conditions
- If the soil in the vicinity of the proposed geotextile location consists of alternate thin layers of silt or clay with potentially water-bearing sand layers on the order of 1 to 3 in in thickness or less
- If the soil is known through past experience to be problematic for geosynthetic drains
- For drains in native soil behind structures except drains contained within granular backfill
- For drains designed to stabilize unstable slopes
- For drains designed to mitigate frost heave

In such cases, obtain assistance from the OSC Materials Laboratory Geotechnical Branch. To initiate the special design provide a plan and cross-section showing:

- The geosynthetic structure to be designed
- Its relative location to other adjacent structures that it could potentially affect
- Its intended purpose
- Any soil data in the vicinity

Consider a site-specific design for temporary silt fences:

- If silt fence must be used in intermittent streams or where a significant portion of the silt fence functions as a barrier that directs flow to the lower portions of the silt fence
- If the fence must be located on steep slopes
- In situations not meeting the requirements in Figures 530-2 and 3
- If the 2 year, 24 hour design storm for the site is greater than the 3 in assumed for the development of Figures 530-2 and 3
- Where concentrated flow is anticipated
- If closer than 7 ft from an environmentally sensitive area
- If more than 2 ft depth of storage is needed

For a site-specific temporary silt fence design, obtain assistance from the OSC Hydraulics Section. To initiate the design, send the following information to the OSC Hydraulics Section and a copy to the OSC Materials Laboratory Geotechnical Branch:

- Plan sheets showing proposed silt fence locations and grading contours
- Estimate of the area contributing runoff to each silt fence, including percentage and general type of vegetative cover within the contributing area
- Any available site soil information

For all site-specific designs of applications not covered by the Standard Specifications, complete plans and special provisions are needed. In general, for site-specific designs of Standard Specification applications, only a minor modification of the appropriate geotextile property table will be needed.

530.06 Design Responsibility

The design responsibility and process for geotextile design are illustrated in Figures 530-4 and 5. The Regional Project Development Office, in particular the Regional Project Manager, is responsible to initiate and develop all Standard Specification geotextile designs, except for roadway separation and soil stabilization applications, which are initiated and developed by the Regional Materials Laboratory.

The Regional Materials Laboratory assists the Regional Project Manager with Standard Specifications underground drainage and permanent erosion control designs.

The Regional Environmental Design Section assists with Standard Specifications, permanent erosion control, and temporary silt fence designs.

Once the Regional Project Manager or Materials Laboratory has determined that a geotextile is appropriate, development of a Standard Specification geotextile design includes the development of plan details showing the plan location and cross-section of the geotextile installation. Standard details for geotextiles as provided in the *Plans Preparation Manual* may be used or modified to adapt to the specific project situation. Note that only minimum dimensions for drains are provided in these standard details.

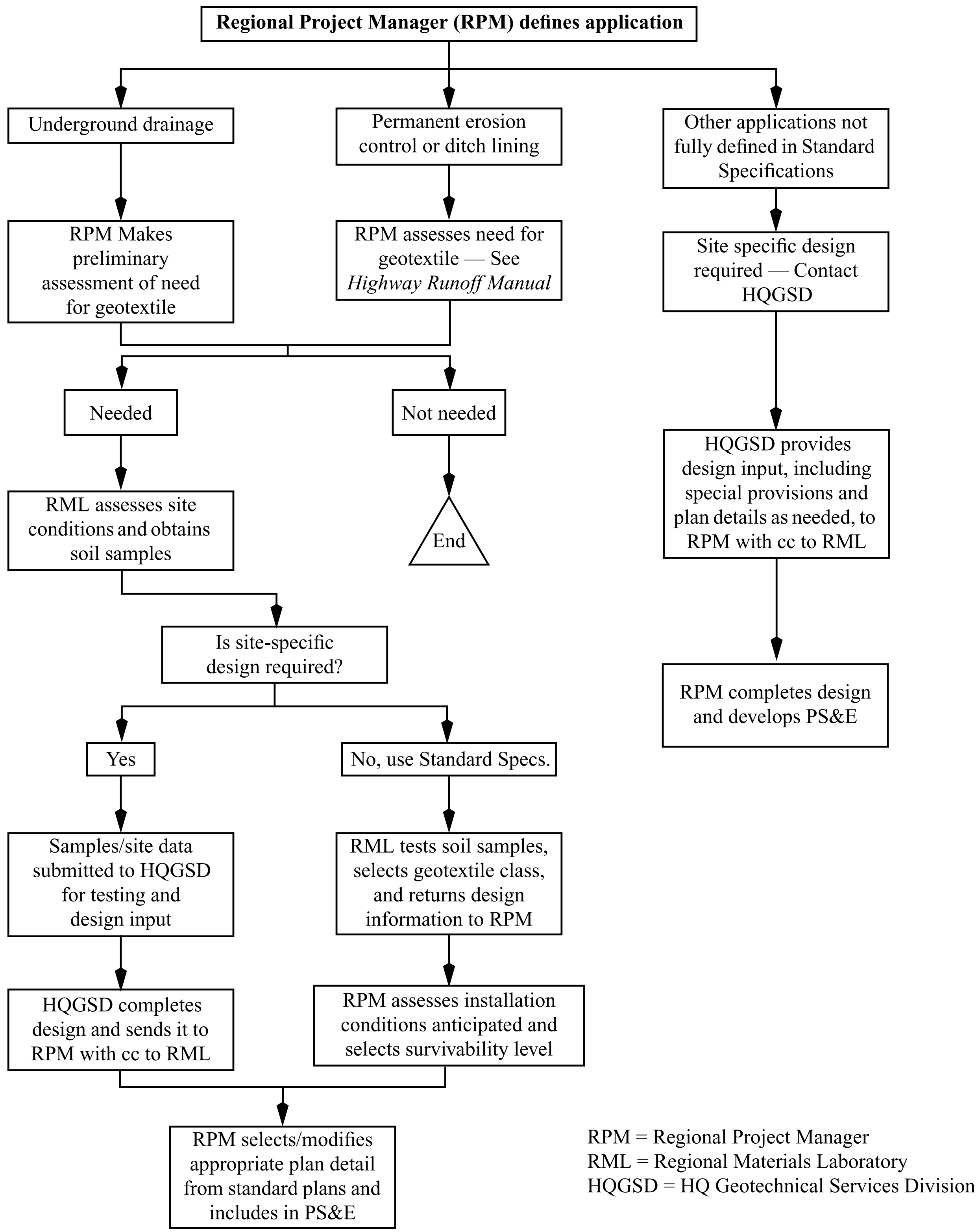
Site-specific geosynthetic designs and applications not addressed by the Standard Specifications are designed by the region with the assistance of the HQ Materials Laboratory Geotechnical Services Division or the HQ Hydraulics Branch as described in 530.05.

Design assistance by the HQ Geotechnical Services Division or HQ Hydraulics Branch for site-specific design of Standard Specifications applications includes determination of geosynthetic properties and other advice as needed to complete the geosynthetic plans and any special provisions required.

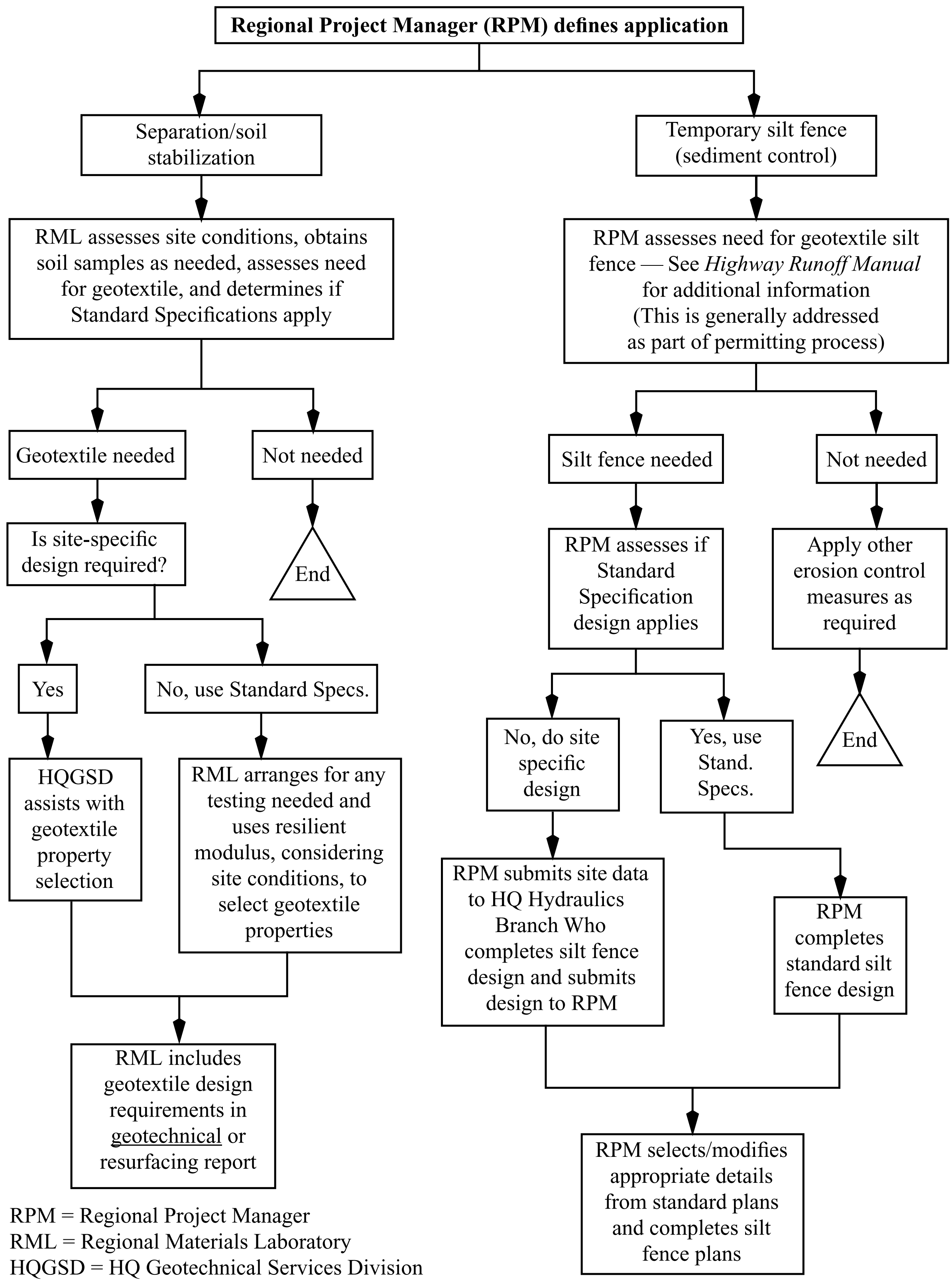
The HQ Geotechnical Services Division is fully responsible to develop and complete the geosynthetic design, plan details that can be used to develop the contract plan sheets, and special provisions for geosynthetic reinforced walls, slopes, and embankments; deep trench drains for landslide stabilization; and other applications that are an integral part of an HQ geotechnical design. The Regional Project Manager incorporates the plan details and special provisions into the PS&E.

530.07 Documentation

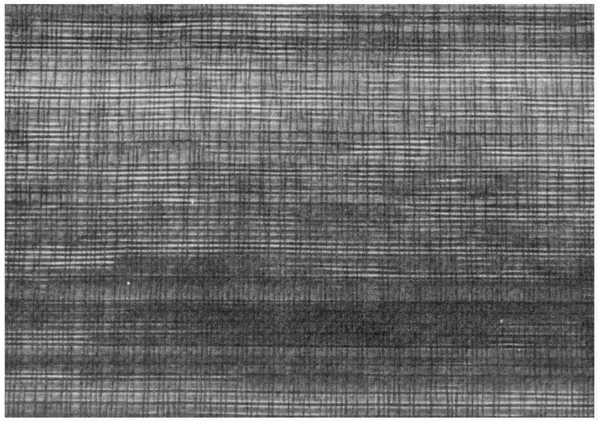
A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/



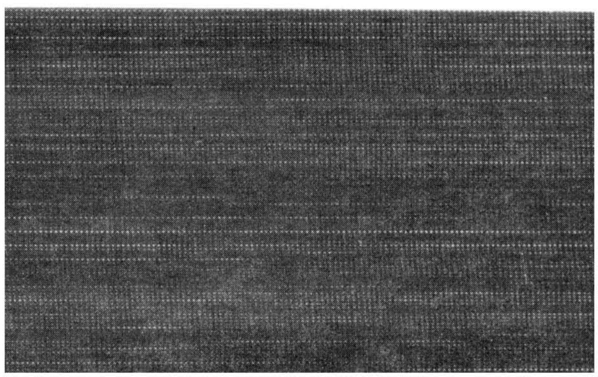
Design Process for Drainage and Erosion Control Geotextiles and Nonstandard Applications
Figure 530-4



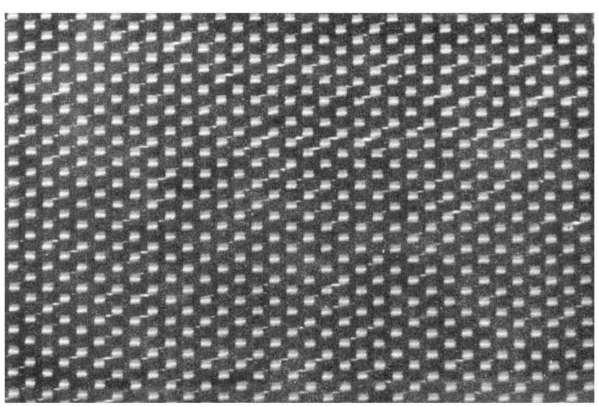
Design Process for Separation, Soil Stabilization, and Silt Fence
Figure 530-5



Slit Film Woven Geotextile

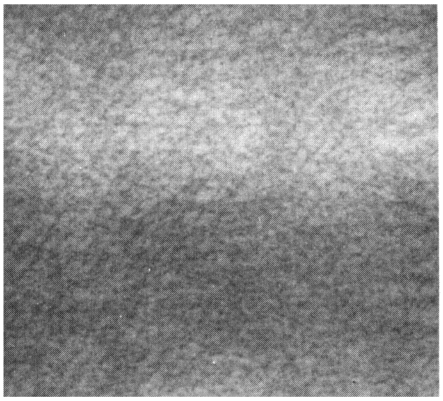


Monofilament Woven Geotextile

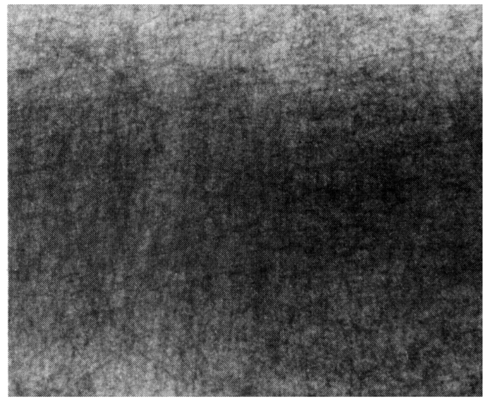


Multifilament Woven Geotextile

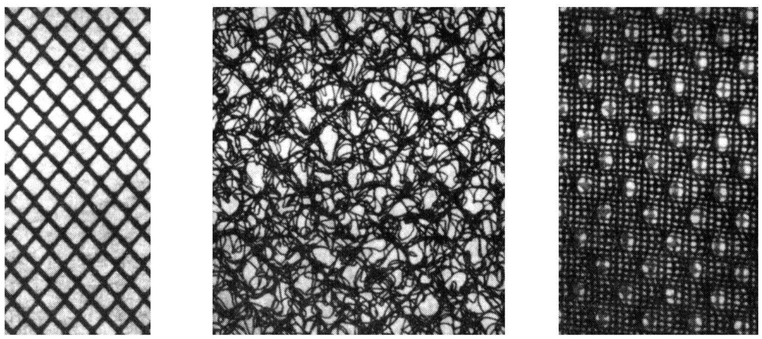
Examples of Various Geosynthetics
Figure 530-6a



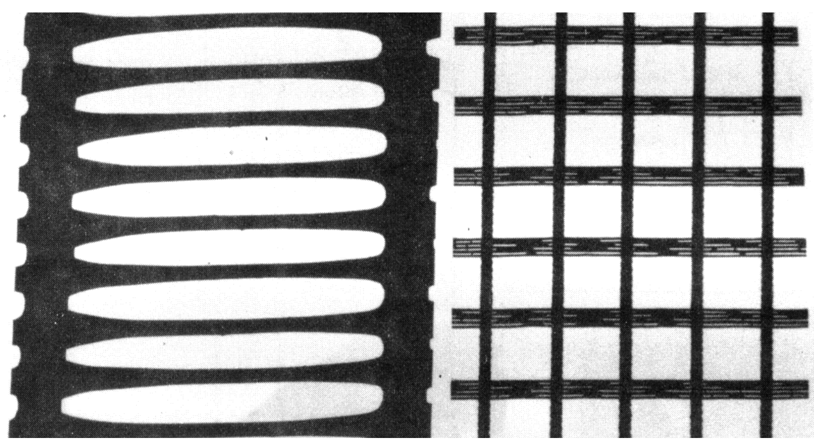
Needle Punched Nonwoven Geotextile



Heat Bonded Nonwoven Geotextile

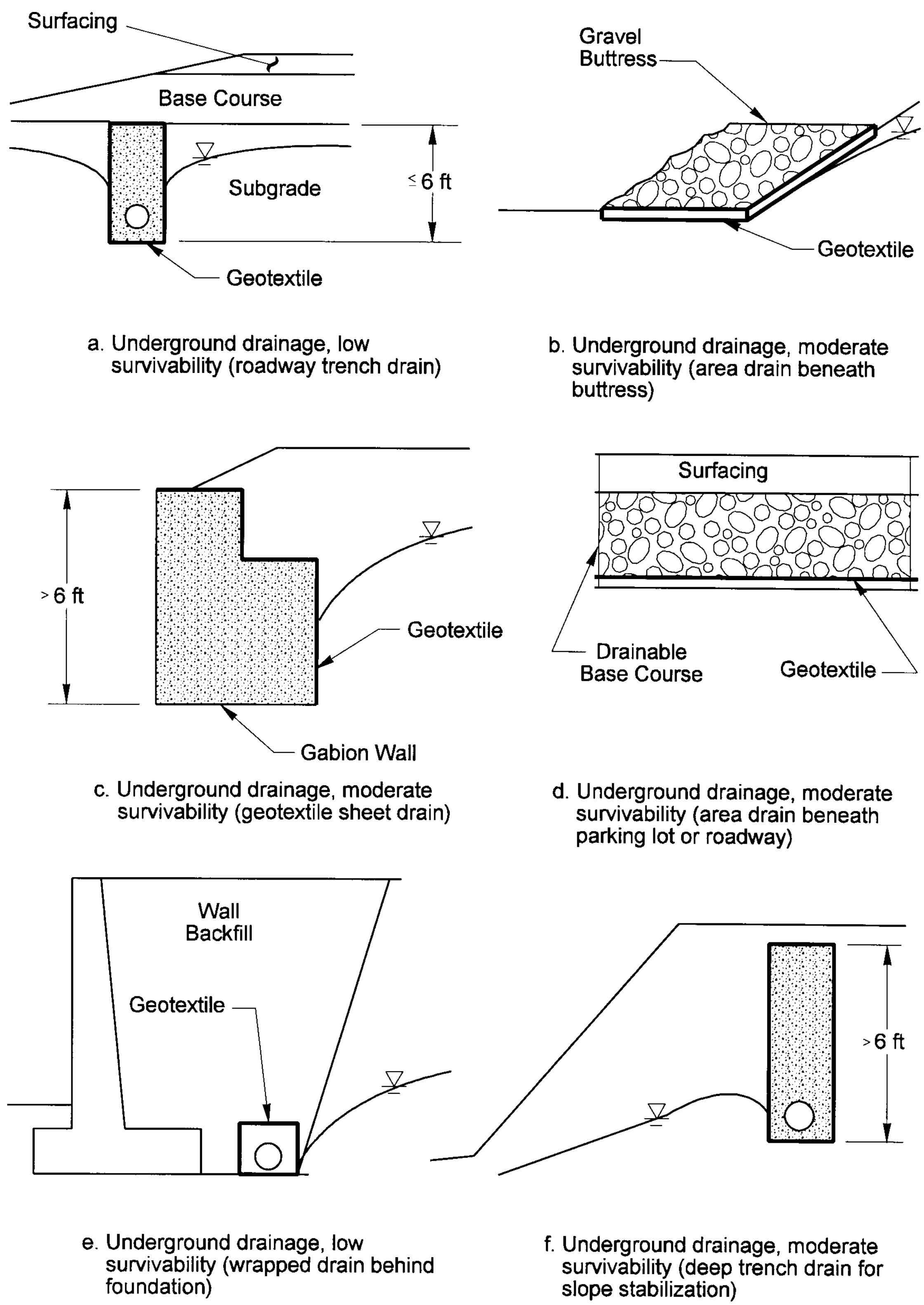


Geocomposite Drains (Geotextile With Core)



Extruded and Woven Geogrids

Examples of Various Geosynthetics
Figure 530-6b



a. Underground drainage, low survivability (roadway trench drain)

b. Underground drainage, moderate survivability (area drain beneath buttress)

c. Underground drainage, moderate survivability (geotextile sheet drain)

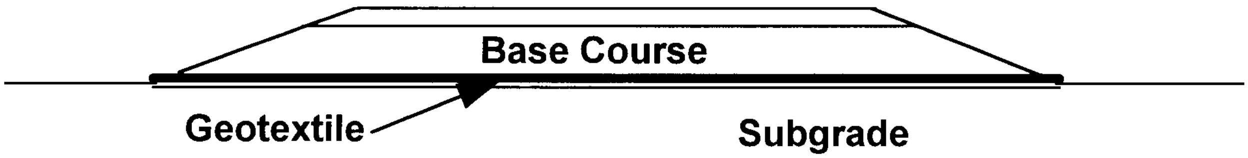
d. Underground drainage, moderate survivability (area drain beneath parking lot or roadway)

e. Underground drainage, low survivability (wrapped drain behind foundation)

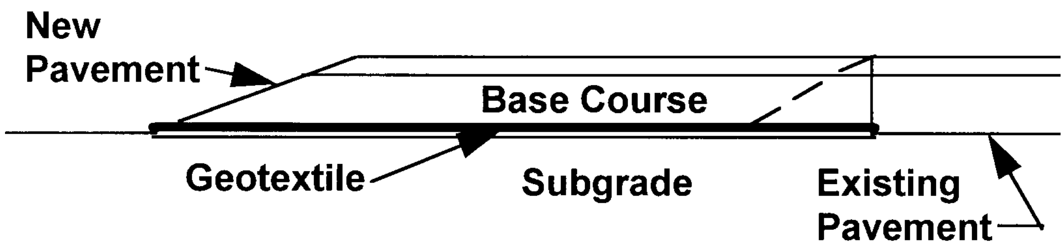
f. Underground drainage, moderate survivability (deep trench drain for slope stabilization)

Geotextile Application Examples

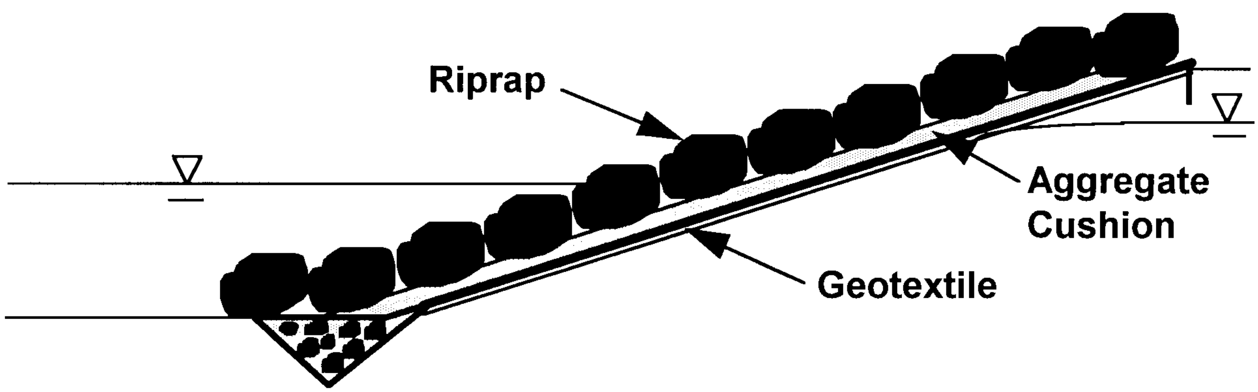
Figure 530-7a



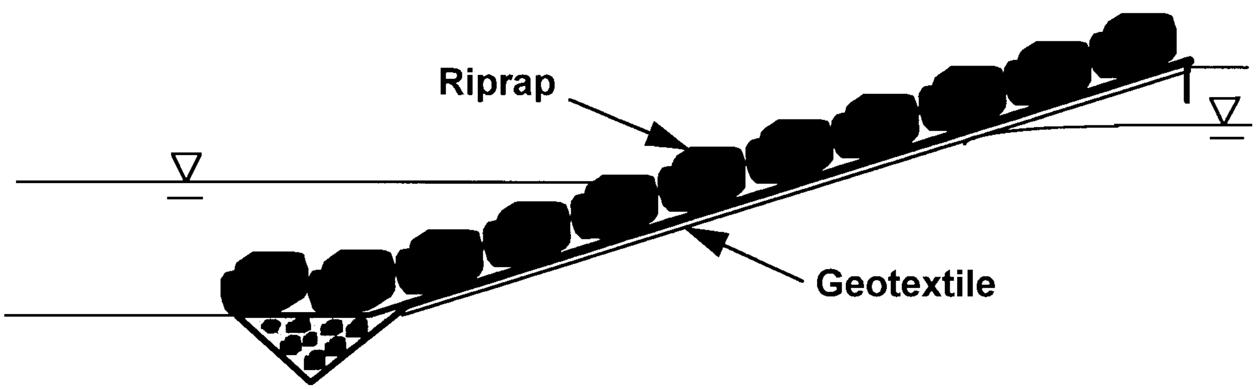
g. Separation or soil stabilization for new roadway (depends on subgrade condition)



h. Separation or soil stabilization for widened roadway (depends on subgrade condition)

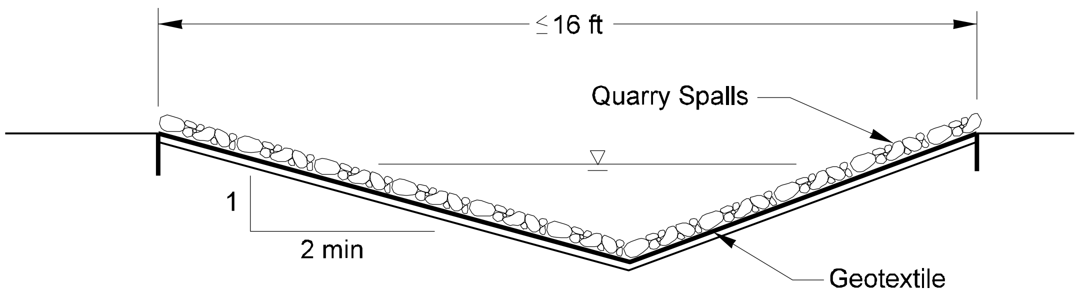


i. Permanent erosion control, moderate survivability

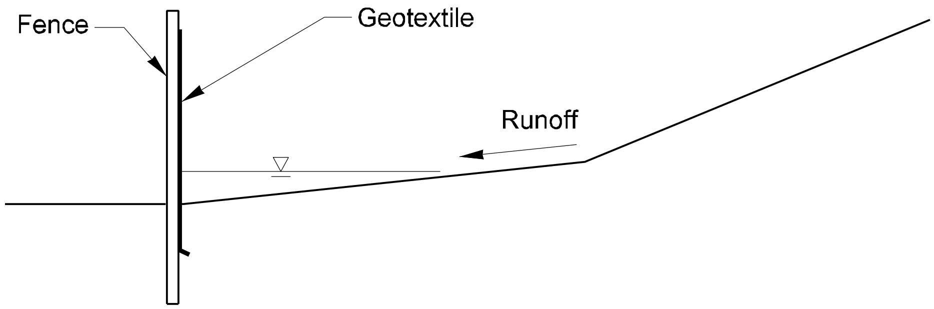


j. Permanent erosion control, high survivability

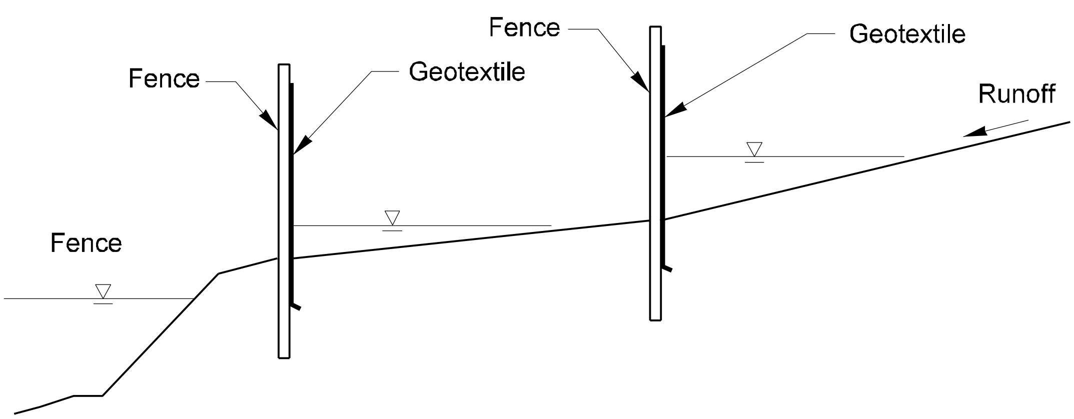
Geotextile Application Examples
Figure 530-7b



k. Ditch lining

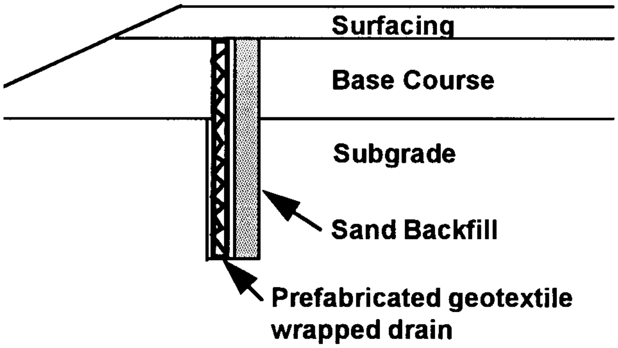


l. Silt fence not immediately adjacent to enviromentally sensitive area

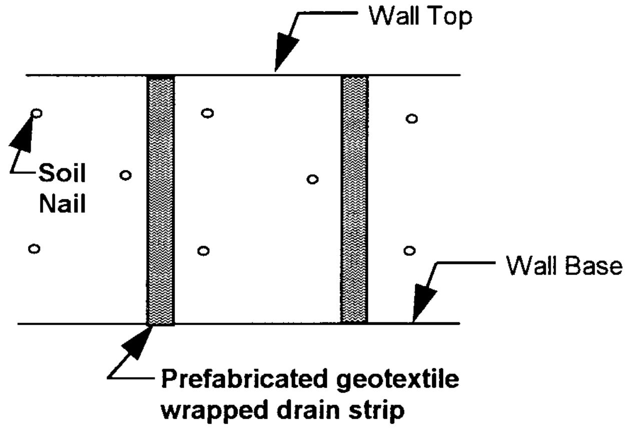


m. Silt fence immediately adjacent to enviromentally sensitive area

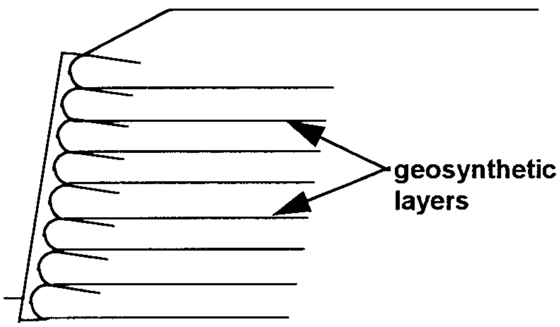
Geotextile Application Examples
Figure 530-7c



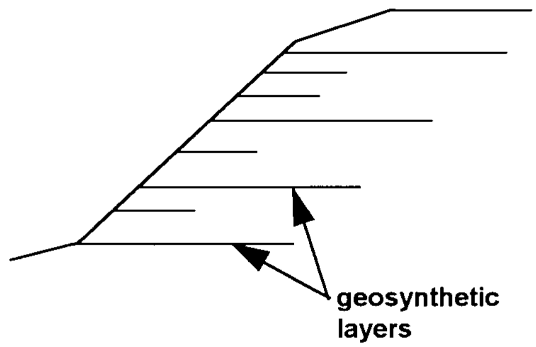
n. Prefabricated edge drain for roadway



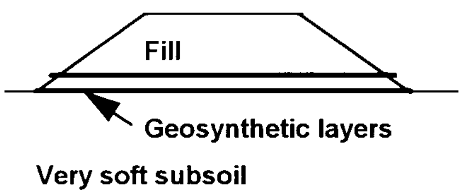
o. Prefabricated drain strip behind wall face



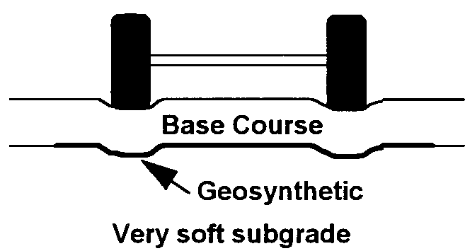
p. Geosynthetic wall



q. Geosynthetic reinforced slope

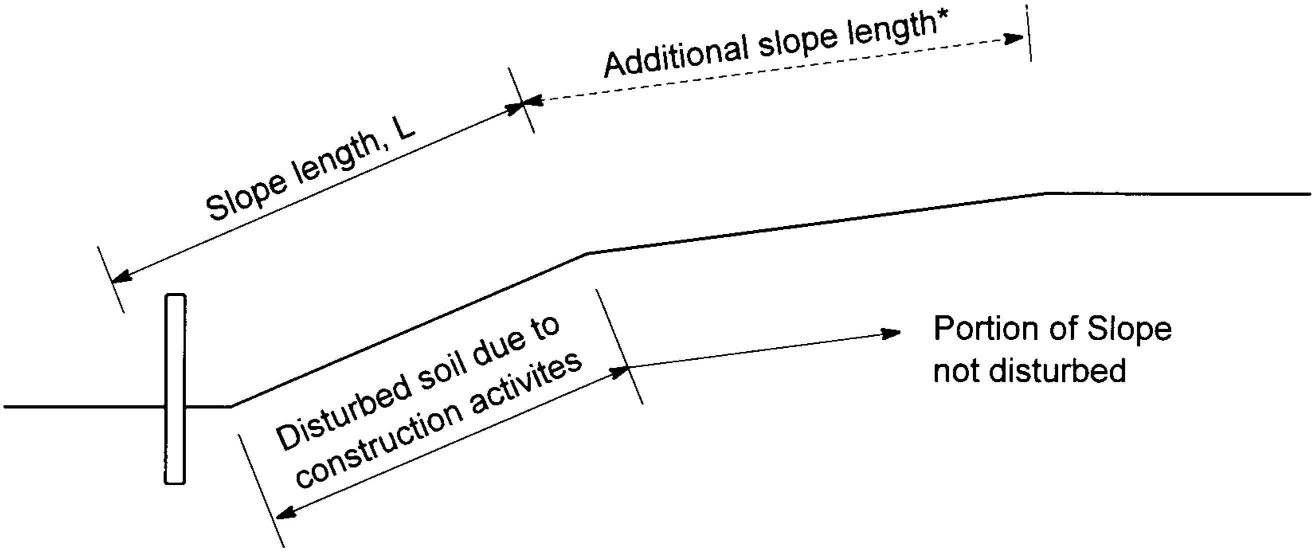


r. Geosynthetic reinforced embankment



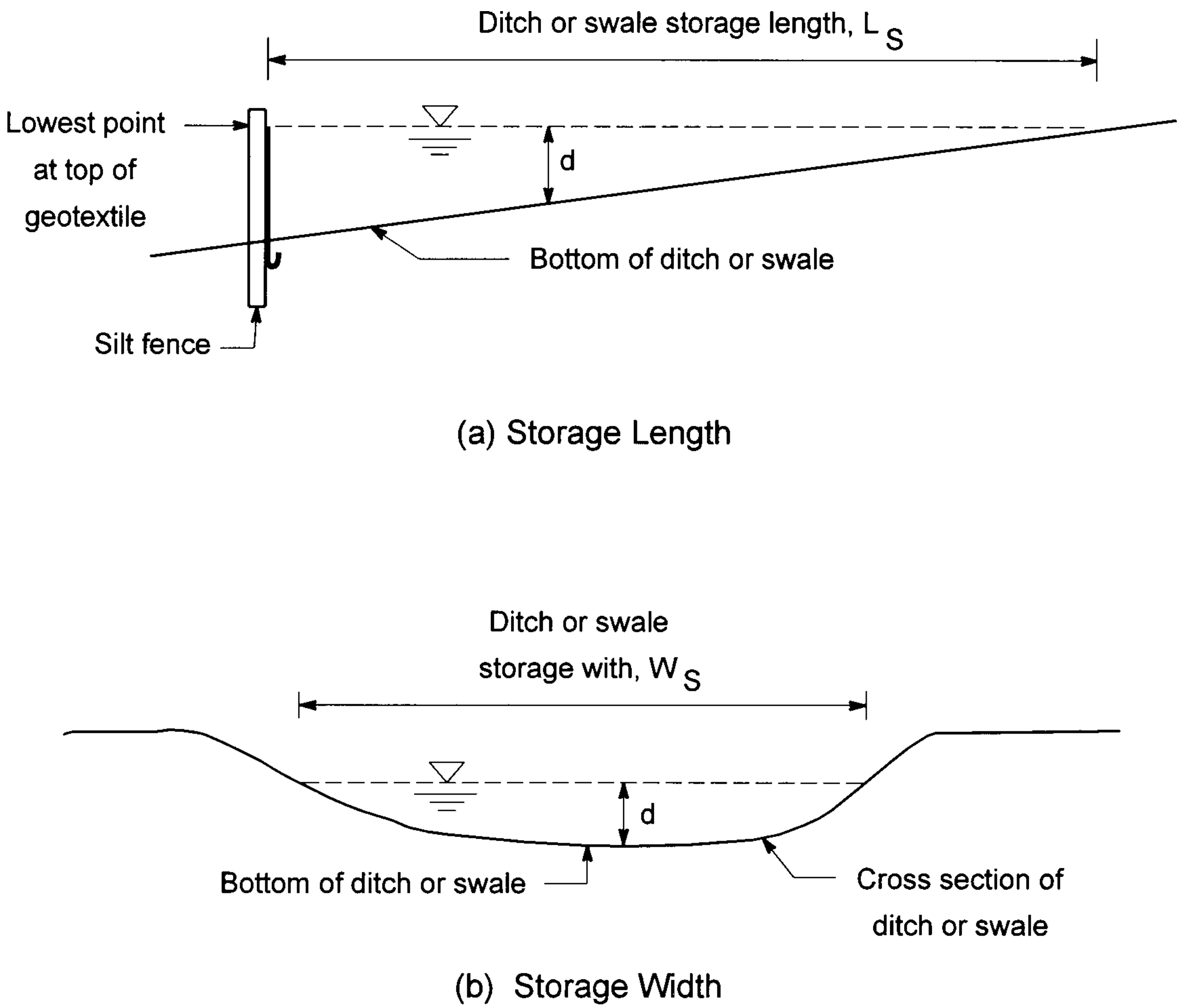
s. Geosynthetic subgrade reinforcement for temporary roads

Geotextile Application Examples
Figure 530-7d

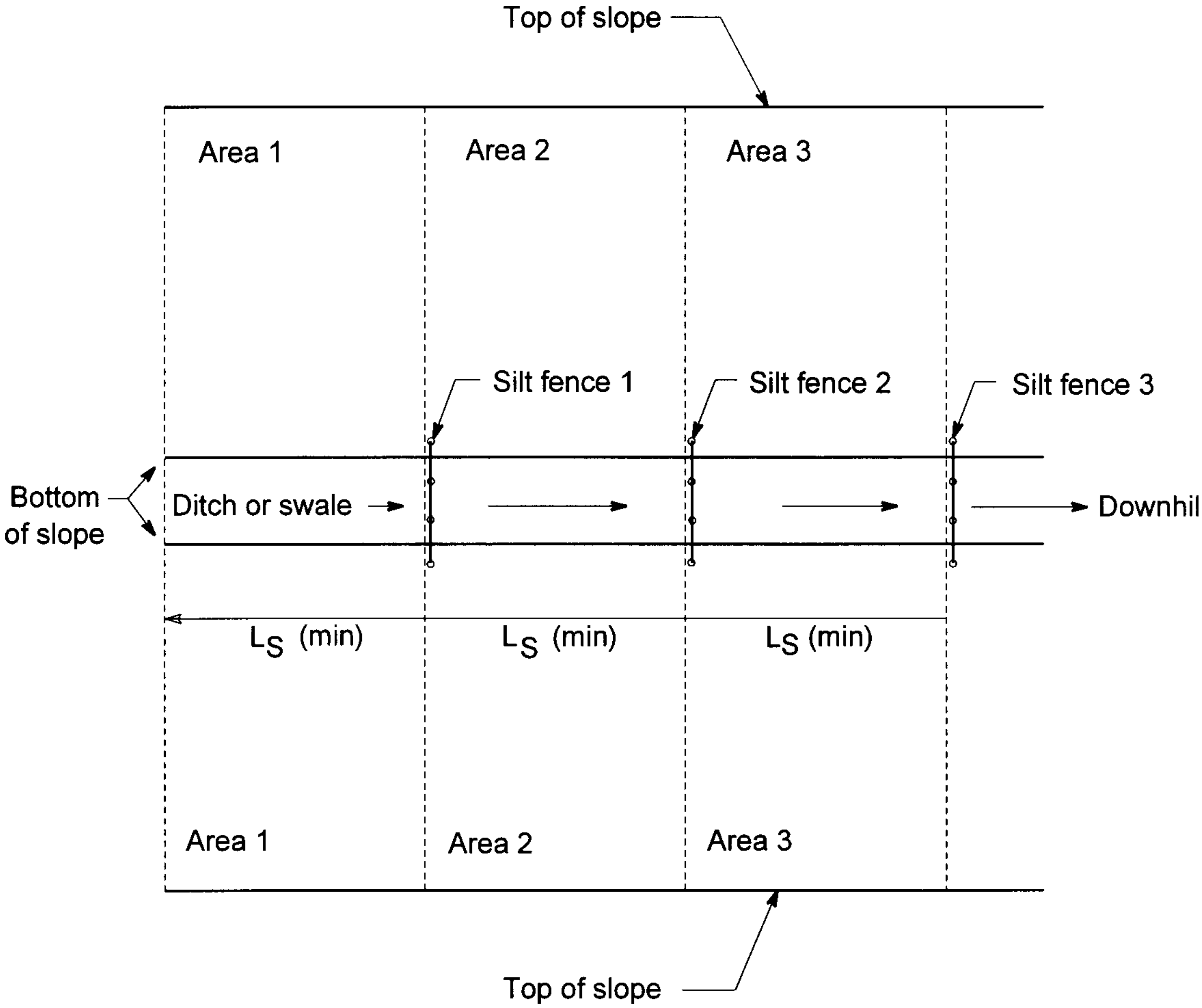


*May need to be included as part of slope length depending on vegetative cover, slope steepness, and degree of development above slope.

Definition of Slope Length
Figure 530-8

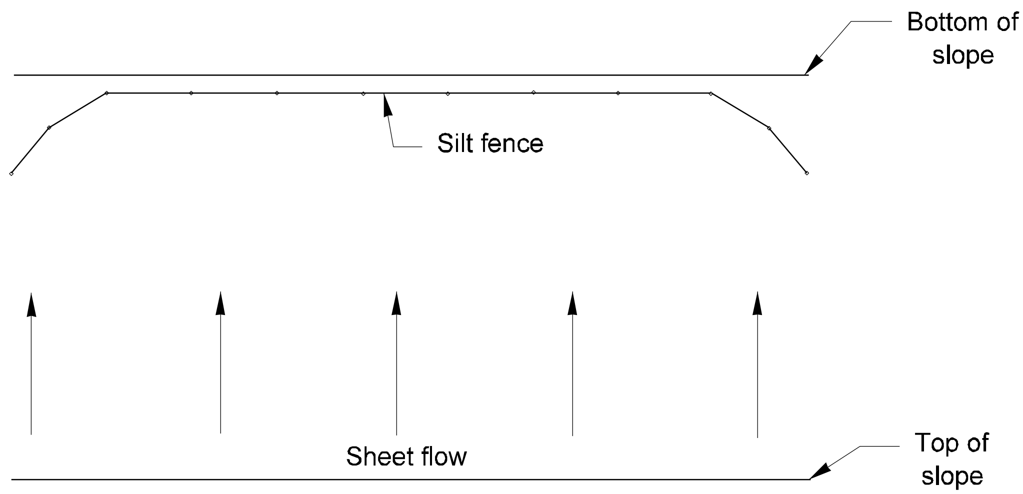


Definition of Ditch or Swale Storage Length and Width
Figure 530-9

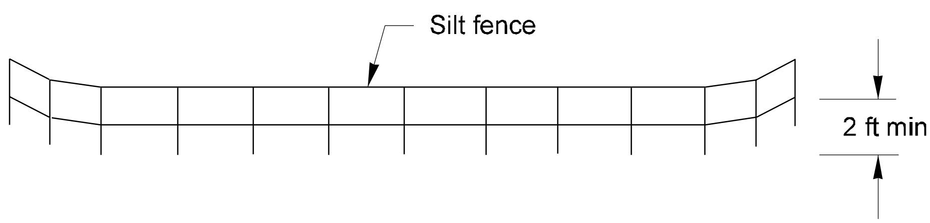


Method to keep contributing area to ditch or swale within allowable limits if contributing area too large based on Figure 530-3.

Silt Fences for Large Contributing Area
Figure 530-10



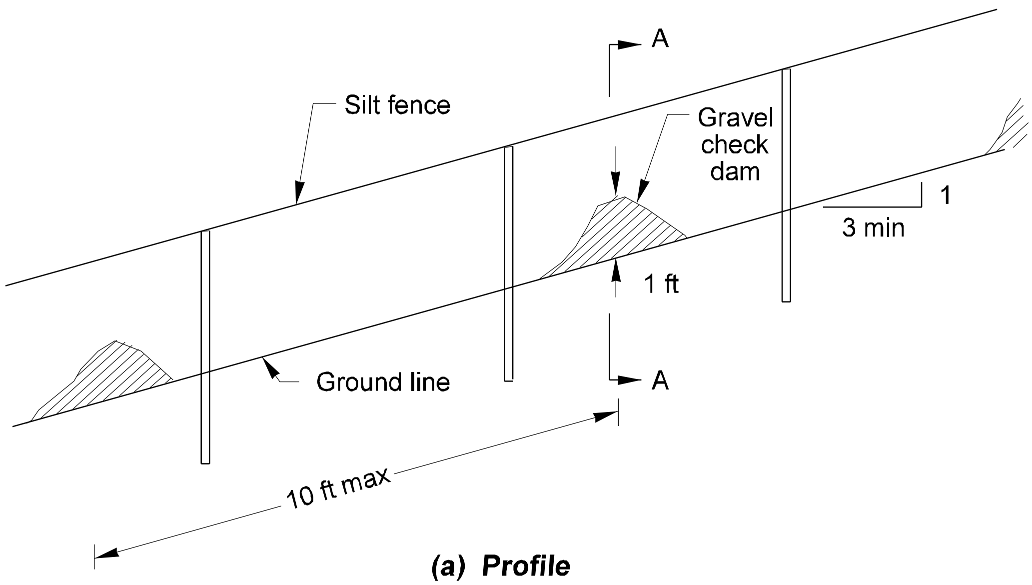
(a) Silt Fence Plan



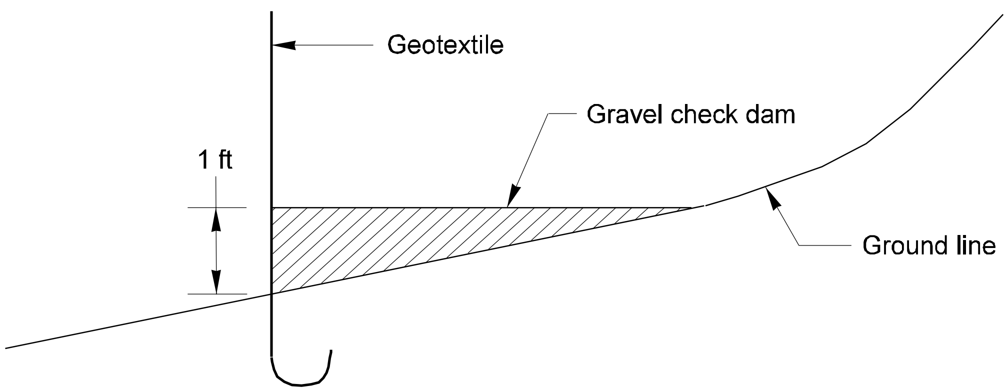
(b) Silt Fence Profile

Silt fence plan and profile illustrating how to insure silt fence will capture runoff water and not allow water to run around ends of fence.

Silt Fence End Treatment
Figure 530-11



(a) Profile



(b) Cross-Section A-A

Gravel Check Dams for Silt Fences
Figure 530-12

610
Highway Capacity

610.01 GENERAL

The term “capacity” is used to express the maximum number of vehicles that have a reasonable expectation of passing over a section of a lane or a roadway during a given time period under prevailing roadway and traffic conditions. Highway capacity is of vital concern in the design of highways. A knowledge of highway capacity is essential to the proper fitting of a planned highway to the requirements of traffic. It helps both in the selection of highway type and in determining dimensional needs such as number of lanes.

The purpose of this section is to provide the user with enough information to perform a preliminary capacity analysis for basic highway sections. This chapter also gives a basis for determining the need for more detailed capacity analysis.

This Design Manual chapter does not cover preliminary capacity analysis for highway portions with signal spacing of less than 2 miles and those within 2,500 feet of interchange ramps.

610.02 DEFINITIONS AND SYMBOLS

(1) Definitions

Average Daily Traffic (ADT). The volume of traffic passing a point or segment of a highway, in both directions, during a period of time, divided by the number of days in the period and factored to represent an estimate of traffic volume for an average day of the year.

Directional Design Hour Volume (DDHV). The traffic volume for the peak hour in the peak direction of flow; usually a forecast of the relevant peak hour volume. (Units of DDHV are vehicles per hour. DDHV should be rounded to the nearest 50 vph.)

Freeway. A divided highway facility that has a minimum of two lanes for the exclusive use of traffic in each direction and full control of access.

Level of Service (LOS). A qualitative measure describing the operational conditions within a traffic stream; generally described in terms of such factors as speed, travel time, freedom to maneuver, comfort and convenience, safety, and others. See Figure 610-1 for appropriate design levels of service for different highway types.

Multilane Highway. A highway with at least two lanes for the exclusive use of traffic in each direction, with or without partial control of access, that may have periodic interruptions to flow at signalized intersections.

Peak Hour Factor (PHF). The ratio of the volume occurring during the peak hour to the maximum rate of flow during a given time period within the peak hour. It is the measure of peaking characteristics of a highway section or intersection.

Service Flow Rate (SFL). The maximum hourly rate of flow that can be accommodated past a point or short uniform segment of traffic lane (for multilane) or the entire roadway (for a two-lane facility), under prevailing traffic, roadway, and control conditions while maintaining a stated level of service; value is specific to a given level of service.

Terrain.

(a) Level Terrain. Any combination of grades and horizontal and vertical alignment permitting heavy vehicles to maintain approximately the same speed as passenger cars; this generally includes short grades of no more than 1 to 2 percent.

(b) Rolling Terrain. Any combination of grades and horizontal or vertical alignment causing heavy vehicles to reduce their speeds substantially below those of passenger cars, but not causing heavy vehicles to operate at crawl speeds for any significant length of time.

(c) Mountainous Terrain. Any combination of grades and horizontal and vertical alignment causing heavy vehicles to operate at crawl speeds for significant distances or at frequent intervals.

Heavy vehicle is defined as any vehicle having more than four tires touching the pavement. Crawl speed is the maximum sustained speed which heavy vehicles can maintain on an extended upgrade of a given percent.

(2) Symbols

K The percentage of ADT occurring in the peak hour.

D The percentage of peak hour traffic in the heaviest direction of flow.

KD The product of K and D.

f_E Adjustment factor to account for the effect of the highway’s access and egress points (intersections, driveways, ramps) and whether or not it is a divided highway. (See Figure 610-2.)

610.03 DESIGN

(1) Design Responsibility

District Location Project Engineer's office initiates the process of highway capacity determination and performs the capacity analysis for the highway segment under consideration. If the capacity analysis goes beyond the scope of this chapter, the district Traffic Design Office or the Travel Data Office of the headquarters Planning, Research and Public Transportation Division should be requested to do the analysis. This request should be made as soon as possible to ensure that the capacity analysis is completed during the design report stage.

(2) Two-Lane Rural Highway

The objective of capacity analysis for two-lane rural highways is to determine the design level of service for a given segment for future sets of conditions.

- Determine the appropriate design level of service from Figure 610-1.
- Select the appropriate maximum allowable ADT directly from Figure 610-3 for the highway's level of service, K factor (percent of ADT occurring in peak traffic) and terrain type. No computations are needed at this stage.
- Compare the maximum allowable ADT to the expected ADT at design year. If the maximum allowable ADT is less than the design year ADT, a more detailed capacity analysis is warranted.

(3) Multi-Lane Highway

- Determine the DDHV, given the anticipated ADT during the deisgn year, using the formula:

  DDHV = ADT x KD where

  KD = 0.11 for rural
  0.08 for suburban
  0.05 for urban

  Use these general values when specific values for the particular corridor are unavailable. Generally, multi-lane highways with less than ten uncontrolled access points(driveways, intersections, ramps) per mile (on one side) are considered to be "rural" while those with more than ten uncontrolled access points per mile are considered to be suburban.
- Select an appropriate value of the service flow rate per lane (SFL) from Figure 610-4 for the highway's level of service (from Figure 610-1), environment type (urban, suburban, or rural) and terrain type.
- Determine the required number of lanes in each direction, N, from the formula:

  $N = DDHV/(SFL \times f_E \times PHF)$

  where f_E is found in Figure 610-2 and PHF in Figure 610-5. Round the value, "N", to the nearest whole number.
- Compare 2N to the number of lanes proposed. The proposed number of lanes should be greater than or equal to 2N. Otherwise, a more detailed capacity analysis is warranted.

(4) Basic Freeway Sections

- Determine the DDHV, given the anticipated ADT during the design year, using the formula:

  DDHV = ADT x KD where

  KD = 0.11 for rural freeways
  0.07 for suburban freeways
  0.05 for urban freeways

  Use these values when specific values for the particular corridor are unavailable.
- Select an appropriate value of the service flow rate per lane, SFL, from Figure 610-6 for the prevailing truck percentage and terrain and for the required LOS (from Figure 610-1).
- Determine the required number of lanes in one direction, N, from the formula:

  N = DDHV/(SFL x PHF)

  where PHF can be obtained from Figure 610-5. Round the value, "N", to the nearest whole number.
- Compare 2N to the number of lanes proposed. The proposed number of lanes should be greater than or equal to 2N. Otherwise, a more detailed capacity analysis is warranted.

(5) Miscellaneous Highway Sections

For the capacity analysis of intersections, highways with signal spacing of 2 miles or less, highways within 2,500 feet of interchange ramps, ramps, weaving sections, transit systems, and bicycle and pedestrian trails, refer to the *Highway Capacity Manual* (Special Report No. 209, Washington, D.C.: Highway Research Board, 1985). Refer to Chapter 910 for channelization guidelines. The district Traffic Design Office or the Travel Data Office of the Headquarters Planning, Research and Public Transportation Division should be requested to do the capacity analysis on these miscellaneous highway sections.

Highway Type[2]	Rural[1] Level	Rural[1] Rolling	Rural[1] Mountainous	Urban and[1] Surburban
Principal Arterial	B	B	B	C
Minor Arterial	B	B	C	C
Collector	C	C	D	D
Local Access	D	D	D	D

NOTES:
(1) Refer to 610.02 and Chapter 440 for definitions of these area types..
(2) Refer to Chapters 120 & 440 for definitions of these highway types.

TYPE OF AREA AND APPROPRIATE LEVEL OF SERVICE
Figure 610-1

	No Access Control		Partial Access Control	
Type	Divided	Undivided	Divided	Undivided
Rural	1.00	0.95	1.00	0.95
Suburban	0.90	0.80	1.00	0.95

ADJUSTMENT FACTOR FOR TYPE OF MULTILANE HIGHWAY AND DEVELOPMENT ENVIRONMENT, f_E
Figure 610-2

K-FACTOR	LEVEL OF SERVICE A	B	C	D	E
	Level Terrain[2]				
0.10	2,400	4,800	7,900	13,500	22,900
0.11	2,200	4,400	7,200	12,200	20,800
0.12	2,000	4,000	6,600	11,200	19,000
0.13	1,900	3,700	6,100	10,400	17,600
0.14	1,700	3,400	5,700	9,600	16,300
0.15[5]	1,600[5]	3,200[5]	5,300[5]	9,000[5]	15,200[5]
	Rolling Terrain[3]				
0.10	1,100	2,800	5,200	8,000	14,800
0.11	1,000	2,500	4,700	7,200	13,500
0.12	900	2,300	4,400	6,600	12,300
0.13	900	2,100	4,000	6,100	11,400
0.14	800	2,000	3,700	5,700	10,600
0.15[5]	700[5]	1,800[5]	3,500[5]	5,300[5]	9,900[5]
	Mountainous Terrain[4]				
0.10	500	1,300	2,400	3,700	8,100
0.11	400	1,200	2,200	3,400	7,300
0.12	400	1,100	2,000	3,100	6,700
0.13	400	1,000	1,800	2,900	6,200
0.14	300	900	1,700	2,700	5,800
0.15[5]	300[5]	900[5]	1,600[5]	2,500[5]	5,400[5]

NOTES:

(1) Assumed conditions include 60/40 directional split, 14 percent trucks, 4 percent RV's and no buses.

(2) 20 percent, no passing zones.

(3) 40 percent, no passing zones.

(4) 60 percent, no passing zones.

(5) Use for rural two-lane highways, when k-factor is unavailable.

MAXIMUM ADT VS. LEVEL OF SERVICE AND
TYPE OF TERRAIN FOR TWO-LANE RURAL HIGHWAYS[1]
Figure 610-3

LEVEL OF SERVICE	PERCENT TRUCKS[2]				
	0	5	10	15	20
	Level Terrain				
A	700	700	650	650	600
B	1,100	1,050	1,000	1,000	1,000
C	1,400	1,350	1,300	1,250	1,250
D	1,750	1,700	1,650	1,600	1,550
E	2,000	1,950	1,850	1,800	1,750
	Rolling Terrain				
A	700	600	550	500	450
B	1,100	950	850	800	700
C	1,400	1,200	1,100	1,000	900
D	1,750	1,500	1,350	1,250	1,100
E	2,000	1,750	1,550	1,450	1,250
	Mountainous Terrain				
A	700	500	400	350	300
B	1,100	800	650	550	450
C	1,400	1,050	850	700	600
D	1,750	1,300	1,050	850	750
E	2,000	1,500	1,200	1,000	850

NOTES:

(1) Service flow rates are in units of vehicles per hour per lane (vphpl).

(2) Truck percentages should include both the single units (two and three axle trucks and buses) and the combinations (trucks with trailers and trailer combinations).

SERVICE FLOW RATE PER LANE (SFL)[1] FOR MULTILANE HIGHWAYS
Figure 610-4

Metropolitan Area Population	Peak-Hour Factor
Over 1,000,000	0.91
500,000 - 1,000,000	0.83
Under 500,000	0.77

PEAK-HOUR FACTORS
Figure 610-5

LEVEL OF SERVICE	PERCENT TRUCKS[2]				
	0	5	10	15	20
	Level Terrain				
A	700	650	650	600	600
B	1,100	1,050	1,000	950	950
C	1,550	1,500	1,450	1,350	1,300
D	1,850	1,800	1,700	1,600	1,550
E	2,000	1,900	1,850	1,750	1,700
	Rolling Terrain				
A	700	600	550	500	450
B	1,100	950	850	750	700
C	1,550	1,350	1,200	1,050	1,000
D	1,850	1,600	1,400	1,300	1,150
E	2,000	1,750	1,550	1,400	1,250
	Mountainous Terrain				
A	700	500	400	350	230
B	1,100	800	650	550	400
C	1,550	1,150	900	750	550
D	1,850	1,350	1,100	900	650
E	2,000	1,500	1,200	1,000	700

NOTES:

(1) Service flow rates are in units of vehicles per hour per lane (vphpl).

(2) Truck percentages should include both the single units (two and three axle trucks and buses) and the combinations (trucks with trailers and trailer combinations).

SERVICE FLOW RATES PER LANE (SFL) FREEWAYS[1]
Figure 610-6

620.01 General

This chapter provides guidance on the design of horizontal alignment, frontage roads, number of lanes, the arrangement of the lanes, and pavement transitions. See the following chapters for additional information:

Chapter	Subject
430	All roadway width requirements for modified design level
440	Lane and shoulder width requirements for full design level
440	Shoulder width requirements at curbs
641	Open highway and ramp lane widths on turning roadways for full design level
642	Superelevation rate and transitions
650	Sight distance
910	Requirements for islands
940	Ramp lane and shoulder requirements

620.02 References

Washington Administrative Code (WAC) 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings"

Utilities Manual M 22-87, WSDOT

Plans Preparation Manual M 22-31, WSDOT

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Right of Way Manual M 26-01, WSDOT

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

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

620.03 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.

frontage road An auxiliary road that is a local road or street located on the side of a highway for service to abutting property and adjacent areas and for control of access.

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

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

620.04 Horizontal Alignment

(1) General

Horizontal and vertical alignments (Chapter 630) are the primary controlling elements for highway design. It is important to coordinate these two elements with design speed, drainage, intersection design, and aesthetic principles in the early stages of design.

Figures 620-2a through 2c show desirable and undesirable alignment examples for use with the following considerations:

(a) Make the highway alignment as direct as practical and still blend with the topography while considering developed and undeveloped properties, community boundaries, and environmental concerns.

(b) Make highway alignment consistent by:

- Using gentle curves at the end of long tangents.
- Using a transition area of moderate curvature between the large radius curves of rural areas and the small radius curves of populated areas.
- Making horizontal curves visible to approaching traffic.

(c) Avoid minimum radii and short curves unless:

- Restrictive conditions are present and are not readily or economically avoidable.
- On two-lane highways, minimum radii will result in tangent sections long enough for needed passing.

(d) Avoid any abrupt change in alignment. Design reverse curves with an intervening tangent long enough for complete superelevation transition for both curves. See Chapter 642 for more information on superelevation transitions.

(e) Avoid the use of curves in the same direction connected by short tangents (broken back curves); substitute a single larger curve.

(f) Avoid compound curves on open highway alignment if a simple curve can be obtained. When compound curves are used, make the shorter radius at least two-thirds the longer radius. Make the total arc length of a compound curve not less than 500 ft.

(g) On divided multilane highways, take advantage of independent alignment to produce a flowing alignment along natural terrain.

(h) The preferred locations for bridges, interchanges, intersections, and temporary connections are on tangent sections in clear view of drivers.

(i) On two-lane, two-way highways, strive for as much passing sight distance as possible. (See Chapter 650.)

(2) Horizontal Curve Radii

Design speed is the governing element of horizontal curves. For guidance regarding design speed selection see Chapter 440 for full design level, Chapter 430 for modified design level, and Chapter 940 for ramps.

Use the following factors to determine the radius for a curve:

- Stopping sight distance where sight obstructions are on the inside of a curve. Median barriers, bridges, walls, cut slopes, wooded areas, buildings, and guardrails are examples of sight obstructions. See Chapter 650 to check for adequate stopping sight distance for the selected design speed.
- Superelevation is the rotation or banking of the roadway cross section to overcome part of the centrifugal force that acts on a vehicle traversing a curve. Design information on the relationship between design speed, radius of curve, and superelevation is in Chapter 642.
- Coordinate vertical and horizontal alignment. (see Chapter 630.)

Spiral curves, although no longer used on new highway construction or major realignment, still exist on Washington highways. Spirals were used to transition between tangents and circular curves with the horizontal curvature rate increasing from tangent to the central curve and decreasing from curve to tangent. Spirals do not pose an operational concern and may remain in place. See the “Green Book” for information on spirals.

(3) Horizontal Curve Length

A curve is not required for small deflection angles. Figure 620-1 gives the maximum allowable angle without a curve. See Chapter 910 for guidance on angle points or short radii curves in the vicinity of intersections at grade.

Design Speed (mph)	Maximum Angle Without Curve
25	2º17’
30	1º55’
35	1º38’
40	1º26’
45	1º16’
50	1º09’
55	1º03’
60	0º57’
65	0º53’
70	0º49’
75	0º46’
80	0º43’

Maximum Angle Without Curve
Figure 620-1

To avoid the appearance of a kink in the road, the desirable length of curve for deflection angles larger than given in Figure 620-1 is at least 500 ft long.

620.05 Distribution Facilities

(1) General

In addition to the main highway under consideration, other facilities can be provided to distribute traffic to and from the highway and to fulfill access requirements. Highway flexibility can be augmented by:

- Frontage roads
- Collector distributor roads
- On and off connections
- Parallel arterial routes with connections between them and the main highway
- Loop highways around large metropolitan areas

A city or county may be asked to accept a proposed distribution facility as a city street or county road. Plan and design these facilities according to the applicable design values as city streets or county roads. (See Chapter 440.)

(2) Frontage Roads

Frontage roads constructed as part of highway development may serve any of the following purposes:

- To reestablish continuity of an existing road severed by the highway.
- To provide service connections to adjacent property that would otherwise be isolated as a result of construction of the highway.
- To control access to the highway.
- To maintain circulation of traffic on each side of the highway.
- To segregate local traffic from the higher speed through traffic and intercept driveways of residences and commercial establishments along the highway.
- To relieve congestion on the arterial highway during periods of high use or in emergency situations.

Frontage roads are generally not permanent state facilities. They are usually turned back to the local jurisdiction. Plan and design frontage roads as city streets or county roads. (See Chapter 440.) Initiate coordination with the local agency that will be the recipient of the facility early in the planning process, and carry through design and construction. See Chapter 1430 for additional guidance on frontage roads and turnbacks.

Outer separations function as buffers between the through traffic on the highway and the local traffic on the frontage road. The width is governed by requirements for grading, signing, barriers, aesthetics, headlight glare, and ramps. Where possible, make the separation wide enough to allow for development on both sides of the frontage road. Wider separations also move the intersection with the frontage road and a cross road farther from the intersection with the through roadway. It also can reduce the amount of limited access control rights to be acquired. (See Chapter 1430.)

Where two-way frontage roads are provided, a driver on the highway must contend with approaching traffic on the right (opposing frontage road traffic) as well as opposing traffic on the left. Make the outer separation wide enough to minimize the effects of approaching traffic, particularly the headlight glare. See Chapter 700 for information on headlight glare considerations. With one-way same-direction frontage roads, the outer separation need not be as wide as with two-way frontage roads.

Wide separations lend themselves to landscape treatment and can enhance the appearance of both the highway and the adjoining property.

A substantial width of outer separation is particularly advantageous at intersections with cross streets. The wider separation reduces conflicts with pedestrians and bicycles.

Where ramp connections are provided between the through roadway and the frontage road, the minimum outer separation width will depend on design requirements for the ramp termini.

620.06 Number of Lanes and Arrangement

(1) General

The basic number of lanes is designated and maintained over a length of highway. The total number of lanes is the basic number of lanes plus any auxiliary lanes required to meet:

- Level of service (volume-capacity).
- Lane balance.
- Flexibility of operation.

(2) Basic Number of Lanes

Keep the basic number of lanes constant over a highway route, or a significant portion thereof, regardless of changes in traffic volume. See Chapter 440 for the minimum number of lanes for each functional class of highway.

Change the basic number of lanes only for general changes in traffic volume over a substantial length of the route. The recommended location for a reduction in the basic number of lanes is on a tangent section between interchanges or intersections.

To accommodate high traffic volumes for short distances, such as between adjacent interchanges, use auxiliary lanes. When consecutive sections between interchanges require auxiliary lanes, consider increasing the basic number of lanes through the entire length.

(3) Auxiliary Lanes

Auxiliary lanes are added to the basic number of lanes to allow additional traffic movements on short segments. These added lanes are based primarily on volume-to-capacity relationships (Chapter 610).

To ensure efficient operation of auxiliary lanes see the following:

910	Left and right turn lanes and storage for turning
940	Weaving and auxiliary lanes associated with interchanges
1010	Truck climbing and passing lanes

620.07 Pavement Transitions

(1) Lane Transitions

(a) **For lane width changes** that create an angle point in an adjacent lane, the maximum angle is given in Figure 620-1. When a lane width change does not create an angle point in an adjacent lane, a 25:1 taper is sufficient.

(b) To **reduce the number of lanes**, a transition is required. The following guidelines apply:

- Locate transitions where decision sight distance exists, preferably on a tangent section and on the approach side of any crest vertical curve (except the end of climbing lanes which are transitioned in accordance with Chapter 1010).
- Supplement the transition with traffic control devices.
- Reduce the number of lanes by dropping only one at a time from the right side in the direction of travel. (When dropping a lane on the left side, an approved deviation is required.) See the MUTCD when more than one lane in a single direction must be dropped.

- Use the following formula to determine the minimum length of the lane transition for high speed conditions (45 mph or more):

  $L = VT$

  Where:

  L = length of transition (ft)
  V = design speed (mph)
  T = tangential offset width (ft)

- Use the following formula to determine the minimum length of the lane transition for low speed conditions (less than 45 mph):

  $$L = \frac{TV^2}{60}$$

  Where:

  L = length of transition (ft)
  V = design speed (mph)
  T = tangential offset width (ft)

(c) **To increase the number of lanes**, a tangential rate of change in the range of 1:4 to 1:15 is sufficient. Aesthetics are the main consideration.

(d) **For turning roadway** widening width transitions, see Chapter 641.

(2) Median Width Transitions

Whenever two abutting sections have different median widths, use long, smooth transitions (L = VT or flatter). When horizontal curves are present, this can be accomplished by providing the transition throughout the length of the curve. When required on a tangent section, the transition may be applied about the center line or on either side of the median based on whether or not the abutting existing section is programmed for the wider median in the future. To satisfy aesthetic requirements, make the transition length as long as feasible.

620.08 Procedures

When the project will realign the roadway, develop horizontal alignment plans for inclusion in the PS&E. Show the following as needed to maintain clarity and provide necessary information:

- Horizontal alignment details (tangent bearing, curve radius, and superelevation rate)
- Stationing
- Number of lanes
- Intersections, road approaches, railroad crossings, and interchanges (Chapters 910, 920, 930, and 940)
- Existing roadways and features affecting or affected by the project

See the *Plans Preparation Manual* for additional plan requirements.

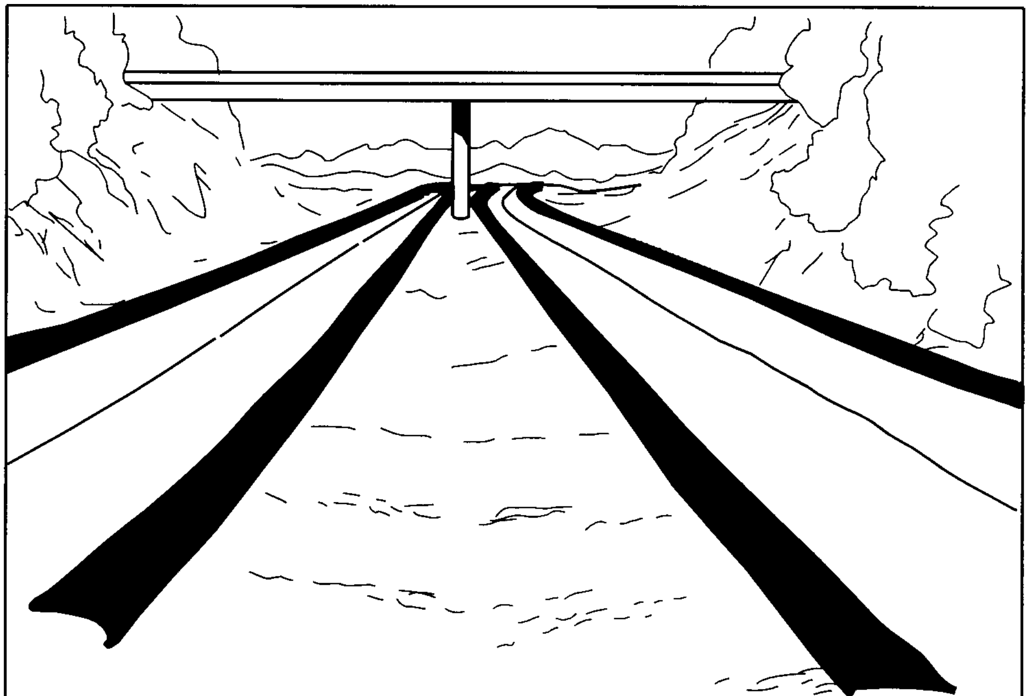
Justify any realignment of the roadway. Include the reasons for the realignment, profile considerations, alternatives considered, and the reasons the selected alignment was chosen.

When the project will change the number of lanes, include a capacity analysis supporting the number selected (Chapter 610) with the justification for the number of lanes.

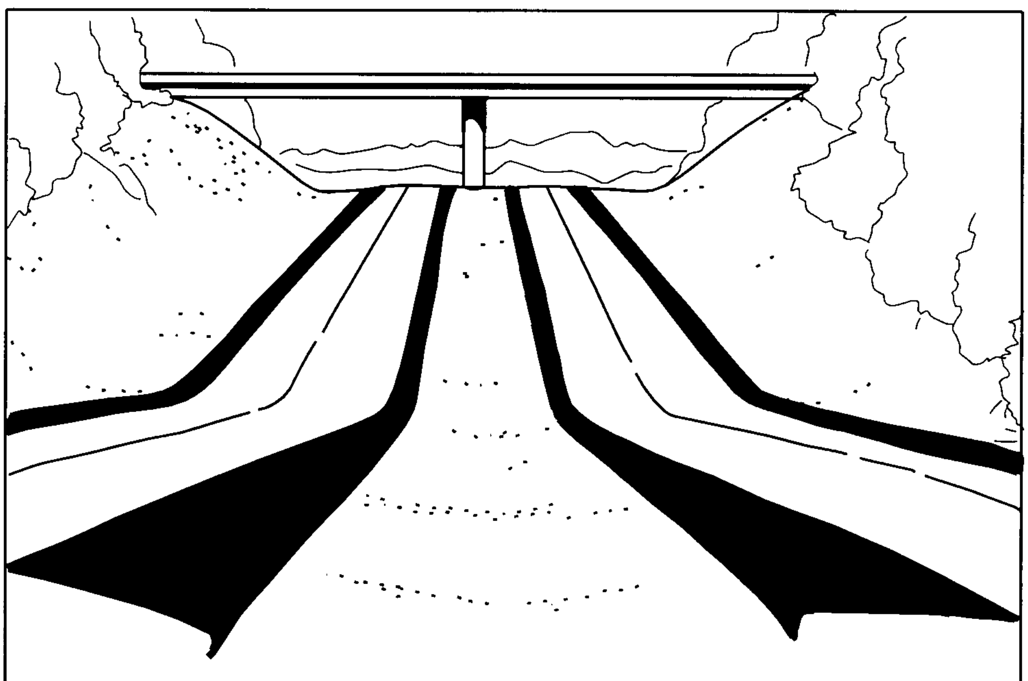
Include with the justification for a frontage road any traffic analyses performed, the social, environmental, and economic considerations, the options considered, and the reasons for the final decision.

620.09 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/

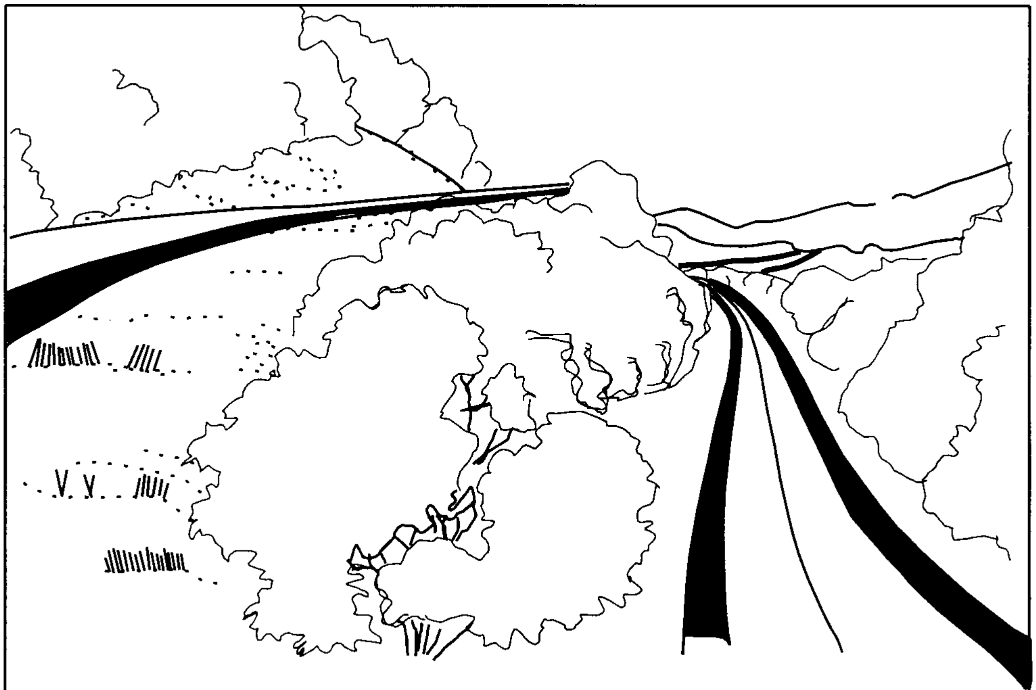


Desirable - Vertical Curves Lengthened

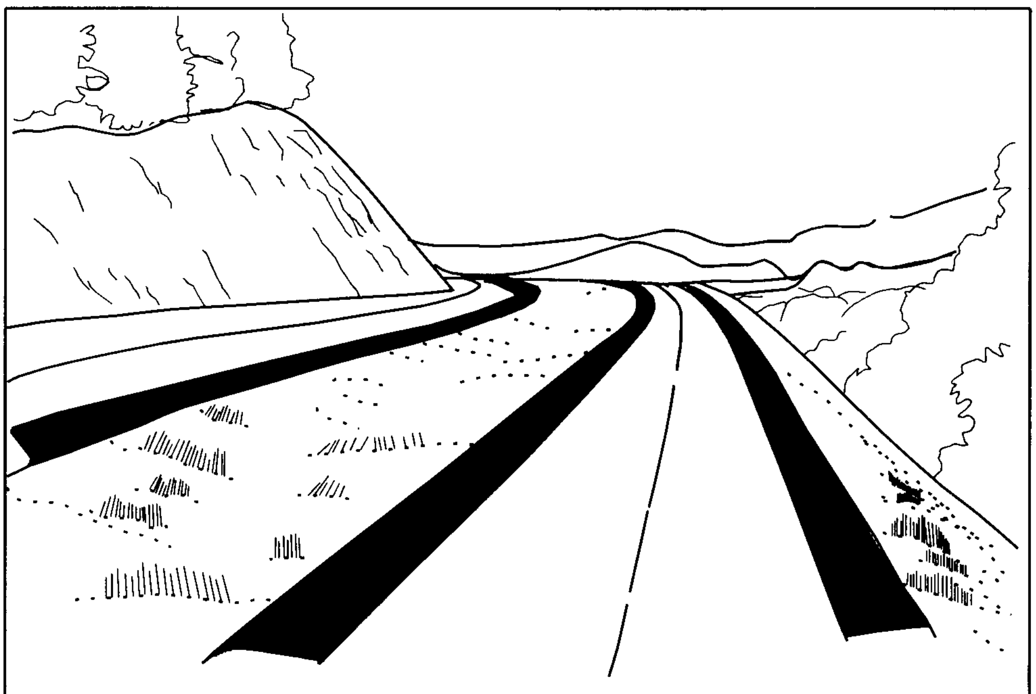


Undesirable - Minimum Vertical Curves Used

Alignment Examples
Figure 620-2a

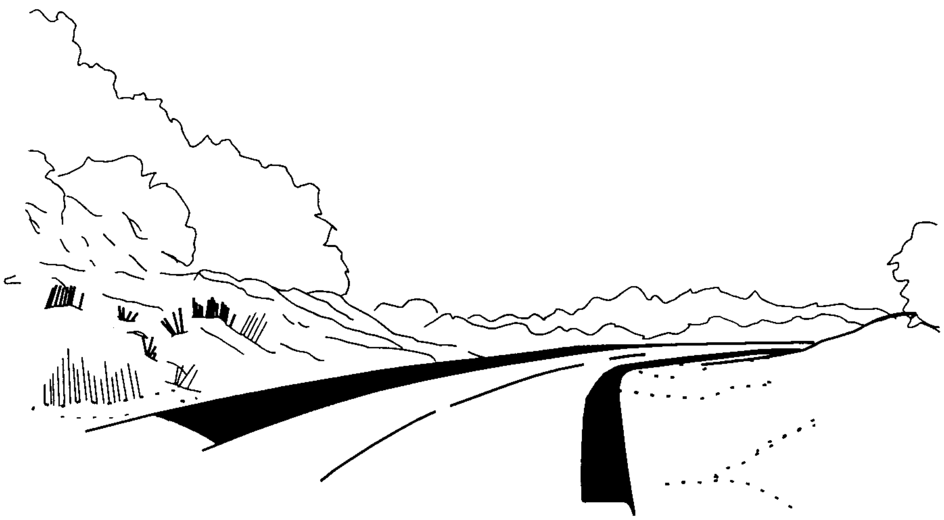


Desirable - Consistency with Topography

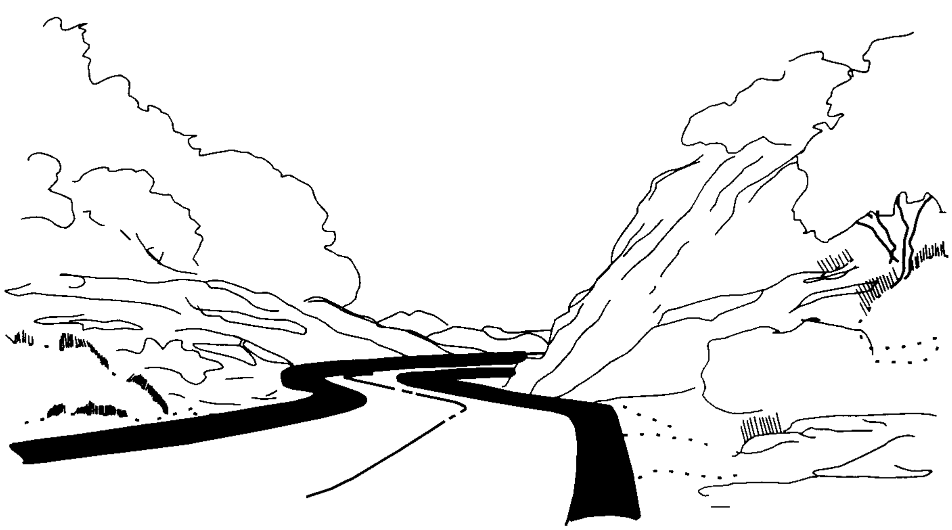


Undersirable - Heavy Cuts and Fills

Alignment Examples
Figure 620-2b



Desirable - Daylighting and a Simple Curve



Undesirable - Short Curve Reversals

Alignment Examples

Figure 620-2c

630.01 General

Vertical alignment (roadway profile) consists of a series of gradients connected by vertical curves. It is mainly controlled by:

- Topography
- Class of highway
- Horizontal alignment
- Safety
- Sight distance
- Construction costs
- Drainage
- Adjacent land use
- Vehicular characteristics
- Aesthetics

This chapter provides guidance for the design of vertical alignment. See the following chapters for additional information:

Chapter	Subject
440	Maximum grade for each functional class
620	Horizontal alignment
650	Sight distance
910	Grades at intersections
940	Maximum grade for ramps

630.02 References

Washington Administrative Code (WAC) 468-18-040, “Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings”

Plans Preparation Manual, M 22-31, WSDOT

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

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

A Policy on Geometric Design of Highways and Streets, (Green Book), 2001, AASHTO

630.03 Vertical Alignment

(1) Design Controls

The following are general controls for developing vertical alignment (also see Figures 630-2a through 2c):

- Use a smooth grade line with gradual changes, consistent with the class of highway and character of terrain. Avoid numerous breaks and short grades.
- Avoid “roller coaster” or “hidden dip” profiles by use of gradual grades made possible by heavier cuts and fills or by introducing some horizontal curvature in conjunction with the vertical curvature.
- Avoid grades that will affect truck speeds and, therefore, traffic operations.
- Avoid broken back grade lines with short tangents between two vertical curves.
- Use long vertical curves to flatten grades near the top of long steep grades.
- Where at-grade intersections occur on roadways with moderate to steep grades, it is desirable to flatten or reduce the grade through the intersection.

- Establish the subgrade at least 1 ft above the high water table (real or potential) or as recommended by the region Materials Engineer. Consider the low side of superelevated roadways.
- When a vertical curve takes place partly or wholly in a horizontal curve, coordinate the two as discussed in 630.04.

(2) Minimum Length of Vertical Curves

The minimum length of a vertical curve is controlled by design speed, the requirements for stopping sight distance, and the change in grade. Make the length of a vertical curve, in feet, not less than three times the design speed, in miles per hour. See Chapter 650 to design vertical curves to meet stopping sight distance requirements. For aesthetics, the desirable length of a vertical curve is two to three times the length required for stopping sight distance.

Sag vertical curves may have a length less than required for stopping sight distance when all three of the following are provided:

- An evaluate upgrade to justify the length reduction.
- Continuous illumination.
- Design for the comfort of the vehicle occupants. For comfort use:

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

where: L = Curve length ft
A = Change in grade %
V = Design speed mph

The sag vertical curve lengths designed for comfort are about 50% of those required for sight distance.

(3) Maximum Grades

Analyze grades for their effect on traffic operation because they may result in undesirable truck speeds. Maximum grades are controlled by functional class of the highway, terrain type, and design speed (Chapters 440 and 940).

(4) Minimum Grades

Minimum grades are used to meet drainage requirements. Avoid selecting a “roller coaster” or “hidden dip” profile merely to accommodate drainage.

Minimum ditch gradients of 0.3% on paved materials and 0.5% on earth can be obtained independently of roadway grade. Medians, long sag vertical curves, and relatively flat terrain are examples of areas where independent ditch design may be justified. A closed drainage system may be needed as part of an independent ditch design.

(5) Length of Grade

The desirable maximum length of grade is the maximum length on an upgrade at which a loaded truck will operate without a 10 mph reduction. Figure 630-1 gives the desirable maximum length for a given percent of grade. When grades longer than the desirable maximum are unavoidable, consider an auxiliary climbing lane (Chapter 1010). For grades that are not at a constant percent, use the average.

When long steep downgrades are unavoidable, consider an emergency escape ramp (Chapter 1010).

(6) Alignment on Structures

Where practical, avoid high skew, vertical curvature, horizontal curvature, and superelevation on structures, but do not sacrifice safe roadway alignment to achieve this.

630.04 Coordination of Vertical and Horizontal Alignments

Do not design horizontal and vertical alignment independently. Coordinate them to obtain safety, uniform speed, pleasing appearance, and efficient traffic operation. Coordination can be achieved by plotting the location of the horizontal curves on the working profile to help visualize the highway in three dimensions. Perspective plots will also give a view of the proposed alignment. Figures 630-2a and 2b show sketches of desirable and undesirable coordination of horizontal and vertical alignment.

Guides for the coordination of the vertical and horizontal alignment are as follows:

- Balance curvature and grades. Using steep grades to achieve long tangents and flat curves, or excessive curvature to achieve flat grades, are both poor designs.
- Vertical curvature superimposed on horizontal curvature generally results in a more pleasing facility. Successive changes in profile not in combination with horizontal curvature may result in a series of dips not visible to the driver.
- Do not begin or end a horizontal curve at or near the top of a crest vertical curve. This condition can be unsafe, especially at night, if the driver does not recognize the beginning or ending of the horizontal curve. Safety is improved if the horizontal curve leads the vertical curve, that is, the horizontal curve is made longer than the vertical curve in both directions.
- To maintain drainage, design vertical and horizontal curves so that the flat profile of a vertical curve will not be located near the flat cross slope of the superelevation transition.
- Do not introduce a sharp horizontal curve at or near the low point of a pronounced sag vertical curve. The road ahead is foreshortened and any horizontal curve that is not flat assumes an undesirably distorted appearance. Further, vehicular speeds, particularly of trucks, often are high at the bottom of grades and erratic operation may result, especially at night.
- On two-lane roads, the need for safe passing sections (at frequent intervals and for an appreciable percentage of the length of the roadway) often supersedes the general desirability for combination of horizontal and vertical alignment. Work toward long tangent sections to secure sufficient passing sight distance.

For grades longer than indicated, consider an auxiliary climbing lane (Chapter 1010).

Grade Length
Figure 630-1

- On divided highways, consider variation in width of median and the use of independent alignments to derive the design and operational advantages of one-way roadways.
- Make horizontal curvature and profile as flat as feasible at intersections where sight distance along both roads is important and vehicles may have to slow or stop.
- In residential areas, design the alignment to minimize nuisance factors to the neighborhood. Generally, a depressed facility makes a highway less visible and less noisy to adjacent residents. Minor horizontal adjustments can sometimes be made to increase the buffer zone between the highway and clusters of homes.
- Design the alignment to enhance attractive scenic views of the natural and manmade environment, such as rivers, rock formations, parks, and outstanding buildings.

When superelevation transition within the limits of a vertical curve is necessary, plot profiles of the edges of pavement to ensure smooth transitions.

630.05 Airport Clearance

For proposed highway construction or alteration in the vicinity of a public or military airport, early contact by the region with the airport authorities is required so that advance planning and design work can proceed within the required FAA regulations (Chapter 240).

630.06 Railroad Crossings

When a highway crosses a railroad at grade, design the highway grade so that a low-hung vehicle will not damage the rails or get hung up on the tracks. Figure 630-3 gives guidance on designing highway grades at railroad crossings. For more information on railroad-highway crossings, see Chapter 930.

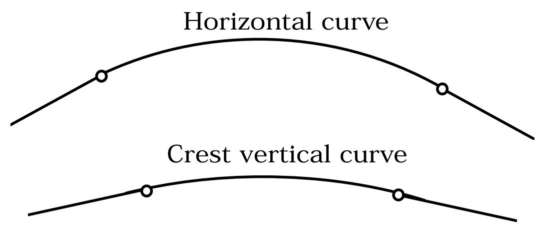
630.07 Procedures

When the project will modify the vertical alignment, develop vertical alignment plans for inclusion in the PS&E to a scale suitable for showing vertical alignment for all proposed roadways including ground line, grades, vertical curves, and superelevation. See the *Plans Preparation Manual* for additional requirements.

When justifying any modification to the vertical alignment, include the reasons for the change, alternatives considered (if any) and why the selected alternative was chosen. When the profile is a result of new horizontal alignment, consider vertical and horizontal alignments together and document the profile with the horizontal alignment justification.

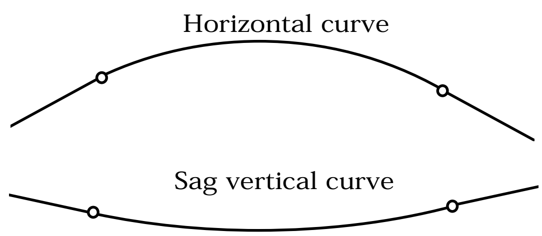
630.08 Documentation

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/



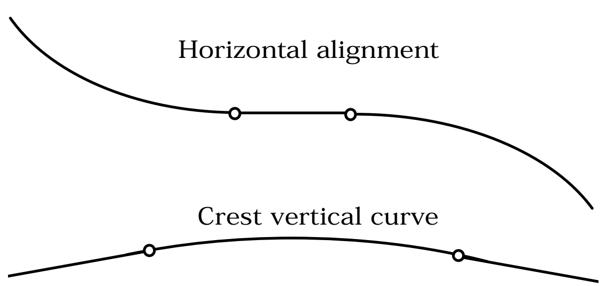
Coinciding Horizontal and Crest Vertical Curves.

When horizontal and crest vertical curves coincide, a satisfactory appearance results.



Coinciding Horizontal and Sag Vertical Curves

When horizontal and sag vertical curves coincide, a satisfactory appearance results.



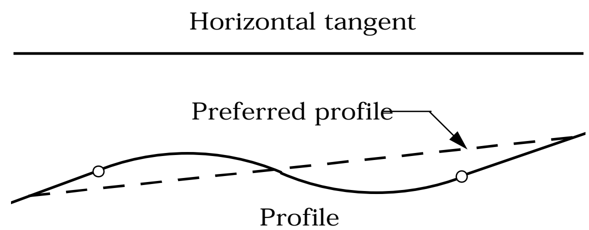
Short Tangent on a Crest Between Two Horizontal Curves

This combination is deficient for several reasons:

- The curve reversal is on a crest making the second curve less visible.
- The tangent is too short for the superelevation transition.
- The flat area of the superelevation transition will be near the flat grade in the crest.

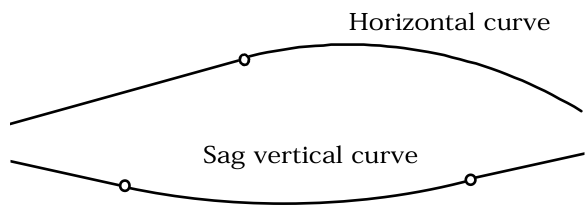
Coordination of Horizontal and Vertical Alignments

Figure 630-2a



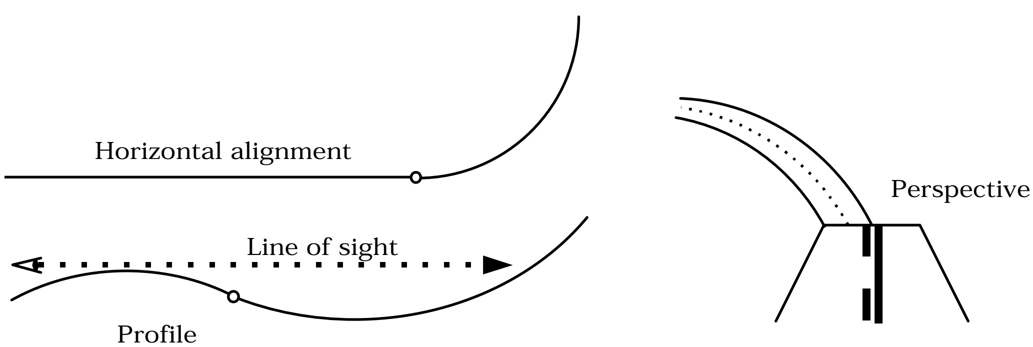
Profile with Tangent Alignment

Avoid designing dips on an otherwise long uniform grade.



Sharp Angle Appearance

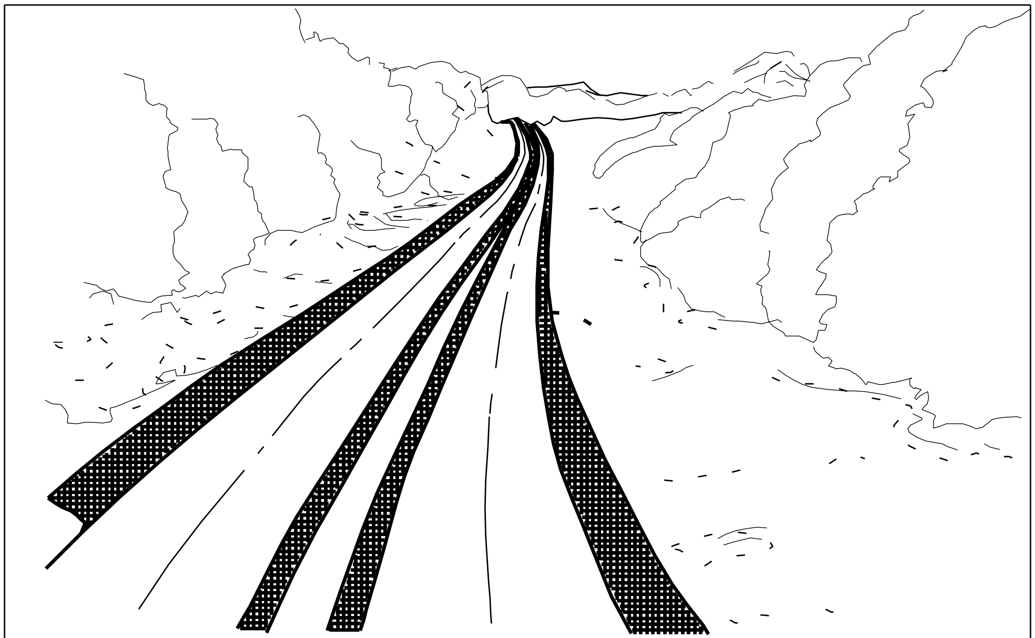
This combination presents a poor appearance. The horizontal curve looks like a sharp angle.



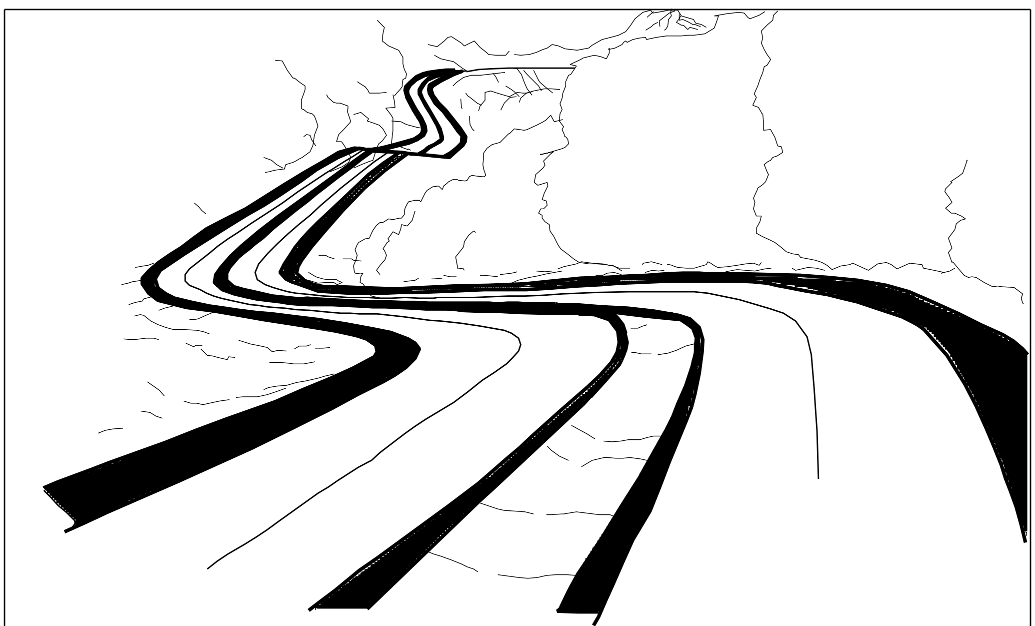
Disjointed Effect

A disjointed effect occurs when the beginning of a horizontal curve is hidden by an intervening crest while the continuation of the curve is visible in the distance beyond the intervening crest.

Coordination of Horizontal and Vertical Alignments
Figure 630-2b

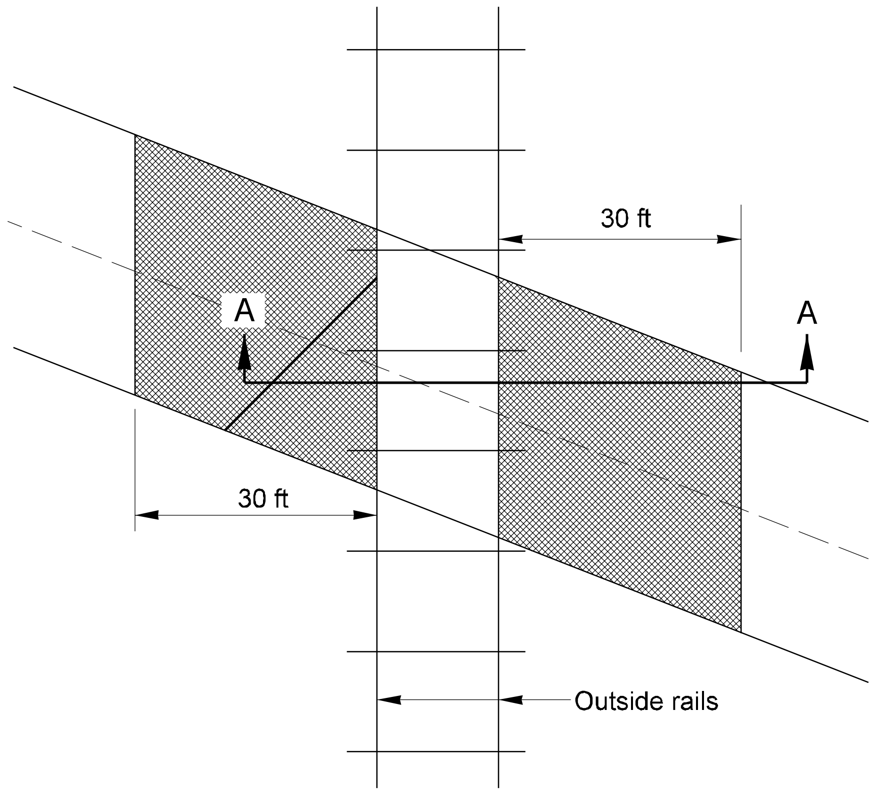


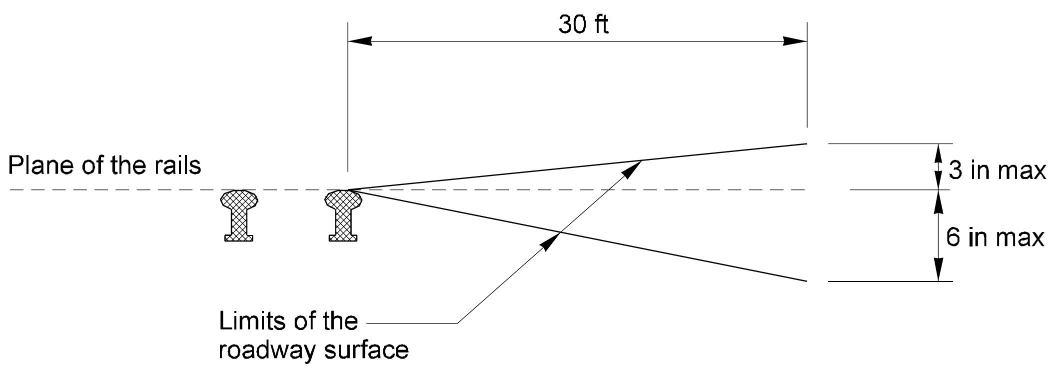
Desirable Coordination of Vertical and Horizontal
Curves and the Use of Flowing Alignment



Undesirable - Vertical and Horizontal Curves
Not Coordinated and Using Minimums

Coordination of Horizontal and Vertical Alignments
Figure 630-<u>2</u>c





Detail A-A

Grading at Railroad Crossings
Figure 630-3

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 urban area. See Chapter 440 for guidance on selecting a design class.

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

See the following chapters for additional information:

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

640.02 References

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

Plans Preparation Manual, M 22-31, WSDOT

Highway Runoff Manual, M 31-16, WSDOT

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

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 2 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 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 traveled way for through traffic and the nearest edge of traveled way of a frontage road or collector/distributor road.

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.

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 roadway between two intersecting legs of an intersection.

undivided multilane A roadway with 2 or more through lanes in each direction on which left-turns are not controlled.

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. See 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 cross section 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. Cross slopes greater than 2% are noticeable in steering and 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. In some areas, a somewhat steeper cross slope may be desirable to improve roadway runoff, although it is undesirable operationally. For these areas, with justification, a 2.5% cross slope may be used.

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 storm water or melt water 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 mph). 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 buffer 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

(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 each other, 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 within wide medians is undesirable. Give preference to selective thinning and limited reshaping of the natural ground. 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.

In cases of unusual geological features or soil conditions, 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 on 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, fill slopes may be as steep as $1^1/_2$H:1V. See Chapter 700 for clear zone and barrier requirements.

The Cut Slope Selection tables on 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.

Rounding, 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 Materials Lab concurrence is required.

There are two basic design treatments applicable to rock excavation (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 forth.

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 $^1/_2$H: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 full implementation of all protection and safety measures applicable to rock control. Use it only when extreme rockfall conditions exist.

  Show Stage 3 as ultimate stage for future construction on the PS&E plans 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 ft intervals. Appropriate terminal treatment is required (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, their width, and vertical spacing is established only after an evaluation of slope stability. Make benches at least 20 ft wide. Provide access for maintenance equipment at 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 Design B (Figure 640-7b). The rock protection fence is placed at any one of the three locations 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 cy in size, and the length of the slope is greater than 350 ft.
- Fence position b is the preferred location for most applications.
- Fence position c is used when the cliff generates boulders greater than 0.25 cy in size, regardless of the length of the slope. On short slopes, this may require placing the fence less than 100 ft 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 (Chapter 710).

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 (Chapter 510). Consult 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 cut slope top-of-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 (Chapter 1120).

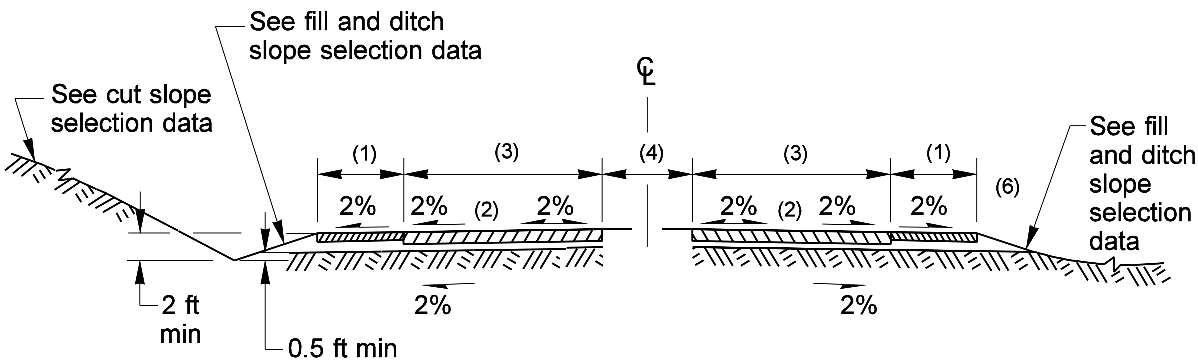
Early in the preliminary bridge plan development, determine preliminary bridge geometrics, end slope rates, and toe of slope treatments. Figure 640-9a provides guidelines for use of slope rates and toe of slope treatments for overcrossings. Figure 640-9b shows toe of slope treatments to be used on the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

640.07 Roadway Sections

Provide a typical 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)] is 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) See Figures 640-5a and 5b for shoulder details. See Chapters 430 and 440 for minimum shoulder width.

(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) See Chapters 430 and 440 for minimum number and width of lanes. See Chapter 641 for turning roadway width.

(4) See Figures 640-6a through 6c for median details. See Chapters 430 and 440 for minimum median width.

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

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

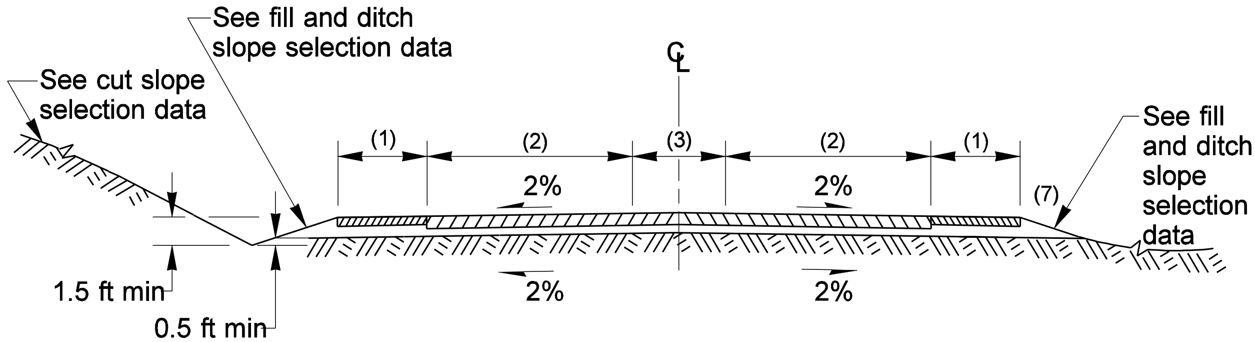
(7) Cut slopes steeper than 2H:1V may be used where favorable soil conditions exist or stepped construction is used. See Chapter 700 for clear zone and barrier requirements.

(8) Fill slopes as steep as $1\frac{1}{2}$H: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) See Figures 640-5a and 5b for shoulder details. See Chapters 430 and 440 for minimum shoulder width.

(2) See Chapters 430 and 440 for minimum number and width of lanes. See Chapter 641 for turning roadway width.

(3) See Chapters 430 and 440 for minimum median width. See Chapter 910 for width when median is a two-way left-turn lane.

(4) Where practical, 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.

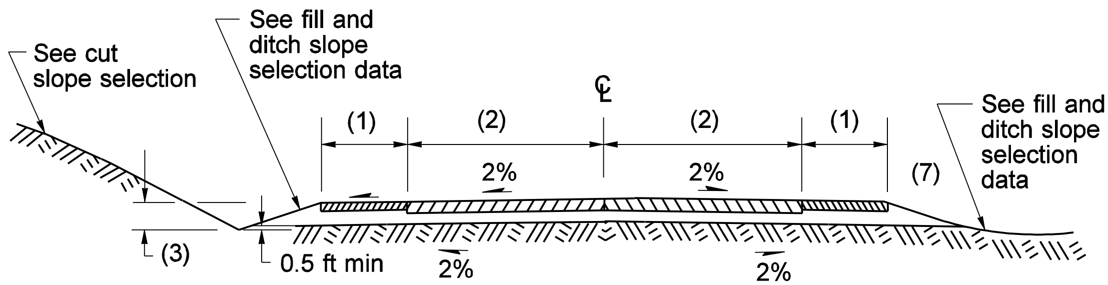
(6) Fill slopes up to $1^1/_2$H:1V may be used where favorable soil conditions exist. See Chapter 700 for clear zone and barrier requirements.

(7) Widen and round foreslopes steeper than 4H:1V as shown on 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) See Figures 640-5a and 5b for shoulder details. See Chapters 430 and 440 for minimum shoulder width.

(2) See Chapters 430 and 440 for minimum width of lanes. See Chapter 641 for turning roadway width.

(3) The minimum ditch depth is 2 ft for Design Class P3 and 1.5 ft for Design Class P-4, P-5, M-2, M-3, M-4, C-2, C-3, C-4, $U_{M/A}$-5, and $U_{M/A}$-6.

(4) Where practical, consider flatter slopes for the greater fill heights.

(5) Fill slopes up to $1^1/_2$H:1V may be used where favorable soil conditions exist. See Chapter 700 for clear zone and barrier requirements.

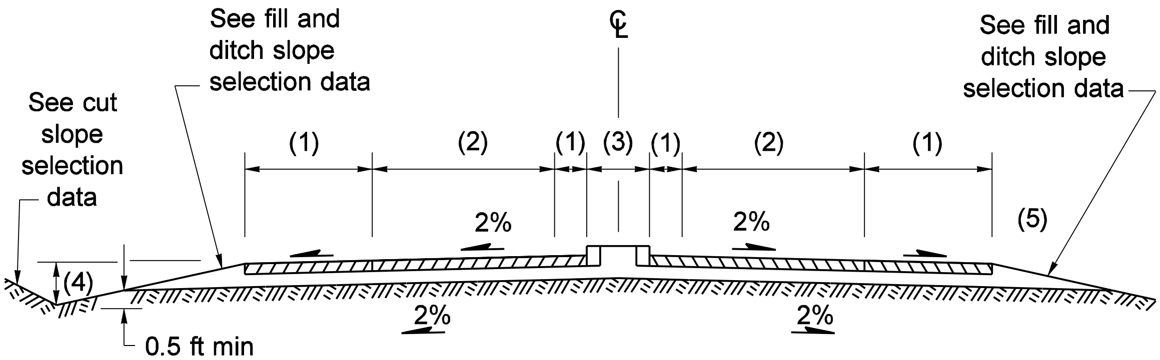
(6) Cut slopes steeper than 2H:1V may be used where favorable soil conditions exist or stepped construction is used. See Chapter 700 for clear zone and barrier requirements.

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

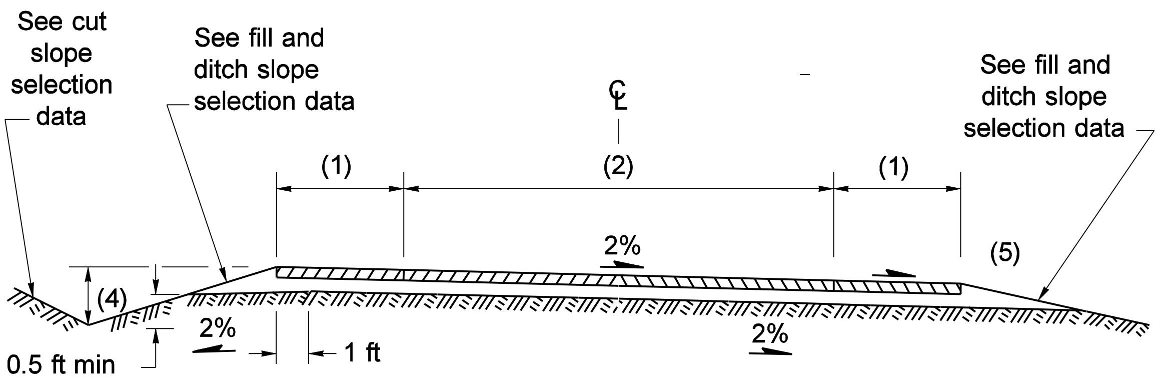
(8) The Cut Slope Selection table is for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable slopes just to meet the slopes given in this table.

Two-Lane Highway Roadway Sections

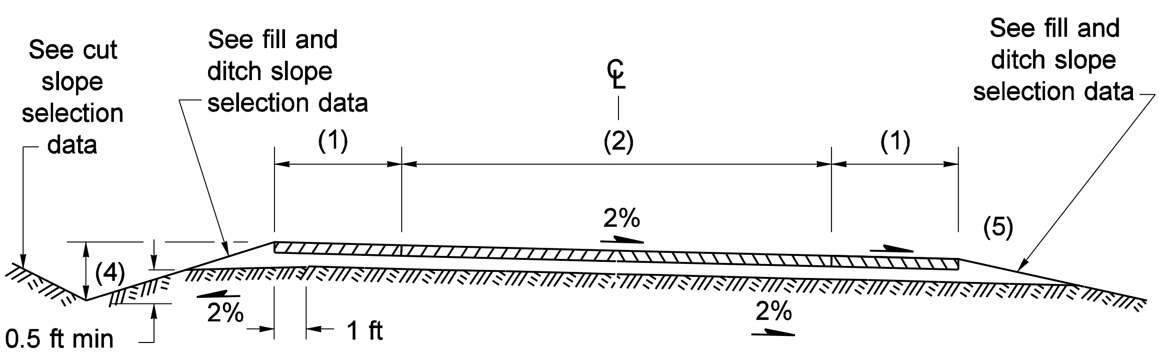
Figure 640-3



Two-Lane Two-Way Ramp



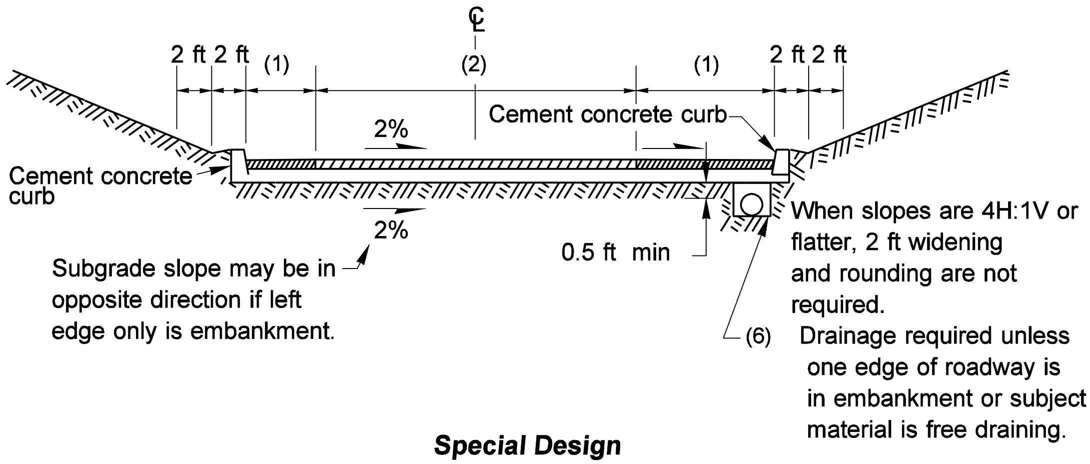
Two-Lane One-Way Ramp



One-Lane Ramp

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) See Figures 640-5a and 5b for shoulder details. See Chapter 940 for minimum shoulder widths.

(2) See Chapter 940 for minimum ramp lane widths. See Chapter 641 for turning roadway width. 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 ft for design speeds over 40 mph and 1.5 ft for design speeds of 40 mph or less. Rounding may be varied to fit drainage requirements when minimum ditch depth is 2 ft.

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

(6) Method of drainage pickup to be determined by the designer.

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

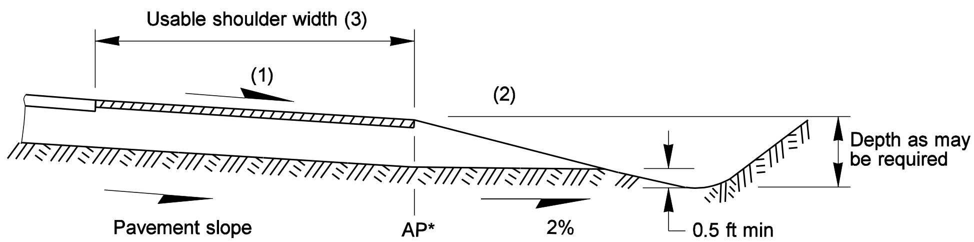
(8) Cut slopes steeper than 2H:1V may be used where favorable soil conditions exist or stepped construction is used. See Chapter 700 for clear zone and barrier requirements.

(9) Fill slopes as steep as $1^1/_2$H:1V may be used where favorable soil conditions exist. See Chapter 700 for clear zone and barrier requirements.

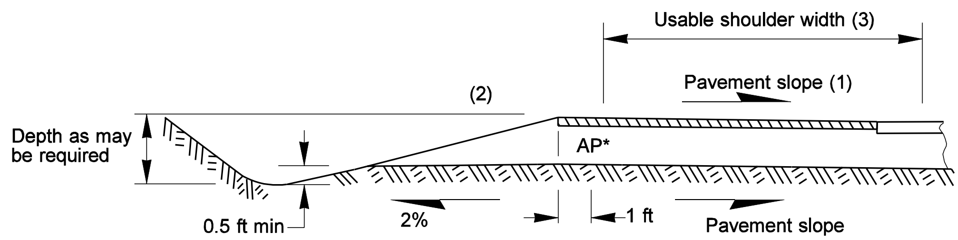
(10) The Cut Slope Selection table is for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable slopes just to meet the slopes given in this table.

Ramp Roadway Sections

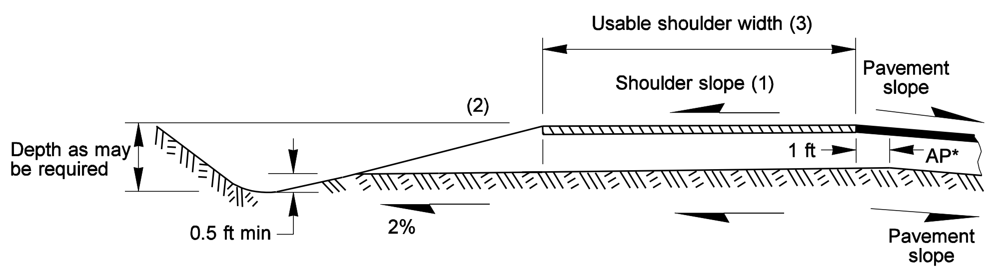
Figure 640-4b



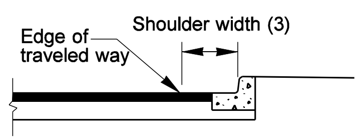
Shoulder Design On The Low Side Of The Roadway For Cross Slopes Greater Than 2%.



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.



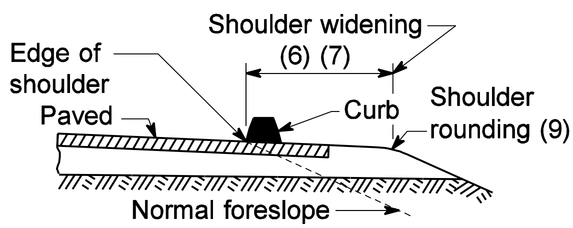
Shoulder Design with Curb (5)(6)

*AP = angle point in the subgrade.

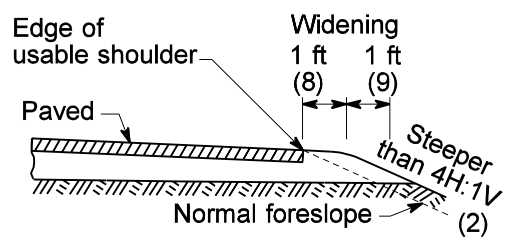
For notes, see Figure 640-5b.

Shoulder Details

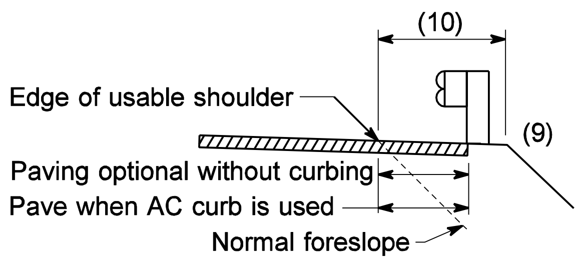
Figure 640-5a



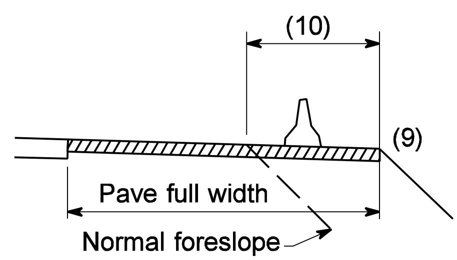
Asphalt Concrete Curb Placement



Shoulder 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 shoulder rounding outside the usable shoulder is required when foreslope is steeper than 4H:1V.

(3) See Chapters 430, 440, and 940 for minimum shoulder width.

(4) On divided multilane highways see Figures 640-6a through 6c for additional details and requirements for median shoulders.

(5) See Chapter 1025 for additional requirements for sidewalks.

(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.

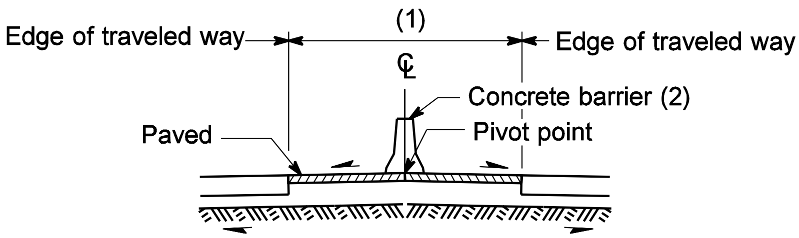
End rounding on the crossroad just beyond the ramp terminals and at a similar location where only a grade separation is involved.

(9) When widening beyond the edge of usable shoulder is required for curb, barrier, or other purposes, additional widening for shoulder rounding is not required.

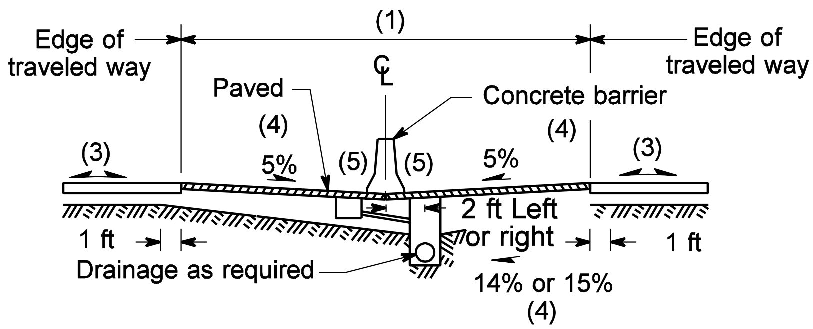
(10) See Chapter 710 for required widening for guardrail and concrete barrier.

Shoulder Details

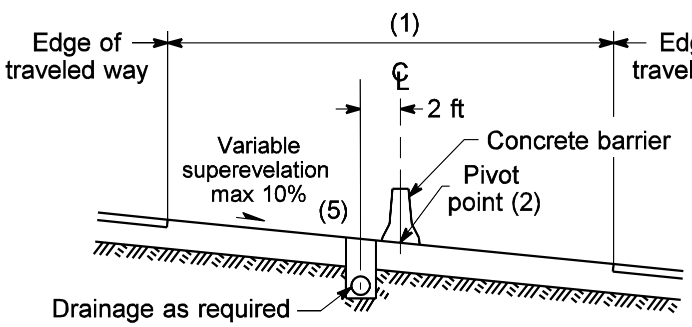
Figure 640-5b



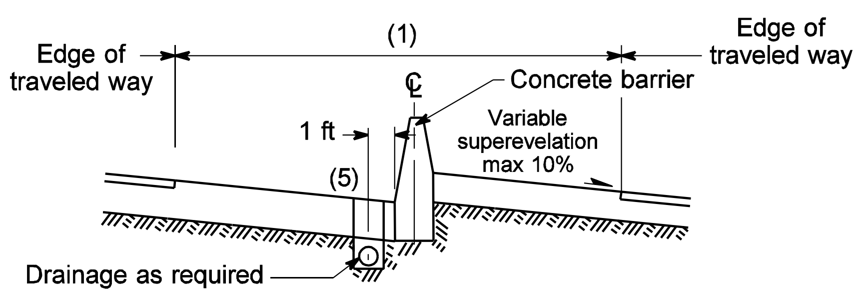
Design A Crowned Median



Design B Depressed Median



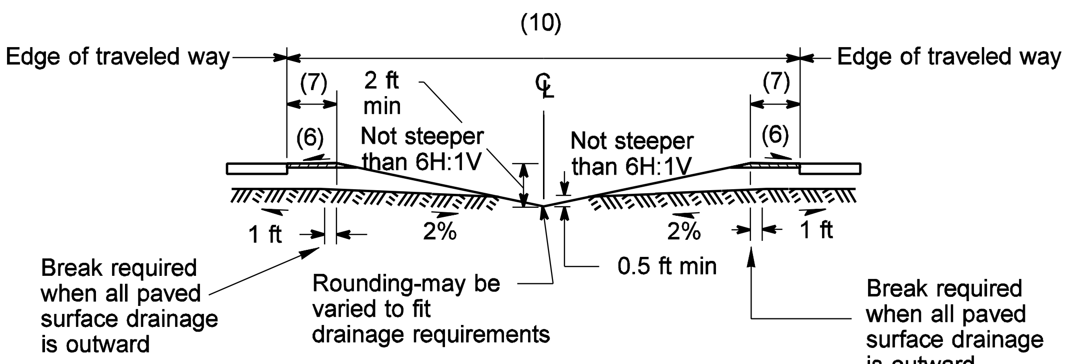
Alternate Design 1 Treatment on Curves



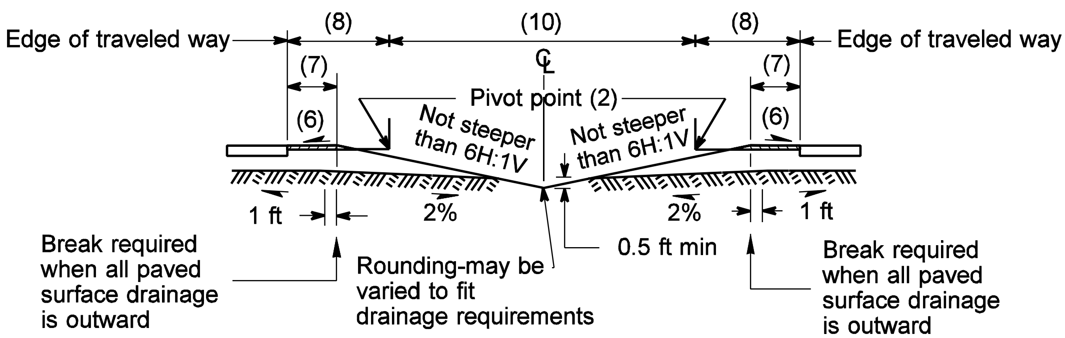
Alternate Design 2 No Fixed Pivot Point (2)

For notes see Figure 640-6c

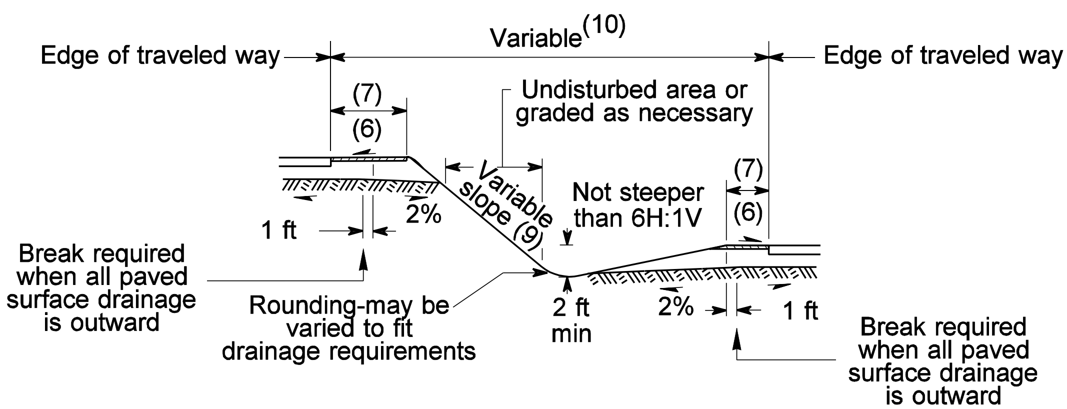
Divided Highway Median Sections
Figure 640-6a



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



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

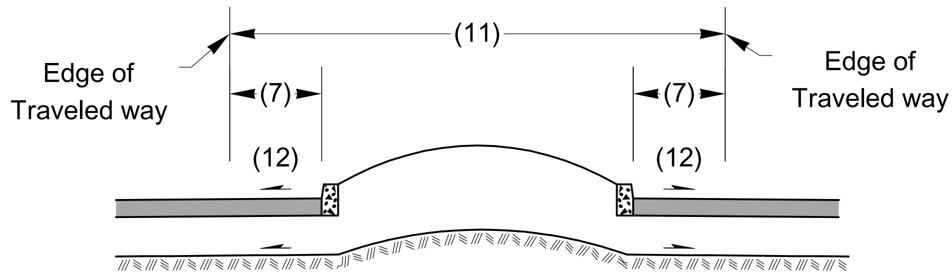


Design E Minimum for 4 or More Lanes with Independent Alignment

For notes, see Figure 640-6c

Divided Highway Median Sections

Figure 640-6b



Design F Raised Median (13)

(1) See Chapters 430, and 440 for minimum median width.

(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 “roll over” 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) 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.

(7) See Chapters 430, and 440 for minimum shoulder width.

(8) Future lane, see Chapter 440 for minimum width.

(9) Widen and round foreslopes steeper than 4H:1V as shown on 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.

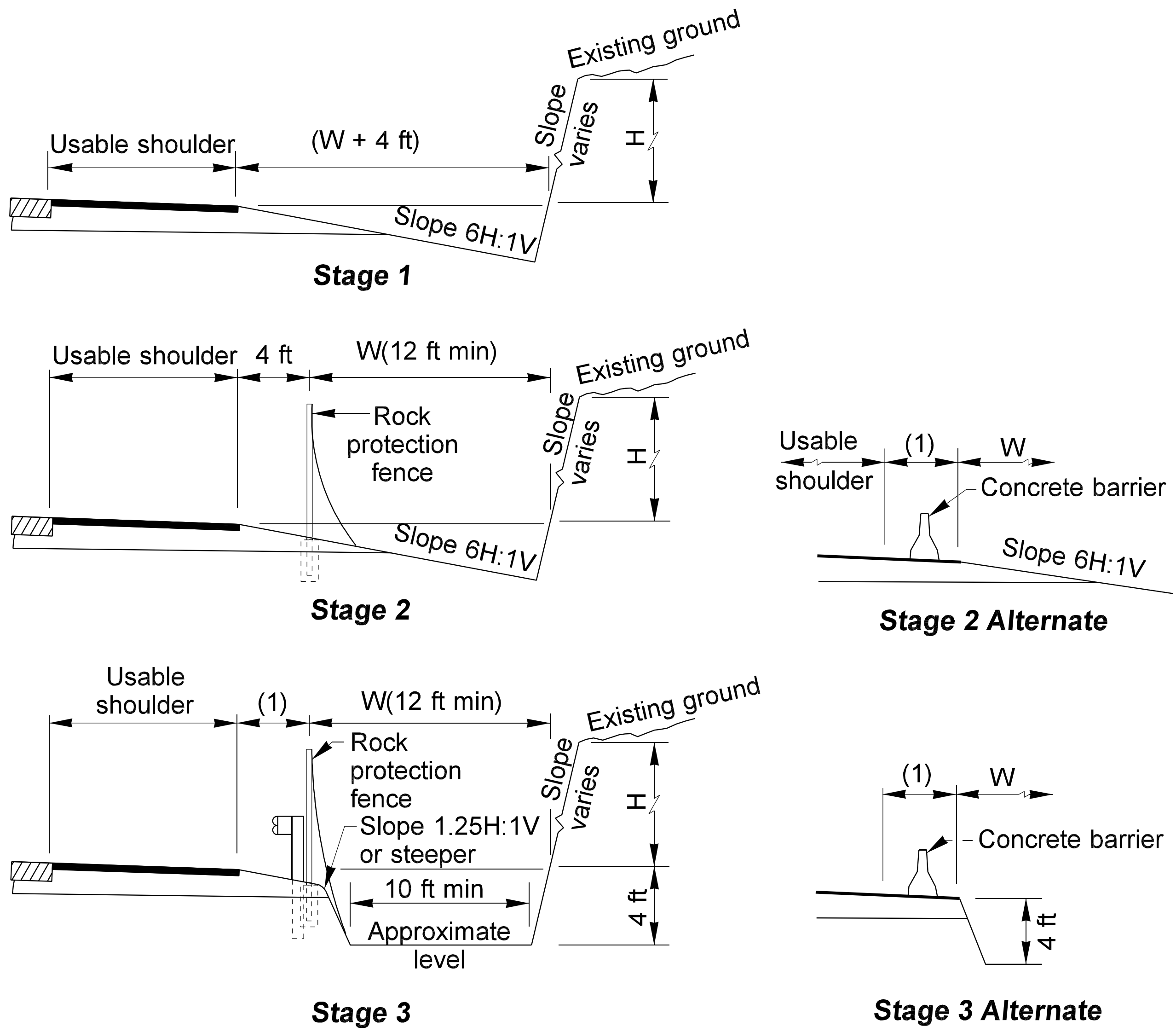
(11) See Chapter 440 for minimum median width. Raised medians may be paved or landscaped. See Chapter 700 for clear zone and barrier requirements when fixed objects or trees are in the median.

(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 ft shall be treated as a normal roadway unless otherwise determined by the region Materials Engineer.

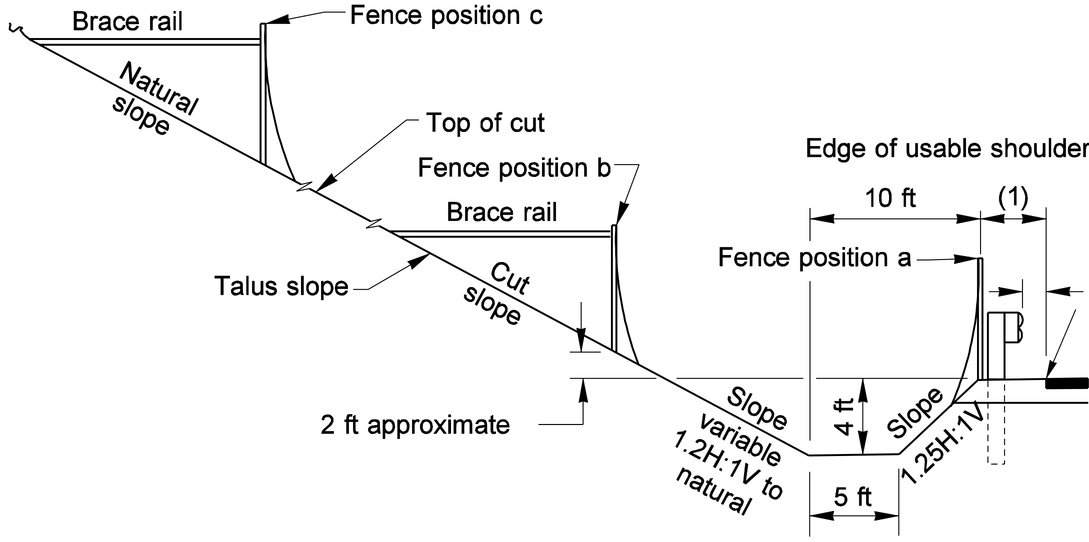
Stage 2 and 3 Alternatives may be used when site conditions dictate.

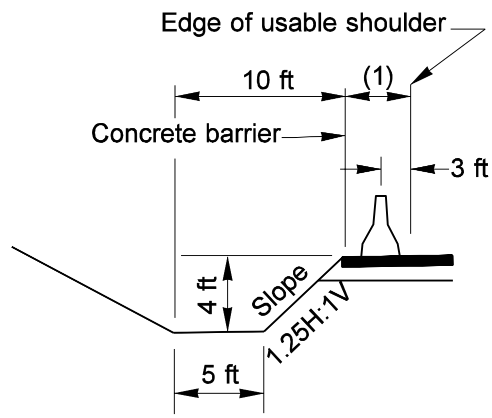
Fence may be used in conjunction with the Stage 3 Alternative. See Chapter 700 for clear zone requirements.

(1) See Chapter 710 for required widening for guardrail and concrete barrier.

Roadway Sections in Rock Cuts, Design A

Figure 640-7a





Shoulder Barrier Alternate

Notes:

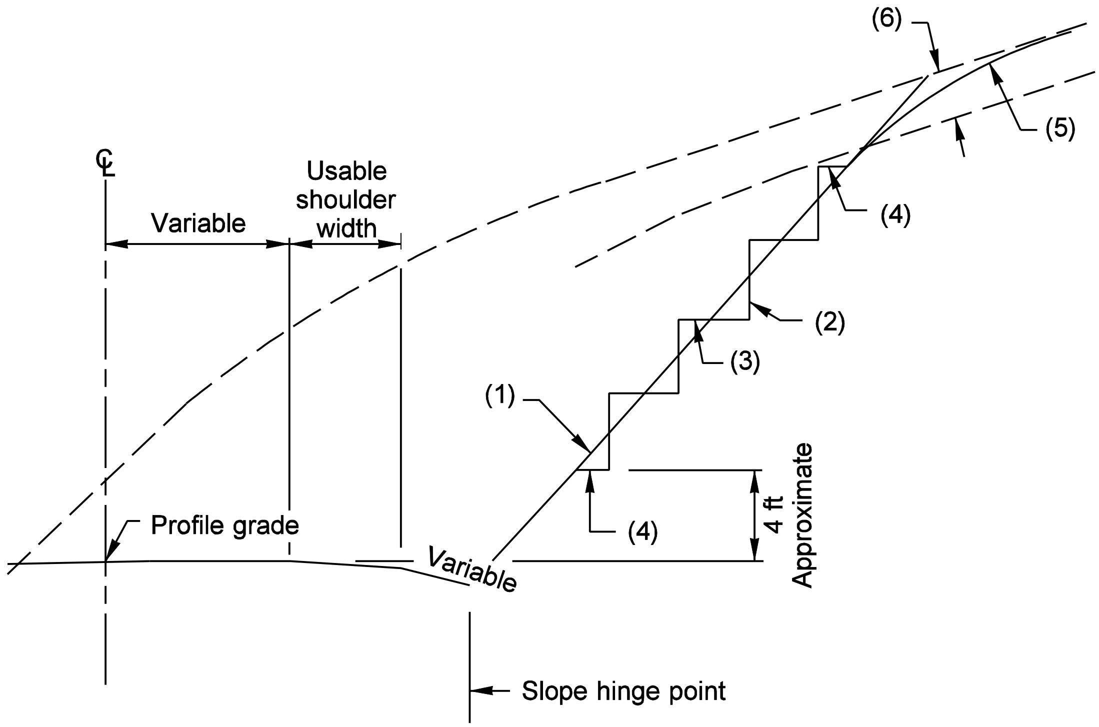
Ordinarily, place fence within a zone of 100 ft to 200 ft maximum from base of cliff measured along slope.

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

(1) See Chapter 710 for required widening for guardrail and concrete barrier.

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 ft to 2 ft
(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	$1^{3}/_{4}$H:1V	> 50 mph	Rounding	
	> 35 ft	2H:1V (2)	≤ 50 mph	No rounding	
End Piers in Cut	Match lower roadway slope.(3)		No rounding, toe at center line of the lower roadway ditch.		(4)
Lower Roadway in Cut	Match lower roadway slope.(3)		No rounding, toe at center line of the lower roadway ditch.		(4)
Ends in Partial Cut and Fill	When the cut depth is > 8 ft and length is > 100 ft, match cut slope of the lower roadway.		When the cut depth is > 8 ft and length is > 100 ft, no rounding, toe at center line of the lower roadway ditch.		(4)
	When the cut depth is ≤ 5 ft or the length is ≤ 100 ft, it is designers choice.		When the cut depth is ≤ 5 ft or the length is ≤ 100 ft, it is designers choice.		(4)

Notes:

(1) See Figure 640-9b

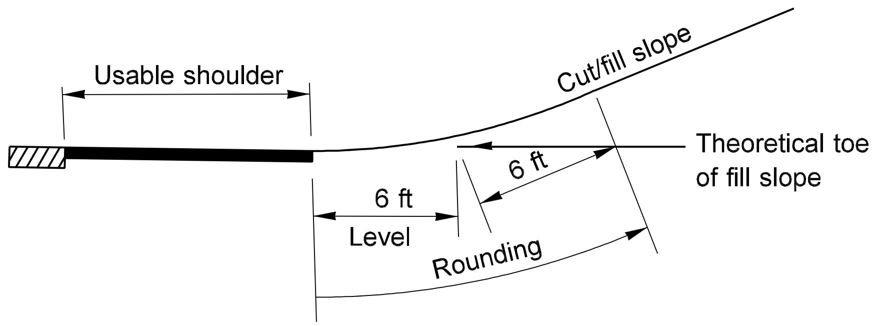
(2) Slope may be $1^{3}/_{4}$H:1V in special cases.

(3) In interchange areas, continuity may require variations.

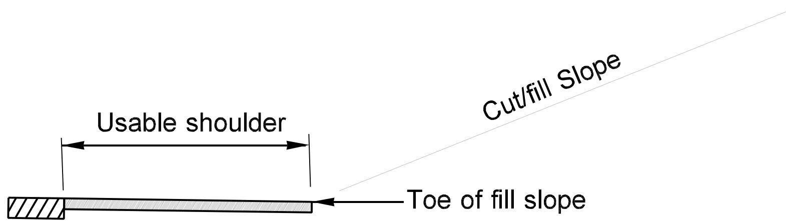
(4) See 640.06.

Bridge End Slopes

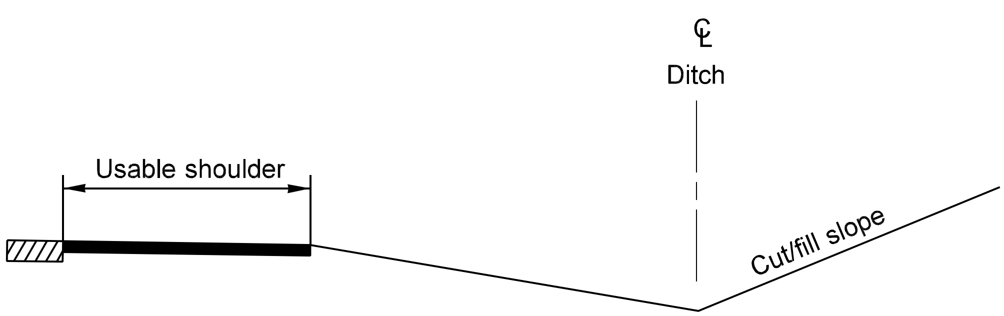
Figure 640-9a



Rounding



No Rounding



Toe at ℄ of Roadway Ditch

Bridge End Slopes

Figure 640-9b

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.

See the following chapters for additional information:

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

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.

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

641.03 Definitions

divided multilane A roadway with 2 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 roadway between two intersecting legs of an intersection.

undivided multilane A roadway with 2 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 ft lanes, when 11 ft lanes are called for, width W may be reduced by 2 ft.

(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 of 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 ft lanes, when 11 ft lanes are called for, width W may be reduced by 2 ft.

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 both 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 because, 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.

(4) Other roadways.

- For roadways with 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 ft per lane, it may be disregarded. If the total roadway width deficiency is less than 2 ft on existing roadways that are to remain in place, correction is not normally required.

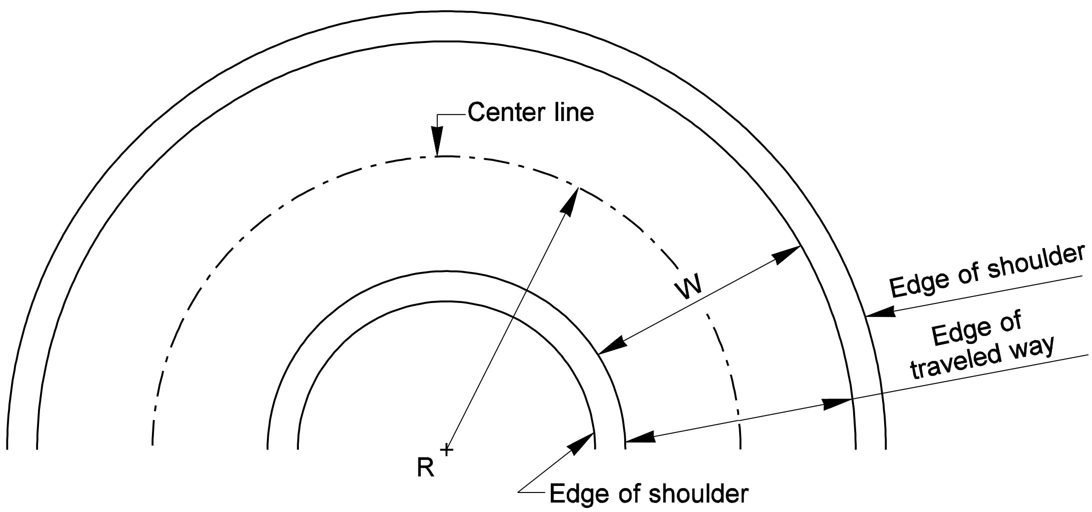
When widening the traveled way:

- 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 ft or less, use a 1:25 taper, for widths greater than 6 ft use a 1:15 taper.

641.05 Documentation

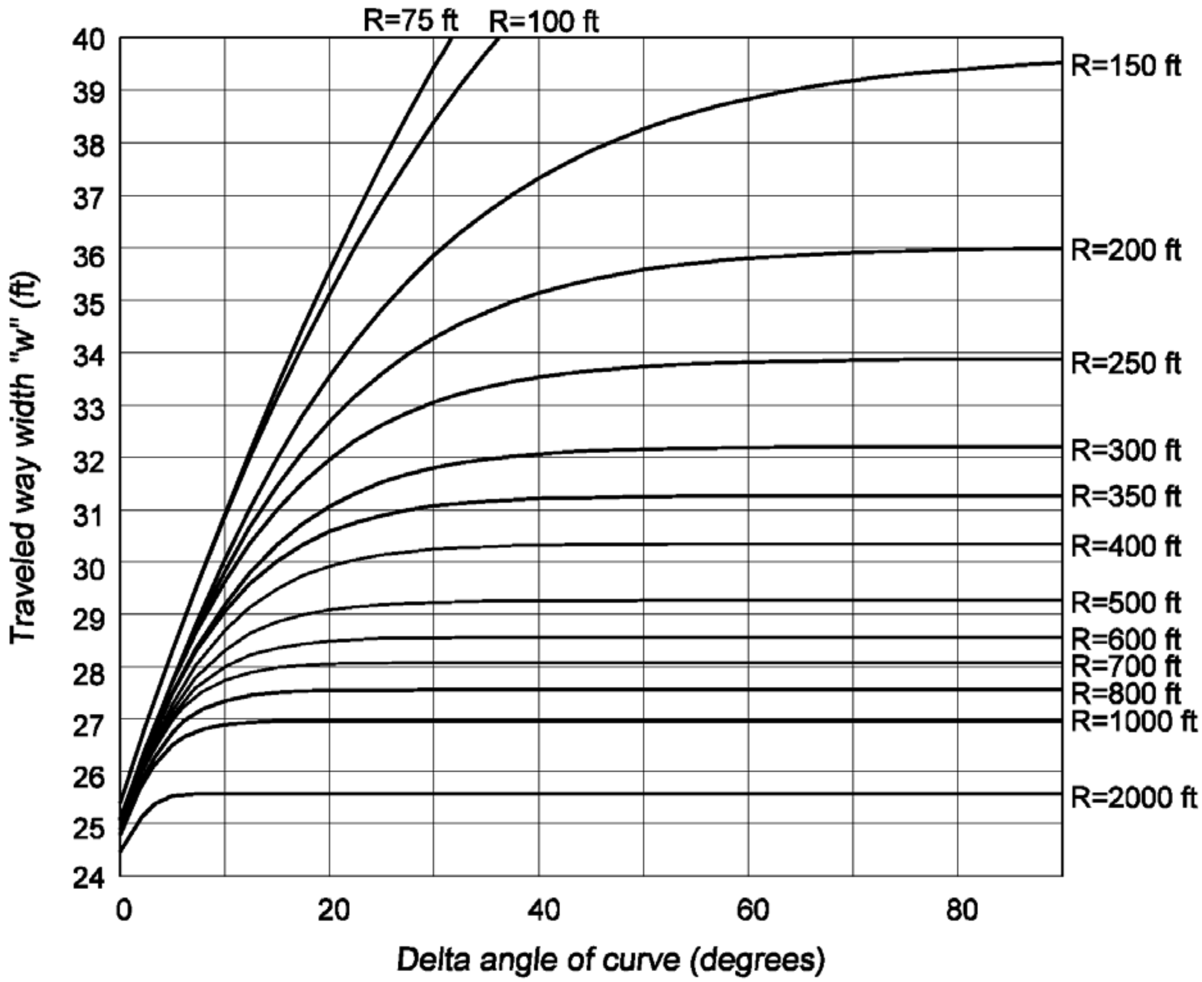
A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

Radius on center line of traveled way (ft)	Design traveled way width (W) (ft)(1)
3,000 to tangent	24
2,999	25
2,000	26
1,000	27
800	28
700	28
600	29
500	29
400	30
350	31
300	32
250	34
200	36
150	40



(1) Width (W) is for facilities with 12 ft lanes, when 11 ft lanes are called for, width may be reduced by 2 ft.

Traveled Way Width for Two-Lane Two-Way Turning Roadways
Figure 641-1a

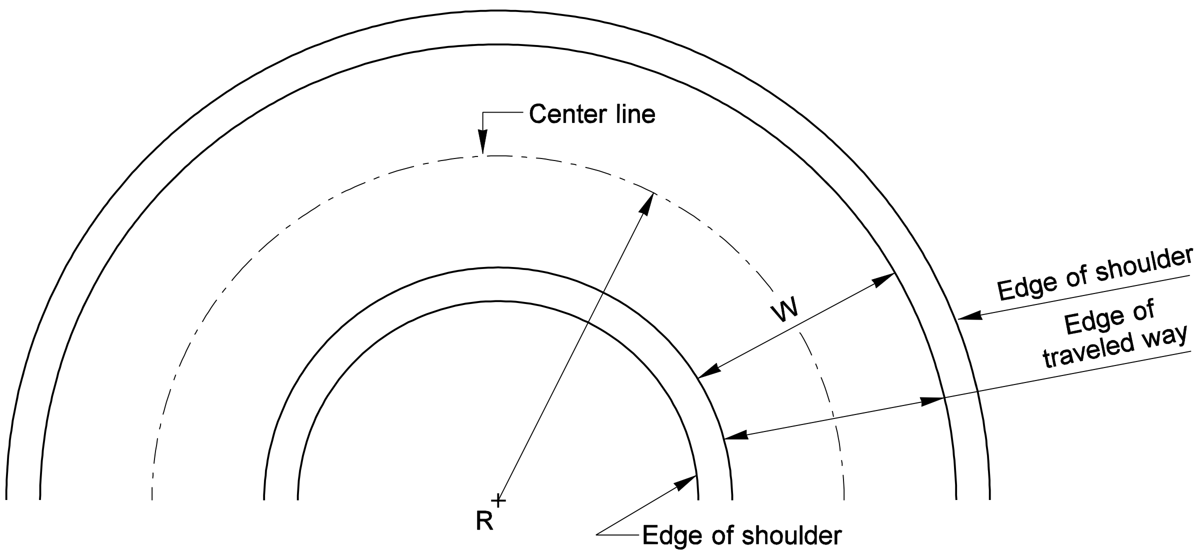


(2) Width (W) is for facilities with 12 ft lanes, when 11 ft lanes are called for, width may be reduced by 2 ft.

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

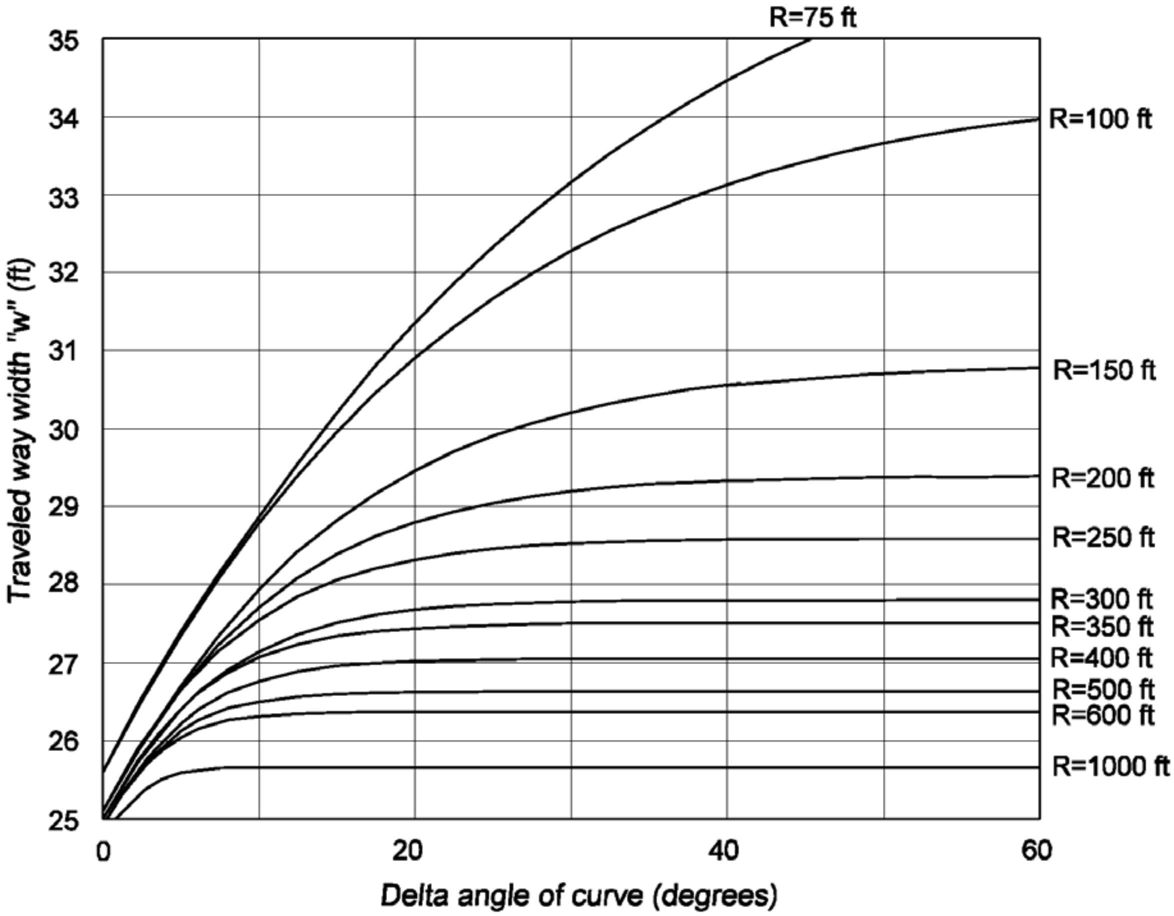
Figure 641-1b

Radius on center line of traveled way (ft)	Design traveled way width (W) (ft)(1)
3,000 to tangent	24
1,000 to 2,999	25
999	26
600	26
500	27
400	27
350	28
300	28
250	29
200	29
150	31
100	34



(3) Width (W) is for facilities with 12 ft lanes, when 11 ft lanes are called for, width may be reduced by 2 ft.

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



(1) Width (W) is for facilities with 12 ft lanes, when 11 ft lanes are called for, width may be reduced by 2 ft.

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

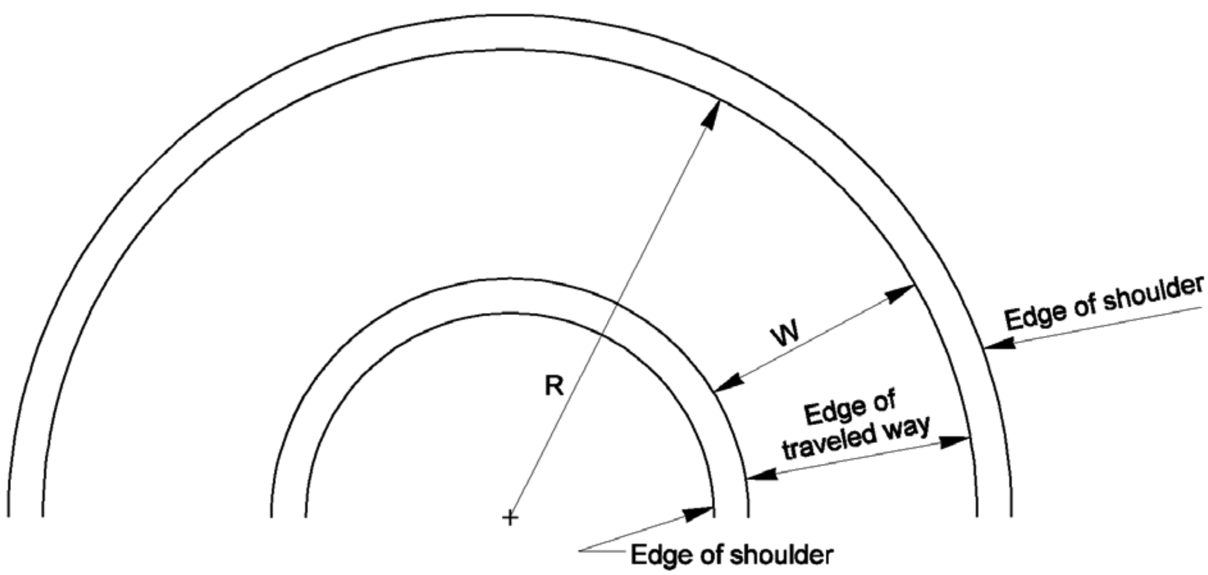
Radius (ft)	Design traveled way width (W) (ft)
7500 to tangent	13 (1)
1600	14
300	15
250	16
200	17
150	17
100	19 (2)
75	21 (3)
50	25 (4)

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

(2) The width given is for a radius on the outside edge of the traveled way. When the radius is on the inside edge of traveled way, the width may be 18 ft.

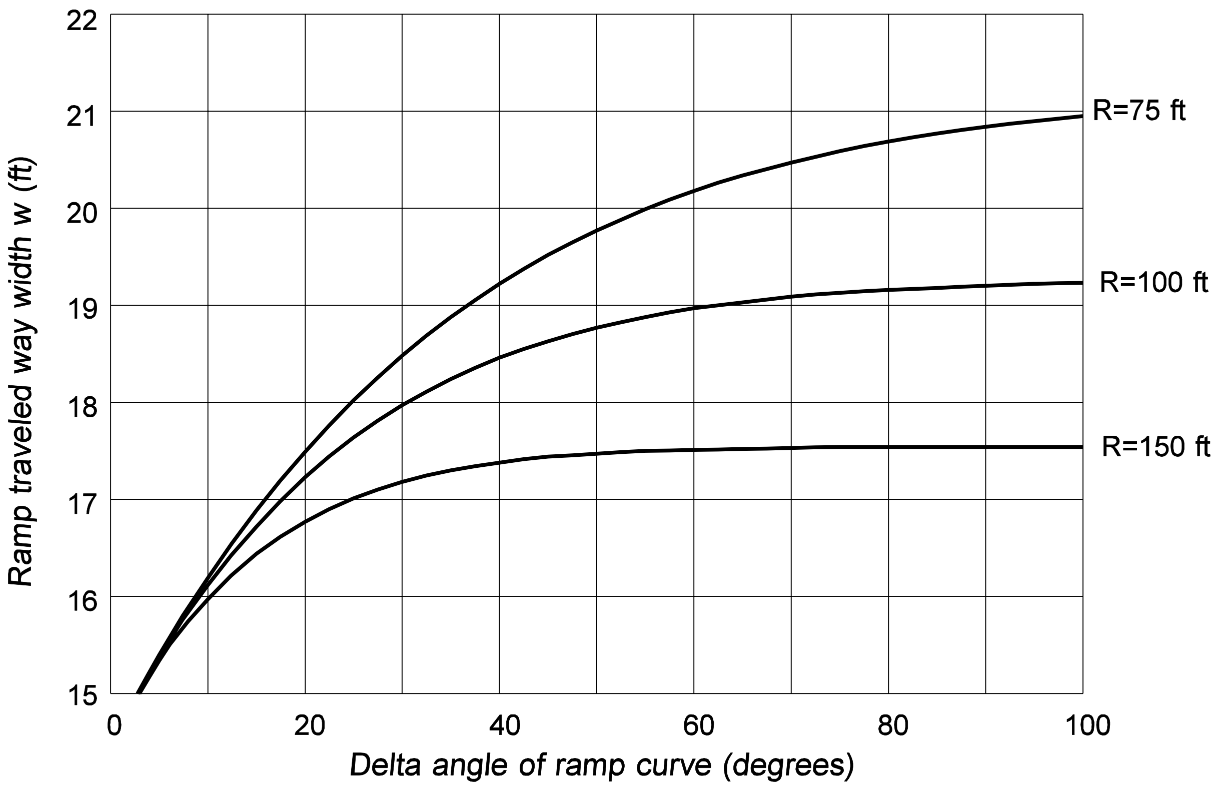
(3) The width given is for a radius on the outside edge of the traveled way. When the radius is on the inside edge of traveled way, the width may be 19 ft.

(4) The width given is for a radius on the outside edge of the traveled way. When the radius is on the inside edge of traveled way, the width may be 22 ft.



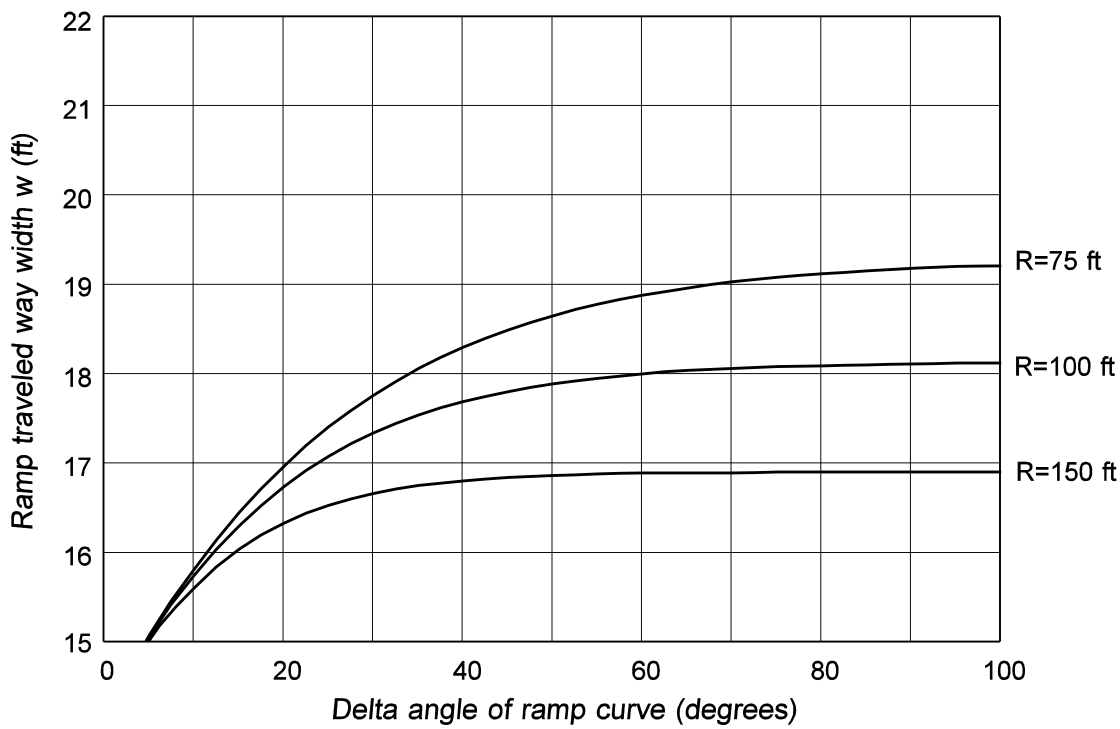
Traveled Way Width for One-Lane Turning Roadways

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

642.01 General

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 the following chapters for additional information:

Chapter	Subject
430	roadway widths and cross slopes for modified design level
440	minimum lane and shoulder widths for full design level
940	lane and shoulder widths for ramps

642.02 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

642.03 Definitions

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.

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

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

superelevation The rotation of the roadway cross section in such a manner as to overcome part of the centrifugal force that acts on a vehicle traversing a curve.

superelevation runoff The length of highway needed to accomplish the change in cross slope from a section with adverse crown removed (level) to a fully superelevated section, or vice versa.

superelevation transition length The length of highway needed to change the cross slope from normal crown or normal pavement slope to full superelevation.

tangent runout The length of highway needed to change the cross slope from normal crown to a section with adverse crown removed (level).

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 roadway between two intersecting legs of an intersection.

642.04 Rates for Open Highways and Ramps

The maximum superelevation rate allowed for open highways or ramps is 10%. (See Figure 642-3a.)

Base superelevation rate and its corresponding radius for open highways on Figure 642-3a, Superelevation Rate (10% Max), with the following exceptions:

- Figure 642-3b, Superelevation Rate (6% Max), may be used under the following conditions:

  1. Urban non freeways.

  2. Mountainous areas or locations that normally experience regular accumulations of snow and ice.

  3. Short-term detours (generally implemented and removed in one construction season). For long-term detours, consider a higher rate up to 10%, especially when associated with a main line detour.

- Figure 642-3c, Superelevation Rate (8% Max), may be used for existing roadways, urban freeways, and areas where the 6% rate is allowed but will not work; for example, where a curve with a radius less than the minimum for the 6 % rate at the design speed is required.

Design the superelevation for ramps the same as for open highways. With justification, superelevation for ramps in urban areas with a design speed of 40 mph or less, may be determined as an urban managed access highway [642.05 & Figure 642-4].

Round the selected superelevation rate to the nearest full percent.

Document which set of curves is being used and, when a curve other than the 10% maximum rate is used, document why the curve was selected.

Depending on design speed, construct large radius curves with a normal crown section. The minimum radii for normal crown sections are shown in Figure 642-1. Superelevate curves with smaller radii in accordance with the appropriate superelevation from Figures 642-3a through 3c.

Design Speed (mph)	Minimum Radius for Normal Crown Section (ft)
15	955
20	1695
25	2,450
30	3,340
35	4,375
40	5,545
45	6,860
50	8,315
55	9,920
60	11,675
65	13,130
70	14,675
75	16,325
80	18,065

Minimum Radius for Normal Crown Section

Figure 642-1

642.05 Rates for Low-Speed Urban Managed Access Highway

Curves on low-speed Urban Managed Access Highways may be superelevated using a higher side friction than used for open highways. Figure 642-4 may be used to determine superelevation for Urban Managed Access Highways with a design speed of 40 mph or less. Figure 642-4 was developed using the higher side friction.

642.06 Existing Curves

Evaluate the superelevation on an existing curve to determine its adequacy. Use the following equation to determine the minimum radius for a given superelevation and design speed:

$$R = \frac{6.69V^2}{e + f}$$

Where:

R = The minimum allowable radius of the curve in feet.

V = Design speed in mph

e = Superelevation rate in percent

f = Side friction factor from Figure 642-2

Superelevation is deficient when the existing radius is less than the minimum from the equation.

For preservation projects, where the existing pavement is to remain in place, the superelevation on existing curves may be evaluated with a ball banking analysis.

Corrective action is required to address deficient superelevation, when the existing radius is less than the minimum radius calculated using the equation or when the maximum speed determined by a ball banking analysis is less than the design speed. Provide superelevation as given in 642.04.

Design Speed (mph)	Side Friction Factor (f)
15	17.5
20	17
25	16.5
30	16
35	15.5
40	15
45	14.5
50	14
55	13
60	12
65	11
70	10
75	9
80	8

Side Friction Factor

Figure 642-2

642.07 Turning Movements at Intersections

Curves associated with the turning movements at intersections are superelevated using the side friction factors for low-speed urban managed access highway curves. Since speeds of turning vehicles are not constant and curve lengths are not excessive, these higher friction factors can be tolerated. Use superelevation rates as high as practical, consistent with curve length and climatic conditions. Figure 642-4 shows the minimum superelevation for given design speed and radius. Use judgment in considering local conditions such as snow and ice. When using high superelevation rates on short curves, provide smooth transitions with merging ramps or roadways.

642.08 Runoff for Highway Curves

For added comfort and safety, provide uniform superelevation runoff over a length adequate for the likely operating speeds. The length of the runoff is based on a maximum allowable difference between the grades on the pivot point and the outer edge of the traveled way for one 12 ft lane.

Provide transitions for all superelevated highway curves as specified in Figures 642-5a through 5e. Which transition to use depends on the location of the pivot point, the direction of the curve, and the roadway cross slope.

Consider the profile of the edge of traveled way. To be pleasing in appearance, do not let it appear distorted. The combination of superelevation transition and grade may result in a hump or dip in the profile of the edge of traveled way. When this happens, the transition may be lengthened to eliminate the hump or dip. If the hump or dip cannot be eliminated this way, pay special attention to drainage in the low areas.

When reverse curves are necessary, provide sufficient tangent length for complete superelevation runoff for both curves (that is, from full superelevation of the first curve to level to full superelevation of the second curve). If tangent length is longer than this but not sufficient to provide full super transitions (that is, from full superelevation of the first curve to normal crown to full superelevation of the second curve), increase the superelevation runoff lengths until they abut. This provides one continuous transition, without a normal crown section, similar to Designs C2 and D2 in Figures 642-5c and 5d except full super will be attained rather than the normal pavement slope as shown.

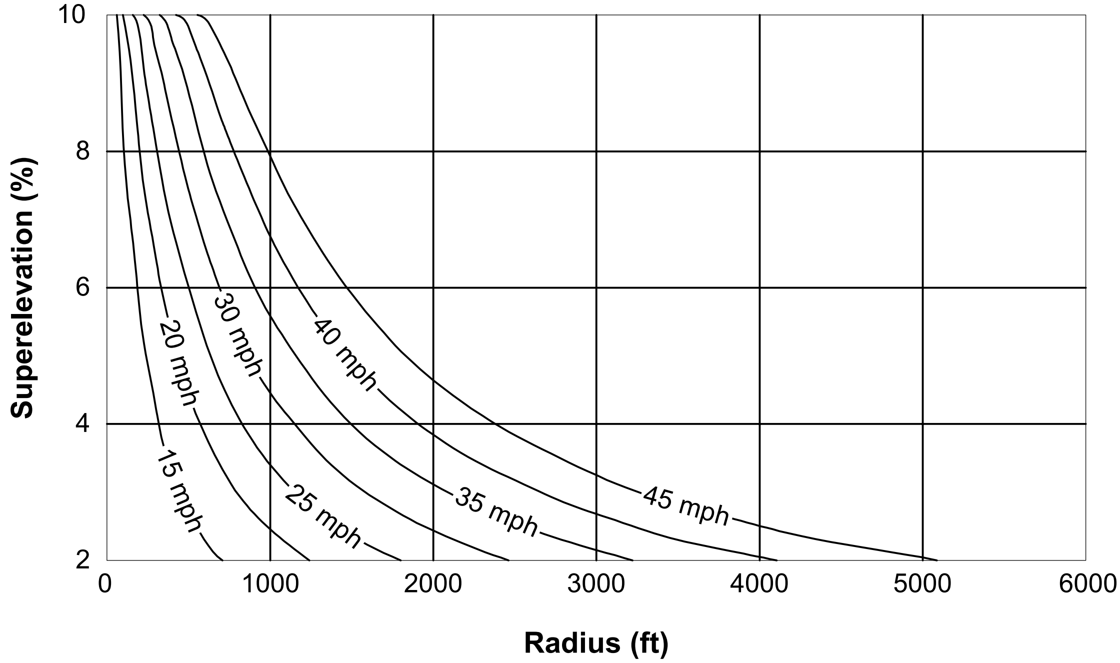
Superelevation runoff is permissible on structures but not desirable. Whenever practical, strive for full super or normal crown slopes on structures.

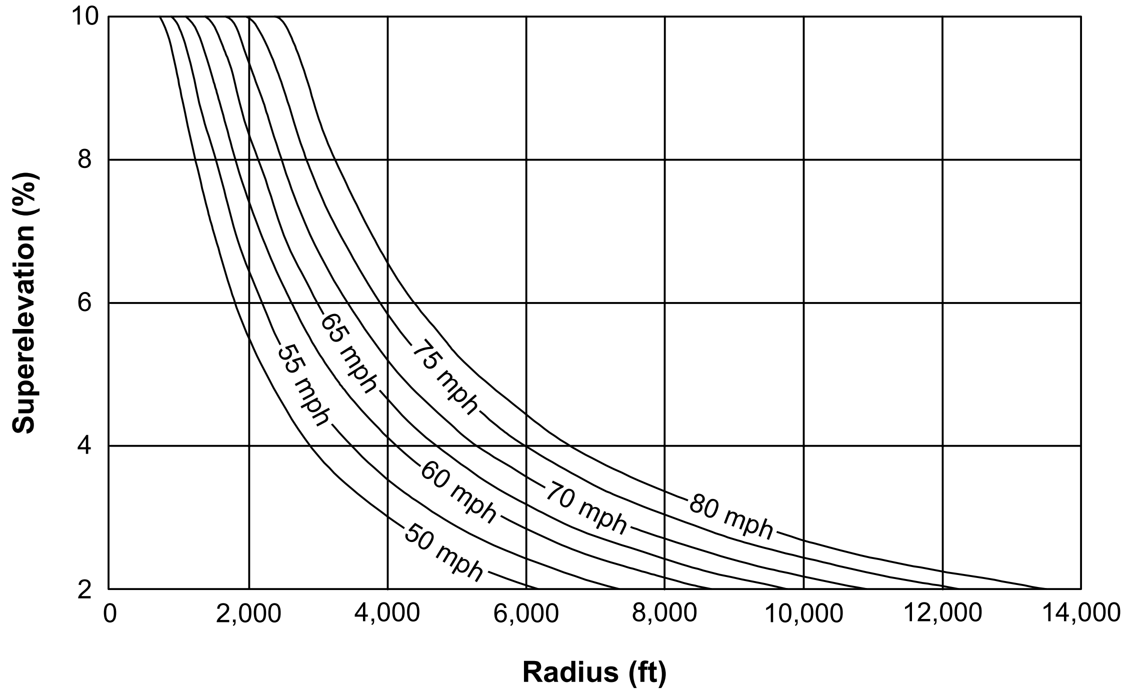
642.09 Runoff for Ramp Curves

Superelevation runoff for ramps use the same maximum relative slopes for specific design speeds used for highway curves. Multilane ramps have a width similar to the width for highway lanes; therefore, Figures 642-5a through 5e are used to determine the superelevation runoff for ramps. Single lane ramps have a lane width of 15 ft in curves, requiring the runoff length to be adjusted. Superelevation transition lengths (L_T) for single-lane ramps are given in Figures 642-6a and 6b. Additional runoff length for turning roadway widening is not required.

642.10 Documentation

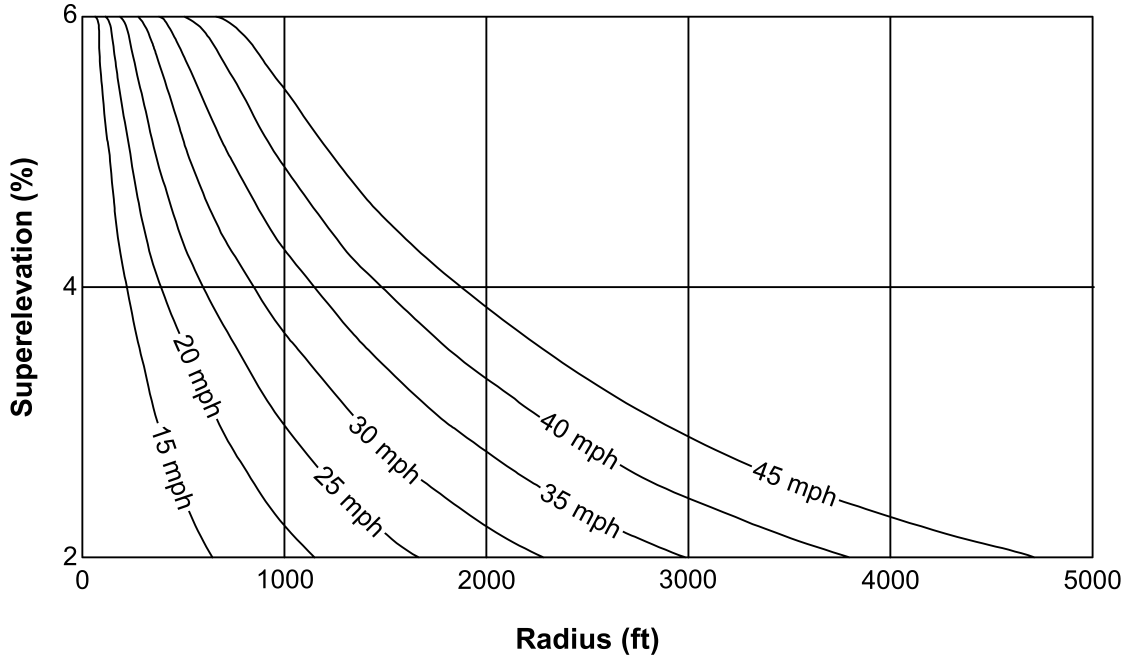
A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

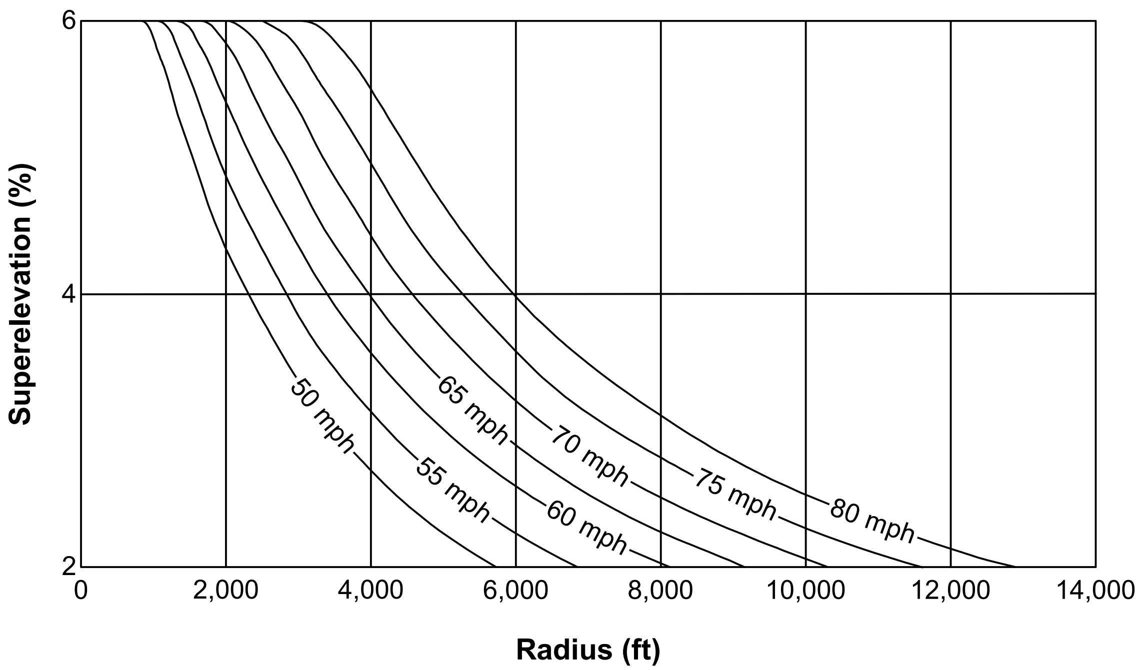




Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	55	100	160	235	325	430	555	700	880	1095	1345	1640	1980	2380

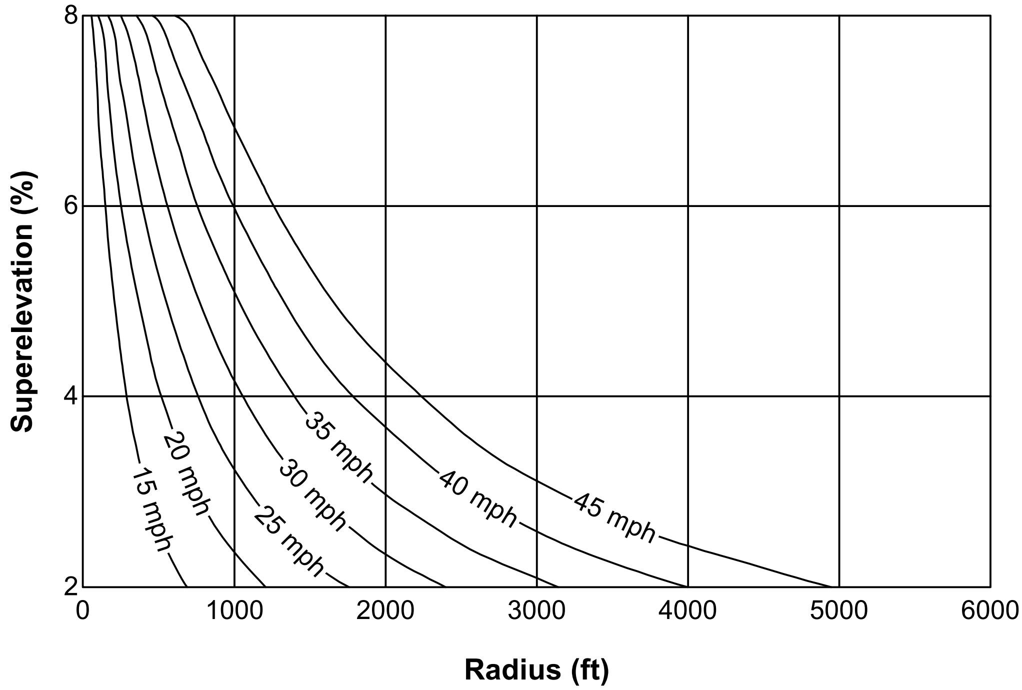
Superelevation Rates (10% max)
Figure 642-3a

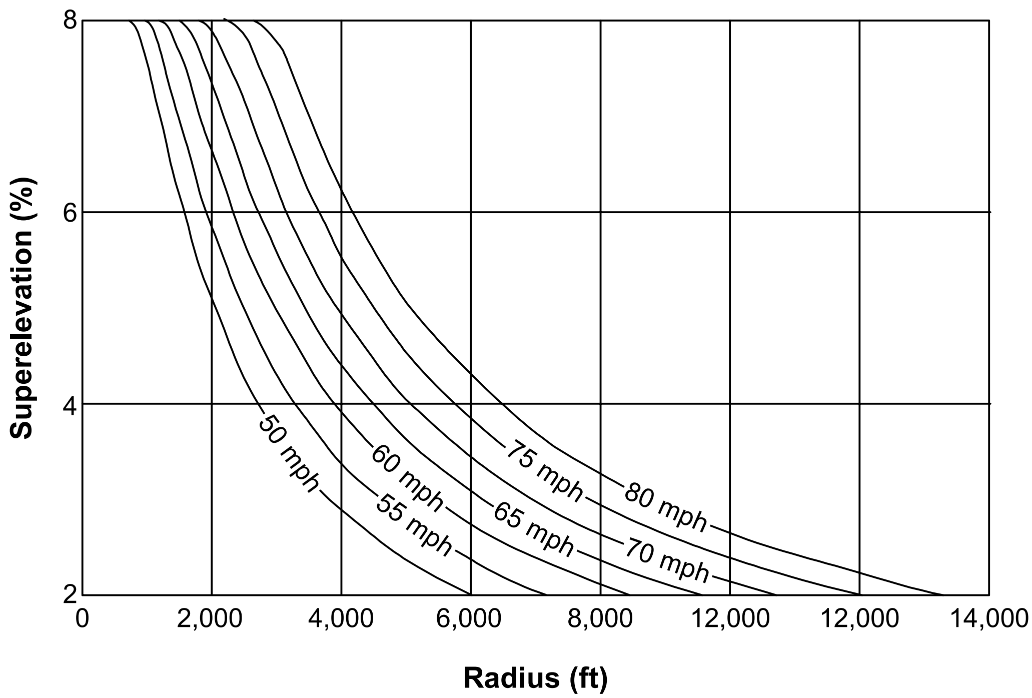




Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	65	120	190	270	385	510	660	840	1065	1340	1665	2050	2510	3055

Superelevation Rates (6% max)
Figure 642-3b

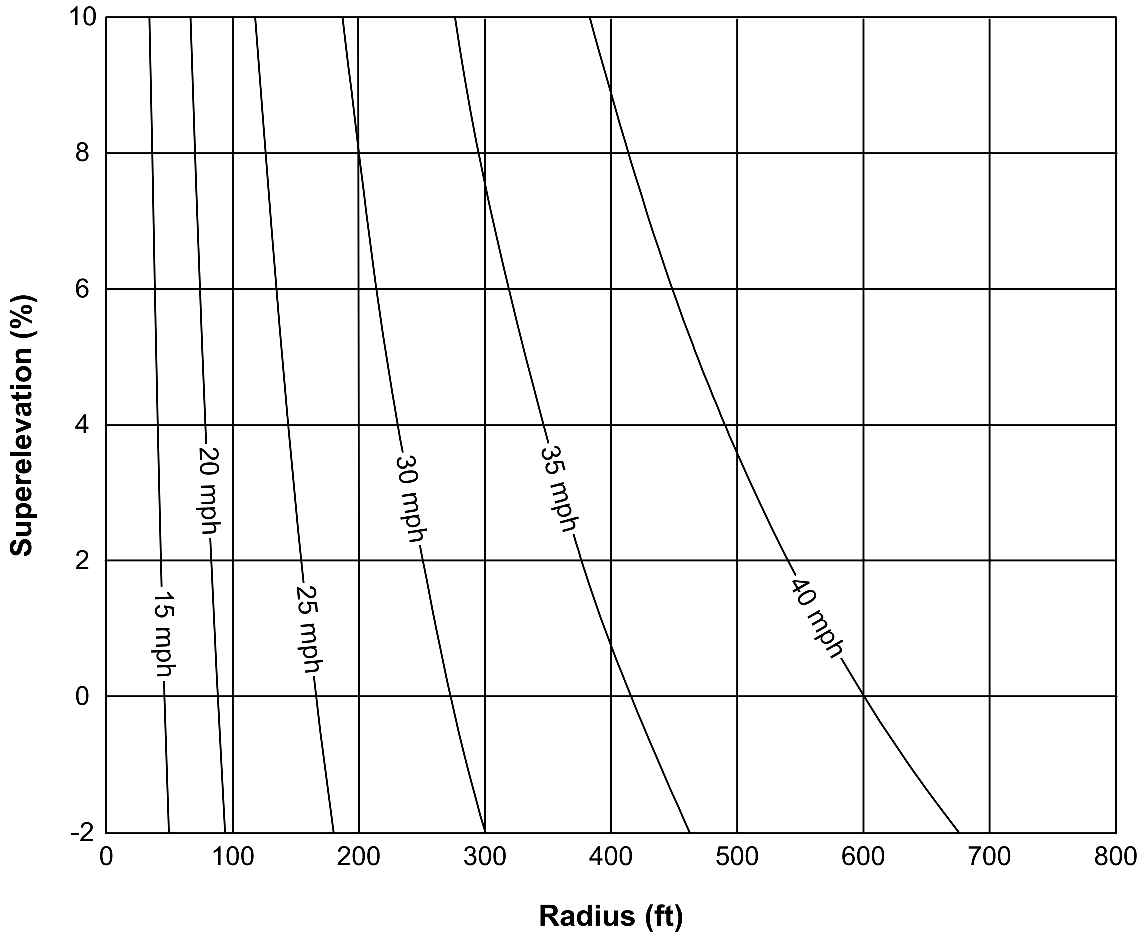




Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	60	110	175	255	350	465	605	760	965	1205	1490	1820	2215	2675

Superelevation Rates (8% max)

Figure 642-3c



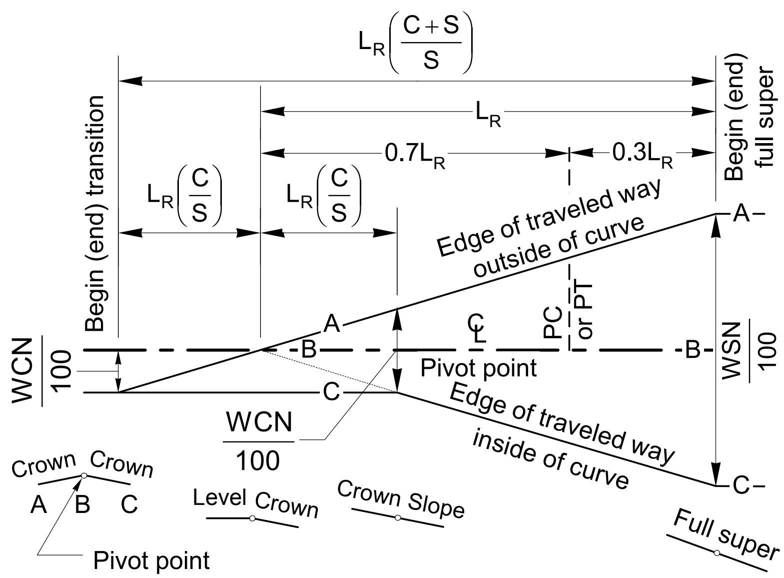
Superelevation Rates for Low-Speed Urban Managed Access Highways
Figure 642-4

S (%)	L_B=Basic runoff in feet for Design Speed of:													
	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph	70 mph	75 mph	80 mph
2	30	30	35	35	40	40	45	50	50	55	55	60	65	70
3	45	50	50	55	60	60	65	70	75	80	85	90	95	105
4	60	65	70	75	75	85	90	95	100	105	110	120	125	135
5	75	80	85	90	95	105	110	120	130	135	140	150	160	170
6	90	95	105	110	115	125	135	145	155	160	170	180	190	205
7	110	115	120	130	135	145	155	170	180	185	195	210	220	240
8	125	130	135	145	155	165	180	190	205	215	225	240	250	275
9	140	145	155	165	175	185	200	215	230	240	250	270	285	310
10	155	160	170	180	195	205	220	240	255	265	280	300	315	345

* Based on one 12 ft lane between the pivot point and the edge of traveled way. When the distance exceeds 12 ft use the following equation to obtain L_R:
$L_R = L_B(1+0.04167X)$

Where:

X = The distance in excess of 12 ft between the pivot point and the furthest edge of traveled way, in feet



Design A Pivot Point on Center Line
Crown Section

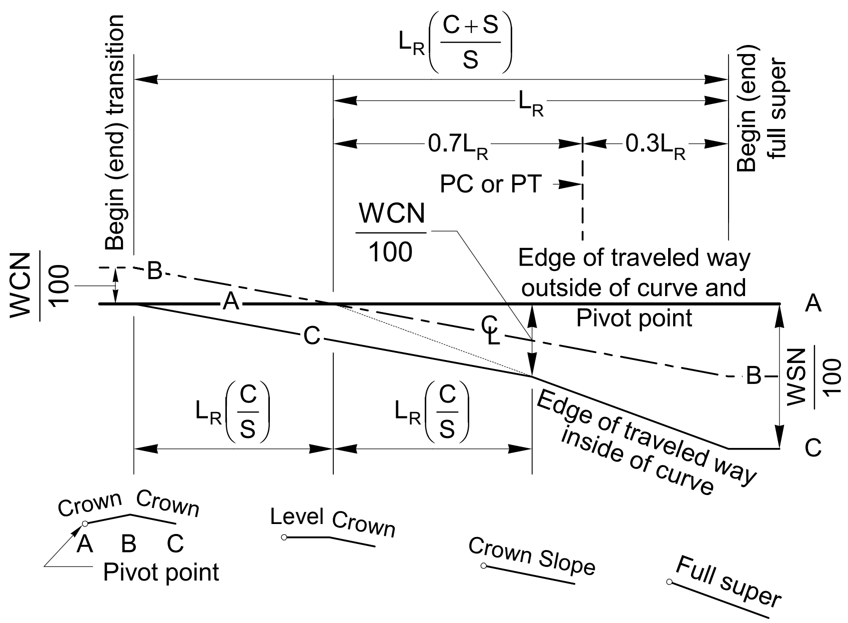
C = Normal crown(%)

S = Superelevation rate (%)

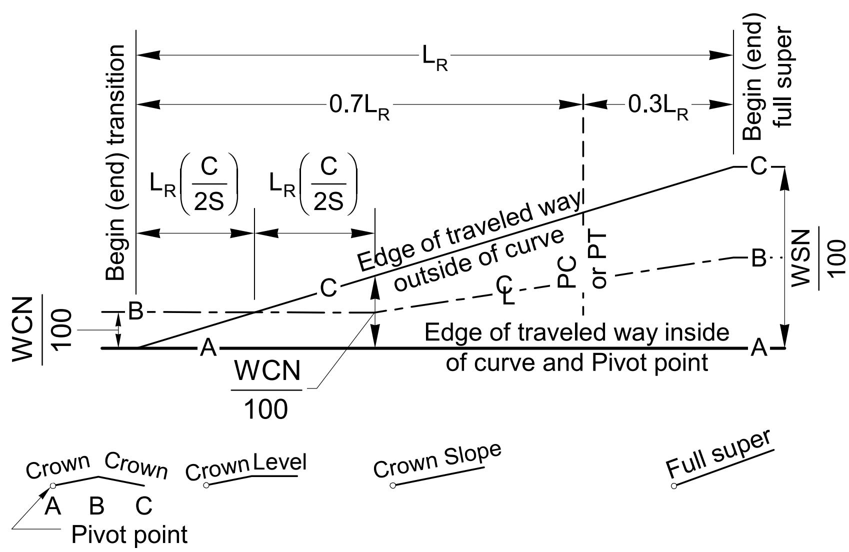
N = Number of lanes between points

W = Width of lane

Superelevation Transitions for Highway Curves
Figure 642-5a



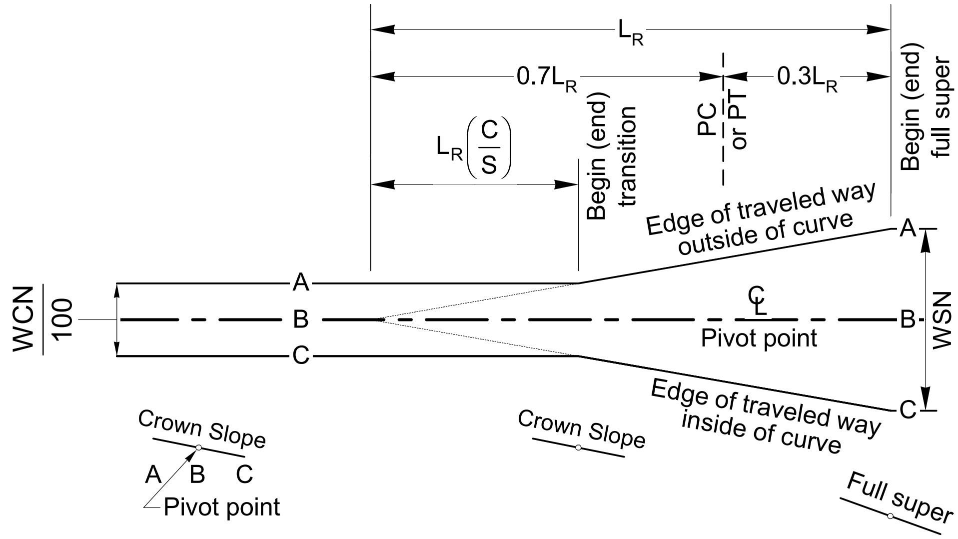
Design B[1] Pivot Point on Edge of Traveled Way
Outside of Curve Crowned Section



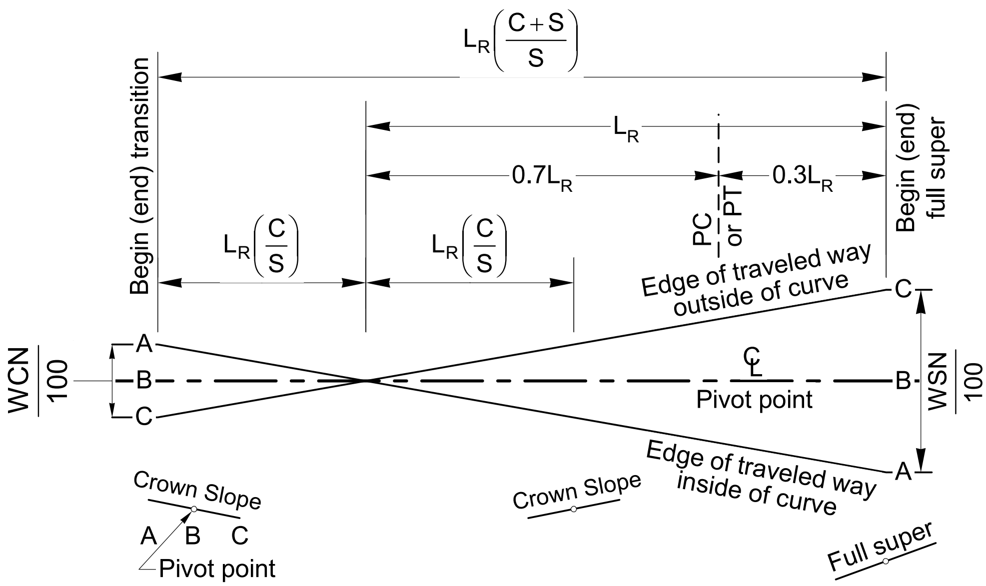
Design B[2] Pivot Point on Edge of Traveled Way
Inside of Curve Crowned Section

C = Normal crown(%)
S = Superelevation rate (%)
N = Number of lanes between points
W = Width of lane

Superelevation Transitions for Highway Curves
Figure 642-5b



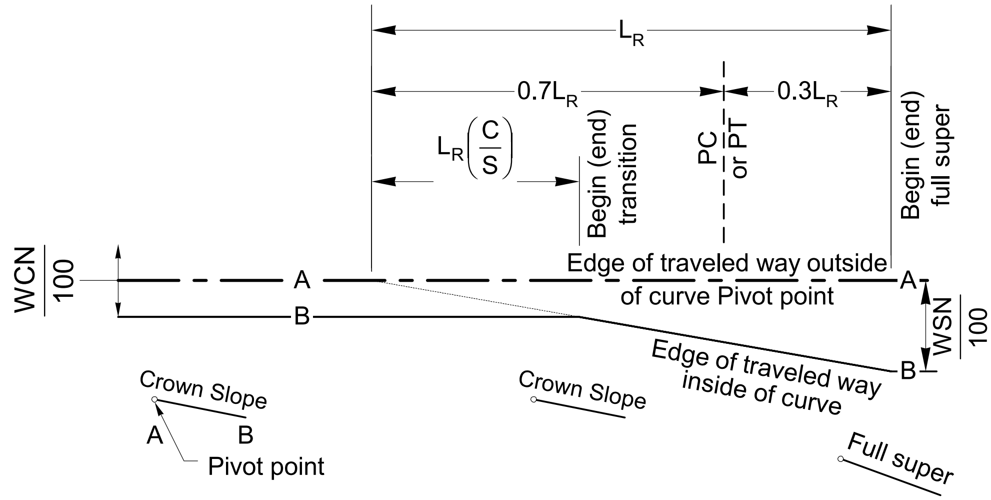
Design C[1] Pivot point on center line curve in direction of normal pavement slope - plane section



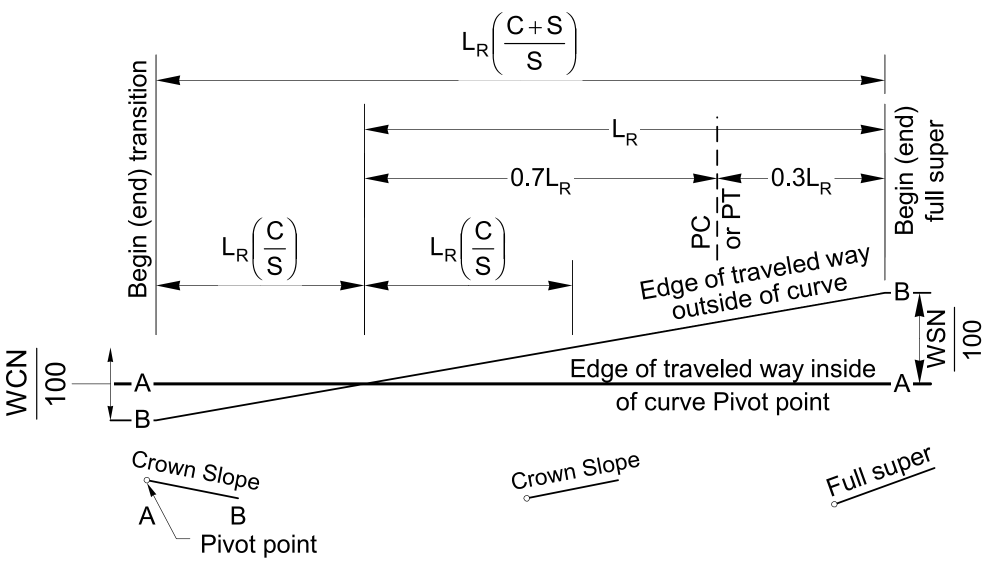
Design C[2] Pivot point on center line curve opposite to normal pavement slope - plane section

C = Normal crown(%)
S = Superelevation rate (%)
N = Number of lanes between points
W = Width of lane

Superelevation Transitions for Highway Curves
Figure 642-5c



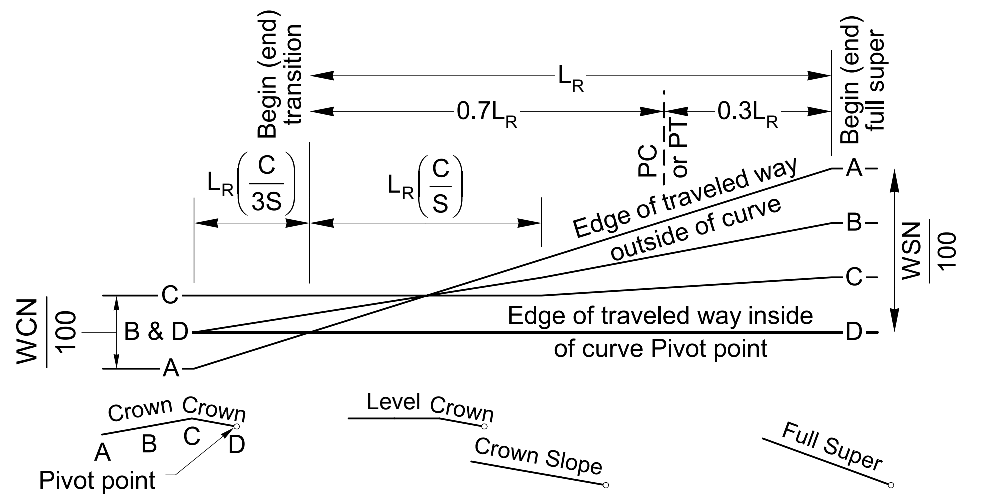
Design D[1] Pivot point on edge of traveled way curve in direction of normal pavement slope - plane section



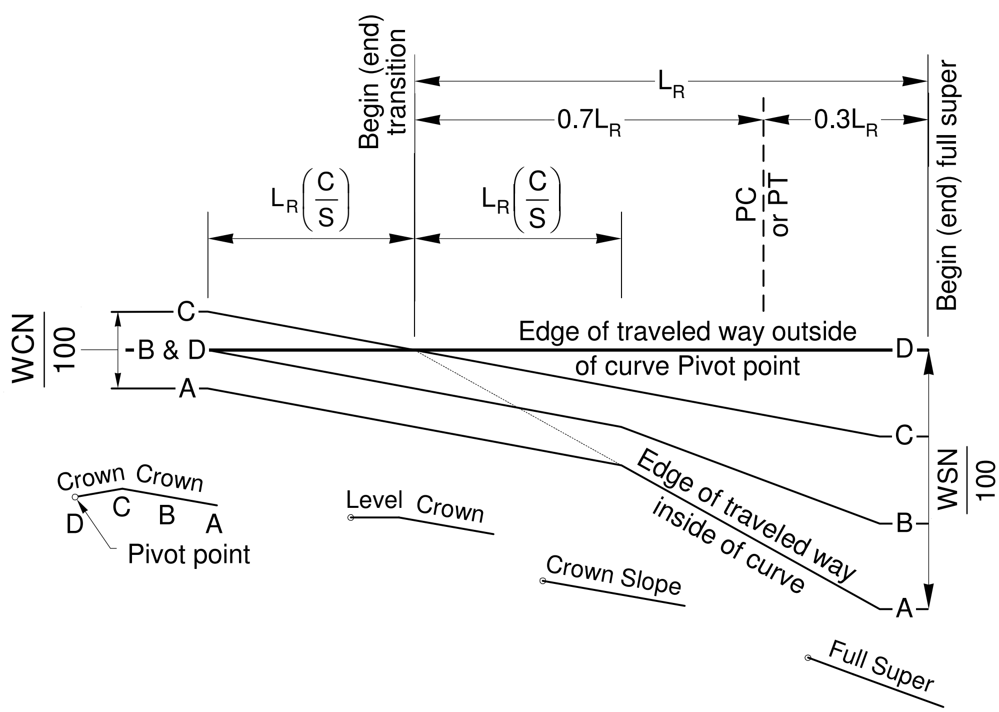
Design D[2] Pivot point on edge of traveled way curve opposite to normal pavement slope - plane section

C = Normal crown(%)
S = Superelevation rate (%)
N = Number of lanes between points
W = Width of lane

Superelevation Transitions for Highway Curves
Figure 642-5d



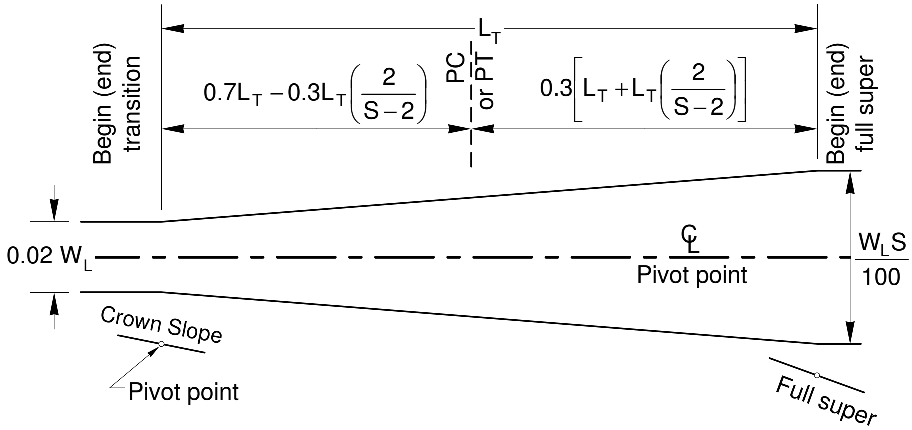
Design E[1] Six lane with median, pivot point on edge of traveled way inside of curve crown section



Design E[2] Six lane with median, pivot point on edge of traveled way outside of curve crown section

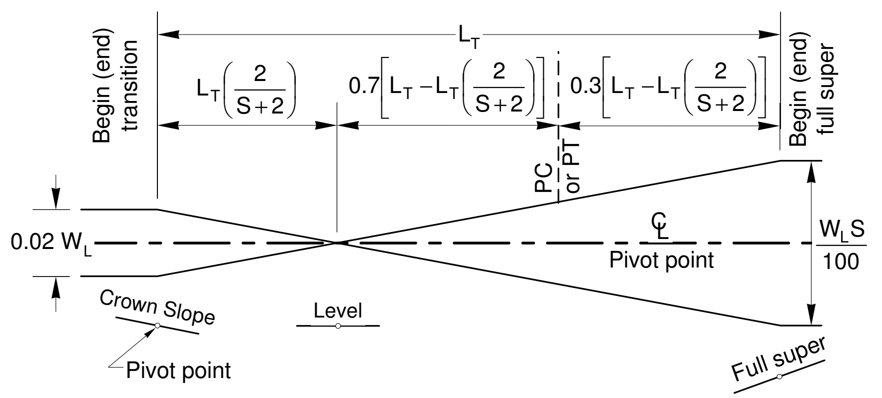
C = Normal crown(%)
S = Superelevation rate (%)
N = Number of lanes between points
W = Width of lane

Superelevation Transitions for Highway Curves
Figure 642-5e



S (%)	Length of transition in feet for Design Speed of:							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
3	10	15	15	15	15	15	15	15
4	20	25	25	25	25	30	30	35
5	30	35	35	35	40	45	45	50
6	40	45	45	50	55	55	60	65
7	50	55	55	60	65	70	75	80
8	60	65	70	75	80	85	90	95
9	70	75	80	85	95	100	105	110
10	80	85	90	100	105	115	120	130

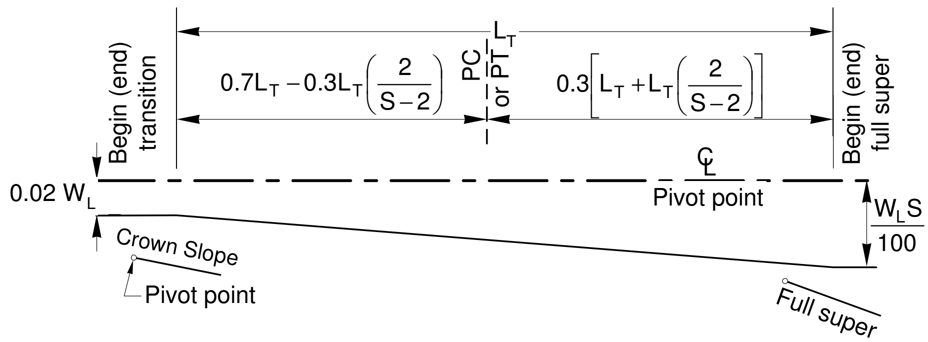
Table 1 Pivot Point on Center Line — Curve in Direction of Normal Pavement Slope



S (%)	Length of transition in feet for Design Speed of:							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
2	40	40	45	50	55	55	60	65
3	50	55	55	60	65	70	75	80
4	60	65	70	75	80	85	90	95
5	70	75	80	85	90	100	105	110
6	80	85	90	95	105	115	120	130
7	90	95	100	110	120	125	135	145
8	100	105	115	120	130	140	150	160
9	110	120	125	135	145	155	165	175
10	120	130	135	145	160	170	180	190

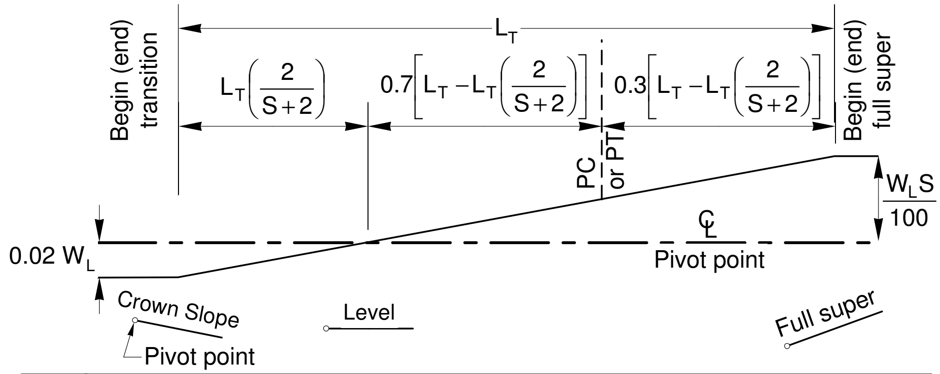
Table 2 Pivot Point on Center Line — Curve in Direction Opposite to Normal Pavement Slope
W_L=width of ramp lane.

Superelevation Transitions for Ramp Curves
Figure 642-6a



S (%)	Length of transition in feet for Design Speed of:							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
3	20	25	25	25	25	30	30	35
4	40	45	45	50	55	55	60	65
5	60	65	70	75	80	85	90	95
6	80	85	90	100	105	115	120	130
7	100	105	115	120	130	140	150	160
8	120	130	135	145	160	170	180	190
9	140	150	160	170	185	195	210	225
10	160	170	180	195	210	225	240	255

Table 3 Pivot point on edge of traveled way — curve in direction of normal pavement slope



S (%)	Length of transition in feet for Design Speed of:							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
2	80	85	90	100	105	115	120	130
3	100	105	115	120	130	140	150	160
4	120	130	135	145	160	170	180	190
5	140	150	160	170	185	195	210	225
6	160	170	180	195	210	225	240	255
7	180	190	205	220	235	255	270	290
8	200	210	225	245	265	280	300	320
9	220	235	250	265	290	310	330	350
10	240	255	270	290	315	340	360	385

Table 4 Pivot point on edge of traveled way — curve in direction opposite to normal pavement slope

W_L=width of ramp lane.

Superelevation Transitions for Ramp Curves

Figure 642-6b

650.01 General

It is essential that the driver of a vehicle be able to see far enough ahead to assess developing situations and take appropriate action. For purposes of design, sight distance is considered in terms of passing sight distance, stopping sight distance, and decision sight distance.

See the following chapters for additional information:

Chapter	Subject
910	Sight distance at intersections at grade
920	Sight distance at road approaches
930	Sight distance at railroad crossings
1020	Sight distance for paths and trails

650.02 References

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT

A Policy on Geometric Design of Highways and Streets, 1994, AASHTO

650.03 Definitions

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

passing sight distance The sight distance (on a two-lane highway) required for a vehicle to execute a normal passing maneuver as related to design conditions and design speed

sight distance The length of highway visible to the driver

stopping sight distance The sight distance required to safely stop a vehicle traveling at design speed

650.04 Passing Sight Distance

(1) Design Criteria

Passing sight distance is the sum of four distances:

- The distance traveled by the passing vehicle during perception and reaction time and initial acceleration to the point of encroachment on the opposing lane.
- The distance the passing vehicle is in the opposing lane.
- The distance that an opposing vehicle travels during two-thirds of the time the passing vehicle is in the opposing lane.
- A clearance distance between the passing vehicle and the opposing vehicle at the end of the passing maneuver.

Passing sight distance is calculated for a passenger car using an eye height of 3.50 ft and an object height of 4.25 ft. Figure 650-1 gives the passing sight distances for various design speeds.

Design Speed (mph)	Passing Sight Distance (ft)
25	935
30	1,085
35	1,280
40	1,475
50	1,770
60	2,065
70	2,460

Passing Sight Distance
Figure 650-1

On two-lane, two-way highways, provide passing opportunities to meet traffic volume demands. This can be accomplished by using numerous sections with safe passing sight distance or by adding passing lanes at critical locations (Chapter 1010).

In the design stage, passing sight distance can be provided by adjusting the alignment either vertically or horizontally to increase passing opportunities.

These considerations also apply to multilane highways where staged construction includes a two-lane, two-way operation as an initial stage. Whether auxiliary lanes are provided, however, depends on the time lag proposed between the initial stage and the final stage of construction.

(2) Vertical Curves

Figure 650-6 gives the length of crest vertical curve needed to provide passing sight distance for two-lane highways.

Sag vertical curves are not a restriction to passing sight distance.

(3) Horizontal Curves

Passing sight distance can be restricted on the inside of a horizontal curve by roadside objects that are 3.60 ft or more above the roadway surface. When the length of curve is greater than the passing sight distance and the sight restriction is more than half the passing sight distance into the curve, use the following formula to determine if the object is close enough to the roadway to be a restriction to passing sight distance:

$$M = R\left[1 - \cos\left(\frac{28.65\,S}{R}\right)\right]$$

Where:

M = The distance from the center line of the roadway to the obstruction

R = Radius of the curve

S = The passing sight distance from Figure 650-1

When the length of curve is less than the passing sight distance or the sight restriction is less than half the passing sight distance into the curve, the desired sight distance may be available with a lesser M distance. When this occurs, the sight distance can be checked graphically.

(4) No-Passing Zone Markings

A knowledge of practices for marking no-passing zones on two-lane roads is helpful in designing a safe highway. The values in Figure 650-1 are the passing sight distances starting at the point the pass begins. The values in the MUTCD are lower than the Figure 650-1 values. They are for no-passing zone marking limits and start at the point the safe pass must be completed.

The MUTCD values are not to be used directly in design but are discussed for the designer's recognition of locations requiring no-passing pavement markings. Sections of highway providing passing sight distance in the range of values between the distances in Figure 650-1 and MUTCD values require careful review by the designer.

650.05 Stopping Sight Distance

(1) Design Criteria

Stopping sight distance is the sum of two distances; the distance traveled during perception and reaction time and the distance required to stop the vehicle.

Stopping sight distance is calculated for a passenger car using an eye height of 3.50 ft and an object height of 0.50 ft. For various design speeds, Figure 650-2 gives the design stopping sight distances, the minimum curve length for a one percent grade change to provide the sight distance for a crest (K_C) and sag (K_S) vertical curve, and the minimum length of vertical curve for the design speed (VCL_m). Figure 650-3 gives the values for existing stopping sight distance and the associated K_C and K_S.

Provide for design stopping sight distance (Figure 650-2) at all points on all highways and on all intersecting roadways.

Design Speed (mph)	Design Stopping Sight Distance (ft)	K_C	K_S	VCL_m (ft)
25	165	20	28	75
30	200	30	36	90
35	260	51	52	105
40	330	82	70	120
50	460	159	105	150
60	655	323	159	180
70	855	550	215	210
80	1,050	830	271	240

Design Stopping Sight Distance
Figure 650-2

Existing stopping sight distance (Figure 650-3) is used when the vertical and horizontal alignments are unchanged and the sight obstruction is existing.

Design Speed (mph)	Existing Stopping Sight Distance (ft)	K_C	K_S
25	165	20	28
30	200	30	36
35	230	40	44
40	295	65	61
50	395	117	88
60	525	207	123
70	625	294	151
80	755	429	187

Existing Stopping Sight Distance
Figure 650-3

(2) Effects of Grade

The grade of the highway has an effect on the stopping sight distance. The vehicle stopping distance is increased on downgrades and decreased on upgrades. Figure 650-4 gives the stopping sight distances for grades steeper than three percent. When evaluating sight distance with a changing grade, use the grade for which the longest sight distance is needed.

Design	Stopping Sight Distance (ft)					
Speed	Down Grades			Up Grades		
(mph)	3-5%	6-8%	≥9%	3-5%	6-8%	≥9%
25	165	165	165	150	150	150
30	195	215	230	180	180	165
35	260	280	295	215	215	215
40	330	360	375	260	260	245
50	490	540	590	360	345	330
60	690	740	785	460	445	425
70	920	1,000	—	575	540	—
80	1,130	—	—	690	—	—

Design Stopping Sight Distance on Grades
Figure 650-4

(3) Crest Vertical Curves

Use Figure 650-7 to find the minimum crest vertical curve length to provide stopping sight distance when given the algebraic difference in grades. The length can also be determined by multiplying the algebraic difference in grades by the K_C value from Figure 650-2 for design or 650-3 for existing ($L=K_C*A$). Both the figure and the equation give approximately the same length of curve. Neither the figure nor the equation uses the sight distance greater than the length of curve equation. When the sight distance is greater than the length of curve and the length of curve is critical, the S>L equation given on Figure 650-7 may be used to find the minimum curve length.

When a new crest vertical curve is built or an existing one is rebuilt, provide Design Stopping Sight Distance from Figure 650-2. An existing crest vertical curve with Existing Stopping Sight Distance from Figure 650-3 may remain in place.

(4) Sag Vertical Curves

Use Figure 650-8 to find the minimum length for a sag vertical curve when given the stopping sight distance and the algebraic difference in grades. The minimum length for a sag vertical curve can also be determined by multiplying the algebraic difference in grades by the K_S value from Figure 650-2 for design or 650-3 for existing ($L=K_S*A$). Both the figure and the equation give approximately the same length of curve. Neither the figure nor the equation uses the sight distance greater than the length of curve equation. When the sight distance is greater than the length of curve and the length of curve is critical, the S>L equation given on Figure 650-8 may be used to find the minimum length of curve.

When a new sag vertical curve is built or an existing one is rebuilt, provide Design Stopping Sight Distance from Figure 650-2. An existing sag vertical curve with Existing Stopping Sight Distance from Figure 650-3 may remain in place.

(5) Horizontal Curves

Use Figure 650-9 to check for adequate stopping sight distance where sight obstructions are on the inside of a curve. A stopping sight distance obstruction is any object 2 ft or greater above the roadway surface (such as median barrier, guardrail, bridges, walls, cut slopes, wooded areas, and buildings). Figure 650-9 (both the equation and the graph) are for use when the length of curve is greater than the sight distance and the sight restriction is more than half the sight distance from the end of the curve. When the length of curve is less than the stopping sight distance or the sight restriction is less than half the stopping sight distance into the curve, the desired sight distance may be available with a lesser M distance. When this occurs, the sight distance can be checked graphically.

Provide Design Stopping Sight Distance from Figure 650-2 for horizontal curves as follows:

- For all new roadways
- When the roadway is widened
- When there is an alignment shift
- For new features (such as median barrier, bridges, walls, or guardrail)
- When additional right of way is required for roadside improvements

When design stopping sight distance is not required, existing features that have Existing Stopping Sight Distance from Figure 650-3, may remain in place.

650.06 Decision Sight Distance

Decision sight distance values are greater than stopping sight distance values because they give the driver an additional margin for error and afford sufficient length to maneuver at the same or reduced speed rather than to just stop.

Provide decision sight distance where highway features create a likelihood for error in information reception, decision making, or control actions. Example highway features include interchanges and intersections; changes in cross section at toll plazas, drop lanes, etc.; and areas of concentrated demand where sources of information compete, as those from roadway elements, traffic, traffic control devices, and advertising signs. If possible, locate these highway features where decision sight distance can be provided. If this is not possible, use suitable traffic control devices and positive guidance to give advanced warning of the conditions.

Use the decision sight distances in Figure 650-5 where highway features require complex driving decisions.

Design speed (mph)	Decision Sight Distance for Maneuvers (ft)				
	A	B	C	D	E
30	230	510	460	510	625
40	345	725	605	725	825
50	510	985	755	900	1,030
60	690	1,310	1,000	1,150	1,280
70	900	1,525	1,100	1,310	1,460
80	1,100	1,790	1,360	1,425	1,640

Decision Sight Distance
Figure 650-5

The maneuvers in Figure 650-5 are as follows:

A. Rural stop

B. Urban stop

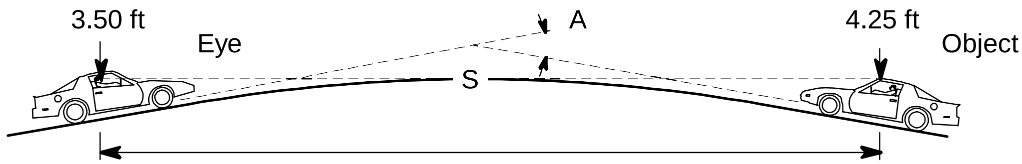
C. Rural speed/path/direction change

D. Suburban speed/path/direction change

E. Urban speed/path/direction change

Decision sight distance is calculated using the same criteria as stopping sight distance; 3.50 ft eye height and 0.50 ft object height. Use the equations on Figures 650-7, 8, and 9 to determine the decision sight distance at vertical and horizontal curves.

P65:DP/DME



Formulas:

When S is less than L

$L = AS^2/3093$

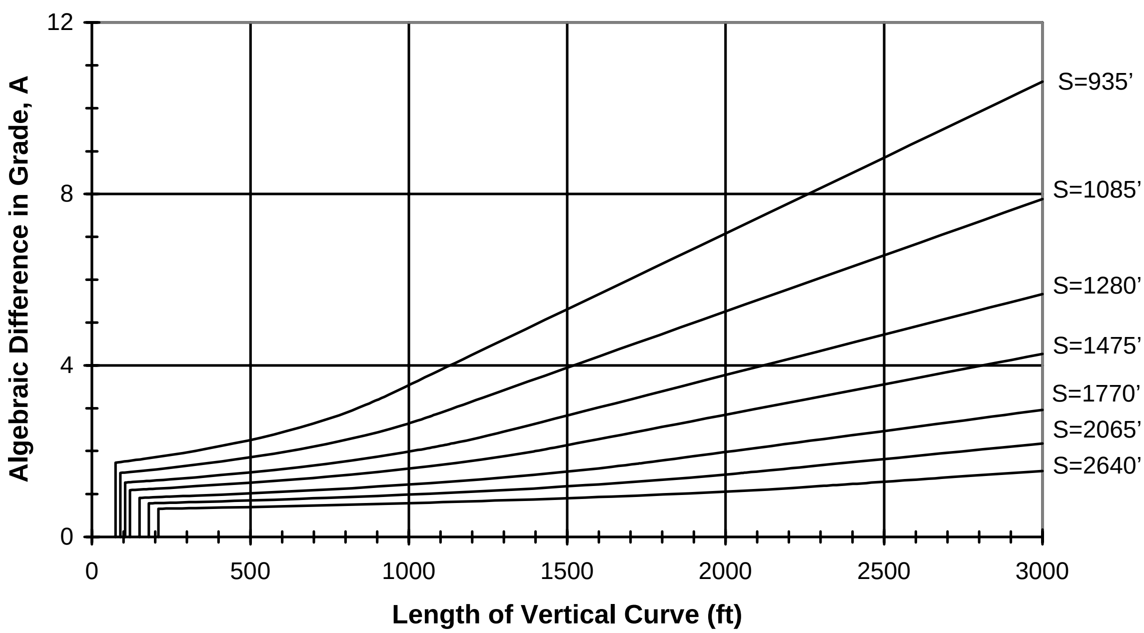
When S is greater than L

$L = 2S - 3093/A$

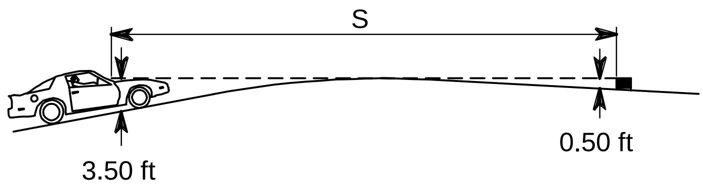
S = Sight distance in feet

L = Length of vertical curve in feet

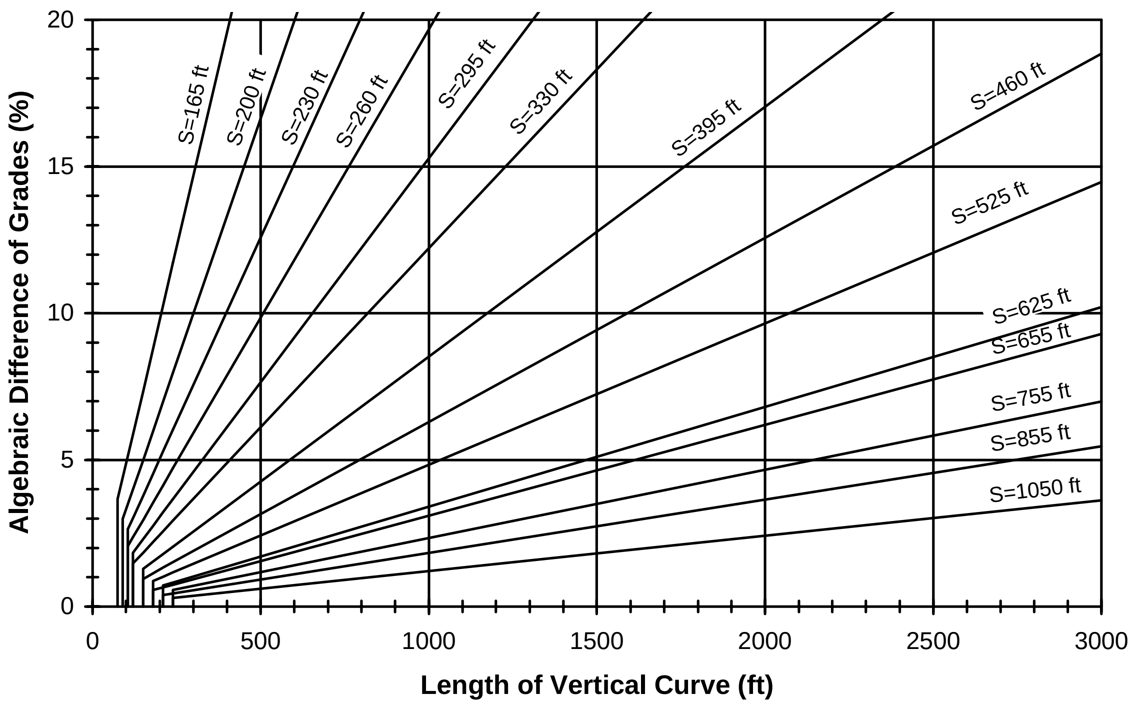
A = Algebraic difference of grades in percent



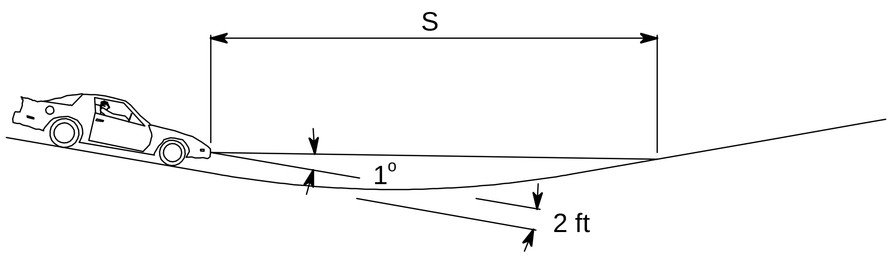
Passing Sight Distance for Crest Vertical Curves
Figure 650-6



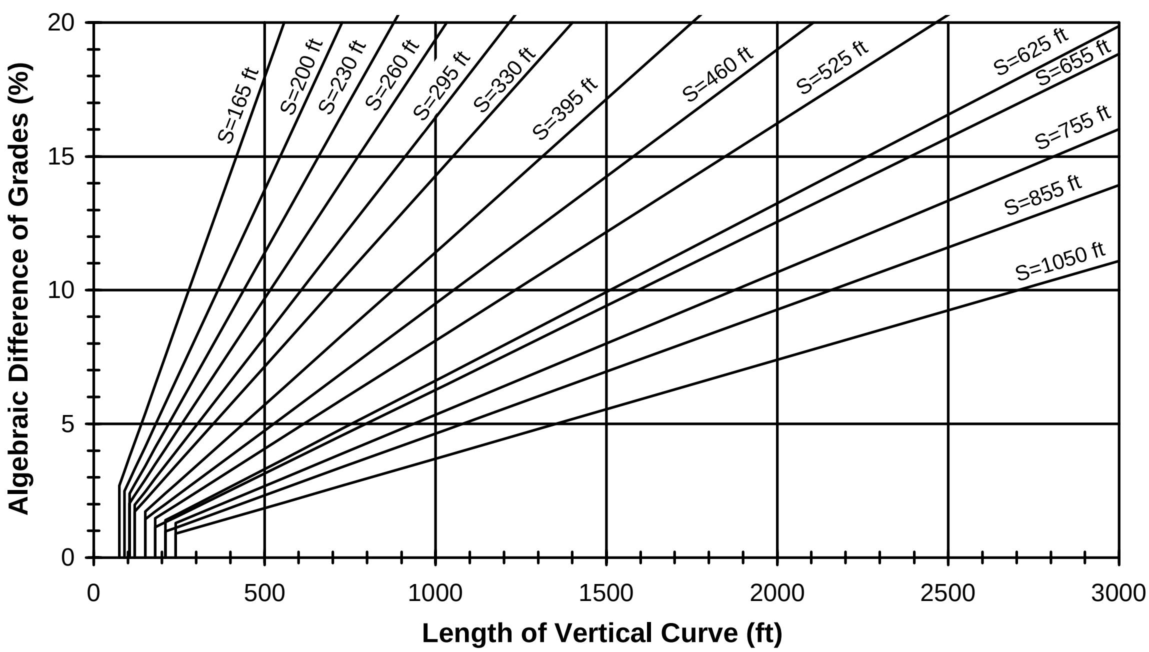
When S > L	When S < L
$L = 2S - 1329/A$ (not used in figure)	$L = AS^2/1329$
L = Curve length (ft) A = Algebraic grade difference (percent) S = Sight distance (ft)	



Stopping Sight Distance for Crest Vertical Curves
Figure 650-7

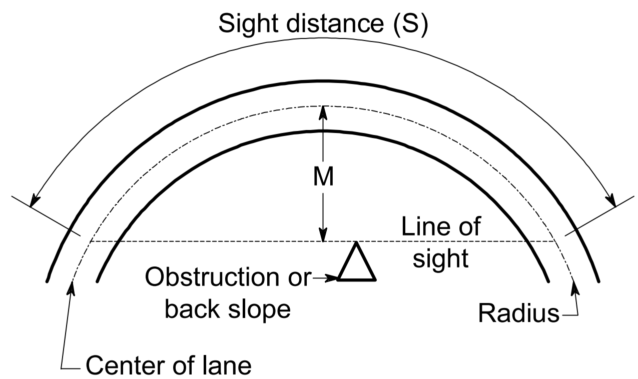


When S > L	When S < L
$L = 2S - \dfrac{400 + 3.5S}{A}$ (not used in figure)	$L = \dfrac{AS^2}{400 + 3.5S}$
L = Curve length (feet) A = Algebraic grade difference (percent) S = Sight distance (feet)	



Stopping Sight Distance for Sag Vertical Curves
Figure 650-8

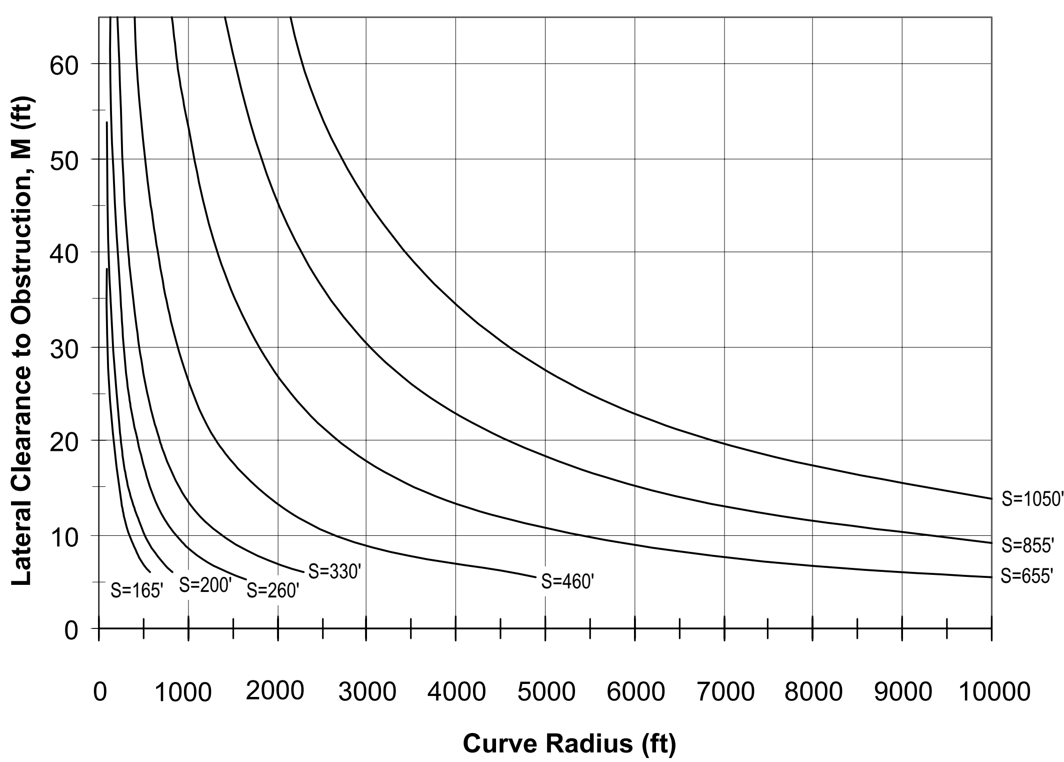
Height of eye: 3.50 ft
Height of object: 0.50 ft
Line of sight is normally 2.00 ft above center line of inside lane at point of obstruction provided no vertical curve is present in horizontal curve.



$$M = R\left(1 - \cos\frac{28.65\,S}{R}\right)$$

$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R-M}{R}\right)\right]$$

$S \leq$ Length of curve
Angle is expressed in degrees



Horizontal Stopping Sight Distance
Figure 650-9

700.01 General

Roadside safety addresses the area outside of the roadway and is an important component of total highway design. There are numerous reasons why a vehicle leaves the roadway. Regardless of the reason, a forgiving roadside can reduce the seriousness of the consequences of a roadside encroachment. From a safety perspective, the ideal highway has roadsides and median areas that are flat and unobstructed by hazards.

Elements such as side slopes, fixed objects, and water are potential hazards that a vehicle might encounter when it leaves the roadway. These hazards present varying degrees of danger to the vehicle and its occupants. Unfortunately, geography and economics do not always allow ideal highway conditions. The mitigative measures to be taken depend on the probability of an accident occurring, the likely severity, and the available resources.

In order of preference, mitigative measures are: removal, relocation, reduction of impact severity (using breakaway features or making it traversable), and shielding with a traffic barrier. Consider cost (initial and life cycle costs) and maintenance requirements in addition to accident severity when selecting a mitigative measure. Use traffic barriers only when other measures cannot reasonably be accomplished. See Chapter 710 for additional information on traffic barriers.

700.02 References

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2001

Revised Code of Washington (RCW) 47.24.020(2), "Jurisdiction, control"

RCW 47.32.130, "Dangerous objects and structures as nuisances"

City and County Design Standards (contained in the *Local Agency Guidelines,* M 36-63), WSDOT

Roadside Design Guide, AASHTO, 2002

Roadside Manual, M 25-30, WSDOT

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

700.03 Definitions

ADT The average daily traffic for the design year under consideration.

clear run-out area The area beyond the toe of a nonrecoverable slope available for safe use by an errant vehicle.

clear zone The total roadside border area, starting at the edge of the traveled way, available for use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a nonrecoverable slope, and/or a clear run-out area. The clear zone cannot contain a critical fill slope.

Design Clear Zone The minimum target value used in highway design.

critical fill slope A slope on which a vehicle is likely to overturn. Slopes steeper than 3H:1V are considered critical fill slopes.

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

nonrecoverable slope A slope on which an errant vehicle will continue until it reaches the bottom, without having the ability to recover control. Fill slopes steeper than 4H:1V, but no steeper than 3H:1V, are considered nonrecoverable.

recoverable slope A slope on which the driver of an errant vehicle can regain control of the vehicle. Slopes of 4H:1V or flatter are considered recoverable.

recovery area The minimum target value used in highway design when a fill slope between 4H:1V and 3H:1V starts within the Design Clear Zone.

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.

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.

700.04 Clear Zone

A clear roadside border area is a primary consideration when analyzing potential roadside and median hazards (as defined in 700.05). The intent is to provide as much clear, traversable area for a vehicle to recover as practical. The Design Clear Zone is used to evaluate the adequacy of the existing clear area and proposed modifications of the roadside. When considering the placement of new objects along the roadside or median, evaluate the potential for impacts and try to select locations with the least likelihood of an impact by an errant vehicle.

(1) Design Clear Zone on All Limited Access State Highways and Other State Highways Outside Incorporated Cities and Towns

Evaluate the Design Clear Zone when the Clear Zone column on the design matrices (see Chapter 325) indicates evaluate upgrade (EU) or Full Design Level (F) or when considering the placement of a new fixed object on the roadside or median. Use the Design Clear Zone Inventory form (Figures 700-2a & 2b) to identify potential hazards and propose corrective actions.

Guidance for establishing the Design Clear Zone for highways outside of incorporated cities is provided in Figure 700-1. This guidance also applies to limited access state highways within the city limits. Providing a clear recovery area that is consistent with this guidance does not require any additional documentation. However, there might be situations where it is not practical to provide these recommended distances. In these situations, document the decision as a deviation as discussed in Chapter 330.

For additional Design Clear Zone guidance relating to roundabouts, see Chapter 915.

While not required, the designer is encouraged to evaluate potential hazards even when they are beyond the Design Clear Zone distances.

For state highways that are in an urban environment but outside of an incorporated city, evaluate both median and roadside clear zones as discussed above using Figure 700-1. However, there might be some flexibility in establishing the Design Clear Zone in urbanized areas adjacent to incorporated cities and towns. To achieve this flexibility, an evaluation of the impacts including safety, aesthetics, the environment, economics, modal needs, and access control can be used to establish the Design Clear Zone. This discussion, analysis, and agreement must take place early in the consideration of the median and roadside designs. An agreement on the responsibility for these median and roadside sections must be formalized with the city and/or county. The justification for the design decision for the selected Design Clear Zone must be documented as part of a project or corridor analysis. (See Chapter 330.)

(2) Design Clear Zone Inside Incorporated Cities and Towns

For managed access state highways within an urban area, it is recognized that in many cases it will not be practical to provide the Design Clear Zone distances shown in Figure 700-1. Roadways within an urban area generally have curbs and sidewalks and might have objects such as trees, poles, benches, trash cans, landscaping, and transit shelters along the roadside.

(a) **Roadside.** For managed access state highways, it is the city's responsibility to establish an appropriate Design Clear Zone in accordance with guidance contained in the *City and County Design Standards*. Document, in the Design Documentation Package, the Design Clear Zone established by the city.

(b) **Median.** For managed access state highways with raised medians, the median's Design Clear Zone is evaluated using Figure 700-1. In some instances, a median analysis will show that certain median designs provide significant benefits to overall corridor or project operations. In these cases, flexibility in establishing the Design Clear Zone is appropriate. To achieve this flexibility, an evaluation of the impacts (including safety, aesthetics, the environment, economics, modal needs, and access control) can be used to establish the median clear zone. This discussion, analysis, and agreement must take place early in the consideration of the flexible median design. An agreement on the responsibility for these median sections must be formalized with the city. The justification for the design decision for the selected Design Clear Zone must be documented as part of a project or corridor analysis. (See Chapter 330.)

(3) Design Clear Zone and Calculations

The Design Clear Zone guidance provided in Figure 700-1 is a function of the posted speed, side slope, and traffic volume. There are no distances in the table for 3H:1V fill slopes. Although fill slopes between 4H:1V and 3H:1V are considered traversable if free of fixed objects, these slopes are defined as nonrecoverable slopes. A vehicle might be able to begin recovery on the shoulder, but will be unable to further this recovery until reaching a flatter area (4H:1V or flatter) at the toe of the slope. Under these conditions, the Design Clear Zone distance is called a recovery area. The method used to calculate the recovery area and an example are shown in Figure 700-3.

For ditch sections, the following criteria determine the Design Clear Zone:

(a) For ditch sections with fore slopes 4H:1V or flatter (see Figure 700-4, Case 1, for an example) the Design Clear Zone distance is the greater of the following:

- The Design Clear Zone distance for a 10H:1V cut section based on speed and the average daily traffic (ADT).
- A horizontal distance of 5 ft beyond the beginning of the back slope.

When a back slope steeper than 3H:1V continues for a horizontal distance of 5 ft beyond the beginning of the back slope, it is not necessary to use the 10H:1V cut slope criteria.

(b) For ditch sections with foreslopes steeper than 4H:1V, and back slopes steeper than 3H:1V the Design Clear Zone distance is 10 ft horizontal beyond the beginning of the back slope. (See Figure 700-4, Case 2, for an example.)

(c) For ditch sections with foreslopes steeper than 4H:1V and back slopes 3H:1V or flatter, the Design Clear Zone distance is the distance established using the recovery area formula (Figure 700-3). (See also Figure 700-4, Case 3, for an example.)

700.05 Hazards to Be Considered for Mitigation

There are three general categories of hazards: side slopes, fixed objects, and water. The following sections provide guidance for determining when these obstacles present a significant hazard to an errant motorist. In addition, several conditions require special consideration:

- Locations with high accident rate histories.
- Locations with pedestrian and bicycle usage. See Chapters 1020, “Bicycle Facilities,” and 1025, “Pedestrian Design Considerations.”
- Playgrounds, monuments, and other locations with high social or economic value might require mitigation such as a barrier.

Use of a traffic barrier for hazards other than those described below requires justification in the Design Documentation Package.

(1) Side Slopes

(a) **Fill Slopes.** Fill slopes can present a hazard to an errant vehicle with the degree of severity dependant upon the slope and height of the fill. Providing fill slopes that are 4H:1V or flatter can mitigate this hazard. If flattening the slope is not feasible or cost effective, the installation of a barrier might be appropriate. Figure 700-5 represents a selection procedure used to determine whether a fill side slope constitutes a hazard for which a barrier is a cost-effective mitigation. The curves are based on the severity indexes and represent the points where total costs associated with a traffic barrier are equal to the predicted accident cost associated with selected slope heights without traffic barrier. If the ADT and height of fill intersect on the “Barrier Recommended” side of the embankment slope curve, then provide a barrier if flattening the slope is not feasible or cost effective. Do not use Figure 700-5 for slope design. Design guidance for slopes is in Chapters 430 and 640. Also, if the figure indicates that barrier is not recommended at an existing slope, that result is not justification for a deviation.

For example, if the ADT is 4000 and the embankment height is 10 ft, barrier will be cost effective for a 2H:1V slope, but not for a 2.5H:1V slope.

This process only addresses the potential hazard of the slope. Obstacles on the slope can compound the hazard. Where barrier is not cost effective, use the recovery area formula to evaluate fixed objects on critical fill slopes less than 10 ft high.

(b) **Cut Slopes.** A cut slope is usually less of a hazard than a traffic barrier. The exception is a rock cut with a rough face that might cause vehicle snagging rather than providing relatively smooth redirection.

Analyze the potential motorist risk and the benefits of treatment of rough rock cuts located within the Design Clear Zone. A cost-effectiveness analysis that considers the consequences of doing nothing, removal, or smoothing of the cut slope, and all other viable options to reduce the severity of the hazard, can be used to determine the appropriate treatment. Some potential options are:

- Redirectional land form.
- Flexible barrier.
- More rigid barrier.
- Rumble strips.

Conduct an individual investigation for each rock cut or group of rock cuts. Select the most cost-effective treatment.

(2) Fixed Objects

Consider the following objects for mitigation:

- Wooden poles or posts with cross sectional area greater than 16 square inches that do not have breakaway features.
- Nonbreakaway steel sign posts.
- Nonbreakaway light standards.
- Trees having a diameter of 4 in or more measured at 6 in above the ground surface.
- Fixed objects extending above the ground surface by more than 4 in; for example, boulders, concrete bridge rails, signal and electrical cabinets, piers, and retaining walls.
- Existing guardrail that does not conform to current design guidance. (See Chapter 710.)
- Drainage items, such as culvert and pipe ends.

Mitigate hazards that exist within the Design Clear Zone when feasible. Although limited in application, there may be situations where removal of hazard outside of the R.O.W is appropriate. The possible mitigative measures are listed below in order of preference.

- Remove.
- Relocate.
- Reduce impact severity (using a breakaway feature).
- Shield the object by using redirectional landform, longitudinal barrier, or impact attenuator.

(a) **Trees**. When evaluating new plantings or existing trees, consider the maximum allowable diameter of 4 in measured at 6 in above the ground when the tree has matured. When removing trees within the Design Clear Zone, complete removal of stumps is preferred. However, to avoid significant disturbance of the roadside vegetation, larger stumps may be mitigated by grinding or cutting them flush to the ground and grading around them. See the *Roadside Manual* for further guidance on the treatment of the disturbed roadside.

(b) **Mailboxes**. Ensure that all mailboxes located within the Design Clear Zone have supports and connections as shown in the Standard Plans. The height from the ground to the bottom of the mailbox is 3 ft 3 in. This height may vary from 3 ft 3 in to 4 ft if requested by the mail carrier. Include a note in the contract plans that gives the height desired if it is to be different from 3 ft 3 in. See Figure 700-6 for installation guidelines.

In urban areas where sidewalks are prevalent, contact the postal service to determine the most appropriate mailbox location. Locate mailboxes on limited access highways in accordance with the "Limited Access" Chapter in Division 14. A turnout, as shown on Figure 700-6, is not required on limited access highways with shoulders of 6 ft or more where only one mailbox is to be installed. On managed access highways, mailboxes must be on the right-hand side of the road in the direction of travel of the postal carrier. Avoid placing mailboxes along high-speed, high-volume highways. Locate Neighborhood Delivery and Collection Box Units (NDCBUs) outside the Design Clear Zone.

(c) **Culvert Ends.** Provide a traversable end treatment when the culvert end section or opening is on the roadway side slope and within the Design Clear Zone. This can be accomplished for small culverts by beveling the end to match the side slope, with a maximum of 4 in extending out of the side slope.

Bars might be necessary to provide a traversable opening for larger culverts. Place bars in the plane of the culvert opening in accordance with the Standard Plans when:

1. Single cross culvert opening exceeds 40 in measured parallel to the direction of travel.
2. Multiple cross culvert openings that exceed 30 in each, measured parallel to the direction of travel.
3. Culvert approximately parallel to the roadway that has an opening exceeding 24 in measured perpendicular to the direction of travel.

Bars are permitted where they will not significantly affect the stream hydraulics and where debris drift is minor. Consult the regional Maintenance Office to verify these conditions. If debris drift is a concern, consider options to reduce the amount of debris that can enter the pipe. (See the *Hydraulics Manual*). Other treatments are extending the culvert to move the end outside the Design Clear Zone or installing a traffic barrier.

(d) **Sign Posts.** Whenever possible, locate signs behind existing or planned traffic barrier installations to eliminate the need for breakaway posts. Place them at least 25 ft from the end of the barrier terminal and with the sign face behind the barrier. When barrier is not present, use terrain features to reduce the likelihood of an errant vehicle striking the sign posts. Whenever possible, depending on the type of sign and the sign message, adjust the sign location to take advantage of barrier or terrain features. This will reduce accident potential and, possibly, future maintenance costs. See Chapter 820 for additional information regarding the placement of signs.

Sign posts with cross sectional areas greater than 16 square inches that are within the Design Clear Zone and not located behind a barrier must have breakaway features as shown in the Standard Plans.

(e) **Traffic Signal Standards/Posts/Supports.** Breakaway signal posts generally are not practical or desirable. Since these supports are generally located at intersecting roadways, there is a higher potential for a falling support to impact vehicles and/or pedestrians. In addition, signal supports that have overhead masts may be too heavy for a breakaway design to work properly. Other mitigation such as installing a traffic barrier is also very difficult. With vehicles approaching the support from many different angles, a barrier would have to surround the support and would be subject to impacts at high angles. Therefore, barrier is generally not an option. However, since speeds near signals are generally lower and drivers are more alert, the potential for a severe impact is reduced. For these reasons, the only mitigation is to locate the support as far from the traveled way as possible.

In locations where signals are used for ramp meters, the supports can be made breakaway as shown on the Standard Plan.

(f) **Fire Hydrants.** Fire hydrants that are made of cast iron can be expected to fracture on impact and can therefore be considered a breakaway device. Any portion of the hydrants that will not be breakaway must not extend more then 4 in above the ground. In addition, the hydrant must have a stem that will shut off water flow in the event of an impact. Mitigate all other hydrants.

(g) **Utility Poles.** Since utilities often share the right of way, utility objects such as poles will often be located along the roadside. It is undesirable/impractical to install barrier for all of these objects so mitigation is usually in the form of relocation (underground or to the edge of the right of way) or delineation. In some instances where there is a history of impacts with poles and relocation is not possible, a breakaway design might be appropriate. Contact Headquarters Design for information on breakaway features. Coordinate with the Utilities Office where appropriate.

(h) **Light Standards.** Provide breakaway light standards unless fixed light standards can be justified. Fixed light standards may be appropriate in areas of extensive pedestrian concentrations, such as adjacent to bus shelters. Document the decision to use fixed bases in the Design Documentation Package.

(3) Water

Water with a depth of 2 ft or more and located with a likelihood of encroachment by an errant vehicle must be considered for mitigation on a project-by-project basis. Consider the length of time traffic is exposed to this hazard and its location in relationship to other highway features such as curves.

Analyze the potential motorist risk and the benefits of treatment of bodies of water located within the Design Clear Zone. A cost-effectiveness analysis that considers the consequences of doing nothing versus installing a longitudinal barrier can be used to determine the appropriate treatment.

700.06 Median Considerations

Medians must be analyzed for the potential of an errant vehicle to cross the median and encounter oncoming traffic. Median barriers are normally used on <u>limited access</u>, multilane, high-speed, high traffic volume <u>highways. These highways</u> generally have posted speeds of <u>45 mph</u> or greater. Median barrier is not normally placed on collector<u>s</u> or other <u>state highways</u> that do not have <u>limited access control</u>. Providing access through median barrier requires openings and, therefore, end-treatments.

Provide median barrier on full access control, multilane highways with median widths of 50 ft or less and posted speeds of 45 mph or more. Consider median barrier on highways with wider medians or lower posted speeds when there is a history of cross median accidents.

<u>When installing a median barrier, provide left-side shoulder widths as shown in Chapters 430 and 440 and shy distance as shown in Chapter 710. Consider a wider shoulder area where</u> the barrier <u>will</u> cast a shadow on the roadway and hinder the melting of ice. See Chapter 640 for additional criteria for placement of median barrier. See

Chapter 710 for information on the types of barriers that can be used. See Chapter 650 for lateral clearance on the inside of a curve to provide the required stopping sight distance.

When median barrier is being placed in an existing median, identify the existing crossovers and enforcement observation points. Provide the necessary median crossovers in accordance with Chapter 960, considering enforcement needs.

700.07 Other Roadside Safety Features

(1) Rumble Strips

Rumble strips are grooves or rows of raised pavement markers placed perpendicular to the direction of travel to alert inattentive drivers.

There are three kinds of rumble strips:

(a) **Roadway rumble strips** are placed across the traveled way to alert drivers approaching a change of roadway condition or a hazard that requires substantial speed reduction or other maneuvering. Examples of locations where roadway rumble strips may be used are in advance of:

- Stop controlled intersections.
- Port of entry/customs stations.
- Lane reductions where accident history shows a pattern of driver inattention.

They may also be placed at locations where the character of the roadway changes, such as at the end of a freeway.

Contact the Headquarters Design Office for additional guidance on the design and placement of roadway rumble strips.

Document justification for using roadway rumble strips.

(b) **Shoulder rumble strips** are placed on the shoulders just beyond the traveled way to warn drivers when they are entering a part of the roadway not intended for routine traffic use. Shoulder rumble strips may be used when an analysis indicates a problem with run-off-the-road accidents due to inattentive or fatigued drivers. A comparison of rolled-in and milled-in Shoulder Rumble Strips (SRS) has determined that milled-in rumble strips, although more expensive, are more cost effective. Milled-in rumble strips are recommended.

When SRS are used, discontinue them where no edge stripe is present such as at intersections and where curb and gutter are present. Where bicycle travel is allowed, discontinue SRS at locations where shoulder width reductions can cause bicyclists to move into or across the area where rumble strips would normally be placed, such as shoulders adjacent to bridges with reduced shoulder widths.

SRS patterns vary depending on the likelihood of bicyclists being present along the highway shoulder, and whether they are placed on divided or undivided highways. Rumble strip patterns for undivided highways are shallower and may be narrower than patterns used on divided highways. They also provide gaps in the pattern, providing opportunities for bicycles to move across the pattern without having to ride across the grooves. There are four shoulder rumble strip patterns. Consult the Standard Plans for the patterns and construction details.

1. **Divided Highways**

SRS are required on both the right and left shoulders of rural Interstate highways. Consider them on both shoulders of rural divided highways. Use the Shoulder Rumble Strip Type 1 pattern on divided highways.

Omitting SRS on rural highways is a design exception (DE) under any one of the following conditions:

- When another project scheduled within two years of the proposed project will overlay or reconstruct the shoulders or will use the shoulders for detours.
- When a pavement analysis determines that installing SRS will result in inadequate shoulder strength.
- When overall shoulder width will be less than 4 ft wide on the left and 6 ft wide on the right.

2. **Undivided Highways**

SRS are not required on undivided highways, but may be used where run-off-the-road accident experience is high. SRS usage on the shoulders of undivided highways demands strategic application because bicycle usage is more prevalent along the shoulders of the undivided highway system. Rumble strips affect the comfort and control of bicycle riders; consequently, their use is to be limited to highway corridors that experience high levels of run-off-the-road accidents. Apply the following criteria in evaluating the appropriateness of rumble strips on the shoulders of undivided highways.

- Use on rural roads only.
- Ensure shoulder pavement is structurally adequate to support milled rumble strips.
- Posted speed is 45 mph or greater.
- Ensure that at least 4 feet of useable shoulder remains between the rumble strip and the outside edge of shoulder. If guardrail or barrier is present, increase the dimension to 5 feet of useable shoulder.
- Preliminary evaluation indicates a run-off-the-road accident experience of approximately 0.6 crashes per mile per year, or approximately 34 crashes per 100 million miles of travel. (These values are intended to provide relative comparison of crash experience and are not to be used as absolute guidance on whether rumble strips are appropriate.)
- Do not place shoulder rumble strips on downhill grades exceeding 4% for more than 500 ft in length along routes where bicyclists are frequently present.
- An engineering analysis indicates a run-off-the-road accident experience considered correctable by shoulder rumble strips.
- Consult the regional members of the Washington Bicycle and Pedestrian Advisory Committee to determine bicycle usage along a route, and involve them in the decision-making process when considering rumble strips along bike touring routes or other routes where bicycle events are regularly held.

The Shoulder Rumble Strip Type 2 or Type 3 pattern is used on highways with minimal bicycle traffic. When bicycle traffic on the shoulder is high, the Shoulder Rumble Strip Type 4 pattern is used.

Shoulder rumble strip installation considered at any other locations must involve the WSDOT Bicycle and Pedestrian Advisory Committee as a partner in the decision-making process.

Consult the following website for guidance on conducting an engineering analysis:

http://www.wsdot.wa.gov/EESC/Design/Policy/RoadsideSafety/Chapter700/Chapter700B.htm

(c) **Center line rumble strips** are placed on the center line of undivided highways to alert drivers that they are entering the opposing lane. They are a countermeasure for crossover accidents. Consult the Headquarters Design Office and the region's Traffic Engineer for guidance on center line rumble strips.

(2) Headlight Glare Considerations

Headlight glare from opposing traffic can cause safety problems. Glare can be reduced by the use of wide medians, separate alignments, earth mounds, plants, concrete barriers, and by devices known as glare screens specifically designed to reduce glare. Consider long term maintenance when selecting the treatment for glare. When considering earth mound and planting to reduce glare, see the *Roadside Manual* for additional guidance. When considering glare screens, see Chapter 650 for lateral clearance on the inside of a curve to provide the required stopping sight distance. In addition to reducing glare, taller concrete barriers also provide improved crash performance for larger vehicles such as trucks.

Glare screen is relatively expensive and its use must be justified and documented. It is difficult to justify the use of glare screen where the median width exceeds 20 ft, the ADT is less than 20,000 vehicles per day, or the roadway has continuous lighting. Consider the following factors when assessing the need for glare screen:

- Higher rate of night accidents compared to similar locations or statewide experience.
- Higher than normal ratio of night to day accidents.
- Unusual distribution or concentration of nighttime accidents.
- Over representation of older drivers in night accidents.
- Combination of horizontal and vertical alignment, particularly where the roadway on the inside of a curve is higher than the roadway on the outside of the curve.
- Direct observation of glare.
- Public complaints concerning glare.

The most common glare problem is between opposing main line traffic. Other conditions for which glare screen might be appropriate are:

- Between a highway and an adjacent frontage road or parallel highway, especially where opposing headlights might seem to be on the wrong side of the driver.
- At an interchange where an on-ramp merges with a collector distributor and the ramp traffic might be unable to distinguish between collector and main line traffic. In this instance, consider other solutions, such as illumination.
- Where headlight glare is a distraction to adjacent property owners. Playgrounds, ball fields, and parks with frequent nighttime activities might benefit from screening if headlight glare interferes with these activities.

There are currently three basic types of glare screen available: chain link (see Standard Plans), vertical blades, and concrete barrier. (See Figure 700-7.)

When the glare is temporary (due to construction activity), consider traffic volumes, alignment, duration, presence of illumination, and type of construction activity. Glare screen may be used to reduce rubbernecking associated with construction activity, but less expensive methods, such as plywood that seals off the view of the construction area, might be more appropriate.

700.08 Documentation

A list of documents that are required to be preserved in the Design Documentation Package (DDP) or the Project File (PF) is on the following website:

http://www.wsdot.wa.gov/eesc/design/projectdev/

Design Clear Zone Distances for State Highways Outside Incorporated Cities**
(In feet from edge of traveled way*)**

Posted Speed mph	Average Daily Traffic	Cut Section (Back Slope) (H:V) 3:1	4:1	5:1	6:1	8:1	10:1	Fill Section (H:V) 3:1	4:1	5:1	6:1	8:1	10:1
35 or Less		The Design Clear Zone-distance is 10 feet											
40	Under 250	10	10	10	10	10	10	*	13	12	11	11	10
	251-800	11	11	11	11	11	11	*	14	14	13	12	11
	801-2000	12	12	12	12	12	12	*	16	15	14	13	12
	2001-6000	14	14	14	14	14	14	*	17	17	16	15	14
	Over 6000	15	15	15	15	15	15	*	19	18	17	16	15
45	Under 250	11	11	11	11	11	11	*	16	14	13	12	11
	251-800	12	12	13	13	13	13	*	18	16	14	14	13
	801-2000	13	13	14	14	14	14	*	20	17	16	15	14
	2001-6000	15	15	16	16	16	16	*	22	19	17	17	16
	Over 6000	16	16	17	17	17	17	*	24	21	19	18	17
50	Under 250	11	12	13	13	13	13	*	19	16	15	13	13
	251-800	13	14	14	15	15	15	*	22	18	17	15	15
	801-2000	14	15	16	17	17	17	*	24	20	18	17	17
	2001-6000	16	17	17	18	18	18	*	27	22	20	18	18
	Over 6000	17	18	19	20	20	20	*	29	24	22	20	20
55	Under 250	12	14	15	16	16	17	*	25	21	19	17	17
	251-800	14	16	17	18	18	19	*	28	23	21	20	19
	801-2000	15	17	19	20	20	21	*	31	26	23	22	21
	2001-6000	17	19	21	22	22	23	*	34	29	26	24	23
	Over 6000	18	21	23	24	24	25	*	37	31	28	26	25
60	Under 250	13	16	17	18	19	19	*	30	25	23	21	20
	251-800	15	18	20	20	21	22	*	34	28	26	23	23
	801-2000	17	20	22	22	23	24	*	37	31	28	26	25
	2001-6000	18	22	24	25	26	27	*	41	34	31	29	28
	Over 6000	20	24	26	27	28	29	*	45	37	34	31	30
65	Under 250	15	18	19	20	21	21	*	33	27	25	23	22
	251-800	17	20	22	22	24	24	*	38	31	29	26	25
	801-2000	19	22	24	25	26	27	*	41	34	31	29	28
	2001-6000	20	25	27	27	29	30	*	46	37	35	32	31
	Over 6000	22	27	29	30	31	32	*	50	41	38	34	33
70	Under 250	16	19	21	21	23	23	*	36	29	27	25	24
	251-800	18	22	23	24	26	26	*	41	33	31	28	27
	801-2000	20	24	26	27	28	29	*	45	37	34	31	30
	2001-6000	22	27	29	29	31	32	*	50	40	38	34	33
	Over 6000	24	29	31	32	34	35	*	54	44	41	37	36

* When the fill section slope is steeper than 4H:1V but not steeper than 3H:1V, the Design Clear Zone distance is modified by the recovery area formula (Figure 700-3) and is referred to as the recovery area. The basic philosophy behind the recovery area formula is that a vehicle can traverse these slopes but cannot recover (control steering) and, therefore, the horizontal distance of these slopes is added to the Design Clear Zone distance to form the recovery area.

** This figure also applies to limited access state highways in cities and median areas on managed access state highways in cities. See 700.04 for guidance on managed access state highways within incorporated cities.

*** See 700.03 for definition of traveled way.

Design Clear Zone Distance Table
Figure 700-1

Washington State
Department of Transportation

Design Clear Zone Inventory

Region	SR	Control Section	MP	to MP	Date
Project Number	Project Title			Responsible Unit	

Item Number	MP to MP	Distance From Traveled Way L	Distance From Traveled Way R	Description	Corrective Actions Considered (2)	Estimated Cost to Correct	Correction Planned (1) Yes	Correction Planned (1) No

(1) Only one “Yes” or “No” per item number. Corrections not planned must be explained on reverse side.
(2) A list of Location 1 & 2 Utility Objects to the forwarded to the region Utility Office for coordination per Control Zone Guidelines.

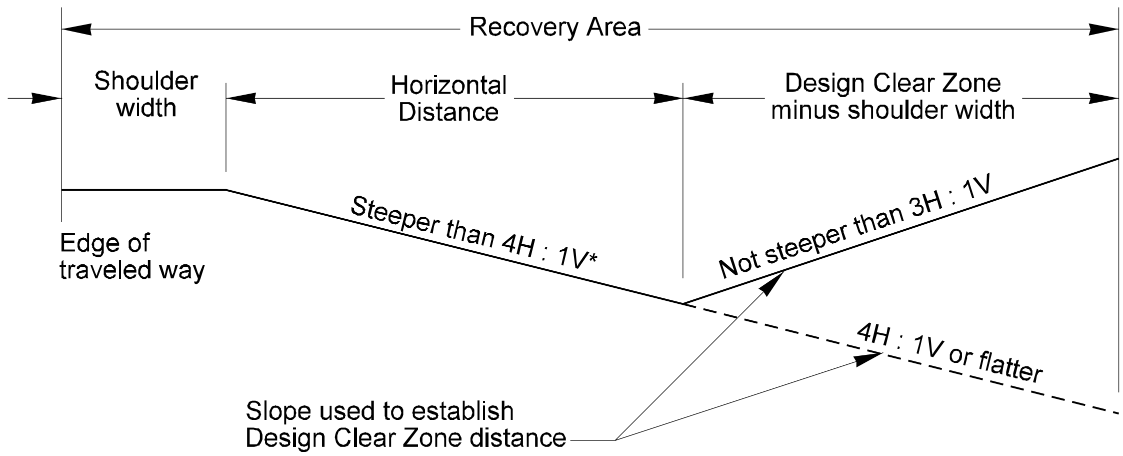
DOT Form 410-026 EF
Revised 9/02

Design Clear Zone Inventory Form
Figure 700-2a

Item Number	Reasons for Not Taking Corrective Action

DOT Form 410-026 EF
Revised 9/02

Design Clear Zone Inventory Form
Figure 700-2b



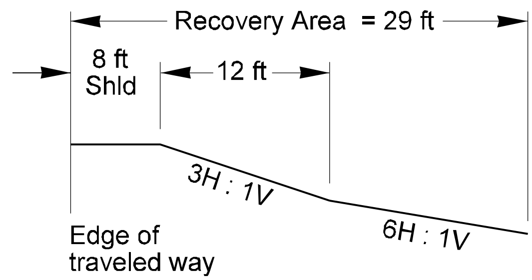
*Recovery area normally applies to slopes steeper than 4H:1V but no steeper than 3H:1V. For steeper slopes, the recovery area formula may be used as a guide if the embankment height is 10 ft or less.

Formula:

Recovery area = (shoulder width) + (horizontal distance)

+ (Design Clear Zone distance - shoulder width)

Example:



Fill section (slope 3H:1V or steeper)

Conditions: Speed - 45 mph

Traffic - 3000 ADT

Slope - 3H:1V

Criteria: Slope 3H:1V - use

Recovery area formula

Recovery area = (shoulder width) + (horizontal distance)

+ (Design Clear Zone distance - shoulder width)

= 8 + 12 + (17 - 8)

= 29 ft

Recovery Area

Figure 700-3

Cut section with ditch (foreslope 4H:1V or flatter)

Conditions: Speed - 55 mph

Traffic - 4200 ADT

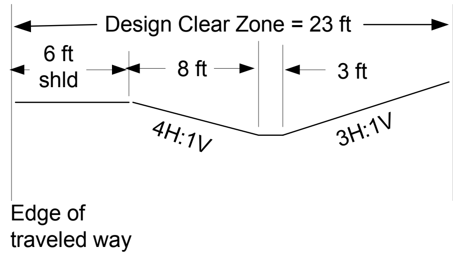
Slope - 4H:1V

Criteria: Greater of

(1) Design Clear Zone for 10H:1V Cut Section, 23 ft

(2) 5 ft horizontal beyond beginning of back slope, 22 ft

Design Clear Zone = 23 ft



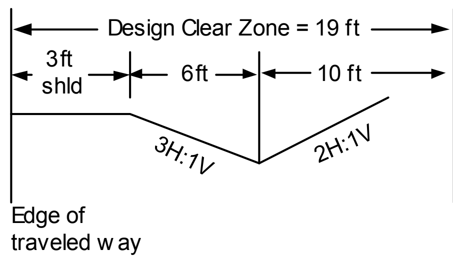
Case 1

Cut section with ditch (foreslope 3H:1V or steeper and back slope steeper than 3H:1V)

Conditions: NA

Criteria: 10 ft horizontal beyond beginning of back slope

Design Clear Zone = 19 ft



Case 2

Cut section with ditch (foreslope 3H:1V or steeper and back slope not steeper than 3H:1V)

Conditions: Speed - 45 mph

Traffic - 3000 ADT

Foreslope - 2H:1V

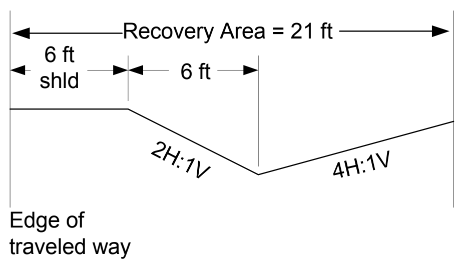
Back slope 4H:1V

Criteria: Use recovery area formula

Recovery Area = (shoulder width) + (horizontal distance) + (Design Clear Zone distance - shoulder width)

= 6 + 6 + (15 - 6)

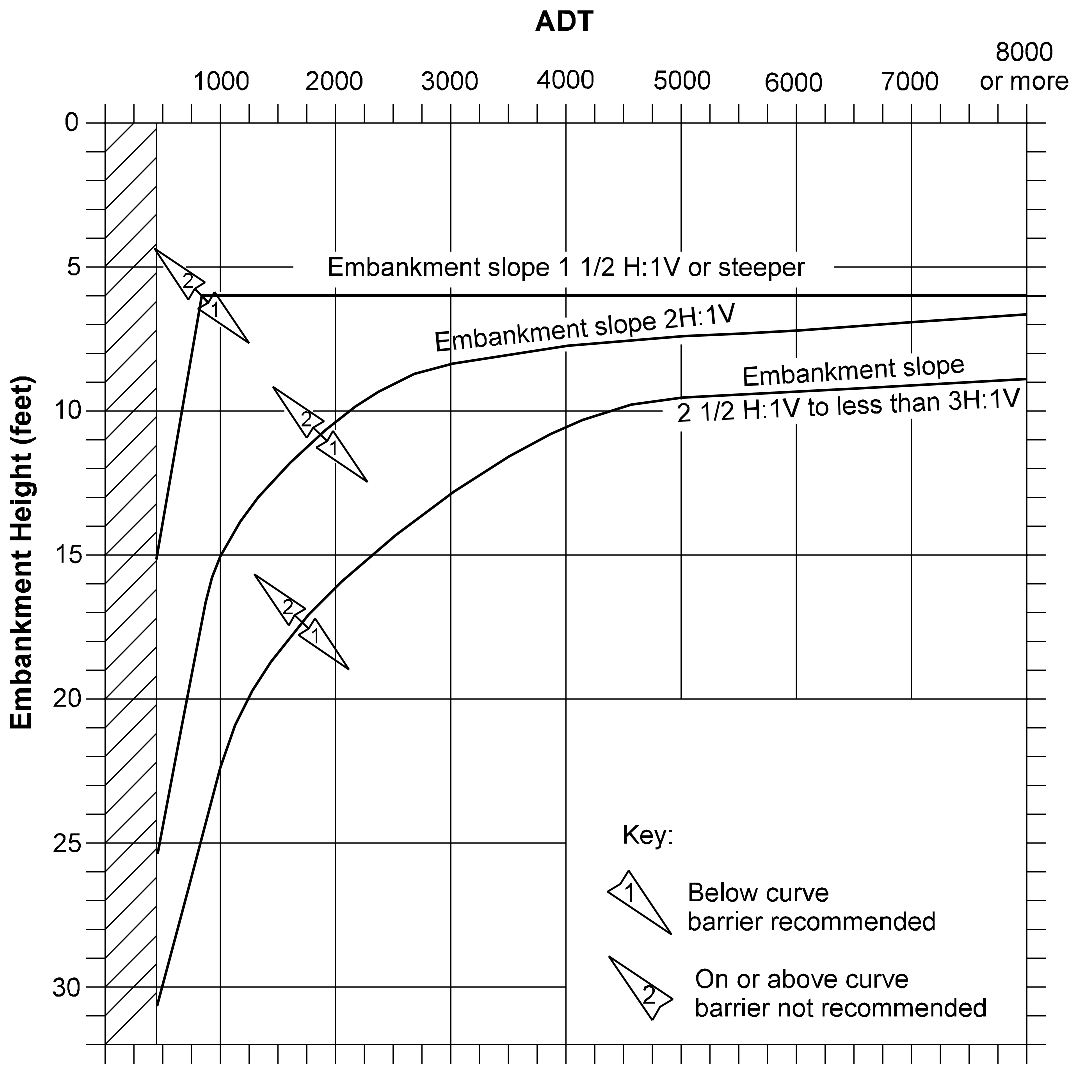
= 21 ft



Case 3

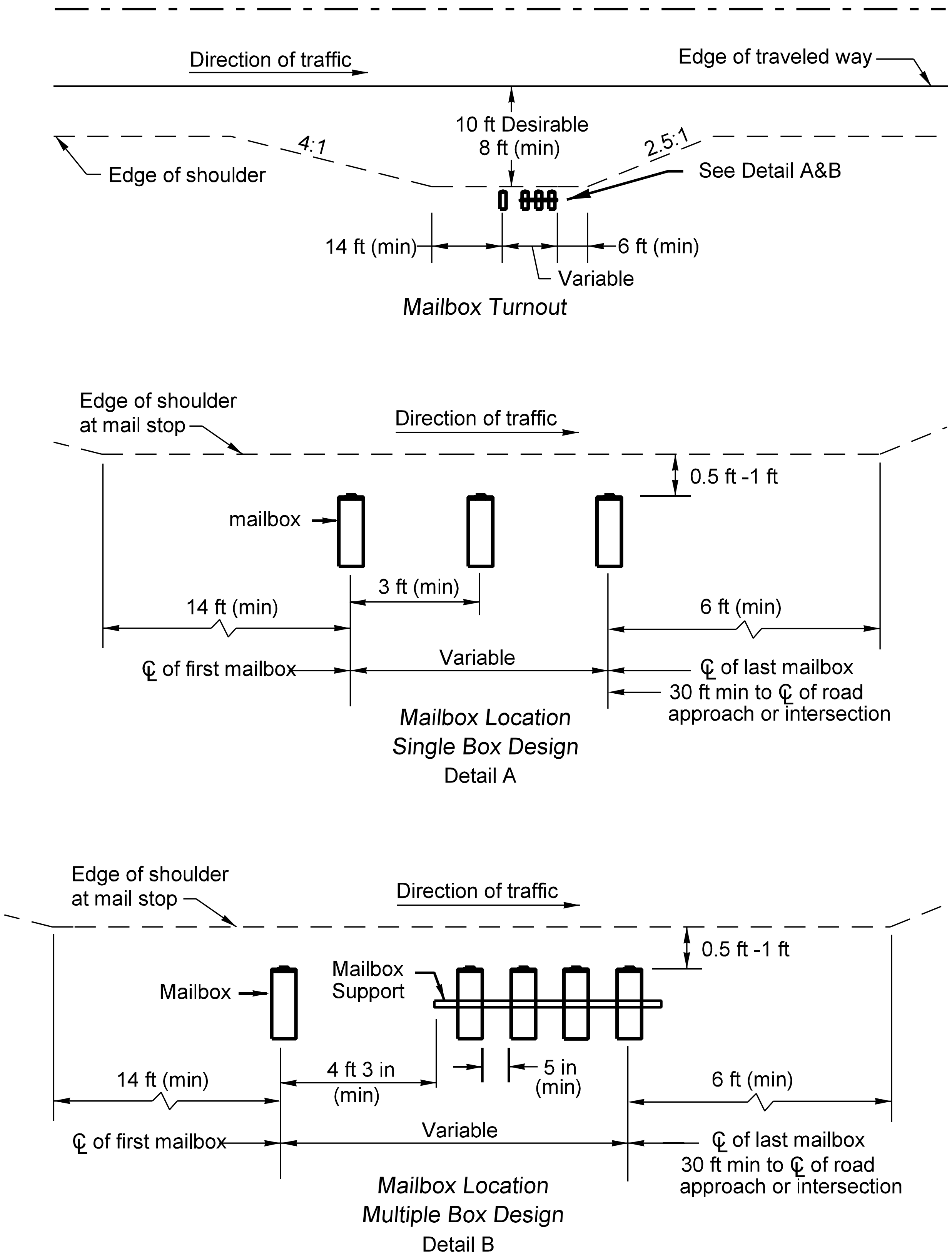
Design Clear Zone for Ditch Sections

Figure 700-4



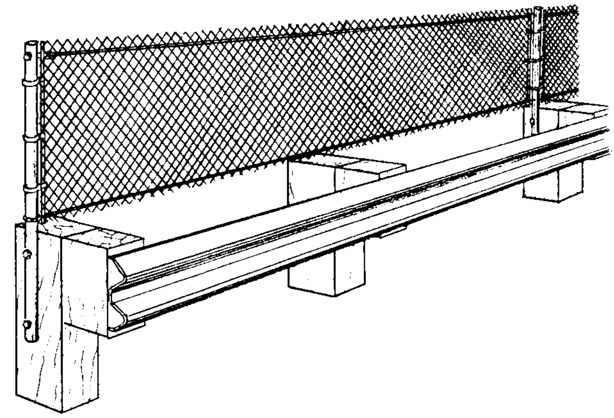
Note: Routes with ADTs under 400 may be evaluated on a case by case basis.

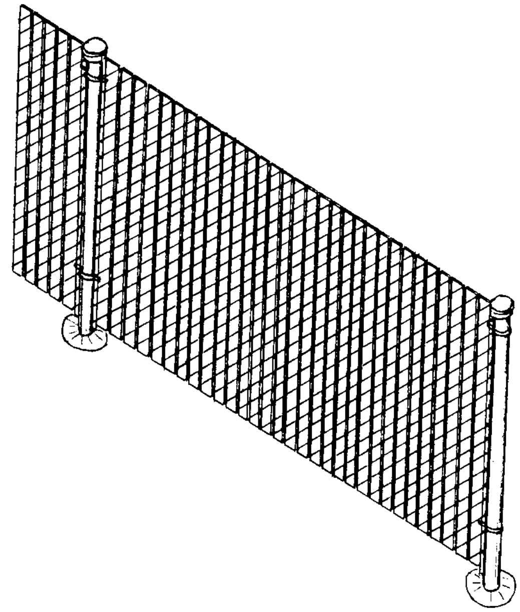
Guidelines for Embankment Barrier
Figure 700-5



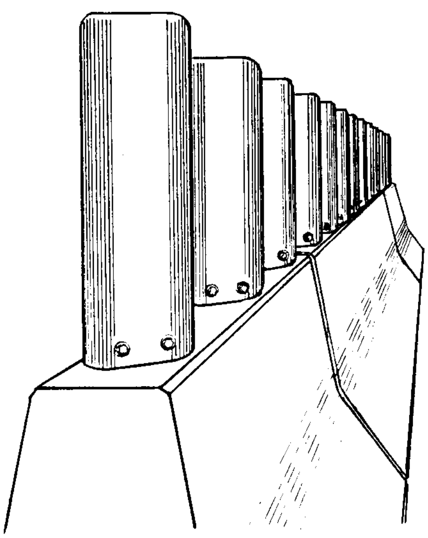
Mailbox Location and Turnout Design

Figure 700-6

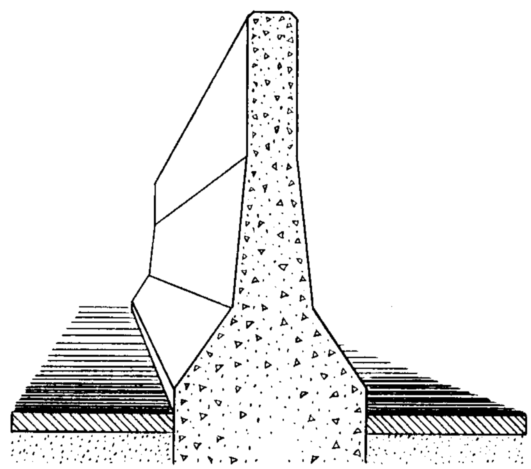




Chain Link



Vertical Blades



Concrete Barrier

Glare Screens
Figure 700-7

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 must only be used when justified by accident history or the criteria in Chapter 700.

710.02 References

Roadside Design Guide, AASHTO

Bridge Design Manual, M 23-50, WSDOT

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. Beam guardrail terminals include 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.

guardrail transition A section of barrier used to produce a gradual stiffening of a flexible or semirigid barrier as it connects to a more rigid barrier or fixed object.

hazard A side slope, a fixed object, or water that, when struck, can result in unacceptable impact forces on the vehicle 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 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. Longitudinal barriers 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.

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 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(3), Transitions and Connections.

Impact attenuators must meet the requirements found in Chapter 720, Impact Attenuators.

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 terminals must meet the requirements found in 710.08(2). 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(2), Terminals and Anchors. Common features of noncrashworthy designs:

- 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.)
- 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.

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 matrices have Design Elements "Standard Run" under Barriers. A "Standard Run" of barrier consists of longitudinal barrier that can be found in the Standard Plans manual.

(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 2 feet from the ground to the top of the rail element, adjust the height to that shown in the Standard Plans. If Type 1 Alternate W-beam guardrail is present, raise the rail element after each overlay.

Overlays in front of safety shaped 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 beginning of the top near-vertical face on either the F or NJ 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 cable barrier.

(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:

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 with 12 foot-6 inch post spacing and no blockouts.
- W-beam guardrail on concrete posts.
- Cable barrier on wood or concrete posts.
- Half-moon or C shape 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 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 mph 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 a NHS highway with a posted speed of 30 mph 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 710.11 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 I2 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 on 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 a 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.

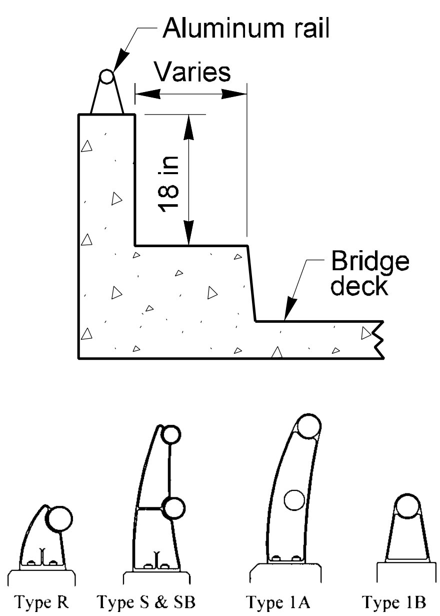
When designing a barrier for use on a Scenic Byway or Heritage Tour Route (formerly Scenic and Recreational Highway), consider barriers that are consistent with the recommendations in the associated Corridor Management Plan (if one is available). Contact the region's Landscape Architect or the Headquarters' Scenic Byways (formerly known as Heritage Corridors) Program manager to determine if the project is on such a designated route. Low cost options, such as using weathering steel beam guardrail (710.06) or cable barrier (710.07) might be feasible on many projects. Higher cost options, such as steel backed timber rail and stone guardwalls (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.

(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



	Curb Width	
Aluminum Rail Type	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

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. 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.

Use a rigid system where deflection cannot be tolerated such as in narrow medians or at the edge of a bridge deck (vertical drop-off). Runs of rigid concrete barrier can be cast-in-place, extruded with appropriate footings, or, for precast concrete barrier, anchored to the underlying material.

See 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 without serious injuries to its occupants.
- To minimize a driver's reaction to the introduction of an object near the traveled way.

Keeping flare rates as flat as practical preserves the barrier's redirectional performance and minimizes the angle of impact. But, 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 traveled way. Transition sections are not normally flared.

Barrier Type	System Type	Deflection
Cable barrier or beam guardrail on G-2 posts	Flexible	up to 12 ft (face of barrier to object)
Beam guardrail Types 1, 1a, 2, and 10	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)
Concrete barrier, anchored	Rigid	no deflection

(1) When placed in front of a 2H:1V or flatter fill slope, the deflection distance can be reduced to 2 ft.

(2) When used as temporary bridge rail, anchor all barrier that is within 3 ft 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

(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 b 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 on Figure 710-11c. For installations on the inside of a curve, determine the length of need as though it was 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.)

Before the actual length of need is determined, establish the lateral distance between the proposed barrier installation and the item shielded. This distance must be 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(2)(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 is placed as far from the traveled way as practical. 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, the deflected system must not become a hazard to 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. For medians wider than 30 feet, provide justification for placing a barrier closer than 15 feet from the edge of a traveled way.

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 on 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.

710.06 Beam Guardrail

(1) Beam Guardrails

Beam guardrail systems are shown in the Standard Plans.

Strong post W-beam guardrail (Types 1 through 4) and thrie beam guardrail (Types 10 and 11) are semirigid barriers used predominately 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. Do not use more than two 8 inch blockouts.

On highways that are constructed of hot mix asphalt (where overlays are anticipated), the Type 1 Alternate guardrail can be used to allow raising of the guardrail without having to adjust the posts.

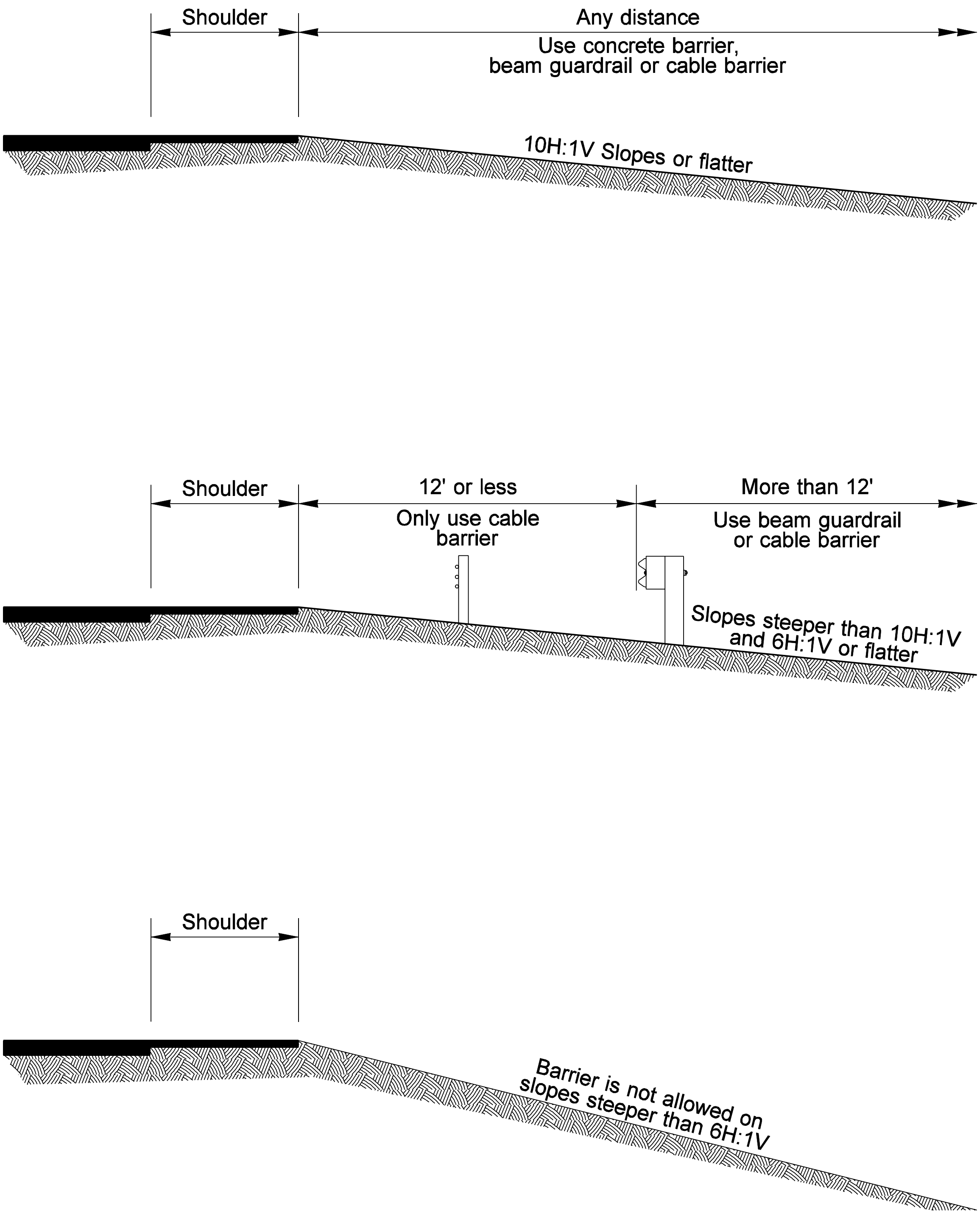
Weak post W-beam guardrail (Type 20) and thrie beam guardrail (Type 21) are flexible barrier systems that can be used where there is adequate deflection distance. These systems use weak steel posts. The primary purpose of these posts is to position the guardrail vertically and they are designed to bend 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 shoulder and the face of the guardrail 10H:1V or flatter. Do not place beam guardrail on a fill slope steeper than 6H:1V. On fill slopes between 6H:1V and 10H:1V, beam guardrail must not be placed within 12 feet of the break point. (See Figure 710-4.)

On the high side of superelevated sections, place beam guardrail at the edge of shoulder.

Generally, 2 feet of shoulder widening behind the barrier is 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 practical, long post installations are available as shown on 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.



Traffic Barrier Locations on Slopes

Figure 710-4

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 the rail washers. In areas where heavy snow accumulations are expected to cause the bolts to pull out, specify snow load post and rail washers in the contract documents. (Snow load post washers are used to prevent the bolts from pulling through the posts and snow load rail washers are used to prevent the bolt head from pulling through the rail.) 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. However, if a curb is necessary, the 3 inch high curb is preferred. The 4 inch high curb can only be used at locations where the 3 inch curb will not be adequate. In new installations, do not use 6 inch high curb in conjunction with beam guardrails. Existing 6 inch high curb is allowed to remain in place. If work requires replacement of an existing 6 inch curb, it must be replaced with a 3 inch or 4 inch curb, whichever is appropriate.

When used in conjunction with beam guardrail, locate curb behind the face of the rail element as shown in the Standard Plans.

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. Weathering steel guardrail might be desirable on Scenic Byways or Heritage Tour Routes. (See 710.05.)

(2) Terminals and Anchors

A guardrail anchor is required at the end of a run of guardrail to develop its 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.)

(a) **Buried Terminals.** 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. The entire BT can be used within the length of need.

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.

(b) **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 2 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 high speed highways (posted speed of 45 mph or greater) use a FLEAT 350 that has a 4 foot offset at the first post. For lower speed highways (posted speed of 40 mph 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 in Place" must be specified.

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

The FHWA has granted approval to use these sole source proprietary terminals without justification on a project by project basis.

(c) **Nonflared Terminal.** Where widening to provide the offset for a flared terminal is not practical, 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 the rail 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 high speed highways (posted speed of 45 mph or greater), use the ET PLUS TL3 or SKT 350 that are 50 feet long. For lower speed highways (posted speed of 40 mph or less), use the ET PLUS TL2 or SKT-TL2 that are 25 feet long.

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 height of embankment, 3 cubic yards of "Embankment in Place" must be specified.

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

The FHWA has granted approval to use these sole source proprietary terminals without justification on a project by project basis.

(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(4) 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(4) cases 9, 12, and 13.)

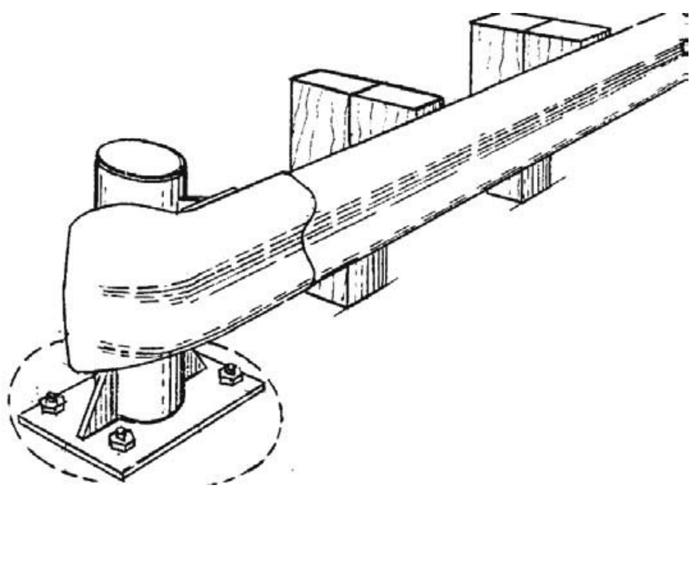
The old Type 3 anchor was primarily used at bridge ends. (See Figure 710-5.) This anchor consisted of a steel pipe mounted vertically in a concrete foundation. Bridge approach guardrail was then mounted on the steel pipe. On one-way highways, these anchors were usually positioned so that neither the 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 710.04(4) 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.

(3) 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 on Figures 710-6 and 10 and detailed in the Standard Plans. The transition pay item includes the connection.



Old Type 3 Anchor
Figure 710-5

	Connection
Unrestrained concrete barrier	A
Rigid untapered safety shaped 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 shaped 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

(4) Guardrail Placement Cases

The Standard Plans contain placement cases that show all of the beam guardrail elements required for typical situations. The following is a description of each.

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 of 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 is 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 and, 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 Placement 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 is 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.

Cases 19 (A and B) are used where it is not possible to install a post at the 6 foot-3 inch spacing. These designs omit one post (which results in a span of 11 feet-6 inches which is consistent with a post spacing of 12 feet-6 inches) and use 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 B, 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 3 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.)

710.07 Cable Barrier

Cable barrier is a flexible barrier system that can be used on a roadside or as a median barrier.

This 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 of 700 feet 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.

Cable barrier can be installed up to one foot in front of side slopes as steep as 2H:1V. This 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.

When cable barrier is to be connected to a more rigid barrier, a transition section is required. Contact the HQ Design Office for details.

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 and 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.

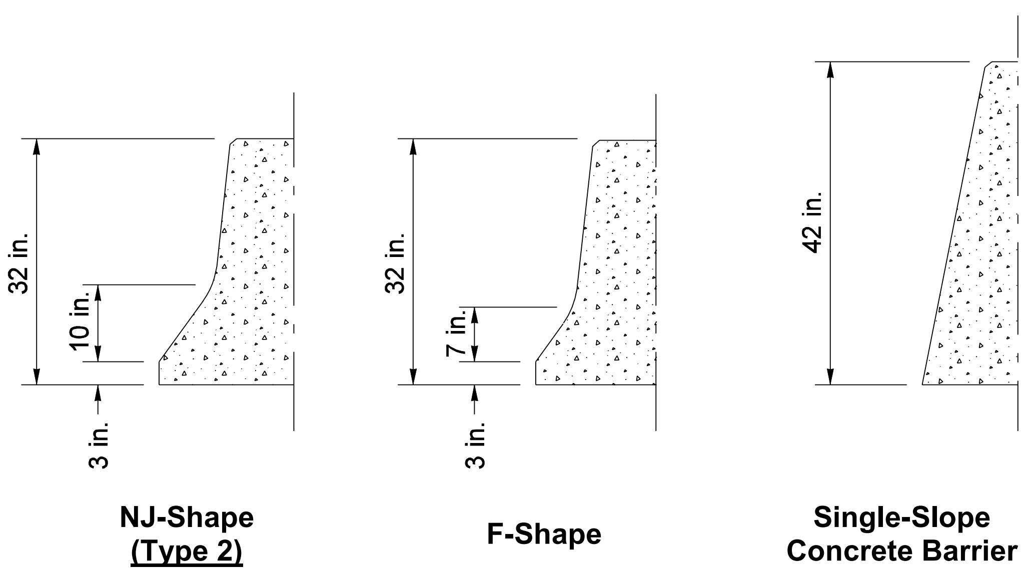
In addition to the standard cable barrier system described above, high-tension cable barrier systems are now available from a few different manufacturers. These systems deflect less than the standard WSDOT design and might have some maintenance benefits. The high-tension cable barrier systems are being evaluated by WSDOT. For more information about high-tension cable barrier systems, contact the HQ Design Office.

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.



Concrete Barrier Shapes

Figure 710-7

(1) Concrete Barrier Shapes

Concrete barriers use a safety shaped (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 on Figure 710-7.

The New Jersey shaped 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.

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 shaped 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 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 shaped 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 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 percent or flatter. In difficult situations, a maximum slope of 8 percent 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 percent).

(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. The Standard Plans allow for a grade separation of up to 10 inches. The barrier must have a depth of embedment equal to or greater than the grade separation. Contact HQ Bridge and Structures for grade separations greater than 10 inches. (See the Standard Plans.)

(2) 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.

A precast or cast-in-place terminal section having a minimum length of 48 feet and a maximum length of 80 feet is another end treatment. It can only be used for posted speeds of 35 mph or less. Contact the HQ Design Office for details on this end treatment.

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 mph or less.

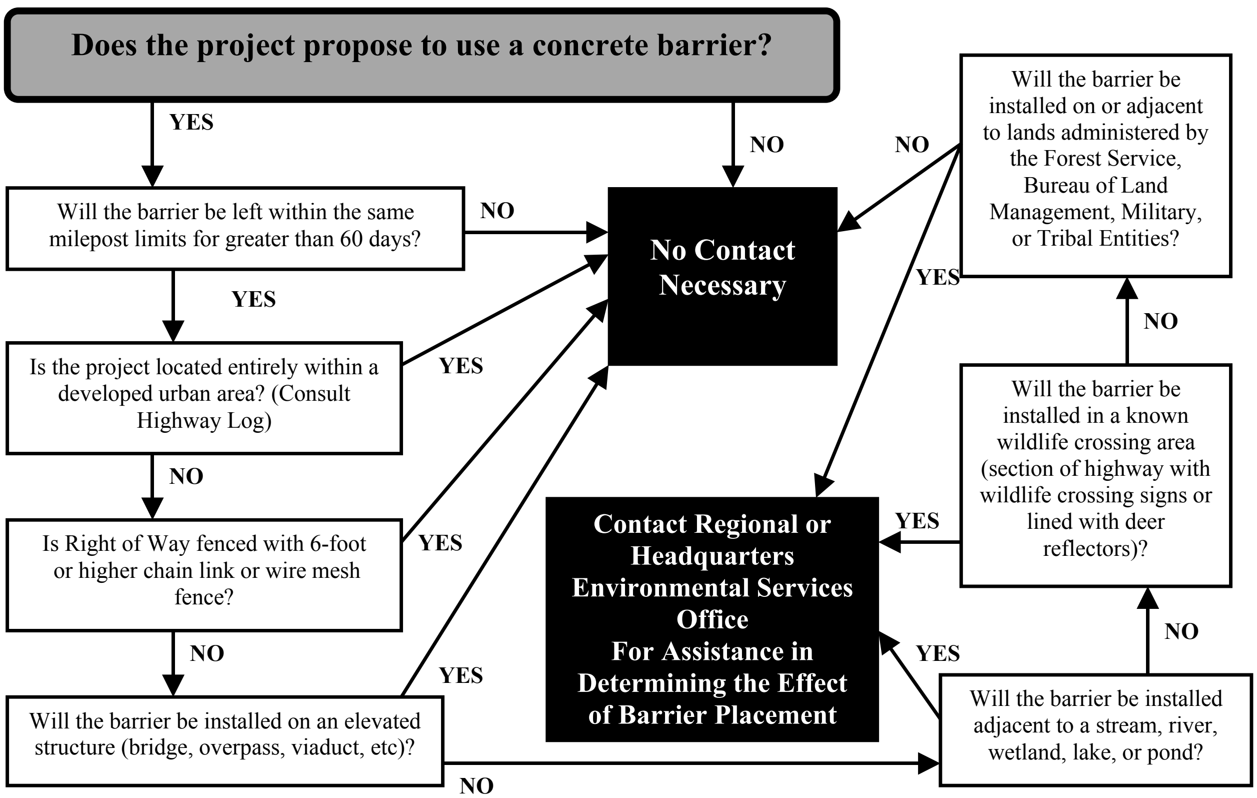
When the Barrier Terminals and Transitions column of a design matrix applies to a project, existing sloped down concrete terminals that are within the Design Clear Zone must be replaced when they do not meet the criteria above.

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.)

(3) 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 for them 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 determine if 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.



Concrete Barrier Placement Guidance <u>(Assessing Impacts to Wildlife)</u>
Figure 710-8

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 it's 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 alternate to the nonproprietary system. However, specifying this system exclusively requires the approval, from the Assistant State Design Engineer, of a public interest finding for the use of a sole source proprietary item.

The most desirable method of terminating the steel backed timber guardrail is to bury the end in a back slope as described in 710.06(2). When this type of terminal is not possible, the use of the barrier is limited to highways with speeds of 45 mph or less. On these lower speed highways, the barriers can be flared away from the traveled way and terminated in a berm.

For details of 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(2). When this type of terminal is not possible, the use of the barrier is limited to highways with posted speeds of 45 mph or less. On these lower speed highways, the barrier can be flared away from the traveled way and terminated in a berm.

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

710.10 Bridge Rails

Bridge rails are traffic barriers that redirect errant vehicles and prevent them from going over the side of the structure. See the *Bridge Design Manual* for information on bridge rail on new bridges and replacement bridge rail on existing bridges.

For most new bridge rail installations, use a 2 foot-8 inch high safety shape (F-Shape) bridge rail. The single slope bridge rail that is 2 feet-10 inches high can be used to be consistent with the heights of connecting single slope barrier (710.08(1)(b)).

Use taller, 3 foot-6 inch, safety shape or single slope bridge rails 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).

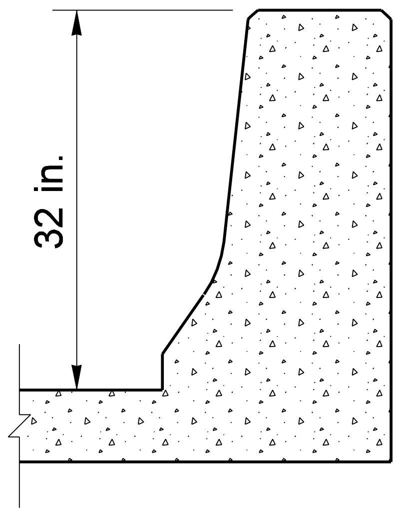
For bridges where high volumes of pedestrian traffic are anticipated, see Chapter 1020 for further guidance.

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(3) for guidance on transitions.

If the bridge rail 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 rail (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 rail system.



Safety Shaped 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 rails. The thrie beam can be mounted to steel posts or the existing bridge rail, depending on the structural adequacy of the bridge deck, the existing bridge rail 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 rail. A key concern is that the existing bridge deck has adequate strength to withstand an impact without causing significant damage to the deck. 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.

Figure 710-15 shows typical installation criteria.

Many bridge rail retrofit projects involve bridges over 250 feet in length. These projects will normally be funded from the I2 program. Shorter bridges may be funded as a spot safety improvement. Contact HQ Project Control and Reporting 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 are as follows:

- Reversible lane entrances and exits.
- Railroad crossings.
- Truck escape ramps (instead of arrester beds – Chapter 1010).
- T-intersections.
- Work zones.

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

A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: 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 in	1 (1) 4 (5)	Figure 710-6
		Concrete Parapet < 20 in	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 (ex. Used with thrie beam bull nose)		1 B	Figure 710-6

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

(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 710.06(2)(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.

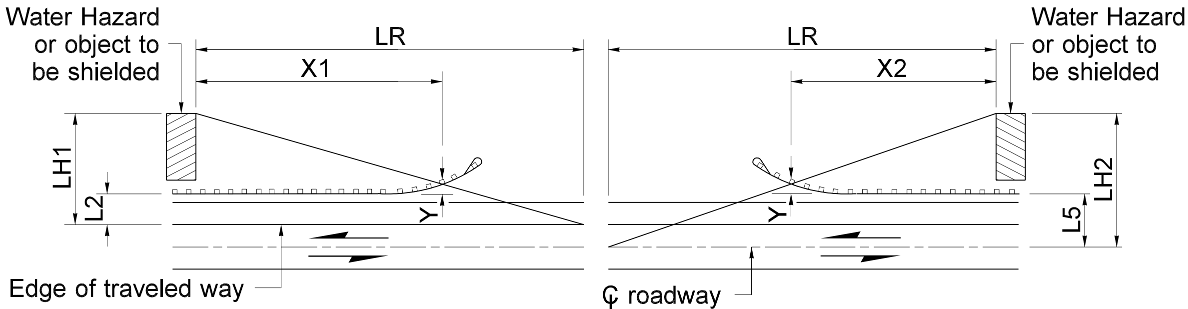
(4) For Service Level 1 bridge rail see 710.06(4), case 14.

(5) Use on highways with speeds 45 MPH or less.

(6) If existing transition has adequate guardrail height, three 10"x10" (nominal) posts and three 6"x8" (nominal) posts spaced 3'-1.5" apart, it is acceptable to nest existing single W-beam element transitions.

Transitions and Connections

Figure 710-10



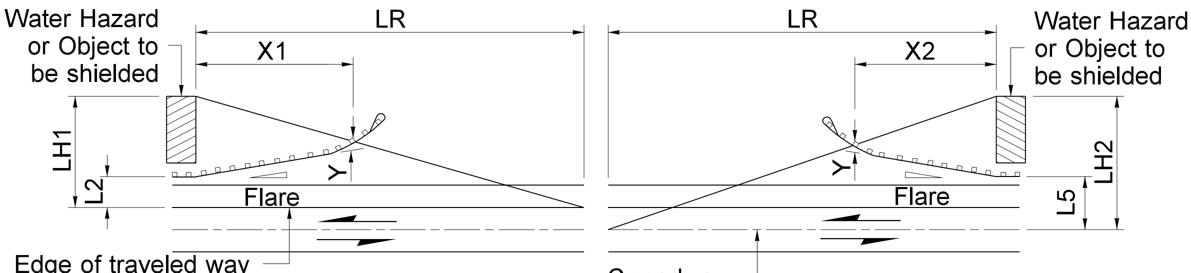
$$X1 = \frac{LH1 - (L2+Y)}{(LH1/LR)}$$

Adjacent-Side Hazard
Barrier Parallel to Roadway

$$X2 = \frac{LH2 - (L5+Y)}{(LH2/LR)}$$

Opposite-Side Hazard
Barrier Parallel to Roadway

Barrier Length of Need for Sheilding Objects Along Tangent Sections of Roadway



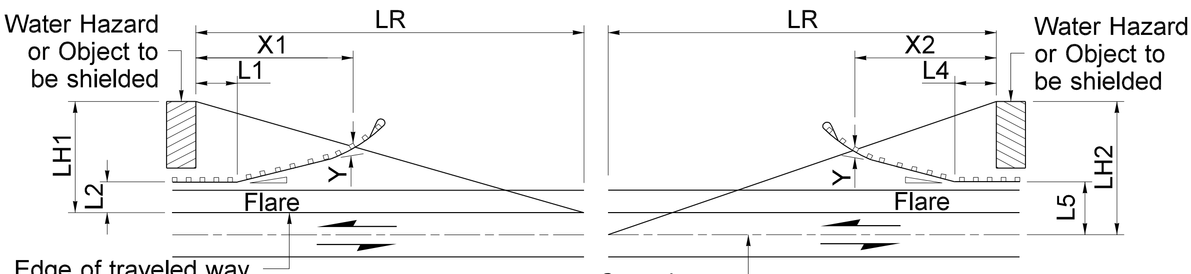
$$X1 = \frac{LH1 - (L2+Y)}{(1/F) + (LH1/LR)}$$

Adjacent-Side Hazard
Barrier Flare Begins at Hazard

$$X2 = \frac{LH2 - (L5+Y)}{(1/F) + (LH2/LR)}$$

Opposite-Side Hazard
Barrier Flare Begins at Hazard

Barrier Length of Need for Sheilding Objects Along Tangent Sections of Roadway



$$X1 = \frac{(LH1 + L1/F) - (L2+Y)}{(1/F) + (LH1/LR)}$$

Adjacent-Side Hazard
Barrier Flare Begins Before Hazard

$$X2 = \frac{(LH2 + L4/F) - (L5+Y)}{(1/F) + (LH2/LR)}$$

Opposite-Side Hazard
Barrier Flare Begins Before Hazard

Barrier Length of Need for Sheilding Objects Along Tangent Sections of Roadway

Barrier Length of Need
Figure 710-11a

Design Parameters							
Posted Speed	ADT						
	Over 10,000	5,000 to 10,000	1,000 to 4,999	Under 1,000	Rigid Barrier		
(mph)	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 center line of roadway to portion of barrier parallel to roadway. Note: if the hazard is outside of the Design Clear Zone when measured from the center line, 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 center line 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.

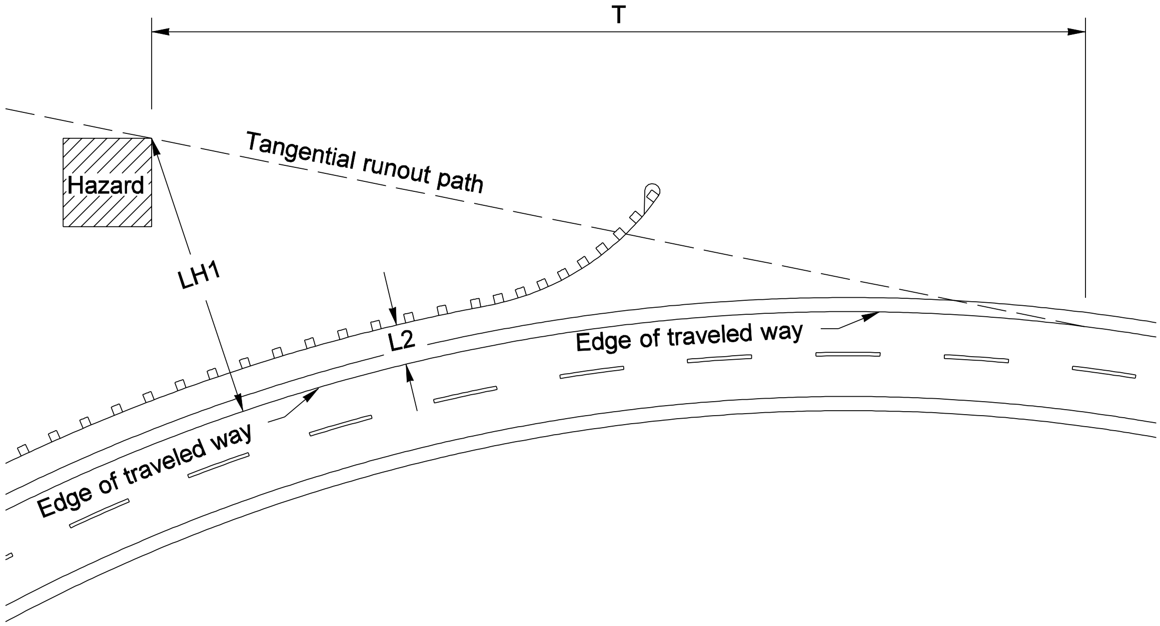
For the SRT 350 and FLEAT 350, use Y = 1.8 feet

For evaluating existing BCT's, 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



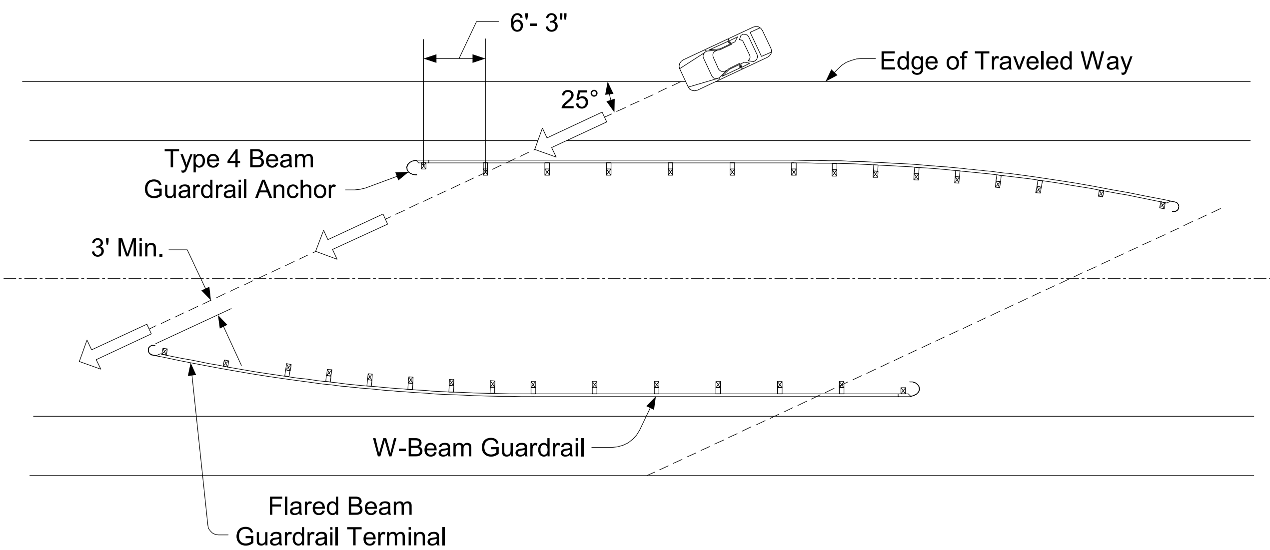
Note:

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.

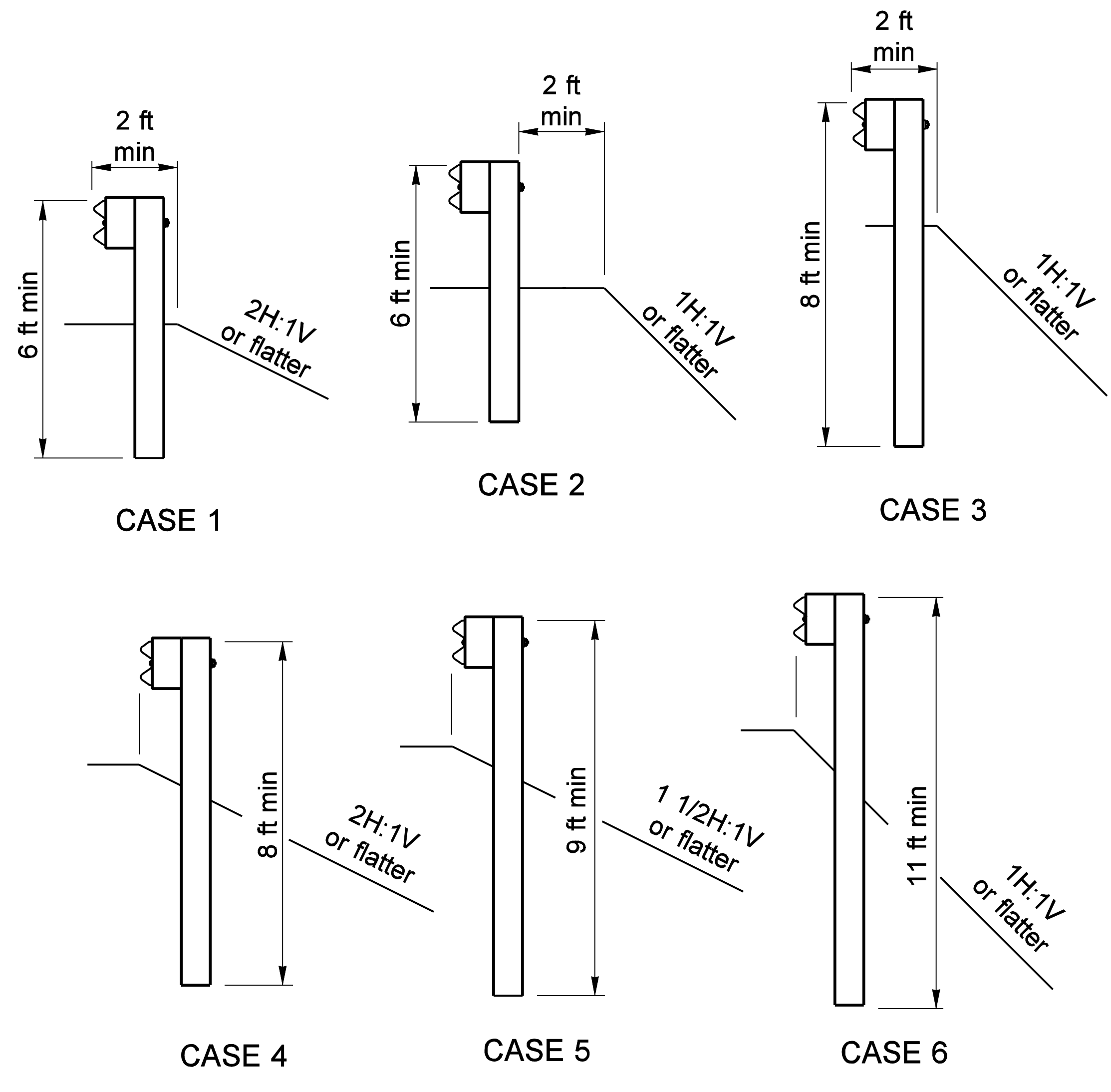
If using LR, follow Figures 710-11a and b.

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



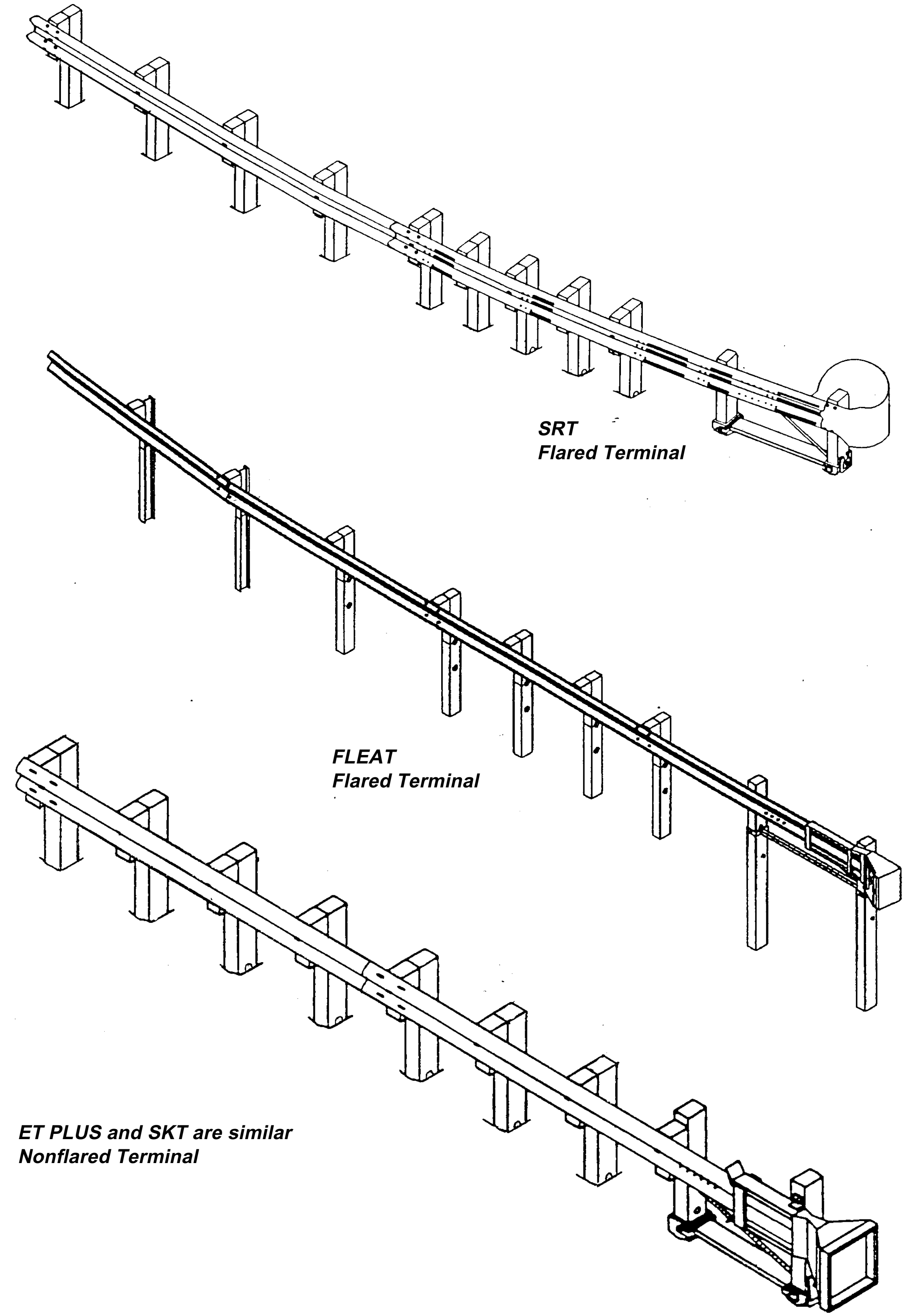
Notes:

Use cases 1, 2, and 3 when there is 2 ft or greater shoulder widening from face of guardrail to the breakpoint.

Use cases 4, 5, and 6 when there is less than 2 ft shoulder widening from face of guardrail to the breakpoint.

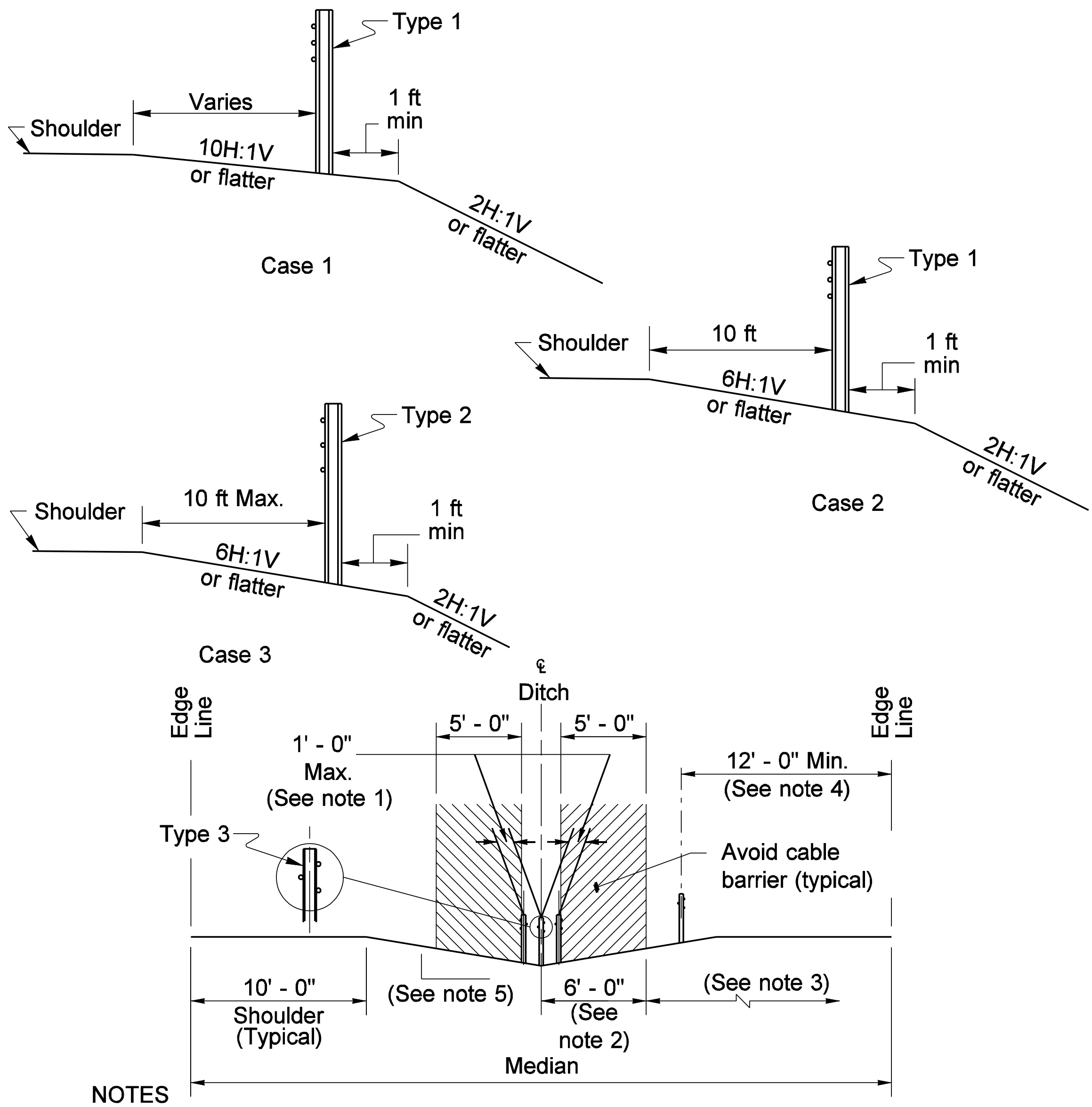
Beam Guardrail Post Installation

Figure 710-12



Beam Guardrail Terminals

Figure 710-13



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 1' to 6' offset of the ditch center line.
3. Cable barrier may be installed a distance of 6' or greater from the ditch center line.
4. Do not install cable barrier closer than 12' to the edge of travelled way.
5. Applies to slopes between 6H:1V or flatter and 10H:1V or steeper.

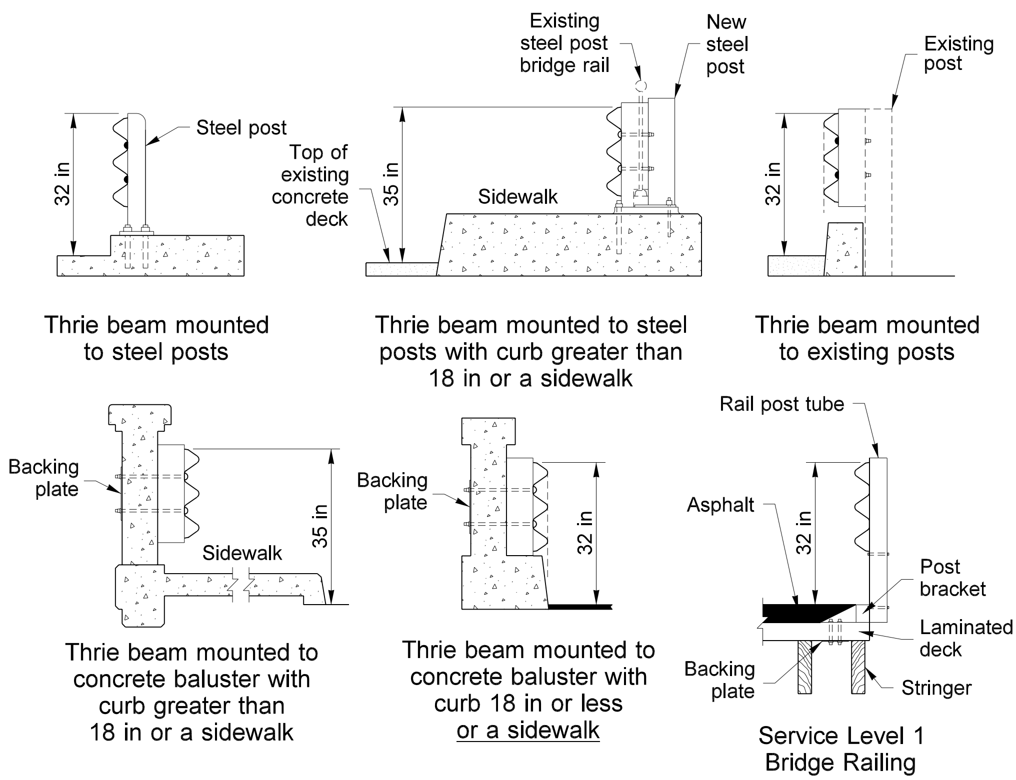
Case 4
Median Installation

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 in	Thrie beam mounted to steel posts[2] at the face of curb. Height = 32 in	Service Level 1 Bridge Rail[2]
> 18 inches	**> 28 ft (curb to curb)**	Thrie beam mounted to steel posts[2] at the face of curb[1] . Height = 32 in		Height = 32 in
> 18 inches	**< 28 ft (curb to curb)**	Thrie beam mounted to existing bridge rail[2] . Height = 35 in	Thrie beam mounted to steel posts[2] in line with existing rail. Height = 35 in	Curb or wheel guard must be removed

(1) Thrie beam may be mounted to the bridge rail to accommodate pedestrians (height = 35 in)

(2) Contact the HQ Bridge and Structures Office for design details on bridge rail retrofit projects.



Thrie Beam Rail Retrofit Criteria

Thrie Beam Rail Retrofit Criteria

Figure 710-15

720.01 Impact Attenuator Systems

Impact attenuator systems are protective systems that prevent an errant vehicle from impacting a hazard by either gradually decelerating the vehicle to a stop when hit head-on or by redirecting it away from the hazard when struck on the side. These barriers are used for rigid objects or hazardous conditions that cannot be removed, relocated, or made breakaway.

Approved systems are shown on Figures 720-2a through 4b and on the Design Office web page at:

http://www.wsdot.wa.gov/EESC/Design/Policy/RoadsideSafety/Chapter720/Chapter720B.htm

(1) Permanent Installations

A description of each permanent installation system's purpose, parts, and function as well as requirements for; transition, foundation, and slope are provided as follows and in Figure 720-5:

(a) **Crash Cushion Attenuating Terminal (CAT)**

1. **Purpose**: The CAT is an end treatment for W-beam guardrail. It can also be used for concrete barrier if a transition is provided.

2. **Description**: The system consists of slotted W-beam guardrail mounted on both sides of breakaway timber posts. Steel sleeves with soil plates hold the timber posts in place. See Figure 720-2a.

3. **Function**: When hit head-on, the slotted guardrail is forced over a pin that shears the steel between the slots. This shearing dissipates the energy of the impact.

4. **Foundation:** Concrete footings or foundations are not required.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Trinity Industries, Inc.

(b) **Brakemaster**

1. **Purpose:** The Brakemaster system is an end treatment for W-beam guardrail. It can also be used for concrete barrier if a transition is provided.

2. **Description:** The system contains an embedded anchor assembly, W-beam fender panels, transition strap, and diaphragm. See Figure 720-2a.

3. **Function:** The system uses a brake and cable device for head-on impacts and for redirection. The cable is embedded in a concrete anchor at the end of the system.

4. **Foundation:** A concrete foundation is not required for this system but a paved surface is recommended.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(c) **QuadTrend 350**

1. **Purpose:** The QuadTrend 350 is an end treatment for 2 feet-8inch high concrete barriers. The system's short length allows it to be used at the ends of bridges where the installation of a beam guardrail transition and terminal is not feasible.

2. **Description:** This system consists of telescoping quadruple corrugated fender panels mounted on steel breakaway posts. See Figure 720-2a.

3. **Function:** Sand-filled boxes attached to the posts dissipate a portion of the energy of an impact. An anchored cable installed behind the fender panels directs the vehicle away from the barrier end.

4. **Foundation:** The system is installed on a concrete foundation to support the steel posts.

5. **Slope:** A 6H:1V or flatter slope is required behind the barrier to allow for vehicle recovery.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(d) **Universal TAU**

1. **Purpose:** The Universal TAU crash cushion system is an end treatment for concrete barrier, beam guardrail, and fixed objects up to 8 feet wide.

2. **Description:** The system is made up of independent collapsible bays containing energy absorbing cartridges that are guided and supported during a head-on hit by high strength galvanized steel cables and thrie beam rail panels. Each bay is composed of overlapping thrie beam panels on the sides and structural support diaphragms on the ends. Structural support diaphragms are attached to two cables running longitudinally through the system and attached to foundations at each end of the system. See Figure 720-2c.

3. **Function:** Overlapping panels, structural support diaphragms, cable supports, cables, and foundation anchors allow the system to resist angled impacts and mitigate head-on impacts.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Barrier Systems, Inc.

(e) **QuadGuard, Wide QuadGuard**

1. **Purpose:** The QuadGuard is an end treatment for concrete barrier and beam guardrail and is also used to mitigate fixed objects up to 7 feet-6 inches wide.

2. **Description:** The system consists of a series of Hex-Foam cartridges surrounded by a framework of steel diaphragms and quadruple corrugated fender panels. See Figure 720-2b.

3. **Function:** The internal shearing of the cartridges and the crushing of the energy absorption material absorb impact energy from end-on hits. The fender panels redirect vehicles impacting the attenuator on the side.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the QuadGuard.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(f) **QuadGuard Elite**

1. **Purpose:** The QuadGuard Elite is an end treatment for concrete barrier and beam guardrail and is also used for fixed objects up to 7 feet-6 inches wide.

2. **Description:** The system consists of telescoping quadruple corrugated fender panels mounted on both sides of a series of polyethylene cylinders. See Figure 720-2b.

3. **Function:** The cylinders are compressed during a head-on impact and will return to their original shape when the system is reset. It is anticipated that this system will require very few replacement parts or extensive repair.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the QuadGuard Elite.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(g) **Reusable Energy Absorbing Crash Terminal (REACT 350), Wide REACT 350**

1. **Purpose:** The REACT 350 is an end treatment for concrete barriers and is also used for fixed objects up to 9 feet wide.

2. **Description:** The system consists of polyethylene cylinders with varying wall thickness, redirecting cables, a steel frame base, and a backup structure. See Figure 720-2d.

3. **Function:** The redirecting cables are anchored in the concrete foundation at the front of the system and in the backup structure at the rear of the system. When hit head-on, the cylinders compress and absorb the impact energy, but the system returns to approximately 80% of its original length immediately. For side impacts, the cables restrain the system enough to prevent penetration and redirect the vehicle. It is anticipated that this system will require very few replacement parts or extensive repair.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope**: If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the REACT 350.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(h) **Inertial Barrier**

Inertial barrier configurations are shown in the Standard Plans. If a situation is encountered where configurations in the Standard Plans are not appropriate, contact the Headquarters Design Office for further information.

1. **Purpose:** Inertial barrier is an end treatment for concrete barrier and to mitigate fixed objects. This system does not provide redirection from a side impact.

2. **Description:** This system consists of an array of plastic containers filled with varying weights of sand. See Figure 720-2d.

3. **Function:** The inertial barriers slow an impacting vehicle by the transfer of the momentum of the vehicle to the mass of the barrier. This system is not suitable where space is limited to less than the widths shown in the Standard Plans. Whenever possible, align inertial barriers so that an errant vehicle deviating from the roadway by 10 degrees would be on a parallel path with the attenuator alignment (See the Standard Plans). In addition, inertial barriers do not provide any redirection and are not appropriate where high angle impacts are likely.

4. **Foundation**: A paved surface is not required.

5. **Slope**: If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 5% for inertial barriers.

(i) **SCI100GM**

1. **Purpose:** The SCI100GM is an end treatment for concrete barrier and beam guardrail.

2. **Description:** The system consists of telescoping quadruple corrugated fender panels mounted on both sides of a series of tubular steel support frames. See Figure 720-2e.

3. **Function:** A hydraulic cylinder is compressed during a head-on impact. It is anticipated that this system will require very few replacement parts or extensive repair.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Work Area Protection Corp.

(2) Work Zone (Temporary) Installation

A description of each work zone (or other temporary) system's purpose, parts and functionality as well as requirements for; transition, foundation, and slope are provided as follows and in Figure 720-5:

(a) **ABSORB 350**

1. **Purpose:** The ABSORB 350 is an end treatment limited to temporary installations for both concrete barrier and the Quickchange Moveable Barrier (QMB).

2. **Description:** The system contains water filled Energy Absorbing Elements. Each element is 2 feet wide, 2 feet-8 inches high, and 3 feet-3 ½ inches long. See Figure 720-3.

3. **Function:** The low speed (below 45 mph) system uses 5 Energy Absorbing Elements and the high-speed (45 mph and above) system uses 8. The energy of an impact is dissipated as the elements are crushed.

4. **Foundation:** The system does not require a paved foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Barrier Systems, Inc.

(b) **Advanced Dynamic Impact Extension Module 350 (ADIEM 350)**

1. **Purpose:** The ADIEM 350 is an end treatment for concrete barrier. At this time, it is limited to temporary installations. Existing permanent installations are experimental and are being used to evaluate long-term durability. Existing permanent units may be reset.

2. **Description:** The system is 30 feet long and consists of 10 lightweight concrete modules on an inclined base. See Figure 720-3.

3. **Functionality:** An inclined base provides a track for placement of the modules and provides redirection for side impacts for roughly half the length. The energy of an impact is dissipated as the concrete modules are crushed.

4. **Foundation:** The system does not require a paved foundation.

5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the ADIEM 350.

6. **Manufacturer/Supplier:** Trinity Industries, Inc.

(c) **QuadGuard cz**

This system is like the permanent QuadGuard listed for permanent systems above except that it can be installed on a 6 inch minimum depth asphalt concrete surface that has a 6 inch minimum depth compacted base. See Figure 720-2b.

(d) **Reusable Energy Absorbing Crash Terminal (REACT 350)**

This is the same system listed for permanent systems above except that it can be installed on a 4 inch minimum depth asphalt concrete surface that has a 6 inch minimum depth compacted base. See Figure 720-2d.

(e) **Non-Redirecting Energy Absorbing Terminal (N-E-A-T)**

1. **Purpose:** The N-E-A-T system is an end treatment for temporary concrete barrier where vehicle speeds are 45 mph or less.

2. **Description:** The N-E-A-T System's cartridge weighs about 300 pounds and is 9 feet-8 inches long. The system consists of aluminum cells encased in an aluminum shell with steel backup, attachment hardware, and

transition panels. It can be attached to the ends of New Jersey shaped portable concrete barrier and the moveable QuickChange Barrier. See Figure 720-3.

3. **Functionality:** The energy of an impact is dissipated as the aluminum cells are crushed.

4. **Foundation:** The system does not require a paved foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(f) **Trinity Attenuating Crash Cushion (TRACC)**

1. **Purpose:** The TRACC is an end treatment for concrete barriers. It is limited to use in construction or other work zones on a temporary basis.

2. **Description:** The 21 foot long TRACC includes four major components: a pair of guidance tracks, an impact sled, intermediate steel frames, and 10 gauge W-beam fender panels. See Figure 720-3.

3. **Functionality:** The sled (impact face) is positioned over the upstream end of the guidance tracks and contains a hardened steel blade that cuts the metal plates on the sides of the guidance tracks as it is forced backwards when hit head-on.

4. **Foundation:** The system requires a concrete foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Trinity Industries, Inc.

(g) **Inertial Barrier**

This is the same system listed for permanent systems above. It is not suitable where space is limited to less than the widths shown in the Standard Plans. See Figure 720-2d.

(h) **Truck Mounted Attenuator (TMA)**

TMAs are portable systems mounted on trucks. They are intended for use in work zones and for temporary hazards.

(i) **TRITON CET**

1. **Purpose:** The Triton CET is an end treatment limited to temporary concrete barrier installations.

2. **Description:** The system contains water filled Energy Absorbing Elements. See Figure 720-3.

3. **Function:** The system uses 6 Energy Absorbing Elements. The energy of an impact is dissipated as the elements are crushed.

4. **Foundation:** The system does not require a paved foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Energy Absorption, Inc.

(3) Older Systems

The following systems are in use on Washington State highways and may be left in place or reset. New installations of these systems require approval from the Headquarters (HQ) Design Office.

(a) **Sentre**

The Sentre is a guardrail end treatment. Its overall length of 17 feet allowed it to be used where space was not available for a guardrail transition and terminal. The system is very similar to the QuadTrend 350 in both appearance and function except that it uses thrie beam fender panels instead of the quadruple corrugated panels. This system requires a transition when used to terminate rigid barriers. See Figure 720-4a.

(b) **TREND**

The TREND is an end treatment with a built-in transition and was used at the end of rigid barriers including bridge rails. The system is similar to the QuadTrend 350 except that it uses thrie beam fender panels. See Figure 720-4a.

(c) **G-R-E-A-T (Guard Rail Energy Absorption Terminal)**

This system was primarily used as an end treatment for concrete barrier. It is similar to the QuadGuard except that it uses thrie beam fender panels. See Figure 720-4a.

(d) **Low Maintenance Attenuator System (LMA)**

The LMA is an end treatment for concrete barrier and beam guardrail and was used for fixed objects up to 3 feet wide. The system is similar to the QuadGuard Elite except that it uses thrie beam fender panels and rubber cylinders. See Figure 720-4b.

(e) **Hex-Foam Sandwich**

The Hex-Foam Sandwich system is an end treatment for beam guardrail and concrete barrier and was also used for fixed objects 3 feet or more in width. This system consists of a number of Hex-Foam cartridges containing an energy absorption material separated by a series of diaphragms and restrained by anchor cables. It is installed on a concrete slab. Impact energy is absorbed by the internal shearing of the cartridges and crushing of the energy absorption material. The lapped panels on the perimeter serve to redirect vehicles for side impacts. If the site has grade or cross slope in excess of 5%, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. See Figure 720-4b.

720.02 Design Criteria

The following design criteria applies to all new or reset permanent and temporary impact attenuators. The design criteria also applies to existing systems to be left in place when the Barrier Terminals and Transition Sections columns on a design matrix applies to the project. (See Chapter 325.)

Impact attenuators must be placed so that they do not present a hazard to opposing traffic. For median and reversible lane locations, the backup structure or attenuator-to-object connection must be designed to prevent opposing traffic from being snagged. It is desirable that all existing curbing be removed and the surface smoothed with asphalt or cement concrete pavement before an impact attenuator is installed. However, curbs 4 inches or less in height, may be retained depending on the practicality of their removal.

In general, attenuators are aligned parallel to the roadway except the inertial barriers.

720.03 Selection

When selecting an impact attenuator system, consider the following:

- Posted speed
- Available space (length and width)
- Maintenance costs
- Initial cost
- Duration (permanent or temporary use)

The posted speed is a consideration for the QuadGuard, REACT 350 (narrow model only), Universal TAU and the inertial barrier systems. Use Figure 720-1 to select permanent system sizes required for the various posted speeds.

Posted Speed (mph)	Quad Guard (Bays)	Universal TAU *(Bays)	REACT 350 (Cylinders)	Inertial Barrier (Type)
40 or less	3	2-3	4	1
45	4	3-4	6	2
50	5	4-5	6	3
55	6	5-7	9	4
60	6	7-8	9	5
65	8	7-8	9	6
70	9	7-8	11	6

*Dependent on width of system

Impact Attenuator Sizes
Figure 720-1

If it is anticipated that a large volume of traffic will be traveling at speeds greater than the posted speed limit, then the next larger unit may be specified.

See Figure 720-5 for a summary of space and initial cost information related to the impact attenuator systems.

When considering maintenance costs, anticipate the average annual impact rate. If few impacts are anticipated, lower cost devices such as inertial barriers might meet the need. Inertial barriers have the lowest initial cost and initial site preparation. However, maintenance will be costly and necessary after every impact. Labor and equipment are necessary to clean up the debris and install new containers (barrels). Also, inertial barriers must not be used where flying debris might be a danger to pedestrians.

The REACT 350 and the QuadGuard Elite have a higher initial cost, requiring substantial site preparation, including a backup or anchor wall in some cases and cable anchorage at the front of the installation. However, repair costs are comparatively low, with labor being the main expense. Maintenance might not be required after minor side impacts with these systems.

For new installations where at least one impact is anticipated per year, limit the selection of impact attenuators to the low maintenance devices (QuadGuard Elite and REACT 350). Consider upgrading existing ADIEM, G-R-E-A-T, and Hex-Foam impact attenuators with these low maintenance devices when the repair history shows one to two impacts per year over a three to five year period.

In selecting a system, one consideration that must not be overlooked is how dangerous it will be for the workers making repairs. In areas with a high exposure to danger, a system that can be repaired quickly is most desirable. Some systems require nearly total replacement or replacement of critical components (such as cartridges or braking mechanisms) after a head-on impact, while others only require resetting.

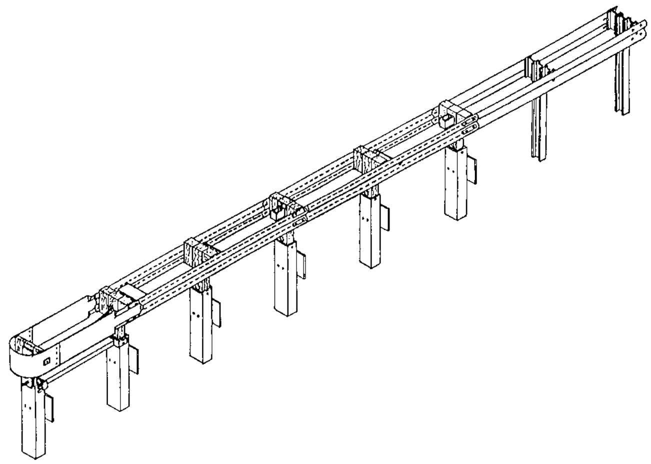
When specifying the system or systems that can be used at a specific location, the list shown in Figure 720-5 is to be used as a starting point. As the considerations discussed previously are analyzed, inappropriate systems may be identified and eliminated from further consideration. Systems that are not eliminated may be appropriate for the project. When the site conditions vary, it might be necessary to have more than one list of acceptable systems within a contract. Systems are not to be eliminated without documented reasons. Also, wording such as *or equivalent* is not to be used when specifying these systems. If only one system is found to be appropriate, then approval from the Assistant State Design Engineer of a public interest finding for the use of a sole source proprietary item is required.

When a transition to connect with a concrete barrier (see Figure 720-5) is required, the transition type and connection must be specified and are included in the cost of the impact attenuator. See Chapter 710 for information on the transitions and connections to be used.

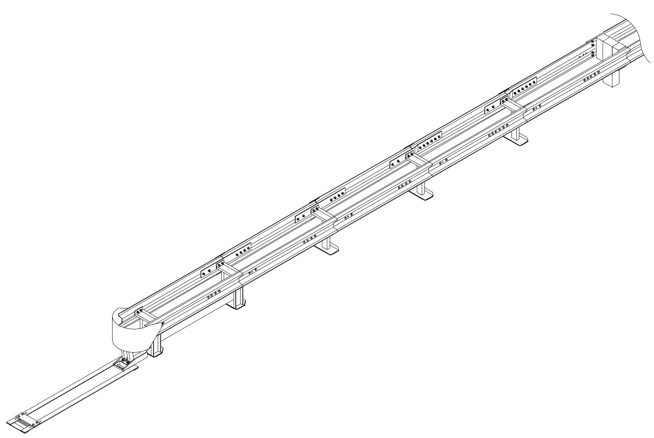
Contractors can be given more flexibility in the selection of work zone (temporary) systems, since long-term maintenance and repair are not a consideration.

720.04 Documentation

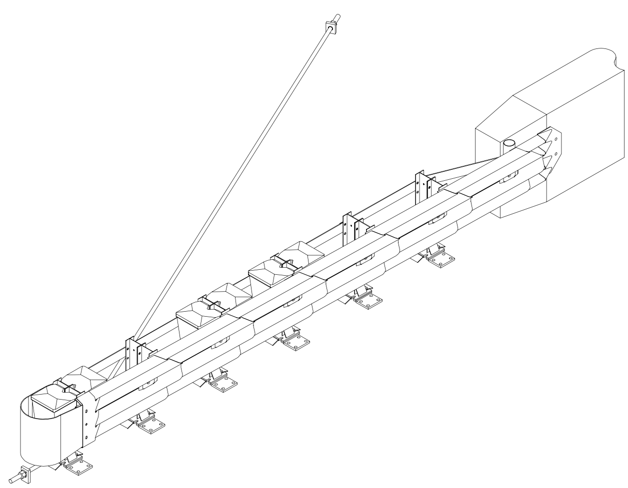
A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/



CAT



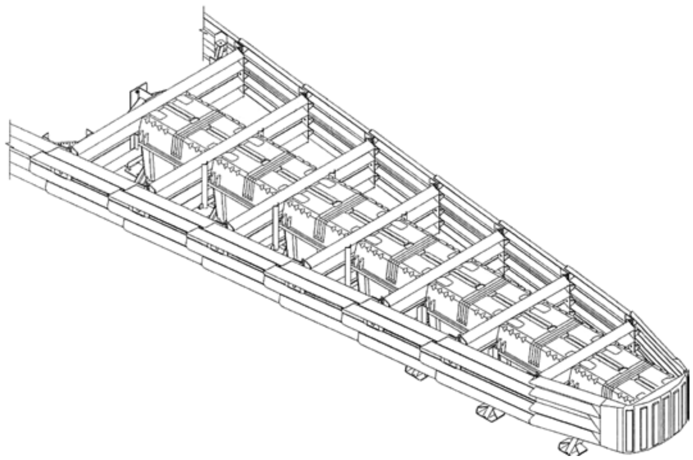
Brakemaster



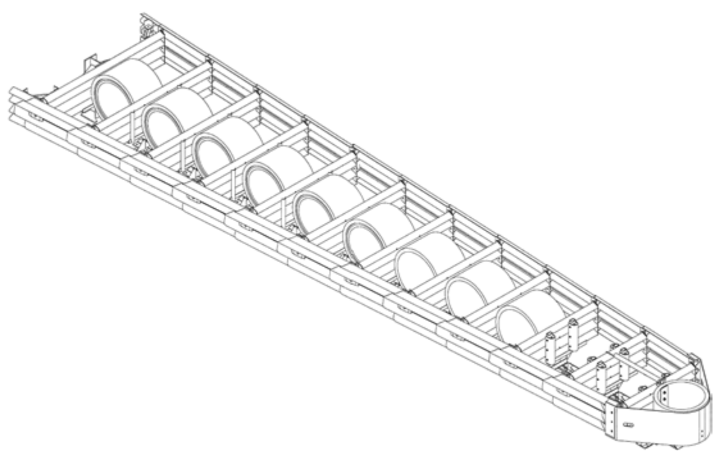
QuadTrend 350

Impact Attenuator Systems — Permanent Installations
Figure 720-2a

QuadGuard CZ



Wide QuadGuard

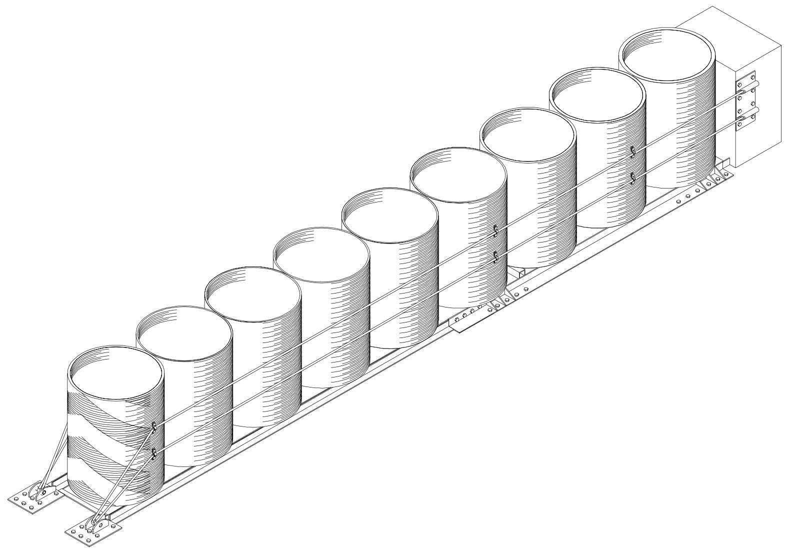


Wide QuadGuard Elite

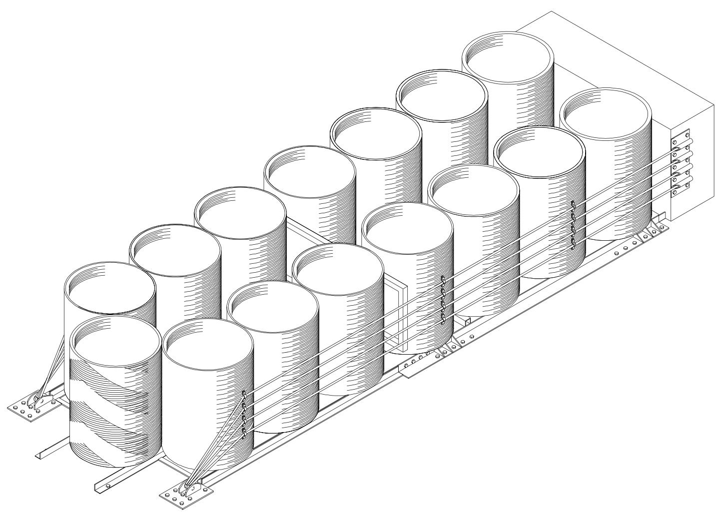
Impact Attenuator Systems — Permanent Installations
Figure 720-2b

Universal TAU

Impact Attenuator Systems — Permanent Installations
Figure 720-2c



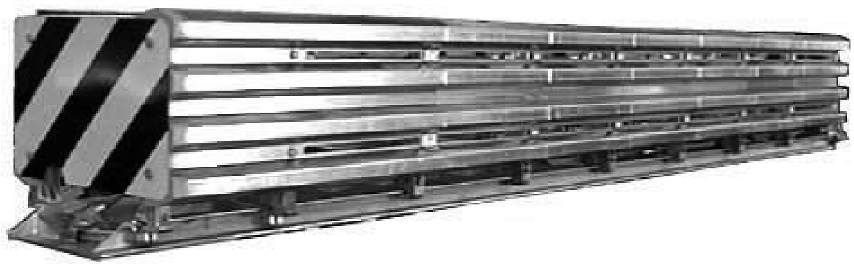
REACT 350



Wide REACT 350

Inertial Barrier

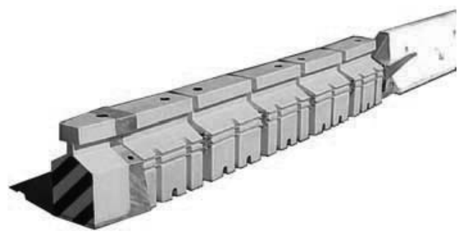
Impact Attenuator Systems — Permanent Installations
Figure 720-2d



SCI100GM

Impact Attenuator Systems—Permanent Installations
Figure 720-2e

ADIEM 350



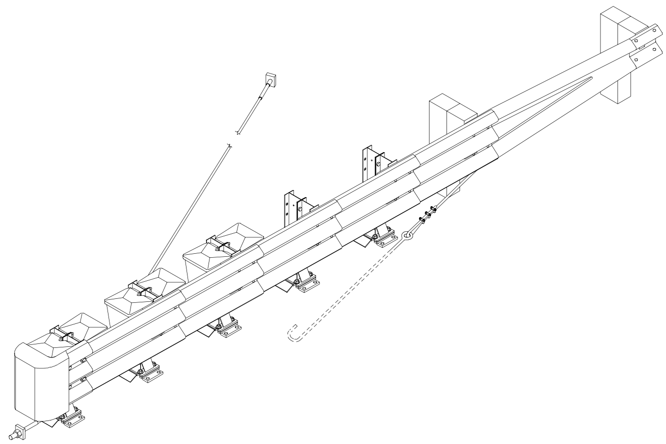
ABSORB 350

TRACC

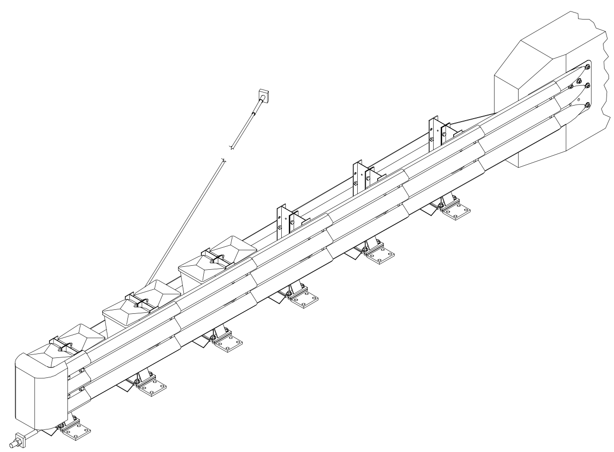
N-E-A-T

TRITON CET

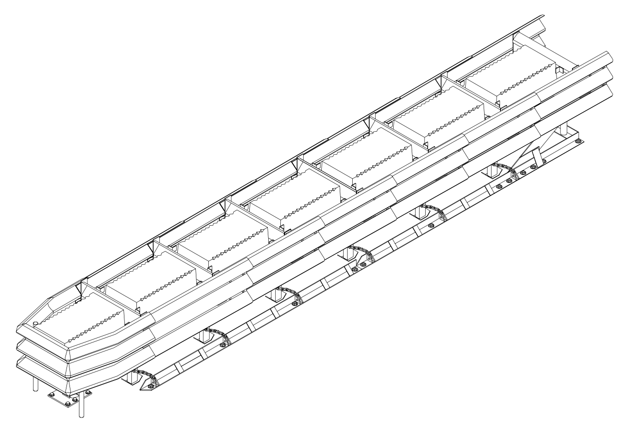
Impact Attenuator Systems — Work Zone Installations
Figure 720-3



Sentre

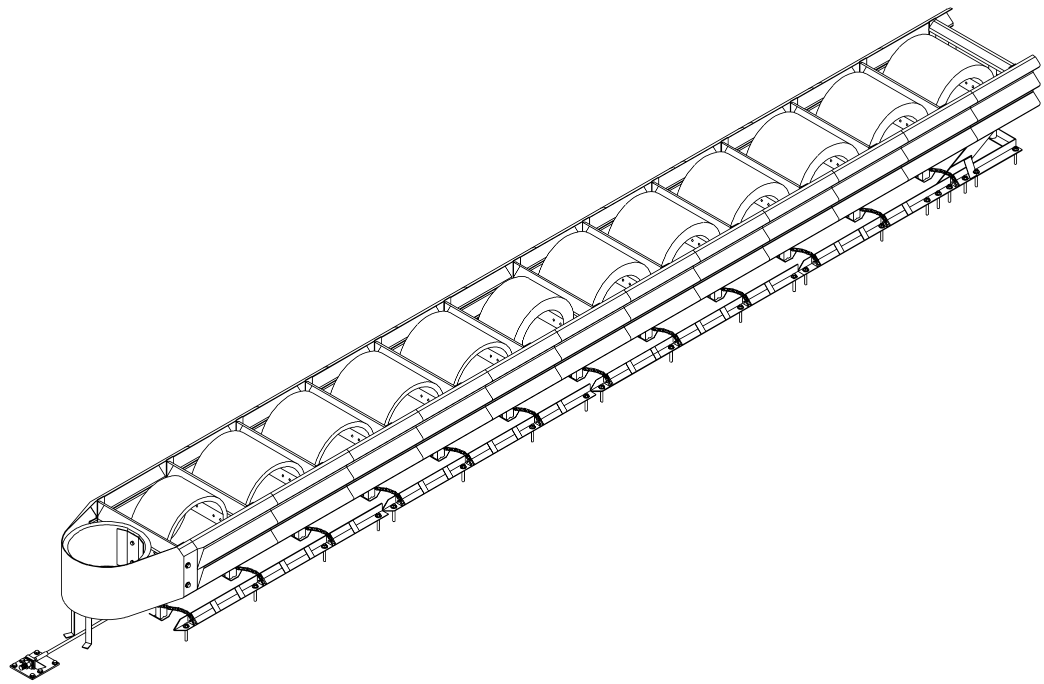


TREND

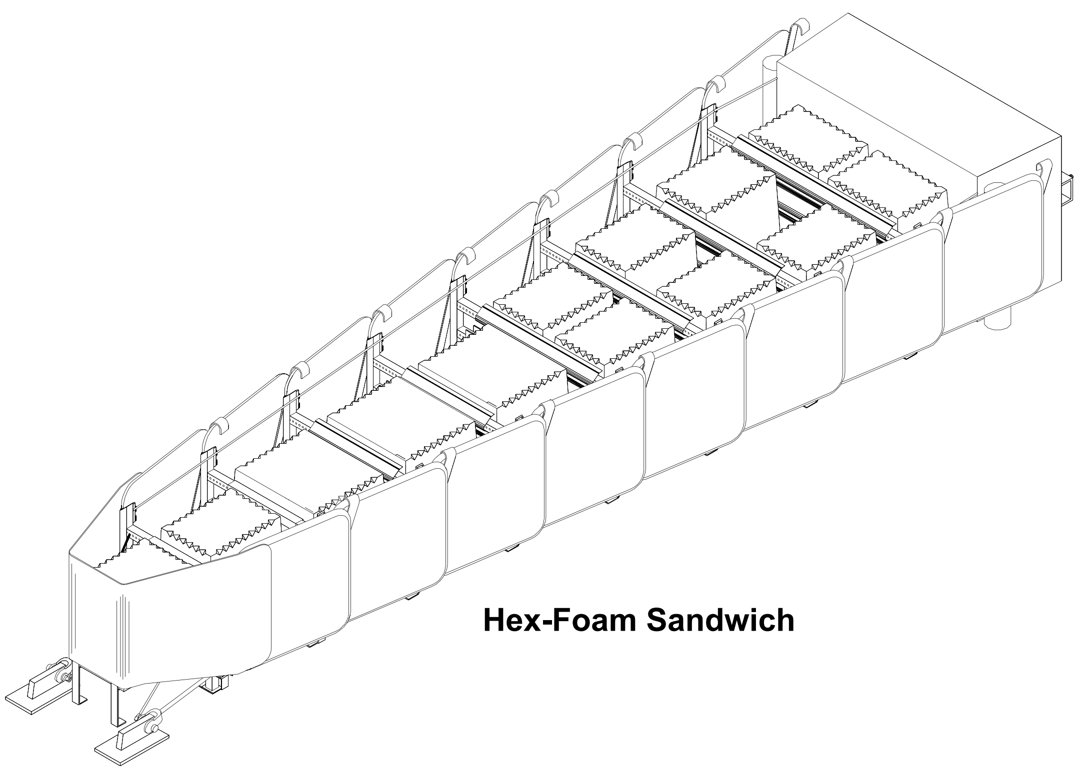


G-R-E-A-T

Impact Attenuator Systems — Older Systems
Figure 720-4a



L.M.A.



Hex-Foam Sandwich

Impact Attenuator Systems — Older Systems
Figure 720-4b

Impact Attenuator Systems (All dimensions in feet)

System	(P) Permanent (T) Temporary (B) Both	Width	Length	Transition to Rigid System Required?	Distance Beyond Length of Need	Initial Cost Category(1)
CAT(2)	P	2	31.25	Y	18.8	A
Brakemaster(2)	P	2	31.5	Y	15.8	A
QuadTrend – 350(6)	P	2	20.7	N	10.5	A
Universal TAU	P	2.9 - 8.7	14 - 26(4)	N	3	B(5)
QuadGuard	B	2, 2.5, 3, 5.75, 7.5, 10	12-30(4)	N	3.3	C(5)
QuadGuard Elite	B	2, 2.5, 3, 5.75, 7.5	35.5	N	3.3	C
REACT 350	B	3	15.25 - 36.25(4)	N	4.3	C(5)
Wide REACT 350	B	6 - 9	23.25	N	4.3	D(5)
Inertial Barriers	B	7	17 - 30(4)	N	(3)	A(5)
SCI100GM	B	2	21.5	N	3	C
ABSORB 350(9)	T	2	17.7 or 27	Y	17.7 or 27(3)	A(5)
ADIEM 350(7)	T	2	30	N	14.1	B
QuadGuard cz	T	2, 2.5, 3, 5.75, 7.5	22	N	3.3	B(5)
N-E-A-T(8)	T	1.9	9.7	N	(3)	A(5)
TRACC	T	2.6	21	N	8	B
TRITON CET(10)	T	2	41	N	(3)	A

1) A ($5,000 to $10,000); B ($10,000 to $15,000); C ($15,000 to $25,000); D ($25,000 to $40,000). These are rough initial cost estimates - verify actual costs through manufacturers/suppliers. Some products are priced very close to the margin between cost categories.
2) Generally for use with double-sided beam guardrail. Use as an end treatment for concrete barrier requires a transition.
3) The N-E-A-T, inertial barriers, and ABSORB 350 may only be used beyond the required length of need.
4) See Figure 720-1 for sizes or configuration type.
5) The length of the QuadGuard, REACT 350, Universal TAU, ABSORB 350, and inertial barriers varies since their designs are dependent upon speed. For a typical 60 mph design: the QuadGuard = 21 ft, the REACT 350 = 31 ft, the ABSORB 350 = 27 ft, the Universal TAU = 26 ft, and the inertial barrier = 30 ft. Costs indicated are for a typical 60 mph design. (except N-E-A-T)
6) Generally for use at the ends of bridges where installation of a beam guardrail transition and terminal is not feasible.
7) Generally for use with concrete barrier. Other uses may require a special transition design.
8) Use limited to highways with posted speeds of 45 mph or less.
9) The ABSORB 350 was primarily intended for the Quickchange Moveable Barrier (QMB) but may be used with other temporary barrier if beyond the length of need.
10) Test Level 3 version on high speed facilities should be limited to locations where the likelihood of being hit is low.

Impact Attenuator Comparison
Figure 720-5

Chapter 810 Work Zone Traffic Control

810.01 General

Highway improvements always have some impact on the users of that facility during the construction phase. The various activities required to improve the highway cannot be undertaken without some disruption to the existing traffic patterns. In all but a very few instances the public must have some form of access through or around the work site. The planning, design, and preparation of contract documents for the modification of these traffic patterns during construction is known as work zone traffic control. The frequency of traffic collisions in work zones is disproportionately higher than at any other highway location and the primary consideration in providing work zone traffic control is safety. Safety is the primary consideration for all people within the work zone, the motorist, pedestrians, bicyclists, contractor's workers, agency's inspectors, surveyors, and other personnel on the site.

Maintaining the optimum carrying capacity of an existing facility during construction is usually not possible. As construction progresses, existing traffic lanes will be either temporarily narrowed or closed and will reduce the highway's capacity. 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. The construction activities that disrupt or reduce traffic flow can often be scheduled for time periods when the traffic volume is minimal.

810.02 References

Manual on Uniform Traffic Control Devices USDOT, Washington DC, including the *Washington State Modifications to the MUTCD*, WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Planning and Scheduling Work Zone Traffic Control, USDOT, 1981

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

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

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

Plans Preparation Manual, M 22-31, WSDOT

Traffic Manual, M 51-02, WSDOT

Construction Manual, M 41-01, WSDOT

Work Zone Traffic Control Guidelines, M 54-44, WSDOT

Highway Capacity Manual, 2000, TRB

810.03 Public Information

Accurate and timely reporting of project information to the public is a valuable element in the overall traffic control strategy. The use of public information resources, such as newspapers, radio, and television, can greatly improve the public's perception and acceptance of the necessary delays and other inconveniences caused by the project's construction. The potential benefits derived from this effort are:

- Advanced notice might encourage motorists to seek alternate routes around the project.

- Reduced traffic volume and driver awareness might result in fewer crashes, safer working conditions, and fewer motorist complaints.
- Motorist acceptance might reduce aggressive driving behavior.

The region's public information officer can provide assistance in this effort.

810.04 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 five classes of zones categorized by the expected duration of work. Different criteria apply to the design and planning for each of these. Several work zone classifications might be present during the construction phase of a project. The following are the five classes of work zones.

(1) Long-Term Stationary Work Zones

Long-term stationary work zones occupy locations longer than 3 days. 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. 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 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.

(2) Intermediate-Term Stationary Work Zones

Intermediate-term stationary work zones occupy a location from overnight to 3 days. At these locations it might not be feasible or practical to use procedures or devices used for long-term stationary temporary traffic control zones. The increased time required to place and remove these devices might significantly lengthen the project, thus increasing the workers exposure time. The region's traffic office is a valuable resource to assist in making this decision.

(3) Short-Term Stationary Work Zones

Short-term stationary work zones are locations where the work will be accomplished during daylight hours and the activity can be accomplished in 12 hours or less. Most maintenance and utility operations use short-term stationary work zones. They are also used for minor construction activities on projects. The work crew is present to maintain and monitor the temporary traffic control devices. The use of flaggers to control traffic is sometimes necessary. Lighting and retroreflective devices are used when seasonal and climatic conditions limit visibility.

(4) 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. These simplified control procedures can often be standardized plans as contained in the Standard Plans and the *Work Zone Traffic Control Guidelines*.

(5) 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 litter cleanup, pothole patching, or utility operations and are similar to short duration work zones. Warning signs, flashing vehicle lights, flags, and channelizing devices are used. 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 are exposed to more extreme hazards 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 to some extent mobile operations in that they can progress along a roadway several miles in a day. These operations, however, are not considered mobile work zones.

810.05 Work Zone Types

The work zone type is the basic layout of the work site and the configuration of traffic lanes. There are ten basic work zone types. See Figures 810-1a through 810-1c. Work sites that are located completely off the roadway and do not disrupt traffic are not included. A description of each of the ten types is as follows:

(1) Lane Constriction

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.

(2) 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.

(3) Shared Right of Way

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.

(4) 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 constructed within the highway's right of way.

(5) 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.

(6) 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 lane width constrictions to maintain the same number of lanes. On higher speed roadways, a portable or temporary barrier is used to separate the two directions of traffic.

(7) Shoulder Use

The traffic lanes are routed onto the shoulder in this work zone type. The structural capacity of the shoulder must first be analyzed to determine its ability to carry the proposed traffic.

(8) 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.

(9) Detour

This work zone type involves total closure of the roadway. Traffic is rerouted to an adjacent street or highway.

(10) Multiple Lane Separation

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.

810.06 Project Definition

Large projects are more successful in managing traffic and providing adequate safety when there is early and ongoing communication between the designer and the construction Project Engineer, who will be responsible for the administration of the contract. Agreement is necessary to ensure that the traffic control plans and specifications will be effective and enforceable. In addition, a meeting (attended by the region's Traffic Engineer, law enforcement officials, a construction project engineer, and representatives from local agencies affected by the planned project) is held early in the design definition phase to discuss construction work zone traffic control strategy options and to select the most feasible approach. Additional traffic control strategy meetings, depending on the size and complexity of the project, are held as more specific design information becomes available.

The options developed for the work zone traffic control strategy define the level of safety provided for motorists, pedestrians, and workers, and predict the acceptable level of service to be maintained for traffic. The objectives of this strategy include the following:

- The safety of motorists and pedestrians traveling through work zones.
- Protection of highway workers from hazards associated with moving traffic.
- Minimize travel delays associated with the work activities.
- Facilitate access to abutting properties and minimize disruption and loss of revenue to adjoining businesses.
- Address issues that might interfere with the contractor's ability to accomplish the work within the specified working days of the contract.

(1) Time Restrictions

The traffic volumes on a highway or street vary greatly both during the day and the week. Generally on weekdays maximum traffic flows (peak hour volumes) occur twice a day, in the morning and in the early evening. Additionally, these traffic flows tend to be unidirectional. In the morning the predominate traffic flow is to a major destination and in the evening the flow is reversed. Construction activities on the portion of the roadway not being used by the peak traffic flow will cause less disruption. After these peak traffic periods, volumes decrease significantly and construction activities during these periods will have less impact on the highway users. During the late evening, traffic volumes drop to extremely low levels. Construction activities during these time periods have minor impacts on the traffic flow, but require additional safety considerations because of reduced visibility and diminished motorist skills during the hours of darkness.

As noted above, construction in work zones can have a negative impact on peak hour traffic demands. It is sometimes necessary to curtail work at certain times during the day and open closed traffic lanes to reduce traffic delays. These periods are referred to as the hours of restriction in the contract and are the hours when all existing lanes are open to traffic. The maximum capacity a traffic lane in construction work zones tends to be lower than that used in normal capacity analysis. This is due in part to the number of visual distractions and to the narrow lanes within the work zone.

Traffic lanes in work zones reach saturation before the traffic volume approaches the theoretical maximum lane capacity of a free-flowing facility. See the *Highway Capacity Manual* and *Planning and Scheduling Work Zone Traffic Control* guidebook for applicable lane volumes and other factors. Several elements, including, lane restrictions, adjacent channelization devices, excessive signing, and distractions along on the roadside, contribute to lower lane capacity in work zones. When the traffic volume exceeds the capacity of the facility, operating speeds start dropping quickly. This slowing at the front of the traffic platoon is then amplified back through the following traffic and severe braking and stopping occurs. Once the traffic flow reaches this "forced flow" condition, traffic backups will occur and normal free flow conditions will not return until well after the usual peak hour condition. When specifying the time restrictions in the contract, consider beginning the restriction before the actual peak hour volume condition occurs.

Certain holidays, particularly those that extend beyond the normal weekend, and special events can generate abnormally high traffic volumes. Restrictions are needed on construction activities that might restrict or reduce the highway's capacity during these times.

When determining the hours of restriction, check the local agency noise ordinances and determine what construction work can be done at night. Construction activities that cause excessive noise, such as pile driving, are usually prohibited at night in urban areas. Also, older types of changeable message signs and arrow panels use noisy engine-powered generators. Limitations on noise levels are also included in the contract documents.

Time restrictions can also affect the time required to complete the project. The total working days specified in the contract must address the possible reduction in productivity caused by the time restrictions imposed on the contractor. When considering time restrictions, estimate the time required to set up and take down the traffic control devices and the time needed by the contractor to bring the construction equipment and materials into the work area. If this total time coupled with the proposed time restrictions does not provide a normal eight to ten hour work shift, productivity will drop and contract costs will escalate.

Excessive disincentives (referred to as liquidated damages in the Standard Specifications) can be included in the contract to encourage the contractor to complete the work within a specified time. When contracts specify unusually short time periods to complete the work or impose numerous time restrictions when work cannot be accomplished, contractors must increase their work force significantly, use abbreviated work shifts, and pay premium wages for work preformed during nontypical work periods. This usually results in disproportionately higher contract bids and during construction can lead to claims against the contract and even litigation to resolve disputes. It might also produce a strained or hostile relationship between the contractor and Project Engineer.

Incentives, in the form of additional monetary compensation, coupled with provisions that allow the contractor latitude in proposing innovative ways of accomplishing the work, are sometimes more effective. Total contract costs can often be less when incentives rather than disincentives are used. Incentives are usually only used when a high level of productivity is required from the contractor to complete the contract or a portion of the contract as soon as possible to reduce road use costs and delays. Incentives are also used when a critical element of the work has significant public concern or political interest. The failure to complete these critical work elements on time can also have an undesirable negative effect and disincentives are included with incentives to emphasis the importance of the work.

Total road user costs are generated during the traffic analysis in the design stage of a project and can be the basis for determining disincentives or incentives in a contract.

(2) Road Closures

Closing a highway, street, or ramp, while not always practical, 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. The time necessary for construction is also reduced and work zone safety is significantly improved. Road closures usually minimize the on-site work zone traffic control, which in turn reduces the construction costs. Road closures can add to the cost of the project because off-site traffic control is needed to provide signing and improvements to detour routes, advanced motorist information signing, and media announcements.

Consider a roadway closure if an alternate route is available. The alternate route must have a sufficient lane capacity to carry the additional traffic volumes and the structural capacity of the pavement must be capable of withstanding the impact of heavier vehicles. Also, determine if there are any vertical clearance restrictions that will prevent trucks from using the route. See Chapter 1120 for vertical clearance requirements. A written agreement with the local agency is usually necessary to route additional traffic on to their roadways. A road closure might isolate private residences or deny access to businesses fronting the highway. State law prohibits "land-locking" property owners. If an alternate and reasonably direct access route is not available for these people, the road closure cannot be considered.

If a road closure is feasible, take the following actions:

- Obtain local agency approval to use a local roadway as a detour.

- Meet with the community and businesses to discuss the roadway closure and find ways to mitigate the community's concerns.
- Determine the maximum number of days allowed for the closure and incorporate this into the contract documents.
- Determine if liquidated damages or incentives for early completion will be necessary to ensure completion of the work within the time required.
- Determine if additional traffic control measures are needed at intersections on the detour route.
- Consider jobsite access for the contractor's workers and equipment.
- Contact emergency services, schools, transit, and civic organizations.
- Develop a method for conveying notification of the planned road closure to the public. Extensive multimedia approaches are necessary for the closures of major highways.

(3) Predicting Delay and Cost

In the work areas of long-term major projects, traffic delays, the possibility of crashes, and other factors contribute to the overall costs of a project. These costs, called user costs, are indirect, being societal, but are considered when proposing work zone traffic control options. These costs involve the following:

- Crashes and the resulting property damage, injuries, and possible fatalities.
- Vehicle delays and loss incurred by the motorist.
- Vehicle operation and fuel consumption.
- Business revenue losses.

Methods of predicting delay and costs are contained in the guidebook, *Planning and Scheduling Work Zone Traffic Control*. The Headquarter's Transportation Data Office can assist in providing factors for various societal costs. Options that provide the least cost to the public are then weighed against the project costs for providing traffic control. Restrictions on high volume highways for extended periods of time can result in extraordinarily higher user costs and might favor a road closure to reduce project costs.

810.07 Work Zone Safety

Effective work zone traffic control strategy encompasses the safety of all users and is not limited to providing clear guidance and warning to the motorist. Work areas present constantly changing roadway conditions that might be unexpected by the motorist and the likelihood of confusing some drivers is increased. The possibility of errant vehicle crashes creates a high degree of vulnerability for workers, flaggers, pedestrians, and bicyclists in the work zone.

(1) Workers

Working on or along the highway on construction projects is one of the more hazardous work environments in the state. 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. Consider the risk to workers when developing the traffic control plans for long-term stationary work zones.

Traffic barriers provide the most effective protection for workers and eliminate the need for flaggers and many traffic control devices. The costs of furnishing and removing temporary traffic barriers on longer duration projects can often be less than the cost associated with the frequent repositioning of other traffic control devices. Intrusion warning devices, used to alert workers to an errant vehicle that has intruded into the work zone, are ineffective on high-speed roadways because the worker has little time to react to the warning. Also, construction and traffic noise can mask the sound emitted from these devices.

(2) Flaggers

In a general sense, flaggers are also workers. Their function in the work zone, however, is uniquely different than other workers and they are treated as a separate group. Flaggers must perform their duties in extremely high-risk situations. Flaggers are not included in traffic control strategies until all other reasonable means of traffic control have been considered. More innovative traffic control methods such as temporary traffic signals, detour routes, and alternative traffic control plans can eliminate the need for flaggers.

Flaggers are normally used to stop traffic for short duration work activities such as intermittent lane closures. They can also be used to watch traffic and alert workers of the approach of an errant vehicle. 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 flaggers 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. Shortwave radios or cellular phones might be necessary to allow flaggers to communicate with one another when they are required to control traffic movements in shared right of way work zones.

(3) Road Users

Road users, rightfully, assume 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) **Motorist.** Effective planning and design of work area traffic control zones begins with the motorist. If motorists can easily understand the traffic control and have adequate time to react or make rational decisions, they will operate their vehicles in a safer 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. Perceived insufficient or conflicting information and too much information conveyed by signing will confuse the motorist and contribute to erratic driving behavior. Credibility might be damaged if signing and other devices warn the motorist of a condition that no longer exists.

(b) **Pedestrians.** Public highways and streets 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. All pedestrian facilities within the work zone must comply with ADA requirements for barrier-free access. See Chapter 1025 for pedestrian 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 mph, the bicyclist can use the same route as motorized vehicles. On higher speed facilities the bicyclist will not be able to match the speed of these motorized vehicles and a different route or detour is sometimes necessary for safety and to reduce vehicular delays. When this is not possible, the bicyclists can be instructed to dismount and walk their bikes through the work zone on the route provided for pedestrians.

Riding surfaces are important for safe bicycle operation. Loose gravel, uneven surfaces, milled pavement, and various asphaltic tack coats endanger the bicyclist. Consider the condition of the surface the bicyclist will be required to use. See Chapter 1020 for more bicycle design requirements.

(d) **Motorcycles.** The riding 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 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 signing for these conditions to alert the motorcycle rider.

(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 issue permits that allow these oversized vehicles to use these routes. If the proposed work zone will not accommodate these vehicles, provide adequate warning signs and notify the region's maintenance offices that issue these permits. In this 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 these oversized vehicles.

810.08 Regulatory Traffic Control Strategies

On highways with high posted speeds and aggressive drivers, traffic control measures can be difficult to enforce without the presence of police. Aggressive driver behavior is common in large metropolitan areas where commuters are a major component of the traffic. In these areas, consider strategies that rely on regulatory signing with law enforcement. The messages conveyed on regulatory signs, as shown in the MUTCD, can be enforced and citations can be issued by law enforcement agencies for infractions. Many signs within a work zone, however, are warning signs and compliance is a desired action and not a requirement. Even the advisory speed plaques installed under warning signs cannot be enforced.

(1) Enhanced Enforcement

Enhanced enforcement is the term used for stationing law enforcement personnel in the work zone. Their presence at the job site is to ensure compliance with motor vehicle laws and to moderate aggressive driver behavior. In general, work zones operate effectively if the correct strategy is implemented and law enforcement personnel are not necessary. Enhanced enforcement is only used when all other forms of traffic control can be shown to be ineffective in performance or excessive in cost.

When considering the use of enhanced enforcement, the initial determination is based on the designer's engineering judgment and the consensus of the region's maintenance, construction, traffic offices, and law enforcement input. Consider the following factors before proposing enhanced enforcement:

- The type of construction activity
- The complexity of the traffic control plans
- The possible need for a speed reduction
- Traffic volumes
- Excessively high speeds
- Abnormally high crash rates
- High frequency of DWI citations
- Nighttime work activities
- Geometric conditions
- Past history of traffic problems in similar areas

(2) Speed Reduction

The speed limits on state highways are set by the State Traffic Engineer and cannot be changed without approval. The speed limit for a facility is usually determined by conducting a speed survey and using the highest speed that 85 percent of the traffic drives.

Motorists tend to drive at a speed that seems appropriate for the conditions. Imposing an artificially low speed limit is rarely effective and even a speed reduction of 10 mph will have a very low compliance rate.

However, speed reductions can decrease crashes and work zone intrusions on high-speed multilane facilities when enhanced enforcement is present and the speed limit can be lowered temporarily during construction. Proposals to reduce the speed limit in these conditions are forwarded to the region's traffic office for consideration. Speed reduction guidelines are outlined in RCW 47.38.020, the *Construction Manual*, and Directive D 55-20, "Reduced Speed in Maintenance and Construction Zones."

The implementation of reduced speed zones is only considered when all other forms of traffic control are not effective in warning the motorist of conditions that require a slower operating speed. Examples of these conditions are:

- Reduced stopping sight distance
- Proximity to traffic barriers
- Severe roadway geometrics
- Extremely narrow lanes

810.09 Traffic Control Plans and Devices

The traffic control plans shown in the MUTCD and the Standard Plans provide the guidelines for individual situations. Most real-world locations have a combination of several situations and other geometric factors that require further augmentation of the traffic control. Traffic control devices are signs, traffic control signals, pavement markings, and other devices placed on or adjacent to a street or highway to regulate, warn, or guide traffic.

(1) Traffic Control Plans

Work zone traffic control plans are prepared for specific construction activities, such as lane reductions, closures, temporary bypasses, and the like, so the contractor has as much freedom as possible in scheduling the work. A specified construction sequence is not desirable because it might favor one contractor's methods of construction and might create an unacceptable bidding climate. All traffic control plans are site-specific in that the alignment of the roadway, lane configuration, intersection locations, and all other physical details peculiar to the project are shown. The traffic control plans shown in the Standard Plans cannot be used in WSDOT administered contracts. Contract specifications are used to identify when construction activities must be curtailed to maintain traffic flow.

The preparation of these plans and specifications requires the designer to not only have a thorough knowledge of highway construction activities but also 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. Traffic control plans are always designed from the perspective of motorists, pedestrians, and bicyclists' to provide the necessary information so they can 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 user's uncertainty.

(2) Physical Barriers

Physical barriers are used to both separate opposing traffic movements and separate the road users from the work zone. They are appropriate when errant vehicle intrusions into the work area are not acceptable. Unacceptable intrusions are those that can jeopardize the safety of the motorist or the workers. Three types of barrier protection are used in construction work zones. These are water-filled barriers, moveable barriers, and temporary concrete barriers.

Physical 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, barricades, or vertical panels do not provide adequate guidance for the motorist or protection for the worker.
- A multiple lane separation 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) **Water-filled barriers** are longitudinal barrier systems that use lightweight modules pinned together and filled with water. 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. Two different water filled barrier systems (Triton and Guardian) have been crash tested with the test vehicle striking the system at a 25 degree angle at 45 mph and 60 mph. The barriers deflected up to 13 ft at 45 mph and 23 ft at 60 mph. At lesser speeds and angles this deflection will be less. However, with this amount of deflection, water-filled barrier will generally not be practical when large deflections or penetration of the barrier system is undesirable. Therefore, they cannot be considered as a substitute for concrete barrier.

The minimum length of water-filled barrier is 100 ft. At a 45 mph impact, the leading 30 ft of the barrier does not contribute to the length of need. For 60 mph, the beginning 60 ft does not contribute to the length of need. One of the water-filled systems, the Triton Barrier, can act as its own end treatment if the end module is left empty and the retaining pin is left out of the exposed end. The other system, the Guardian, requires a crashworthy end treatment or a TMA on the approach end.

(b) **Moveable 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 it 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) **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 two to four 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.

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. Examples of impact attenuators are shown in Chapter 720.

(3) 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. They are most frequently used in short-term or mobile work zones.

(4) 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. Sign messages, color, configuration, and usage are shown in Part VI of the MUTCD. Sign mounting height and lateral placement requirements are somewhat different than those for permanent signing. These requirements are shown in Figures 810-2a and 2b. When preparing the work zone signing plan, review all existing signing in advance of and within the work zone for consistency. Cover or remove existing signs that can be misinterpreted or be inappropriate during construction.

(5) 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 collapsible sign supports or vehicles. Portable changeable message signs (PCMS) and arrow board displays have electronic displays that can be modified. These signs are usually mounted on trailers and use batteries or a generator to energize the electronic displays.

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 speed of traffic 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.

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

(6) Channelization Devices

Channelization devices are used to alert and guide the motorist through the work zone. They are a supplement to signing, pavement markings, and other work zone devices. Cones, tubular markers, and drums are shown in Figure 810-3. Barricade types are shown in Figure 810-4.

(a) **Cones.** Cones are either orange, fluorescent red-orange, or fluorescent yellow-orange in color and are constructed of a material that will not cause injury to the occupants of a vehicles when impacted. Eighteen-inch high cones can be used in the daytime on lower speed roadways. For nighttime operations and high speed roadways, reflectorized 28” high cones are necessary. Traffic cones are used to channelize traffic, divide opposing traffic lanes, and delineate short-term duration work zones.

(b) **Tubular Markers.** Tubular markers are fluorescent orange in color and are constructed of a material that will not cause injury on impact. They are available in heights from 18 inches to 4 feet. The taller marker is used on freeways and other high-speed highways or anyplace where more conspicuous guidance is needed. However, these taller markers, when placed near the edge of a traveled lane, can reduce the capacity of a traffic lane. The motorist will perceive the marker as a hazard and will either decelerate or attempt to move away from the marker to avoid contact. When the carrying capacity is critical, provide as much lateral clearance as possible to eliminate this problem. The shorter marker is less imposing in appearance and provides acceptable delineation.

(c) **Drums.** 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 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.

(d) **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.

- The Type I Barricade is used on lower speed roads and streets to mark a specific hazard or channelize traffic.
- The Type II Barricade is used on higher speed roadways and has more reflective area for nighttime use.
- The Type III Barricades are used for lane and road closures.
- The Direction Indicator Barricade 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.

(7) 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

See Chapter 840 for light level and other electrical design requirements. When flaggers are necessary for nighttime construction activities, always illuminate the flagger stations.

(8) Delineation

Pavement markings provide motorists with clear guidance of the path through the work zone and are necessary in all long-term work zones. Temporary pavement markings can be either painted, thermoplastic tape, or raised pavement markers. Remove existing confusing or contradictory pavement markings.

Other delineation devices are guideposts, concrete barrier delineators, and lateral clearance markers. These devices have retroreflective properties and are used as a supplement in delineating the traveled way during the nighttime. See Chapter 830 for guidepost delineation requirements. 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 four 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. Figure 810-5 shows examples of both types of barrier delineators.

(9) 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's reaction 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 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.

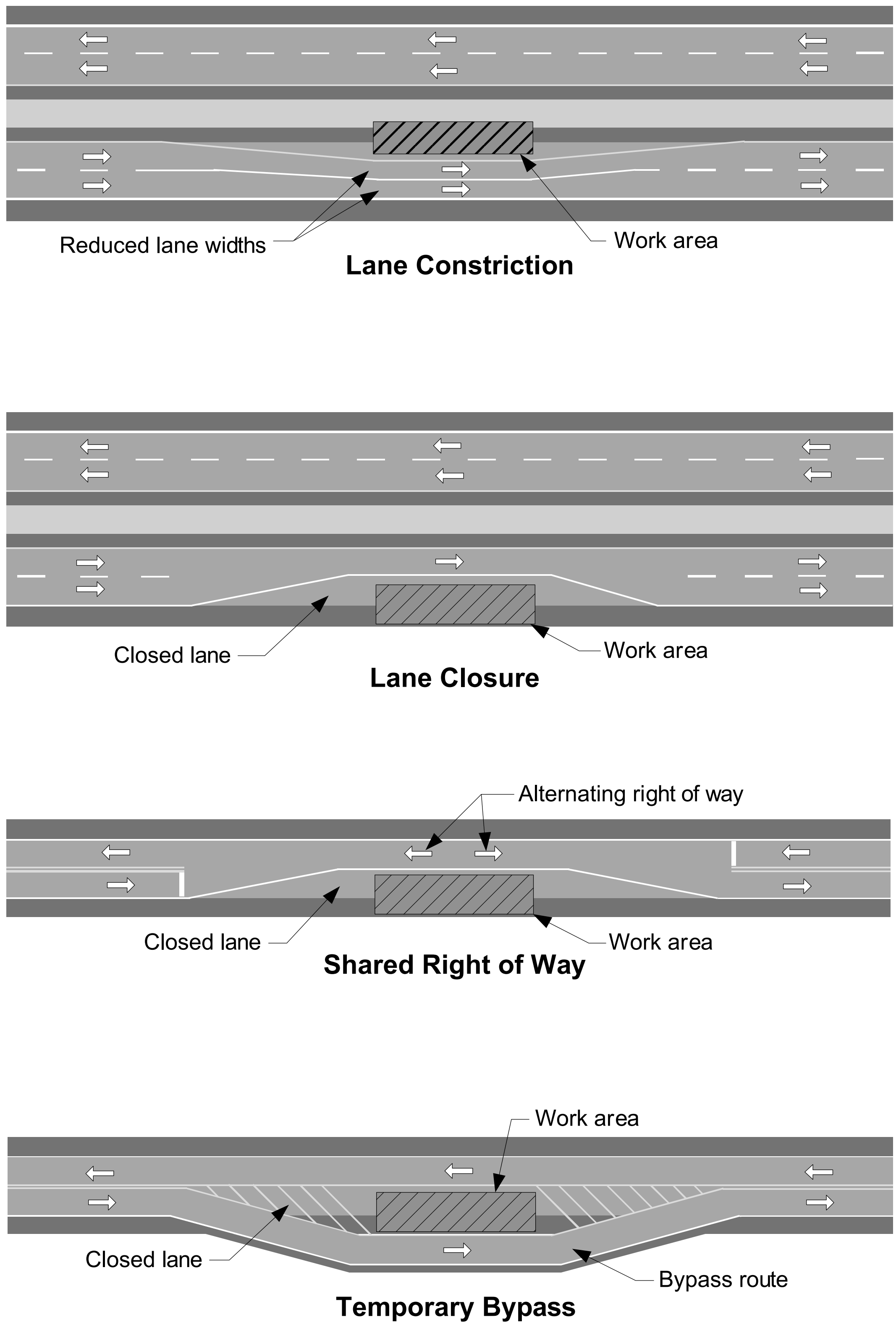
Another type of screening, glare screening, is also used on concrete barriers separating two-way traffic to reduce headlight glare from oncoming traffic. Vertical blade type screens are commonly used in this installation. This screening also reduces the potential for motorist confusion at nighttime by shielding the headlights of other vehicles on adjacent roadways or construction equipment. Make sure the motorist' sight distance to critical roadway features is not impaired by these glare screens.

(10) Portable Traffic Signals

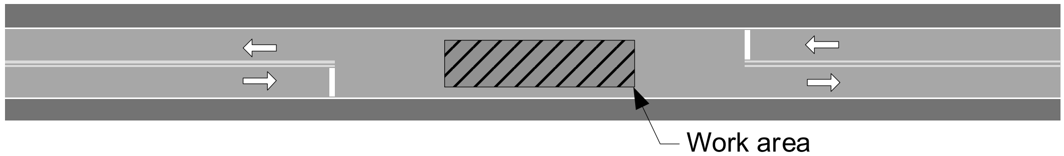
Portable traffic signals are conventional traffic signals used in work zones to control traffic. They are typically used on two-way, two-lane highways where one lane is closed and alternating traffic movements are necessary. They can also be used as a substitute for flaggers to stop traffic. See Chapter 850.

810.10 Documentation

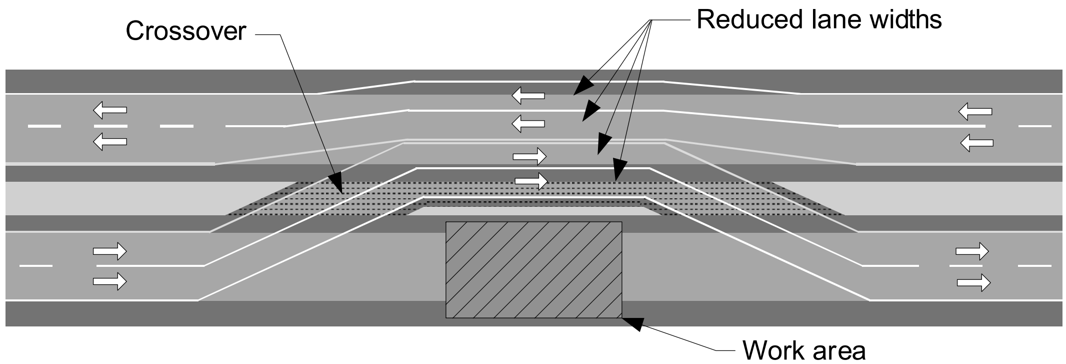
A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev



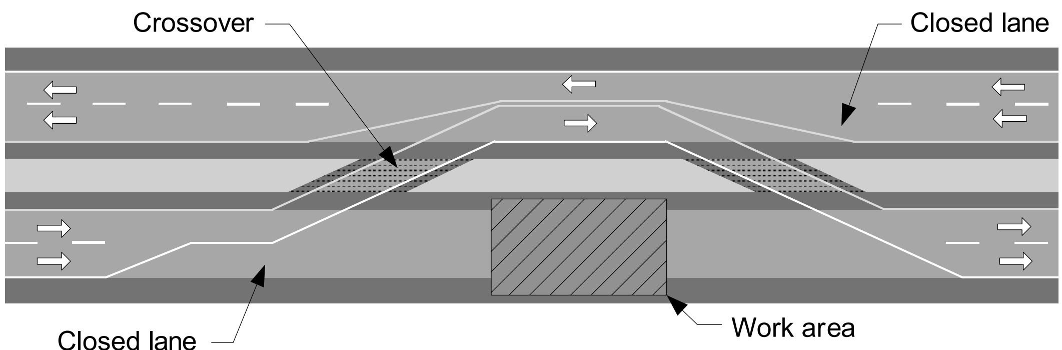
Work Zone Types
Figure 810-1a



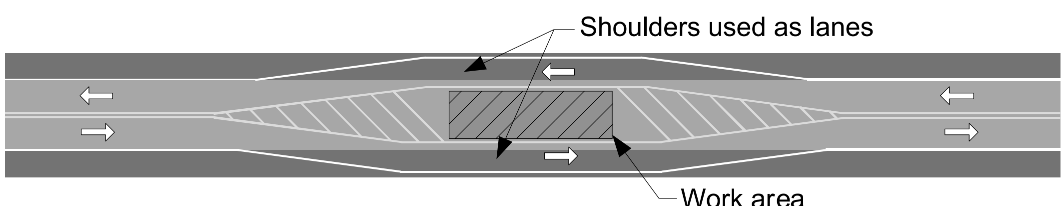
Intermittent Closure



Crossover (with lane constrictions)

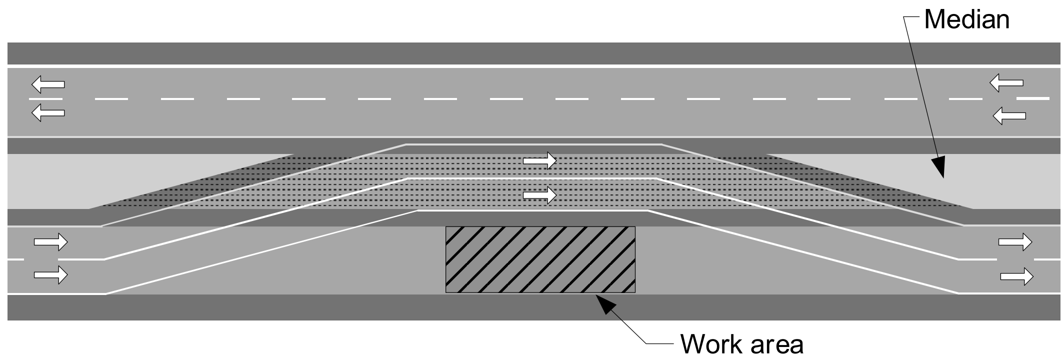


Crossover (with lane closures)

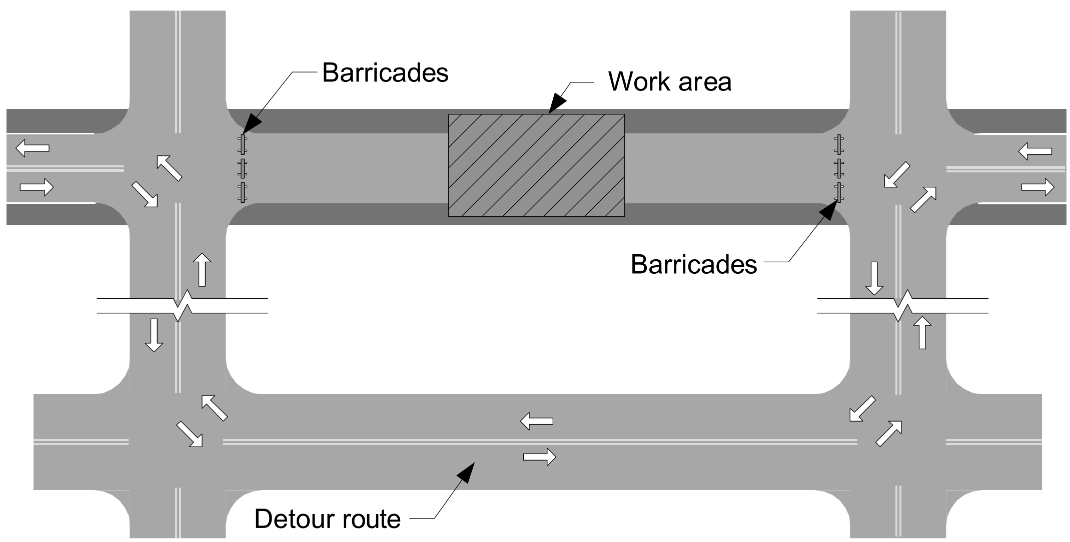


Shoulder Use

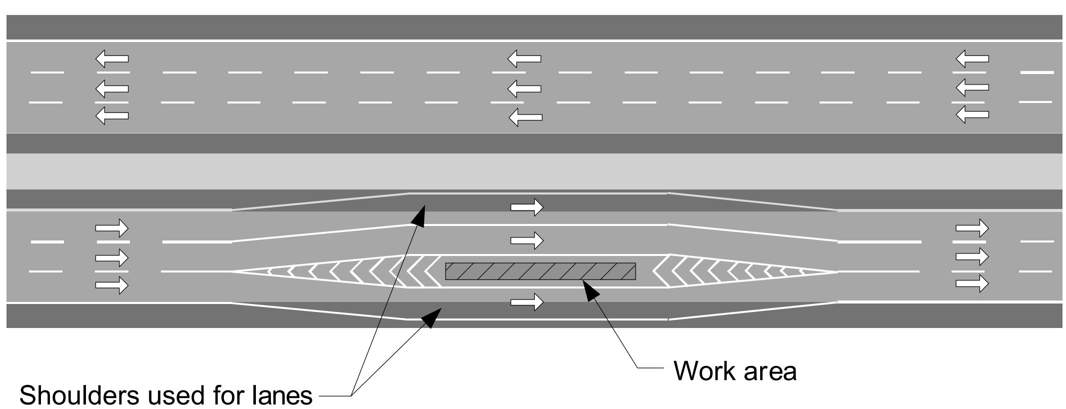
Work Zone Types
Figure 810-1b



Median Use

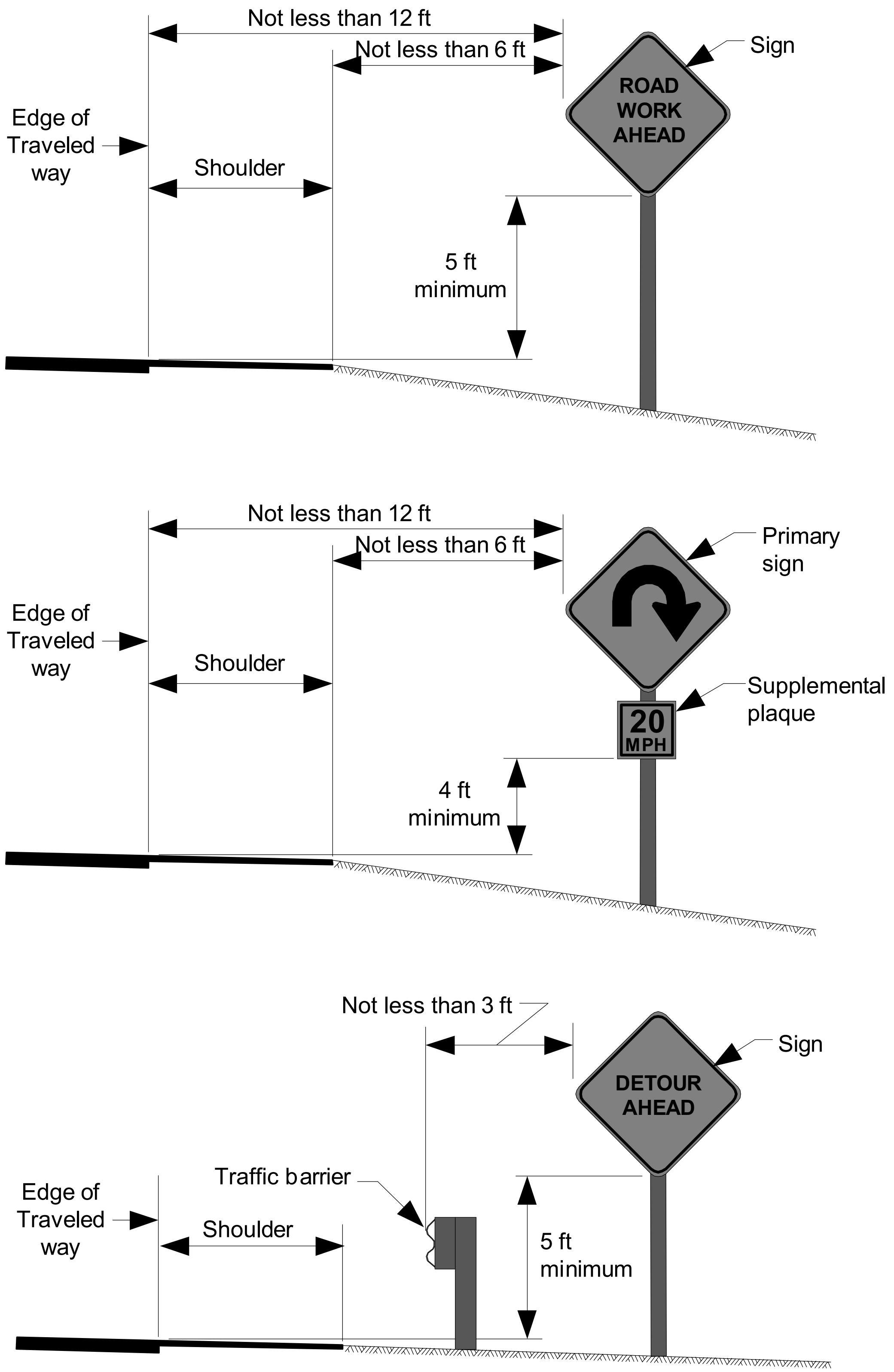


Detour

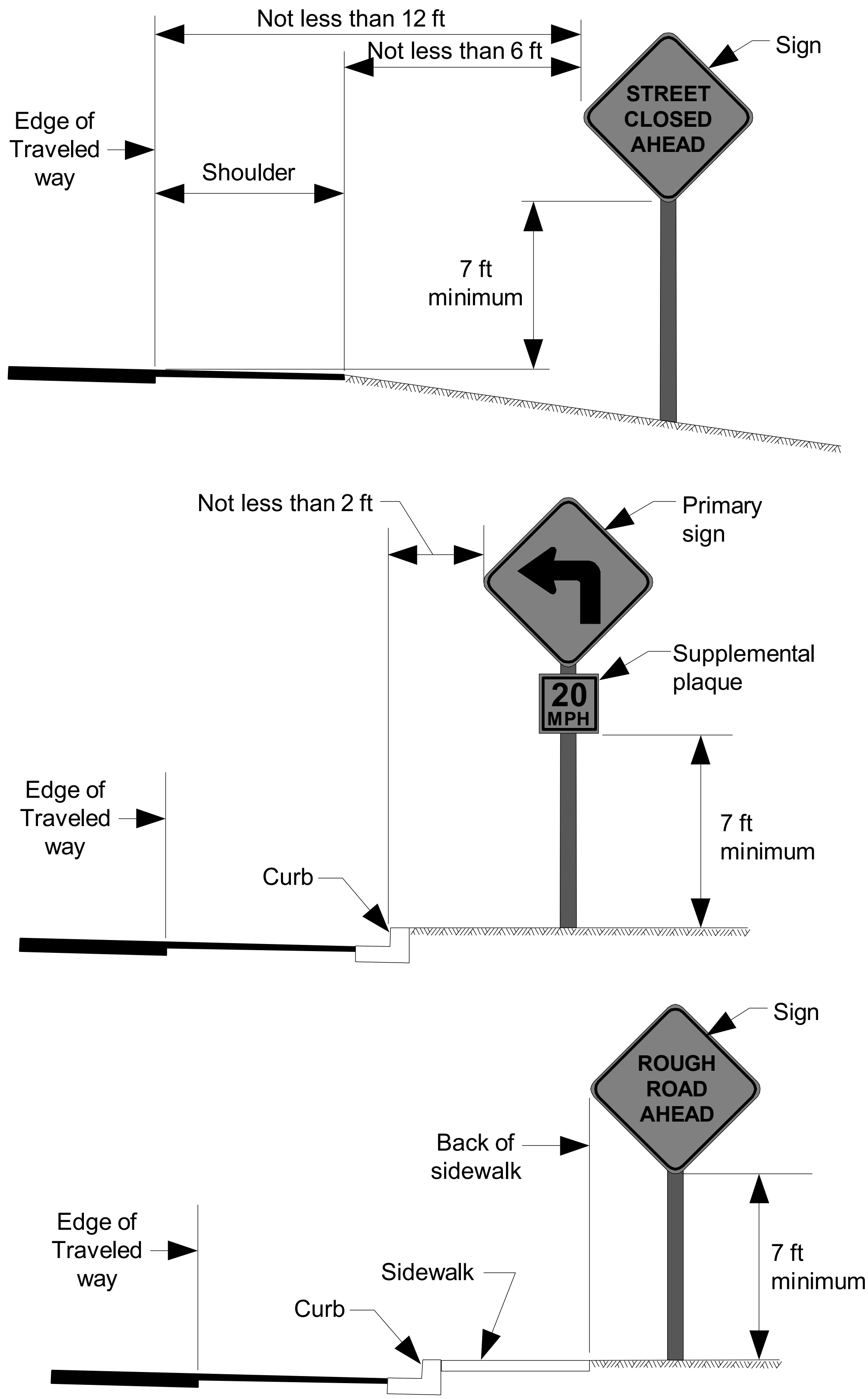


Multiple Lane Separation

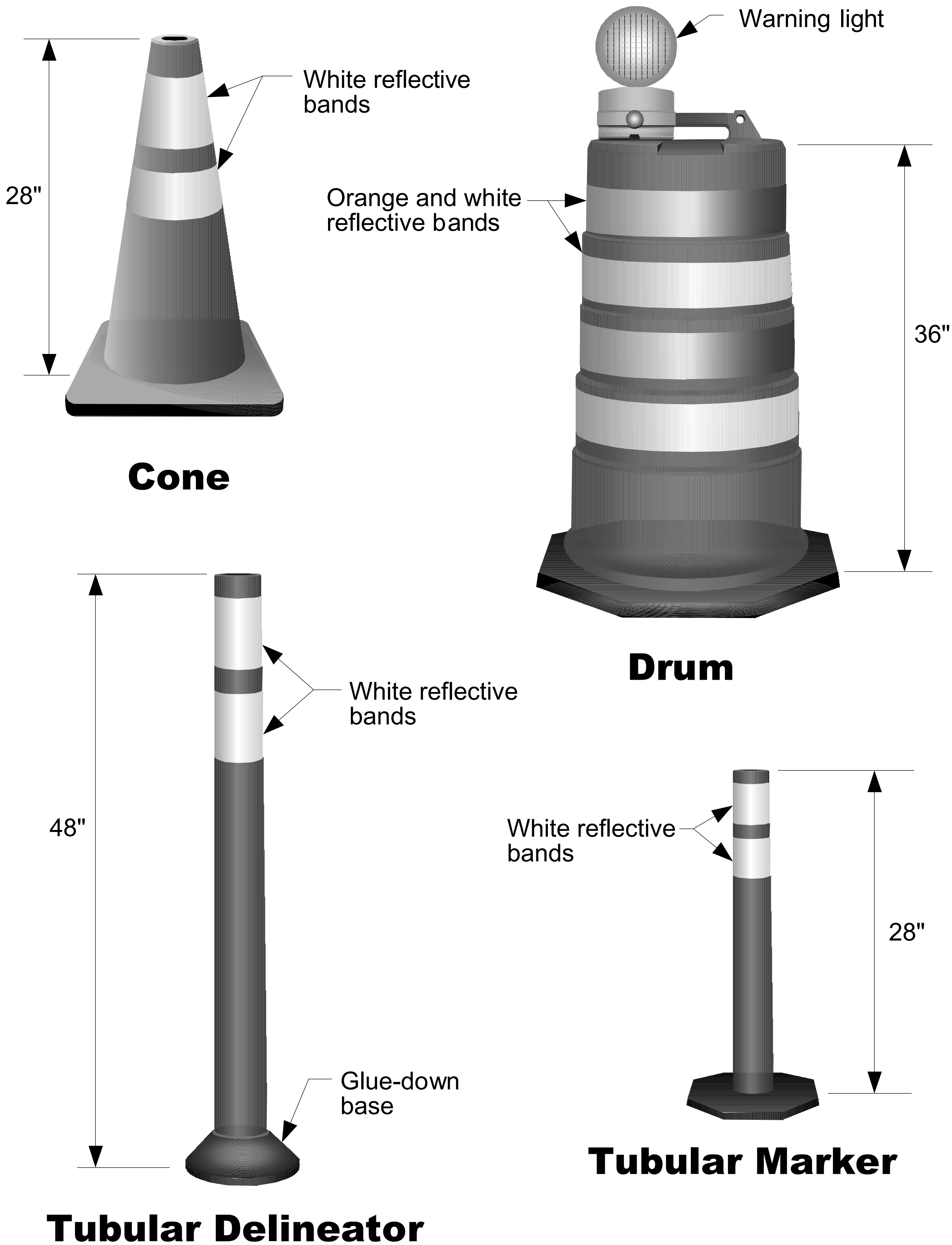
Work Zone Types
Figure 810-1c



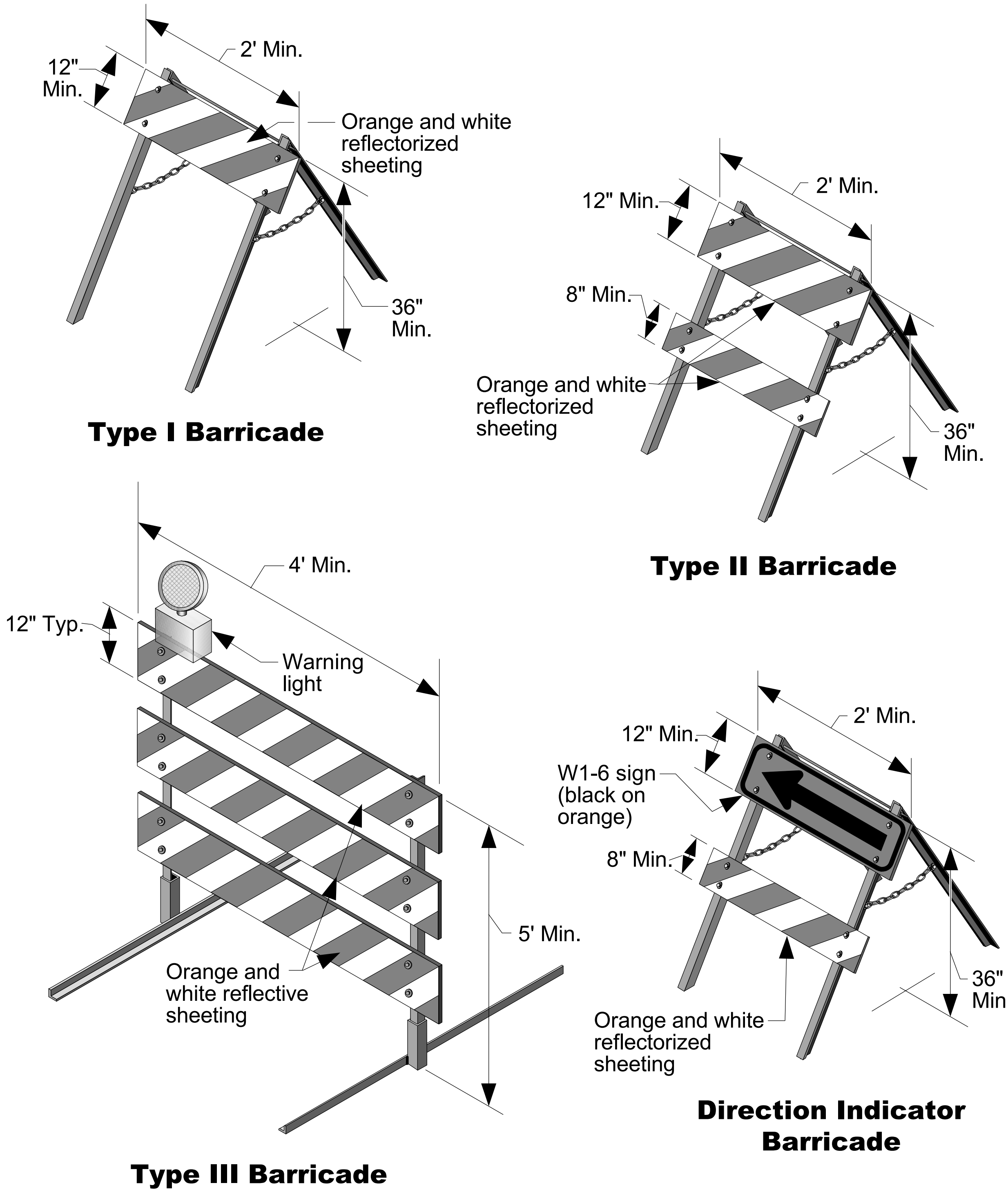
Sign Placement — Rural Areas
Figure 810-2a



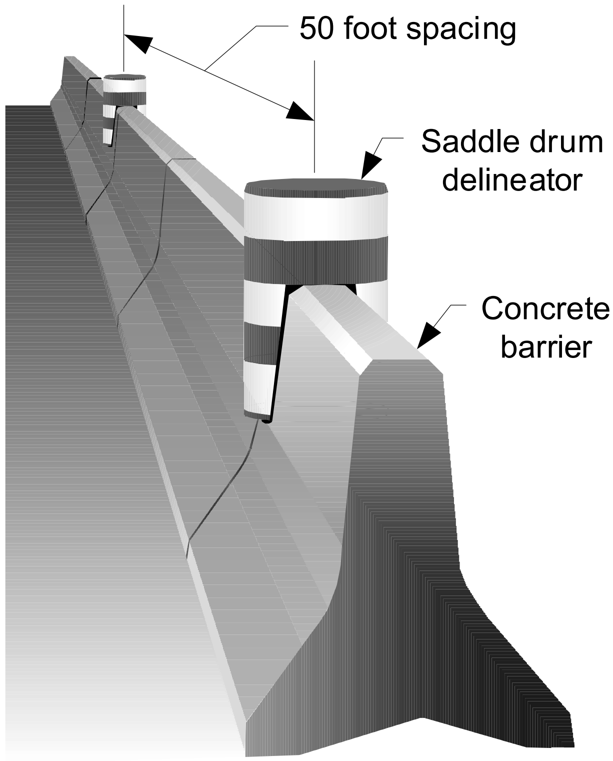
Sign Placement — Urban Areas
Figure 810-2b



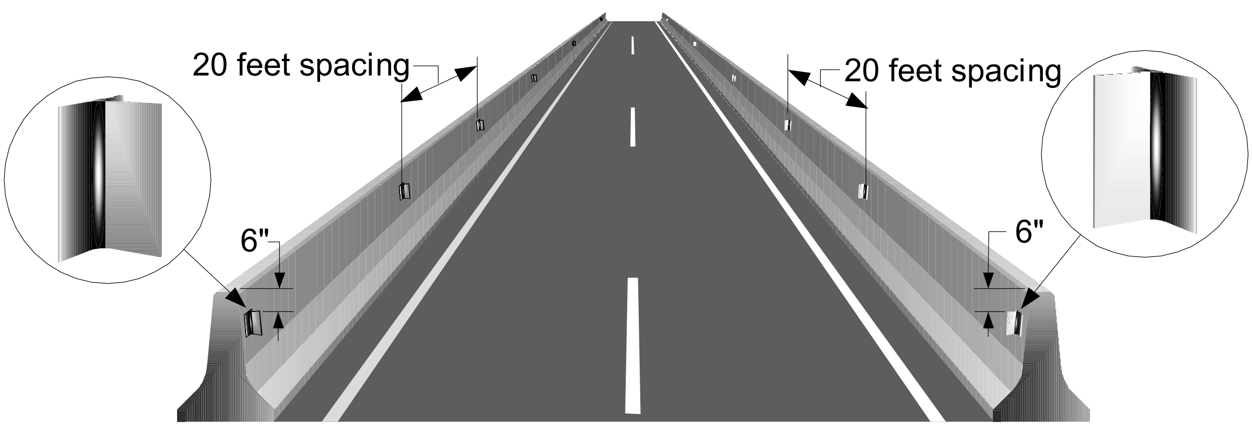
Channelization Devices
Figure 810-3



Barricade Types
Figure 810-4



Saddle Drum Delineators



Concrete Barrier Delineators

Note: Color of delineator matches color of adjacent edge line.

Barrier Delineators
Figure 810-5

820.01 General

Signing is a primary mechanism for regulating, warning, and guiding traffic. Signing must be in place when any section of highway is open to the motoring public. Each highway project has unique and specific signing requirements. For statewide signing uniformity and continuity, it is sometimes necessary to provide signing beyond the project limits. Design characteristics of the facility determine the size and legend for a sign. As the design speed increases, larger sign sizes are necessary to provide adequate message comprehension time. The MUTCD, the *Traffic Manual*, and the *Sign Fabrication Manual* contain standard sign dimensions, specific legends, and reflective sheeting types for all new signs. Guide signing provides the motorist with guidance to destinations. This information is always presented in a consistent manner. In some cases, there are specific laws, regulations, and policies governing the content of the messages on these signs. All proposed guide signs for a project require the approval of the region's Traffic Engineer. The use of nonstandard signs is strongly discouraged and their use requires the approval of the State Traffic Engineer.

The Design Matrices identify the design levels for signing on all preservation and improvement projects. These levels are indicated in the column "Signing" for Interstate main line and the column "Signing, Delineation, and Illumination" for all other routes.

Review and update existing signing within the limits of all preservation and improvement projects as indicated in the matrices. Provide standard signing on projects with either a "B" (basic design level) or "EU" (evaluate upgrade) matrix designation by applying the following criteria to determine the need to replace or modify existing signs:

- Lack of nighttime retroreflectivity.
- Substantial damage, vandalism, or deterioration.
- Age of signs (seven to ten years old).
- A change in sign use policy.
- Improper location.
- Message or destination changes necessary to satisfy commitments to public or local agencies.
- Substandard mounting height.
- Change in jurisdiction, for example a county road becomes a state route.

Address sign support breakaway features when identified in the "Clear Zone" columns of the Matrices. When the "F" (full design level) matrix designation is present, the preceding criteria are still applicable and all existing signing is required to conform to the current policy for reflective sign sheeting requirements. Remove or replace signing not conforming to this policy.

820.02 References

Revised Code of Washington (RCW) 47.36.030, Traffic control devices

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT, Washington DC, 1988, including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT, 1996

Traffic Manual, M 51-02, WSDOT

Sign Fabrication Manual, M 55-05, 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

Plans Preparation Manual, M 22-31, WSDOT

Directive D 32-20, "State Route Mileposts," WSDOT

820.03 Design Components

(1) Location

The MUTCD contains the guidelines for positioning signs. Check sign locations to ensure that the motorist's view of the sign is not obscured by other roadside appurtenances. Also, determine if the proposed sign will obstruct the view of other signs or limit the motorist's sight distance of the roadway. Reposition existing signs, when necessary, to satisfy these visibility requirements. Where possible, locate signs behind existing traffic barriers, on grade separation structures, or where terrain features will minimize their exposure to errant vehicles.

(2) Longitudinal Placement

The MUTCD and the *Traffic Manual* provide guidelines for the longitudinal placement of signs that are dependent on the type of sign. Select a location to fit the existing conditions to ensure visibility and adequate response time. In most cases, signs can be shifted longitudinally to enhance safety without compromising their intended purpose.

(3) Lateral Clearance

The MUTCD contains minimum requirements for the lateral placement of signs. These requirements are shown in Figures 820-1a and 820-1b. When possible, position the signs at the maximum practical lateral clearance for safety and reduced maintenance costs. Locate large guide signs and motorist information signs beyond the Design Clear Zone, when limited right of way or other physical constraints are not a factor. See Chapter 700. On steep fill slopes, an errant vehicle is likely to be partially airborne from the slope break near the edge of shoulder to a point 12 ft down the slope. When signs are placed on fill slopes steeper than 6:1, locate the support at least 12 ft beyond the slope break. Use breakaway sign support features, when required, for signs located within the Design Clear Zone and for signs located beyond this zone where there is a possibility they might be struck by an errant vehicle. Breakaway features are not necessary on sign posts located behind traffic barriers. Install longitudinal barrier to shield signs without breakaway features within the Design Clear Zone when no other options are available.

Sign bridges and cantilever sign structures have limited span lengths. Locate the vertical components of these structures as far from the traveled way as possible and, where appropriate, install traffic barriers or land forms. See Chapter 710.

Do not locate sign posts in the bottom of a ditch or where the posts will straddle the ditch. The preferred location is beyond the ditch or on the ditch backslope. In high fill areas, where conditions require placement of a sign behind a traffic barrier, consider adding embankment material to reduce the length of the sign supports.

(4) Sign Heights

For ground-mounted signs installed at the side of the road, provide a mounting height of at least 7 ft, measured from the bottom of the sign to the edge of traveled way. Supplemental plaques, when used, are mounted directly below the primary sign. At these locations, the minimum mounting height of the plaque is 5 ft.

Do not attach supplemental guide signs to the posts below the hinge mechanism or saw cut notch on multiple post installations. The location of these hinges or saw cuts on the sign supports are shown in the Standard Plans.

A minimum 7 ft vertical height from the bottom of the sign to the ground directly below the sign is necessary for the breakaway features of the sign support to function properly when struck by a vehicle. The minimum mounting height for new signs located behind longitudinal barriers is 7 ft, measured from the bottom of the sign to the edge of traveled way. A lower mounting height of 5 ft may be used when replacing a sign panel on an existing sign assembly located behind longitudinal barrier.

Signs used to reserve parking for people with disabilities are installed at each designated parking stall and are mounted between 3 ft and 7 ft above the surface at the sign location. Figures 820-1a and 820-1b show typical sign installations.

(5) Foundations

Foundation details for wood and steel ground mounted sign supports are shown in the Standard Plans. That manual also contains foundation designs for truss-type sign bridges and cantilever sign structures. Three designs, Types 1, 2, and 3, are shown for each structure.

An investigation of the foundation material is necessary to determine the appropriate foundation design. The Type 1 foundation design uses a large concrete shaft and is the preferred installation when the lateral bearing pressure of the soil is 2,500 psf or greater. The Type 2 foundation has a large rectangular footing design and is an alternate to the Type 1 foundation when the concrete shaft is not suitable. The Type 3 foundation is used in poorer soil conditions where the lateral bearing pressure of the soil is between 1,500 psf and 2,500 psf. Use the data obtained from the geotechnical report to select the foundation type.

If a nonstandard foundation or monotube structure design is planned, forward the report to the Bridge and Structures Office for their use in developing a suitable foundation design. See Chapter 510.

(6) Sign Posts

Ground mounted signs are installed on either wood posts, laminated wood box posts, or steel posts. The size and number of posts required for a sign installation are based on the height and surface area of the sign, or signs, being supported. Use the information in Figures 820-2, 820-3, and 820-4 to determine the posts required for each installation. Use steel posts with breakaway supports that are multidirectional if the support is likely to be hit from more than one direction. Design features of breakaway supports are shown in the Standard Plans. Steel posts with Type 2A and 2B bases have multidirectional breakaway features.

820.04 Overhead Installation

Conditions justifying the use of overhead sign installations are noted in the MUTCD. Where possible, mount overhead signs on grade separation structures rather than sign bridges or cantilever supports.

Details for the construction of truss-type sign bridges and cantilever sign supports are shown in the Standard Plans.

The Bridge and Structures Office designs structure mounted sign mountings, monotube sign bridges, and monotube cantilever sign supports. For overhead sign installation designs, provide sign dimensions, horizontal location in relation to the roadway, and the location of the lighting fixtures, to facilitate design of the mounting components by the Bridge and Structures Office.

(1) Illumination

In urban areas, all overhead signs on multilane highways are illuminated. In rural areas, all overhead regulatory and warning signs including guide signs with “Exit Only” panels on both multilane and conventional highways are illuminated. All other overhead signs are only illuminated when one of the following conditions is present:

- Sign visibility is less than 800 ft due to intervening sight obstructions such as highway structures or roadside features
- Ambient light from a non-highway light source interferes with the sign’s legibility
- The sign assembly includes a flashing beacon

Sign illumination is provided with sign lighting fixtures mounted directly below the sign. The light source of the fixture is a 175 watt mercury vapor lamp. Provide one sign light for a sign with a width of 16 ft or less. For wider signs, provide two or more sign lights with a spacing not exceeding 16 ft. If two or more closely spaced signs are in the same vertical plane on the structure, consider the signs as one unit and use a uniform light fixture spacing for the entire width.

Voltage drops can be significant when the electrical service is not nearby. See Chapter 840 for guidance in calculating electrical line loss.

In areas where an electrical power source is more than $^1/_2$ mile away, utility company installation costs can be prohibitive. Reconsider the benefit of an overhead sign installation at these locations.

(2) Vertical Clearance

The minimum vertical clearance from the roadway surface to the lowest point of an overhead sign assembly is 17 ft-6 in. The maximum clearance is 21 ft.

(3) Horizontal Placement

Consider roadway geometrics and anticipated traffic characteristics in order to locate signs above the lane, or lanes, to which they apply. Install advance guide signs and exit direction signs that require an EXIT ONLY and "down arrow" panel directly above the drop lanes. To reduce driver confusion as to which lane is being dropped, avoid locating a sign with an EXIT ONLY panel on a horizontal curve.

(4) Service Walkways

Walkways are provided on structure-mounted signs, truss-type sign bridges, and truss-type cantilever sign supports where the roadway and traffic conditions prohibit normal sign maintenance activities. Normally, monotube sign bridges and cantilever sign supports do not have service walkways.

Vandalism of signs, particularly in the form of graffiti, can be a major problem in some areas. Vandals sometimes use the service walkways. Maintenance costs in cleaning or replacing vandalized signs at these locations can exceed the benefit of providing the service walkway.

820.05 Mileposts

Milepost markers are a part of a statewide system for all state highways and are installed in accordance with the Directive D 32-20, State Route Mileposts.

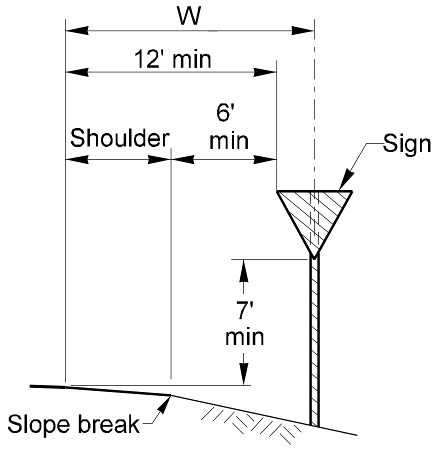
820.06 Guide Sign Plan

A guide sign plan is used by the region to identify existing and proposed guide signing on state highways. The plan provides an easily understood graphic representation of the signing and allows assessment of the continuity in signing to motorist destinations, activities, and services. It is also used to identify deficiencies or poorly defined routes of travel. A guide sign plan for safety and mobility improvement projects is desirable. When proposed highway work affects signing to a city or town, the guide sign plan can be furnished to the official governing body for review and consideration. The guide sign plan is reviewed and approved by the region's Traffic Engineer.

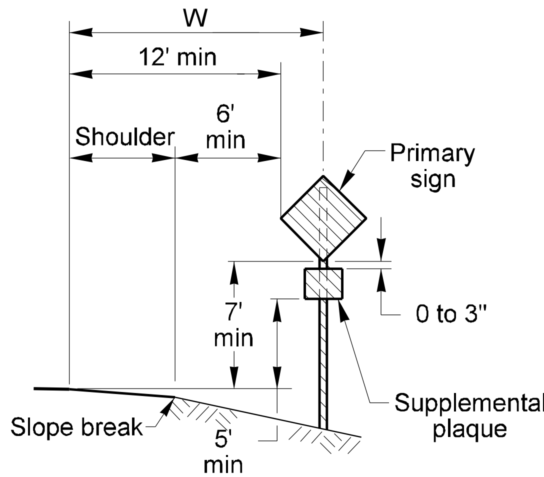
820.07 Documentation

Include the following items in the project file:

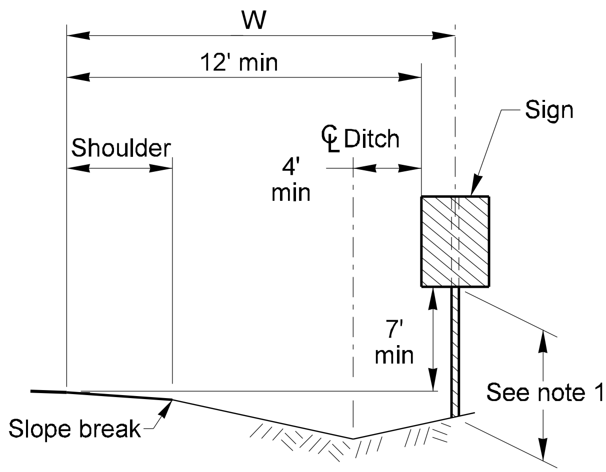
- ☐ An inventory of all existing signing within the project limits
- ☐ Approval of proposed guide signs
- ☐ Approval of non-standard signs
- ☐ Soils investigations for all sign bridge and cantilever sign supports



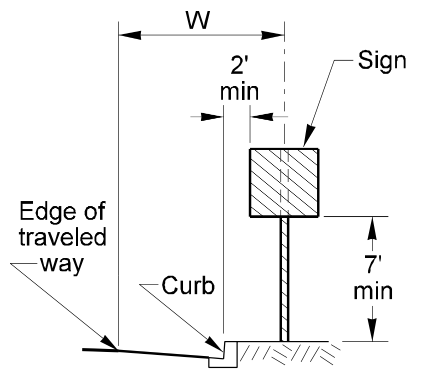
Sign Installation in Fill Section



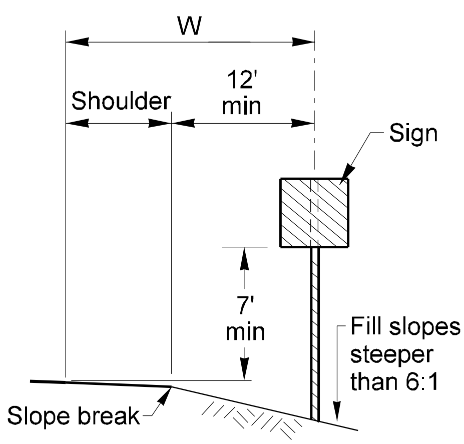
Sign with Supplemental Plaque Installation in Fill Section



Sign Installation in Ditch section



Sign Installation in Curb Section



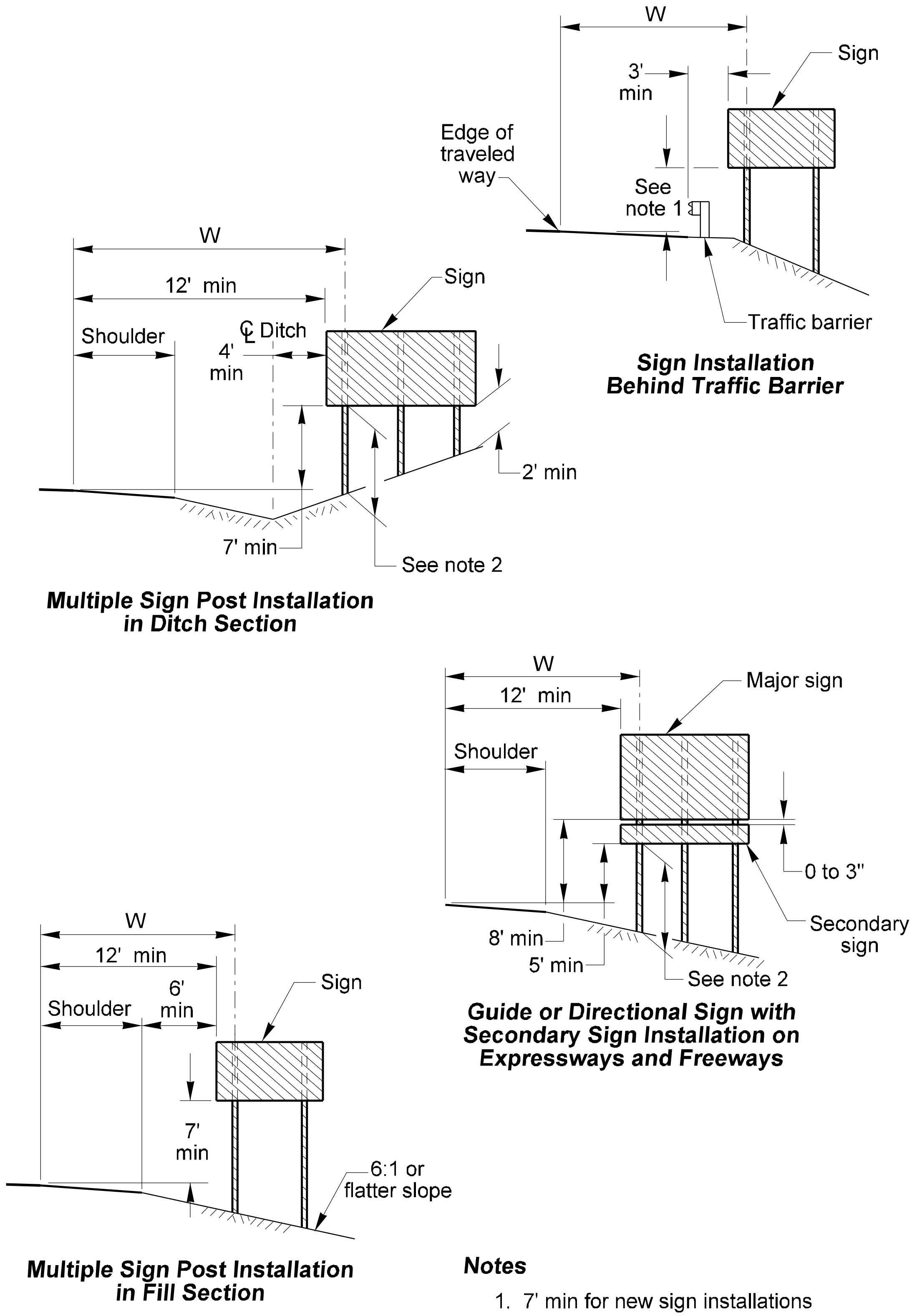
Sign Installation on Steep Fill Slopes

Notes

1. 7' min vertical clearance for sign supports with breakaway features

Sign Support Locations

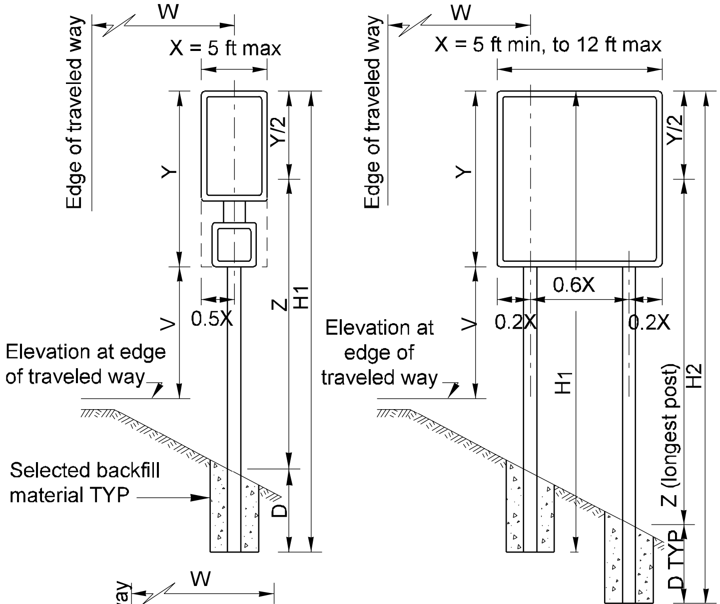
Figure 820-1a



Notes

1. 7' min for new sign installations
   5' min for existing sign installations
2. 7' min vertical clearance for sign supports with breakaway features

Sign Support Locations
Figure 820-1b



For the purpose of post selection, X and Y are as follows:

Single sign, or back-to-back signs, X and Y are the overall dimensions of the sign.

Multiple sign installations, X and Y are the dimensions of a rectangle enclosing all signs.

Z is the height from ground line to mid-height of sign at longest post.

H1 + H2, etc., equals overall post length.

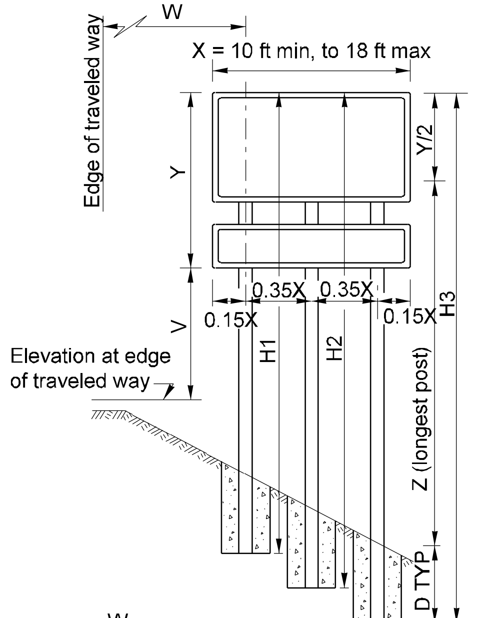
D is the required post embedment depth.

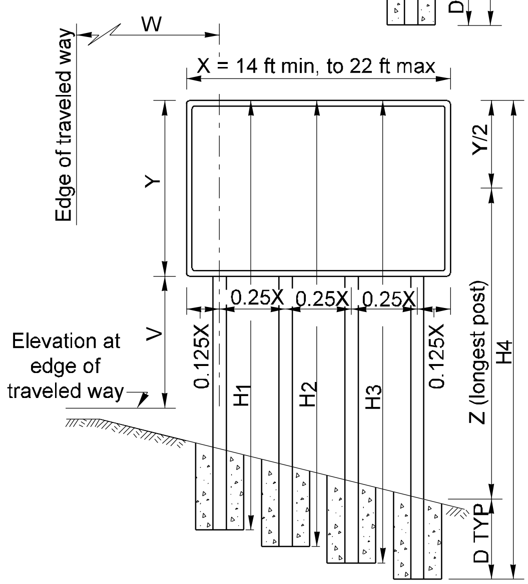
V is the vertical clearance from edge of traveled way.

Post size	(X)(Y)(Z) in ft^3 * *				D
	1 Post	2 Post	3 Post	4 Post	
4x4	60*	135	175	235	3 ft
4x6	175*	355	530	705	4 ft
6x6	210	425	635	845	4 ft
6x8	300	850	1280	1700	4 ft
6x10	385	1180	1770	2360	5 ft
8x10	575	1610	2410	3215	5 ft
8x12	775	2310	3465	4620	6 ft

*Single post application utilizing Western Red Cedar has (X)(Y)(Z) allowable of 50 and 155 respectively.

**Values shown are the maximum permitted. If the quantity (X)(Y)(Z) exceeds the limit for 8X12 posts, use steel post installations.





When sign is to be located in the clear zone or outside of the clear zone, but in an area where it is likely to be struck by an errant vehicle, the following configurations are not permitted:

1. Timber posts larger than 6X8.
2. Signs less than 12 ft wide and three 6X6 or larger posts.
3. Signs less than 17 ft wide and four 6X6 or larger posts.

Use steel or laminated wood posts in these situations.

Design Example

Given: 36 in wide, 42 in high sign with a 18 in wide, 24 in high sign mounted 3 in below. 8 ft shoulder with 2% slope and 6H:1V embankment. W = 15 ft.
V =5 ft.

Solution: Use single post. X=3 ft, Y=5.75 ft, Z=5.75/2 +(0.02x8)+5 + 7/6 = 9.21. (X)(Y)(Z)=3x5.75x9.21=159 ft^3. From table, select smallest post having (X)(Y)(Z) of 159 ft^3 or more. Use 4X6 post. H=Z + Y/2 + D=9.46 + 6.25/2 + 4.0=16.6 ft. Use 6X6 when using Western Red Cedar.

Design Example

Given: 10 ft wide. 4 ft high sign. 10 ft shoulder with 2% slope and 6H:1V embankment. W=35 ft. V=7 ft. Assume sign is inside of clear zone.

Solution: Try two posts. X=10 ft, Y=4 ft, Z=4/2 + 7 + (0.02x10) + (25 + 0.6x10)/6=14.37 ft. (X)(Y)(Z)=10x4x14.37=5.75 ft. From table, select smallest post having (X)(Y)(Z) of 575 or more. Two 6X6 posts are not sufficient, use 6X8 posts because three 6X6 posts would require a traffic barrier.

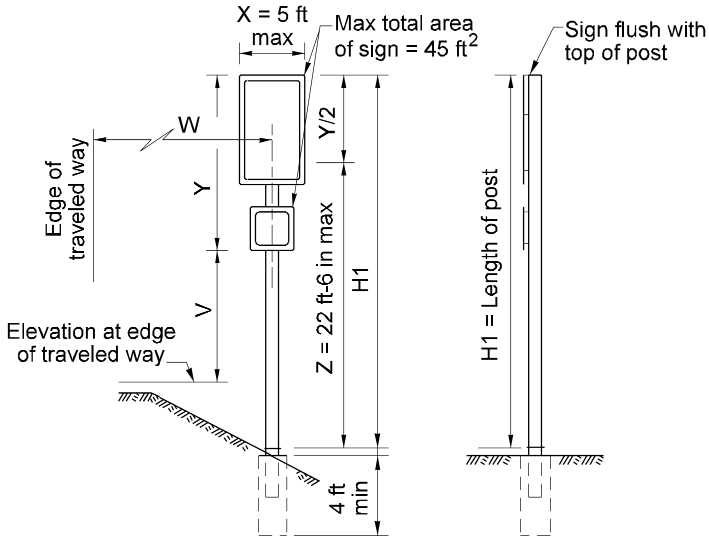
H2=14.37 + 2 + 4=20.4 ft

H1=20.4 - (0.6x10)/6=19.8 ft

All dimensions are in ft unless otherwise noted.

Wood Posts

Figure 820-2



For the purpose of post selection, X and Y are as follows:

Single sign, or back-to-back signs, X and Y are the overall dimensions of the sign.

Multiple sign installations, X and Y are the dimensions of a rectangle enclosing all signs.

Z is the height from the base connection (2 1/2 in above the post foundation) to mid-height of sign at the longest post.

H1, H2, etc., equals overall post length (base connection to top of sign).

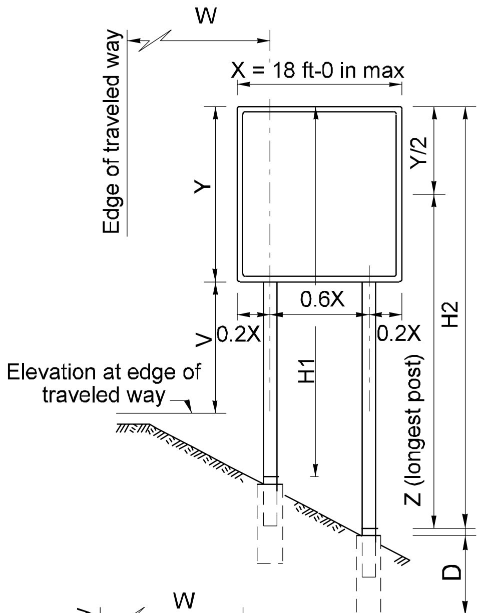
D is the required post embedment depth (see standard plans).

V is the vertical clearance from the edge of traveled way.

Single Post Signs

For a maximum 20 ft^2 sign, use 4 in standard pipe for Z less than 18 ft 6 in or 5 in standard pipe for Z greater than 18 ft 6 in.

For a maximum 45 ft^2 sign, use 5 in standard pipe for Z less than 15 ft 6 in or 6 in standard pipe for Z greater than 15 ft 6 in.



Two and Three post signs

Post Selection (X)(Y)(Z) in ft^3*		Post Size	
2 Posts	3 Posts	* *	AASHTO M183
1570	2355	W6x9	W6x12
2810	4220	W6x12	W6x16
4940	7410	W8x18	W8x21
7580	11370	W10x22	W10x26

*Value shown are the maximum permitted.

* *AASHTO M222 or M223 may be used as an acceptable alternative to AASHTO M 183 at the sizes listed.

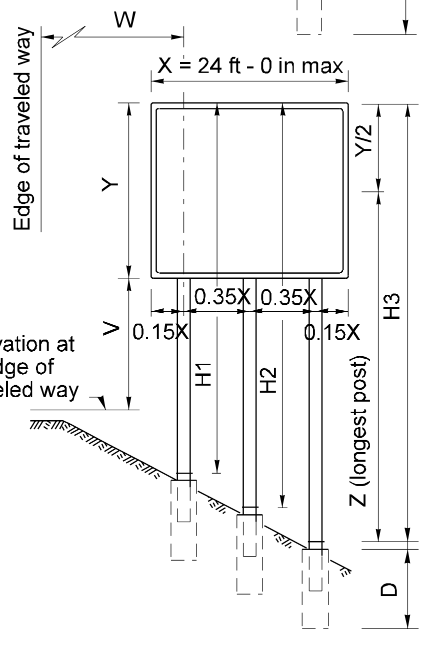
Design Example

Given: 22 ft wide, 12 ft high sign. 10 ft shoulder with 2% slope and a 3H:1V embankment slope. W = 32 ft.

Solution: Use three posts. X = 22 ft, Y = 12 ft, V = 7 ft, Z = 12/2 + 7 + (0.02x10) + (22 + 0.70x22)/3 - 0.21 = 25.46 ft. (X)(Y)(Z) = 22x12x25.46 = 6721 ft^3. From table, select smallest post having (X)(Y)(Z) of 6721 or more. Use W8x18 (AASHTO M222 or M223) or W8x21 (AASHTO M183) posts.

H3 = 25.46 + 12/2 = 31.46 ft = 31 ft 5 1/2 in
H2 = 31.46 - (0.35x22)/3 = 28.89 ft = 28 ft 10 5/8 in
H1 = 31.46 - (0.70x22)/3 = 26.33 ft = 26 ft 4 in

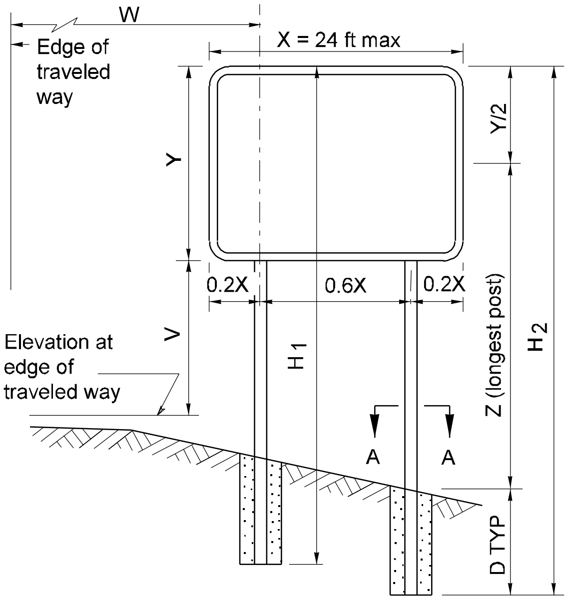
For any sign installation located within the clear zone distance of the lane edge, the total weight of all the posts in the 7 ft wide path shall not exceed a combined post weight of 36 lbs/ft. If the proposed sign configuration does not meet this criteria, relocate, resize or provide additional protection for the proposed installation.
Use the following table to determine post weights.
All dimensions are in feet unless otherwise noted.



Wide Flange Beam Dimensions

Beam size	Weight lbs/ft
W6x9	9
W6x12	12
W6x16	16
W8x18	18
W8x21	21
W10x22	22
W10x26	26

Steel Posts
Figure 820-3



For the purpose of post selection, X and Y are as follows:

Single sign, or back-to-back signs. X and Y are the overall dimensions for the sign.

Multiple sign installations, X and Y are the dimensions of a rectangle enclosing all signs.

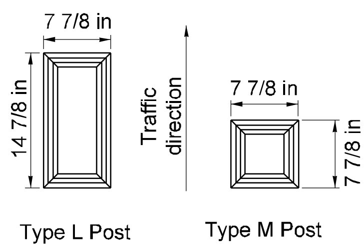
Z is the height from ground line to mid-height of sign at the longest post.

H_1 and H_2 equal overall post length.

D is the required post embedment depth.

V is the vertical clearance from edge of traveled way.

Box Post Type	Z (ft)	(X)(Y)(Z) ft^3
M	15 < Z < = 30	1329
M	Z < 15	1661
L	15 < Z < = 30	3502
L	Z < 15	4378



SECTION A-A

Design Example
Given: 16 ft wide, 6 ft high sign. 10 ft shoulder with 2% slope and a 6H:1V embankment. W = 25 ft. V = 7 ft.
Solution: Use two posts. X = 16 ft. Y = 6 ft.
For two posts: Z = 6/2 + 7 +(0.02x10) + (15 + 0.6x16)/6 = 14.3 ft.
(X)(Y)(Z) = 16x6x14.3 = 1,373 ft^3
From table, select smallest post having (X)(Y)(Z) of 1,373 or more and meets the "Z" requirements.
Use two M posts

H_2 = Z + Y/2 + D = 14.3 + 3.0 + 6.0 = 23.3 ft.

H_1 = 23.3 - (0.6x16)/6 = 21.7 ft.

Design Example
Given: 18 ft wide, 8 ft high sign, 10 ft shoulder with 2% slope and a 6H:1V embankment. W = 25 ft, V = 7 ft.

Solution: Use two posts. X = 18 ft, Y = 8 ft.
For two posts: Z = 8/2 + 7 + (0.02x10) + (15 + 0.6x18)/6 = 15.5 ft.
(X)(Y)(Z) = 18x8x15.5 = 2,232 ft^3.
From table, select smallest post having (X)(Y)(Z) of 2,232 or more and meets the "Z" requirements.
Use two L posts.

H_2 = Z + Y/2 + D = 15.5 + 4.0 + 9.0 = 28.5 ft.

H_1 = 28.5 - (0.6x18)/6 = 26.7 ft.

All dimensions are in feet unless otherwise noted.

Z (ft)	Total Sign Area (Square Feet)					
	Up to 50	51 to 100	101 to 150	151 to 200	201 to 250	251 to 290
9 to 12	6	6	7	8	9	10
12.1 to 15	6	6	7.5	9	10	
15.1 to 18	7.0	7.5	9			
18.1 to 22	7.0	8	10		Not Permitted	
22.1 to 26	7.5	8.5				

Laminated Post Embedment Depth

Laminated Wood Box Posts

Figure 820-4

830.01 General

The primary function of delineation is to provide the visual information needed by the driver to operate a vehicle safely in a variety of situations. Delineation can be the marking of highways with painted or more durable pavement marking lines and symbols, guide posts, and other devices. These devices use retroreflectance, reflecting light from a vehicle's headlights back to the driver, to enhance their visibility at nighttime. WSDOT uses the latest edition of FHWA's *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) as a guide for design, location, and application of delineation.

Delineation is a required safety item of work and is addressed on all projects. A decision to omit delineation work can only be justified if the existing delineation is unaffected by construction and an evaluation of accident rates clearly shows that delineation is not a contributing factor.

830.02 References

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT, Washington, DC, 1988, including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT, 1996

Roadway Delineation Practices Handbook, FHWA report, Washington, DC, 1994

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

Sign Fabrication Manual, M 55-05, WSDOT

830.03 Pavement Markings

(1) Pavement Marking Types

Pavement markings have specific functions. They guide the movement of traffic and promote safety on the highway. In some cases, they are used to supplement the messages of other traffic control devices. In other cases, markings are the only way to convey a message without distracting the driver. Pavement markings are installed and maintained to provide adequate performance year round. Adequate performance is defined as meaning the marking meets or exceeds standards of both daytime and nighttime visibility. Pavement markings are classified as either longitudinal or transverse. Centerlines, lane lines, where applicable, and edge lines, except as noted, are required on all paved State highways unless an exception is granted by the State Traffic Engineer with justification. Guidelines for the application of various pavement markings are provided in Chapter 910 for intersections and channelization, Chapter 940 for interchanges, and the Standard Plans.

(a) Longitudinal pavement markings define the boundary between opposing traffic flows. They also define the edges of traveled way, multiple traffic lanes, turn lanes, and special use lanes. Longitudinal pavement markings are:

skip center line. A broken yellow line used to separate lanes of traffic moving in opposite directions, where passing in the opposing lane is allowed.

double yellow center line. Two parallel solid yellow lines used to separate lanes of traffic moving in opposite directions where passing in the opposing lane is prohibited.

edge line. A solid white line used to define the outer edge of the traveled way. Edge lines are not required where curbs or sidewalks are 4 ft or less from the traveled way.

dotted extension line. A broken white line that is an extension of an edge line used at exit ramps, intersections on horizontal curves, and other locations where the direction of travel for through traffic is unclear.

wide line. A wide solid white line used to separate lanes of traffic moving in the same direction at ramp connections, storage lanes at intersections, and high occupancy vehicle lanes.

wide dotted line. A wide broken white line used to designate a portion of a high occupancy vehicle lane located on an arterial highway where general purpose vehicles may enter to make a turn at an intersection.

wide skip line. A wide broken white line used to designate a portion of a high occupancy vehicle lane located on a divided highway where general purpose vehicles may enter to make an exit.

lane line. A broken white line used to separate lanes of traffic moving in the same direction.

drop lane line. A wide broken white line used in advance of a wide line to delineate a lane that ends at an off ramp or intersection.

no-pass line. A solid yellow line used in conjunction with a skip center line where passing in the opposing lane is prohibited.

reversible lane line. Two broken yellow lines used to delineate a lane where traffic direction is periodically reversed.

two way left turn line. Two yellow lines, one solid and one broken, used to delineate each side of a two way left turn lane.

barrier line. A very wide solid yellow line used to separate opposing traffic movements where all movements over the line are prohibited. Barrier line locations require the approval of the region's Traffic Engineer.

(b) Transverse pavement markings define pedestrian crossings and vehicle stopping points at intersections. They are also used to warn the motorist of approaching conditions, required vehicular maneuvers, or lane usage. Typical transverse pavement markings are:

crosswalk line. A series of parallel solid white lines used to define a pedestrian crossing.

stop bar. A solid white line used to indicate the stopping point at an intersection or railroad crossing.

traffic arrow. A white marking used in storage lanes and two way left turn lanes to denote the direction of turning movement. Arrows are also used at ramp terminals and intersections on divided highways to discourage wrong way movements.

traffic letters. White markings forming word messages, such as "ONLY", used in conjunction with a traffic arrow at drop lane situations. Traffic letters are not required for left and right turn storage lanes where the intended use of the lane is obvious.

handicapped parking stall symbol. A white marking used to designate parking stalls provided for motorists with disabilities.

HOV symbol. A white diamond marking used for high occupancy vehicle lanes. Typical spacing is 500 ft for divided highways and 300 ft for arterial highways.

railroad crossing symbol. A white marking used in advance of a railroad crossing where grade crossing signals or gates are located or where the posted speed of the highway is 40 mph or higher.

bicycle lane symbol. A white marking consisting of a symbol of a bicyclist and an arrow used in a marked bike lane. Typical spacing is between 150 ft and 250 ft.

drainage marking. A white line used to denote the location of a catch basin, grate inlet or other drainage feature in the shoulder of a roadway.

aerial surveillance marker. White markings used at one mile and one-half mile intervals on sections of highways where the State Patrol uses airplanes to enforce speed limits.

(2) Pavement Marking Materials

Pavement markings are available in various materials. These materials are divided into two categories, paint and plastic. When selecting the pavement marking material to use in a project, consider the initial cost of the material, its service life, location, traffic conditions, the snow and ice removal practices of the particular maintenance area, and the region's ability to maintain the markings. Only consider plastic marking material if the pavement is in good condition and will not require major reconstruction for at least the service life of the material. See Figure 830-1 for the recommended pavement marking materials for different highway types and snow removal practices.

Paint is the most common pavement marking material. It is relatively easy to apply and dries quickly (30 - 90 seconds), after application. This allows the application to be a moving operation which minimizes traffic control costs and delay to the roadway users. Paint is applied on construction contracts with two coats; the first coat is 10 mils thick, followed by a second coat 15 mils thick. The disadvantage of painted pavement markings is its short service life. Only on very low volume roadways subjected to little sanding or snow removal activity will paint provide adequate performance for a year.

Plastic markings have a higher installation cost than paint. They can, however, be a more cost effective measure than paint because of their longer service life. Plastic marking materials currently listed in the Qualified Products List include the following:

- **Thermoplastic.** Thermoplastic material consists of resins and filler materials in solid form at room temperature. The material is heated to a semiliquid, molten state (400 degrees Fahrenheit) and is then applied to the roadway by spray or extrusion methods. This material can be used for both transverse and long line applications. Special equipment is required for both the initial application and subsequent maintenance renewal. Sprayed material can be applied at a thickness of 30 mils and dries in 30 to 60 seconds. The service life of material applied in this manner is slightly longer than that of paint. Extruded material is applied at a thickness of 125 mils and has a drying time of 15 minutes. This material can be applied as a flat line or it can be applied with ridges or bumps that enhance wet night visibility These bumps produce a rumble effect similar to rumble strips when a vehicle crosses over the marking. The service life of extruded material is about 3 years. Thermoplastic pavement markings costs about three times more than paint. Failure is usually a result of delamination, rather than wear and abrasion. The material has a different coefficient of expansion than pavement material. Changes in temperature cause the thermoplastic material to crack. This allows the intrusion of moisture between the thermoplastic material and the pavement surface and eventually causes the delamination.
- **Preformed Tape.** Preformed tapes are composed of thermoplastic or other materials that are fabricated under factory conditions. After curing, the material is cut to size and shipped to the work site in rolls or in flat pieces. The material is then applied to the roadway with an adhesive or with heat to activate a preapplied bonding agent. Preformed tapes are available in a thickness of either 60 mils, 90 mils, or 125 mils. Preformed tape will last between 3 and 4 years in a rubber bit snow plow removal area. Preformed tape is about 5 times more expensive than paint. The most durable application of preformed tapes is achieved when the tape is rolled into hot asphalt and the top of the tape is flush with the surface of the pavement. Preformed tapes can have acceptable service lives in ice chisel snow removal areas when the tape is installed in a groove ground into the pavement.
- **Methyl Methacrylate (MMA).** Methyl methacrylate application can be either by spraying or extrusion. Sprayed applications are typically two coats, 45 mils thick. Extruded applications are 90 mils thick for dense asphalt or PCC pavement or 120 mils thick for open graded asphalt pavement.

The aterial is not heated and can be applied within a temperature range of 40 to 100 degrees Fahrenheit, provided the pavement surface is dry. The material can be used for both transverse and longitudinal applications. The material can also be applied with bumps that enhance wet night visibility. The bumps also produce the rumble effect. MMA can have acceptable service life in ice chisel snow removal areas if the material is installed in a 250 mil deep groove ground into the pavement. MMA has a service life of between 4 and 8 years. MMA, depending on the application, can cost between 5 and 10 times more than paint.

- **Raised Pavement Markers (RPMs).** RPMs are installed as positioning guides with long line pavement markings. They can also be installed as a complete substitution for certain long line markings.. RPMs have a service life of two years. RPMs provide good wet night visibility and a rumble effect. RPMs cost 2 to 3 times more than paint when used in substitution applications. RPMs are made from plastic materials and are available in three different types.

  Type 1 markers are 4″ diameter, 3/4″ high, and nonreflectorized.

  Type 2 markers are 4″ wide, 2 1/2″ to 4″ long, 3/4″ high, and reflectorized.

  Type 3 markers are 4″ wide, 6″ to 12″ long, 3/4″ high, and reflectorized.

  Type 2 RPMs are not used as a substitute for right edge lines. They can only be used to supplement the right edge line markings; at lane reductions, at sections with reduced lane widths such as narrow structures, and at the gore of exit ramps. All other applications supplementing right edge line markings require approval of the region’s Traffic Engineer. Type 3 RPMs are used in locations where additional emphasis is desired. These locations include vehicle separations and islands. Approval of the region’s Traffic Engineer is required for all installations of Type 3 RPMs.

  Reflectorized RPMs are not required for center and lane line applications in continuously illuminated sections of highway. However, if reflectorized RPMs are used at an intersection within an illuminated section, they are also provided throughout that section.

830.04 Guide Posts

(1) General

Guide posts are retroreflective devices mounted at the side of the roadway to indicate alignment. They are considered to be guidance devices rather than warning devices. They are used as an aid to nighttime driving primarily on horizontal curves; all multilane divided highways; ramps; tangent sections where they can be justified due to snow, fog, or other reduced visibility conditions; and at intersections without illumination.

The types of guide posts and their application are as follows:

(a) **Type W.** Guide posts with silver-white reflective sheeting, facing traffic, used on the right side of divided highways, ramps, right-hand acceleration and deceleration lanes, intersections, and ramp terminals.

(b) **Type WW.** Guide posts with silver-white reflective sheeting, on both sides, used on the outside of horizontal curves on two-way, undivided highways.

(c) **Type Y.** Guide posts with yellow reflective sheeting, facing traffic, used on the left side of ramps, left-hand acceleration and deceleration lanes, ramp terminals, intersections on divided highways, median crossovers, and horizontal curves on divided highways.

(2) Placement and Spacing

Guide posts are placed not less than 2 ft or more than 8 ft outside the outer edge of the shoulder. Place guide posts at a constant distance from the edge of the roadway. When an obstruction intrudes into this space, position the guide posts to smoothly transition to the inside of the obstruction. Guide posts are not required along continuously illuminated divided or undivided highways. See Figure 830-2 for guide post placement requirements.

830.05 Barrier Delineation

Traffic barriers are delineated where guide posts are required, such as bridge approaches, ramps, and other locations on unilluminated roadways. See Figure 830-2. At these locations, the barrier delineation has the same spacing as that of guide posts. Barrier delineation is also required when the traffic barrier is 4 ft or less from the traveled way. Use a delineator spacing of no more than 40 ft at these locations.

Beam guardrail is delineated by either mounting flexible guide posts behind the rail or by attaching shorter flexible guide posts to the wood guardrail posts.

Concrete barrier is delineated by placing retroreflective devices on the face of the barrier about 6″ down from the top. Consider mounting these devices on the top of the barrier at locations where mud or snow accumulates against the face of the barrier.

The terminal ends of impact attenuators are delineated with modified Type 3 Object Markers. These are the impact attenuator markers in the *Sign Fabrication Manual*. When the impact attenuator is used in a roadside condition, the marker with diagonal stripes pointing downward toward the roadway is used. When the attenuator is used in a gore where traffic will pass on either side, the marker with chevron stripes is used.

830.06 Wildlife Warning Reflectors

(1) Reflector System

Collisions between automobiles and wildlife (predominately deer) produce a substantial economic cost through damage to vehicles, human injuries, fatalities, and loss of the wildlife resources.

A wildlife warning reflector system has been developed to reduce this accident potential. This system consists of a series of reflectors mounted adjacent to the roadway. During the hours of low natural light (dusk, dawn, and night), light from the headlights of an approaching vehicle is reflected to the adjacent roadside by the reflectors. This reflected light creates an "optical fence" causing deer to remain motionless until the vehicle has passed.

The Headquarters (HQ) Environmental Services biologist maintains a history of vehicle-deer collisions on state highways and can furnish the region with prospective "optical fence" locations. The biologist is available to assist with a benefit/cost analysis of proposed reflector installations. Consider wildlife reflectors where the deerkill for any one mile section exceeds five kills per year. Also, consider wildlife reflectors for special circumstances such as at a high use deer crossing where a short section of this reflector system might be appropriate. After-installation maintenance costs can be a prohibitive factor when considering a wildlife reflector system. To remain effective, dirty reflectors must be cleaned periodically and reflector posts damaged by snow plowing or errant vehicles must be replaced.

(2) Reflector Placement

Spacing of the wildlife reflectors along the shoulder edges is dependent upon the geometric configuration of the highway and upon the roadside conditions. Reflectors are placed along both sides of the roadway in a staggered arrangement with the longitudinal spacing roughly equal to the combined transverse width of the roadway and reflector offset. See Figures 830-3 and 830-4 for examples of wildlife reflector placements. More detailed information for reflector placement in different locations is available from the manufacturer. Contact the HQ Environmental Services biologist or the HQ Traffic Office.

830.07 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 website: http://www.wsdot.wa.gov/eesc/design/projectdev/

Ice Chisel Snow Removal Areas					
Roadway Classification	Marking Type				
	Center Lines	Lane Lines	Edge Lines	Wide Lines	Special Markings
Interstate	N.A.	Plastic Insets	Paint	Paint	Paint
Major Arterial	Paint and RRPMs	Paint	Paint	Paint	Paint
Minor Arterial	Paint	Paint	Paint	Paint	Paint
Collector	Paint	Paint	Paint	Paint	Paint
Steel Blade Snow Removal Areas					
Roadway Classification	Marking Type				
	Center Lines	Lane Lines	Edge Lines	Wide Lines	Special Markings
Interstate-Urban	N.A.	Plastic	Paint or Plastic	Paint or Plastic	Paint or Plastic
Interstate-Rural	N.A.	Paint	Paint or Plastic	Paint or Plastic	Paint or Plastic
Major Arterial	Paint and RRPMs or Plastic	Paint	Paint or Plastic	Paint or Plastic	Paint or Plastic
Minor Arterial	Paint	Paint	Paint	Paint or Plastic	Paint or Plastic
Collector	Paint	Paint	Paint	Paint or Plastic	Paint or Plastic
Rubber Blade Snow Removal Areas					
Roadway Classification	Marking Type				
	Center Lines	Lane Lines	Edge Lines	Wide Lines	Special Markings
Interstate-Urban	N.A.	RPMs only or Plastic and RPMs	Paint or Plastic	Plastic	Plastic
Interstate-Rural	N.A.	RPMs only or Plastic and RPMs	Paint	Plastic	Plastic
Major Arterial	Paint and RPMs or Plastic and RPMs	Paint and RPMs	Paint	Plastic	Plastic
Minor Arterial	Paint and RPMs	Paint and RPMs	Paint	Plastic	Plastic
Collector	Paint and RPMs	Paint	Paint	Plastic	Plastic

Notes

1. Insets are grooves ground into the pavement and filled with material, usually methyl methacrylate.
2. Plastic refers to methyl methacrylate, thermoplastic, or preformed tape.
3. See Standard Plan H-5d for RPM substitute applications.
4. See Standard Plan H-3 and H-3a for RPM applications with paint or plastic.
5. Special Markings include arrows, symbols, letters, channelizing lines, and transverse markings.
6. RRPMs refers to RPMs installed in a groove ground into the pavement.
7. Type 2 RPMs are not required with painted or plastic center or lane line in continuously illuminated sections. See Section 830.03(2).

Pavement Marking Material Guide
Figure 830-1

Highway Type	Guide Posts on Tangents (See Note 1)	Guide Posts on Horizontal Curves (See Note 1)
Divided Highways with Continuous Illumination		
Main Line	None	None
Bridge Approaches	None	None
Intersections	None	None
Lane Reductions	Standard Plan H-1d	Standard Plan H-1d
Median Crossovers	None	None
Ramps	Standard Plan H-1b	Standard Plan H-1b
Divided Highways without Continuous Illumination		
Main Line with RPMs	None	Standard Plan H-1c
Main Line without RPMs	Right Side Only (0.10 mile spacing)	Standard Plan H-1c
Bridge Approaches	Standard Plan H-1e	Standard Plan H-1e
Intersections	Standard Plan H-1a	Standard Plan H-1a
Lane Reductions	Standard Plan H-1d	Standard Plan H-1d
Median Crossovers	Standard Plan H-1d	Standard Plan H-1d
Ramps	Standard Plan H-1b	Standard Plan H-1b
Undivided Highways with Continuous Illumination		
Main Line	None	None
Bridge Approaches	None	None
Intersections	None	None
Lane Reductions	Standard Plan H-1d	Standard Plan H-1d
Undivided Highways without Continuous Illumination		
Main Line	See Note 2	Standard Plan H-1c (See Note 2)
Bridge Approaches	Standard Plan H-1e	Standard Plan H-1e
Intersections with Illumination	None	None
Intersections without Illumination	Standard Plan H-1d	Standard Plan H-1d
Lane Reductions	Standard Plan H-1d	Standard Plan H-1d

Note 1: See Standard Plan H-1 for lateral placement of guide posts.
Note 2: Installation of guide posts on tangents and on the inside of horizontal curves is allowed at locations approved by the region's Traffic Engineer.

Guide Post Placement
Figure 830-2

Wildlife Reflectors on a Tangent Section
Figure 830-3

Wildlife Reflectors on the Outside of a Curve
Figure 830-4

840.01 General

Illumination is provided along highways, in parking lots, and at other facilities to enhance visual perception of conditions or features that require additional driver, 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 (as per WAC 468-18-050) with partial, modified, or full limited access control regardless of the location and on state highways located outside the corporate limits of cities. Cities are responsible for illumination of state highways within their corporate limits but outside of WSDOT limited access control.

840.02 References

Revised Code of Washington (RCW) 47.24.020, "Jurisdiction, control."

Washington Administrative Code (WAC) 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings"

Washington Administrative Code (WAC) 468-18-050, "Policy on the construction, improvement and maintenance of intersections of state highways and city streets"

Directive D 22-21, "Truck Weigh Stations and Vehicle Inspection Facilities on State Highways"

Roadway Lighting Handbook, Federal Highway Administration, Implementation Package 78-15, Washington, D.C. 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, D.C. 1983

An Informational Guide for Roadway Lighting, AASHTO, Washington, DC 1984

American National Standard Practice for Roadway Lighting, IES RP-8-1983, New York, NY 1983

Recommended Practice for Tunnel Lighting, IESNA RP-22-96, New York, NY 1996

National Electrical Code, NFPA, Quincy, MA

City Streets as a Part of the State Highway - Final Report, WSDOT 1997

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

840.03 Definitions

footcandle The illumination of a surface one square foot in area on which is uniformly distributed a flux of one lumen. A footcandle equals one lumen per square foot.

lamp lumens The total light output from a lamp in lumens. (A lumen being a unit of luminous flux.)

luminance Luminous intensity per unit projected area of any surface, as measured from a specific direction. The units of luminance are footcandles. Roadway luminance is the light projected from a luminaire that travels toward a given area, represented by a point on the pavement surface and then back towards the observer, opposite to the direction of travel.

luminous flux The time rate of flow of light.

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 center line.The maximum veiling luminance ratio is 0.3:1.

minimum light level The minimum light intensity of illumination at any single point within the design area measured just prior to relamping the system.

minimum average light level The average of all light intensities within the design area measured just prior to relamping the system.

mounting height The vertical distance between the surface of the design area and the center of the light source of the luminaire. This is the distance used to compute the light level of 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. In curb and sidewalk areas, the H1 distance is assumed to equal the mounting height. Typically, the mounting height in fill sections is less than the H1 distance while the mounting height in cut sections is equal to or greater than the H1 distance.

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 angle points and shadow areas.

spacing The distance in feet measured on center line between adjacent luminaires.

uniformity ratio The ratio of the minimum average light level on the design area to the minimum light level of the same area.

veiling luminance The stray light produced within the eye by the light source that alters the apparent brightness of an object within the visual field and the background against which it is viewed. Conceptually, veiling luminance is the light that travels directly from the luminaire to the observers eye.

840.04 Required Illumination

The design matrices identify the design levels for illumination on all preservation and improvement projects. (See Chapter 325.) These levels, basic or full, are indicated in the columns.

At the basic design level for minor safety or preservation work, providing breakaway features on existing light standards (when required), replacing deficient electrical components, and other minor work would be the extent of consideration. Providing additional lighting or relocating light standards on preservation projects may be considered as a spot safety enhancement.

A full design level notation in a design matrix column indicates that the required illumination specified in this chapter is necessary. 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.

Figures 840-1 through 840-5 show examples of illumination for highway applications. Illumination in these examples and the locations listed below are required on state highways.

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 number of light standards to illuminate the design area of all freeway off-ramp gore areas and on-ramp acceleration tapers. See 840.06(2).

(2) Freeway Ramp Terminals

A single light standard is required at the intersection of a ramp terminal with a two-lane roadway. At the intersection of a ramp terminal with a multilane roadway, additional lighting is required to illuminate the intersection design area. See Figure 840-5. Additional illumination is also required if the intersection has left-turn channelization or a traffic signal.

(3) Intersections With Left-Turn Channelization

Illumination of the intersection area and the left-turn storage 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 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 if they are interested in participating.

(4) Intersections With Traffic Signals

All traffic signals on state highways are illuminated. The extent of illumination is the same as for intersections with left-turn channelization. Illumination of the crossroad is beneficial and 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, illumination is the responsibility of that agency.

(6) Transit Flyer Stops

Illuminate the loading area of a transit flyer stop located within the limited access boundaries.

(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 840-6 for the parking area and bus loading zone. During periods of low usage at night, only security lighting 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 less vehicles. Provide security level lighting for those lots owned and maintained by the state. Security lighting consists of lighting the entrance and exit to the lot.

(9) Truck Weigh Sites

Provide illumination of the scale platforms, parking areas, and inspection areas of weigh sites.

(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.

(11) Long Tunnels

Long tunnels have a portal to portal length greater than the stopping sight distance. Provide both nighttime and daytime illumination for long tunnels.

840.05 Additional Illumination

At certain locations, additional illumination is desirable to provide better definition of nighttime driving conditions or to provide consistency with local agency goals and enhancement projects. For improvement projects, consider additional illumination on state highways where there is a diminished level of service or a nighttime accident frequency condition exists.

Diminished Level of Service is a mobility condition where the nighttime peak hour level of service is D or lower. When volumes are used to determine the level of service, use traffic 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 Accident Frequency Condition is when the number of nighttime accidents equals or exceeds the number of daytime accidents. An engineering study that indicates illumination will result in a reduction in nighttime accidents is required to demonstrate justification. Consider the seasonal variations in lighting conditions when reviewing reported accidents. Accident reporting forms, using a specific time period to distinguish between "day" and "night," might not indicate the actual lighting conditions at the time of an accident. Consider the time of year when determining if an accident occurred at nighttime. An accident occurring at 5:00 p.m. in July would be a daytime accident, but an accident occurring at the same time in December would be during the hours of darkness.

The mitigation of high nighttime, pedestrian accident locations requires different lighting strategies than vehicular accident locations. Provide light levels to emphasize crosswalks and adjacent sidewalks. Multiple lane highways with two-way left-turn lanes, in urban build up areas, are typically high speed facilities with numerous road approaches. These roadways allow numerous vehicle entry and exit points and provide few crossing opportunities for pedestrians. Additional illumination may be justified for this condition.

Document the justification for the additional illumination in the Design Documentation Package (DDP).

(1) Highways

Proposals to provide full (continuous) illumination require 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.

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 major cross roads.
- The segment is in an urban area.
- The nighttime accident frequency condition exists.
- A benefit cost analysis between the required and full (continuous) illumination.

(b) On the main line of highways without full 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 the nighttime accident 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 due to traffic control features.
- The nighttime accident frequency condition exists.
- The criteria for continuous mainline illumination have been satisfied.

(3) Crossroads

At crossroads, consider additional illumination when a diminished level of service exists and the nighttime accident frequency exists. Also, consider additional illumination if the crossroad is in a tunnel, undercrossing, or lid.

(4) Intersections Without Channelization

Consider illumination of intersections without channelization in urban areas and other locations if a nighttime accident frequency requirement is satisfied or the traffic volumes and movements would be improved with the installation of left turn channelization.

(5) Tunnels, Underpasses, or Lids

Consider illumination of tunnels, underpasses or lids if portal conditions result in a brightness in the tunnel 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.

(6) Construction Zones and Detours

Consider illumination of construction zones and detours under the following conditions:

- if construction activities take place on the roadway at night.

- when traffic flow is split around an obstruction.
- for detours, where the alignment and grade are unusual and require additional driver, cyclist, or pedestrian alertness.

(7) Transit Stops

The responsibility for lighting at transit stops is shared with the transit company. Consider illumination of transit stops with shelters, as this generally is indicative of higher passenger usage. Negotiation with the transit agencies is required for the funding and maintenance of this illumination. If the transit agency is 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.

(8) Bridges

Justification for illuminating bridges is the same as that for highways with or without full limited access control, as applicable.

(9) Railroad Crossing Without Gates or Signals

Illumination of these facilities is justified if there is a potential for nighttime accidents. Consider the extent of nighttime train activity in making this determination. Also, consider illumination if there is a probability that railroad cars will be stopped on the crossing during the nighttime.

(10) Walkways and Bicycle Trails

Illumination of pedestrian walkways is justified 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. In these conditions the walkways and bicycle trails are illuminated to the level shown in Figure 840-6.

(11) Rest Areas

Provide illumination at the roadway diverge and merge sections within rest areas and the parking areas as for a major parking lot.

840.06 Design Criteria

(1) Light Levels

Light levels vary with the class of highway, development of the adjacent area, and the level of nighttime activity. Light level requirements for highways and other facilities are shown in Figure 840-6. 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 standard or security lighting installations. See Chapters 430 and 440 for design classes of highways.

The types of activity areas, shown below, are related to the number of pedestrian crossings. 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 pedestrian hour usage. Examples are: downtown retail areas, near 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 pedestrian hour usage. Examples are: 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 pedestrian hour usage. Examples are 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 that is 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.

Design area requirements for various applications are shown in Figures 840-1 through 840-5 and the following:

- One-lane off-ramp. Two main line through lanes and the ramp lane, including gore area, from the gore point to a point 200 ft (minimum) down stream of the gore point. A 100 ft 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 ft upstream of the gore point to a point 200 ft downstream from the gore point. A 100 ft longitudinal tolerance either way from the gore point is allowed.
- One-lane on-ramp. Two main line through lanes and the ramp lane, from a point where the ramp lane is 10 ft wide to a point 200 ft upstream. A 100 ft 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 lanes are 22 ft wide to a point 200 ft upstream. A 100 ft 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 crossings. The roadway width from a point 50 ft either side of the track (the approach side only for one way roadways).
- Transit loading areas. The lane width and length designated for loading.
- Major parking lots. The entire area designated for parking including internal access lanes.
- Scale platforms at weigh sites. The approach width from the beginning of the scale platform to the end of the platform.
- Inspection areas at weigh sites. The area dedicated to inspection as agreed upon with the Washington State Patrol.

(3) Light Levels for Tunnels and Underpasses

Short tunnels and underpasses, with a length to vertical clearance ratio of 10:1 or less, normally do not have daytime illumination. Short tunnels 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. 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.

Long tunnels are divided into zones for the determination of daytime light levels. Each zone is equal in length to the wet 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 motorist's view on the portal approach. The brightness level is defined as the average brightness measured over a 20 degree cone at a point 500 ft 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 5 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 adequate illumination of fire protection equipment, alarm pull boxes, phones, and emergency exits in long tunnels to minimize the risk associated with catastrophic accidents.

(4) Light Standards

(a) **Light Standards.** Light standards are the most common supports used to provide illumination for highway facilities. The 40 ft and 50 ft high light standards with breakaway 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 use 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 that propose 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 10 ft clearance from the power line to any portion of the light standard or luminaire. Consult the <u>HQ</u> Bridge and Structures Office when mounting lights 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 length of the mast arm can vary from 6 ft to 16 ft to allow for this placement. The preferred position for the luminaire is over the edge line. However, some flexibility is acceptable with the luminaire position to allow for placement of the light standard. When necessary, the luminaire can be positioned up to 4 ft <u>from</u> the edge line. See Figure 840-7.

When light standards are located within the Design Clear Zone, breakaway features are used to reduce the severity of a potential impact. To allow these breakaway features to function as intended, it is preferred that they be installed on slopes that are 6H:1V or flatter (cut or fill slope). On fill slopes where flattening of the slope to achieve a 6H:1V slope is not practical, consider locating the light standard at least 12 ft beyond the slope break. If this is not possible, locate the light standard at the slope break. Do not place the light standard on a fill slope that is 3H:1V or steeper unless it is behind a traffic barrier.

When placing the light standard on a cut slope, that is 3H:1V or flatter (such as the backslope of a ditch), the preferred location is outside of the Design Clear Zone. If this is not practical, the light standard may be installed with a modified foundation that matches the slope's surface. In this case, it is critical that the light standard be positioned at least 4 ft beyond the bottom of the ditch. Locate light standards on slopes steeper than 3H:1V outside of the Design Clear Zone. Even when located beyond the Design Clear Zone, it is desirable to use a breakaway base if there is a possibility it could be struck by an errant vehicle.

In curb and sidewalk sections, locate the light standard behind the sidewalk.

Breakaway bases on light standards are a safety requirement for higher speed roadways. They are not always desirable at other locations. Locations where fixed bases are installed are:

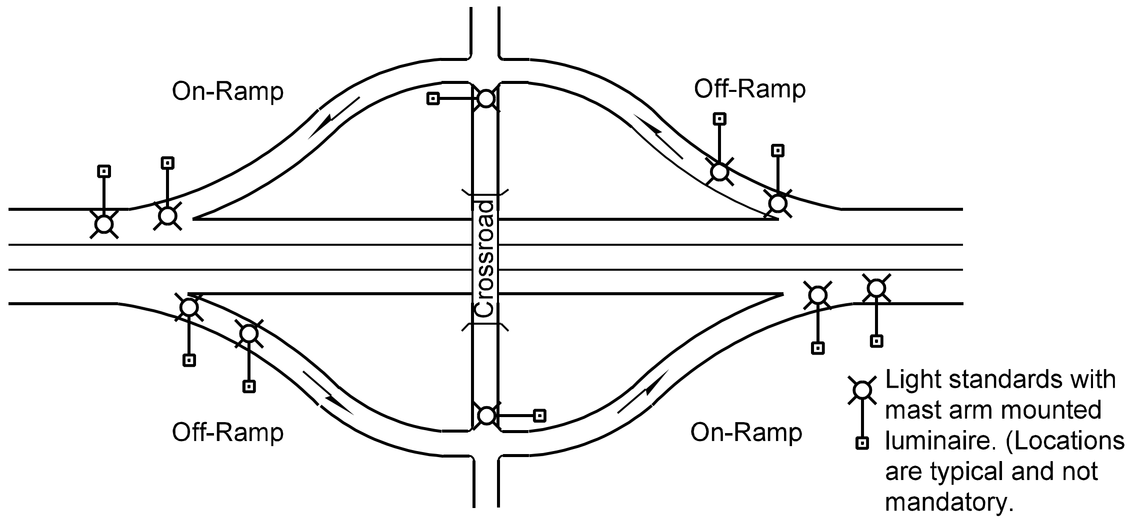
- Parking lots.
- Medians where the light standard is mounted on median barrier.
- Behind traffic barrier, beyond the barrier's deflection design value (See Chapter 710).
- Along highways with posted speeds of 35 mph or less where there is medium or high pedestrian activity.
- Pedestrian walkways, bike paths, and shared use paths.

(b) **Light Standard Heights.** Unusual pole heights require longer fabrication time and are not recommended. Use pole heights of 40 ft and 50 ft for roadway illumination. These pole heights will result in variable mounting heights for the luminaires. 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. Initial construction costs, long term maintenance, clear zone mitigation, spill-over light on to adjacent properties, and negative visual impacts are important factors when considering high mast illumination. Shorter light standards of 30 ft 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 has an oval pattern, and a Type V distribution has a circular pattern. 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 preferred. Recommended mounting heights and initial lumens for various luminaire wattages are shown in Figure 840-8.

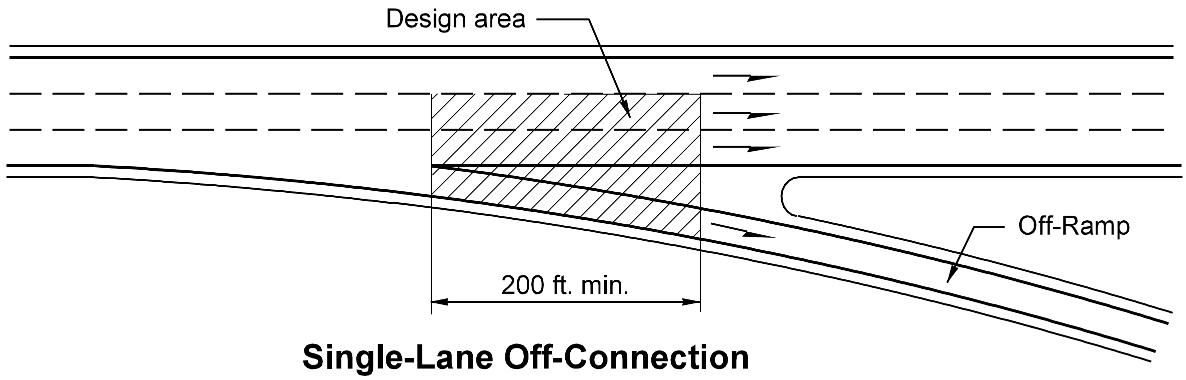
840.07 Documentation

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 website: http://www.wsdot.wa.gov/eesc/design/projectdev/



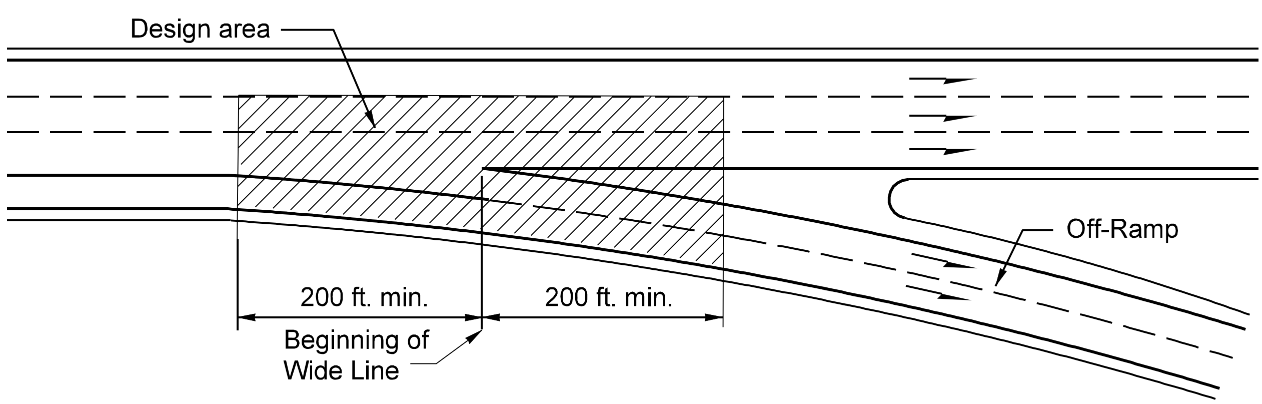
Required Illumination for a Typical Diamond Interchange

(Shown for single lane ramp connection and a two-lane crossroad without channelization.)



Single-Lane Off-Connection

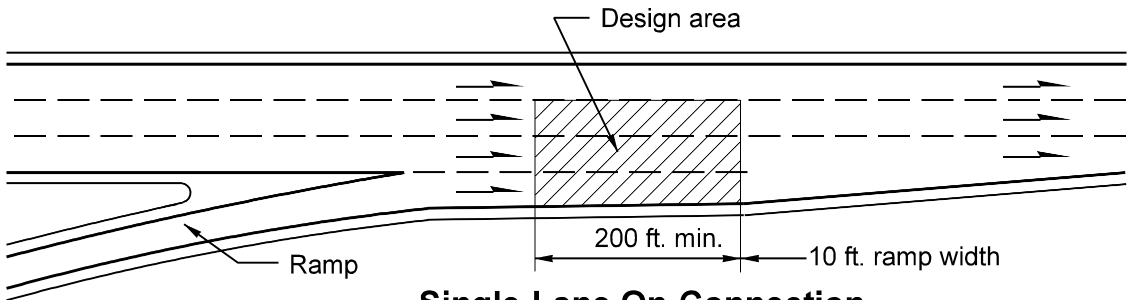
(The design area can be shifted up to 100 ft. from the beginning of the Wide Line.)



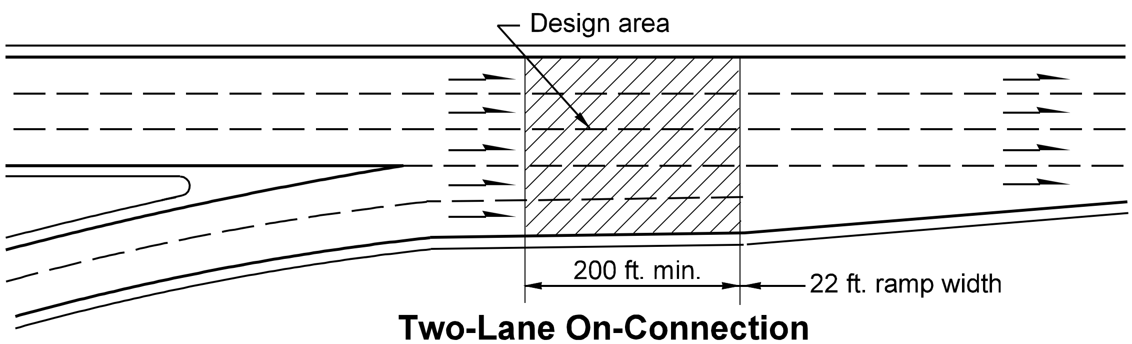
Two-Lane Off-Connection

(The design area can be shifted up to 100 ft. from the beginning of the Wide Line.)

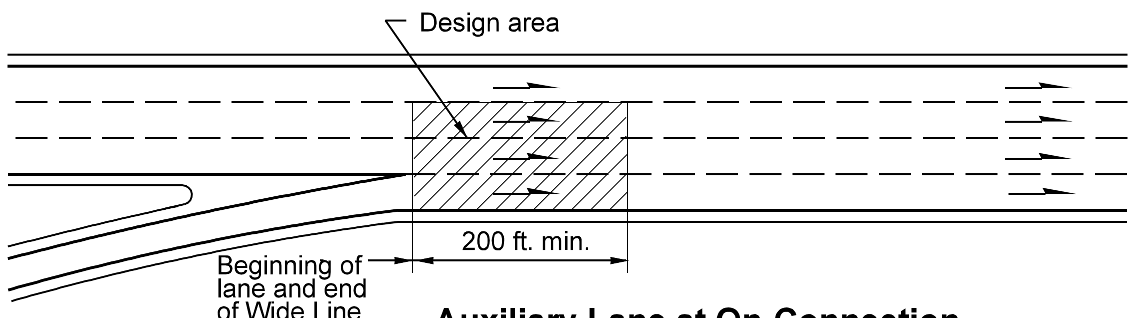
Freeway Lighting Applications
Figure 840-1



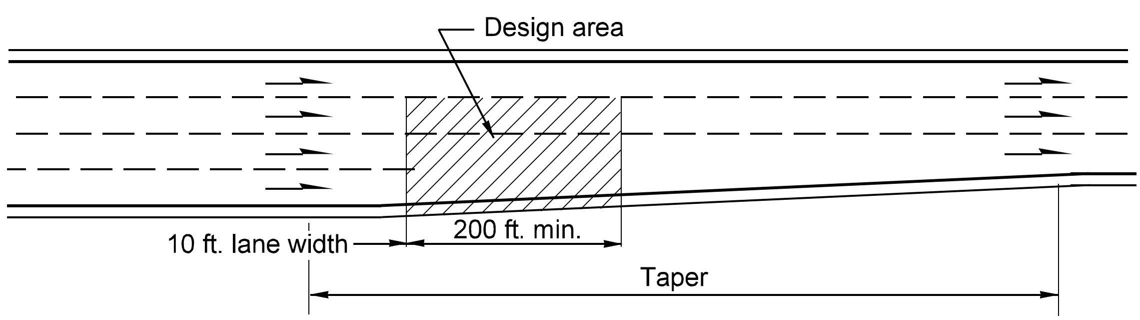
Single-Lane On-Connection
(The design area can be shifted up to 100 ft. from the 10 ft. wide ramp point.)



Two-Lane On-Connection
(The design area can be shifted up to 100 ft. from the 22 ft. wide ramp point.)

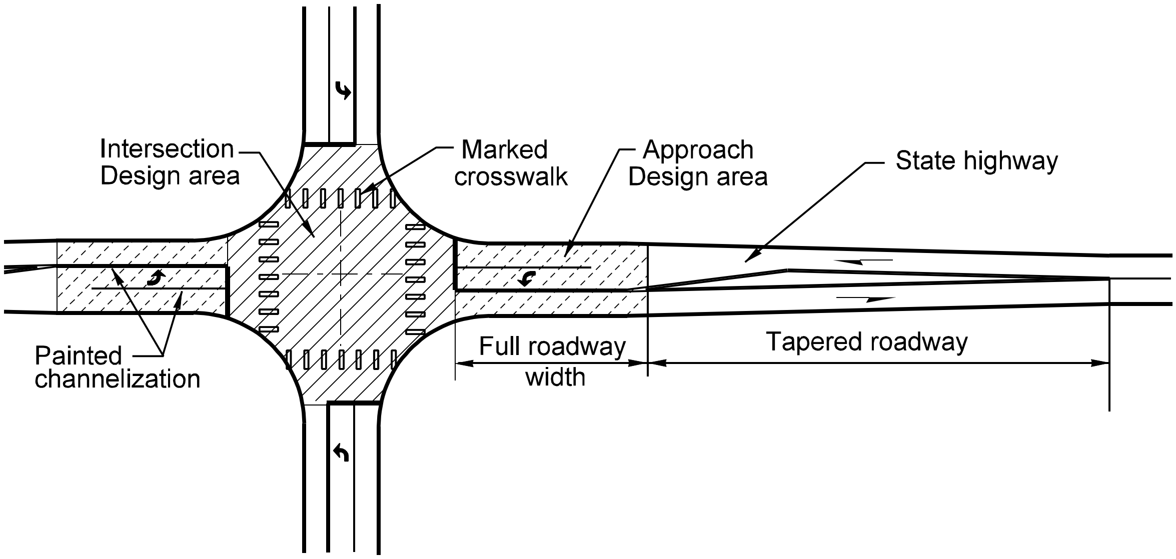


Auxiliary Lane at On-Connection
(Required only if significant weaving problem exists.)
(The design area can be shifted up to 100 ft. from the 22 ft. wide ramp point.)

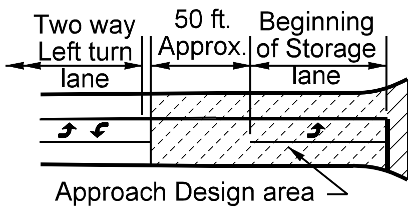


Lane Reduction

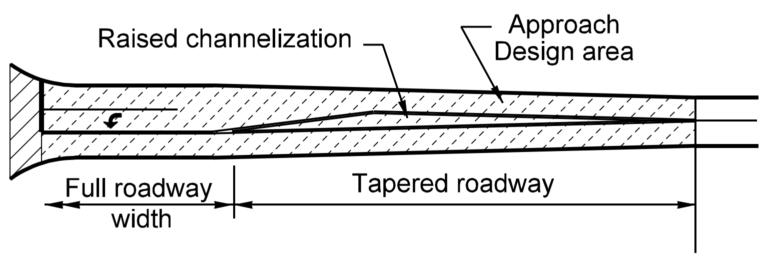
Freeway Lighting Applications
Figure 840-2



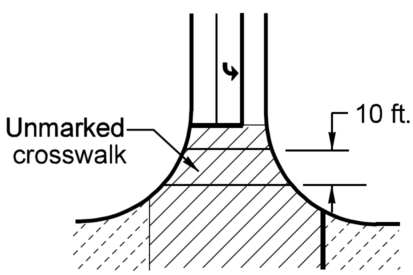
Intersection with Left-Turn Channelization



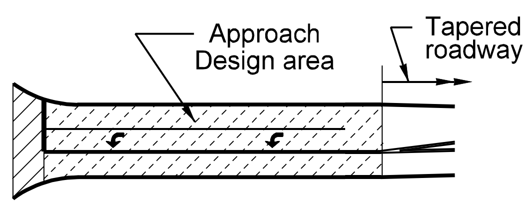
Alternate for Transitions to Two-Way Left-Turn Lanes



Alternate for Raised Channelization

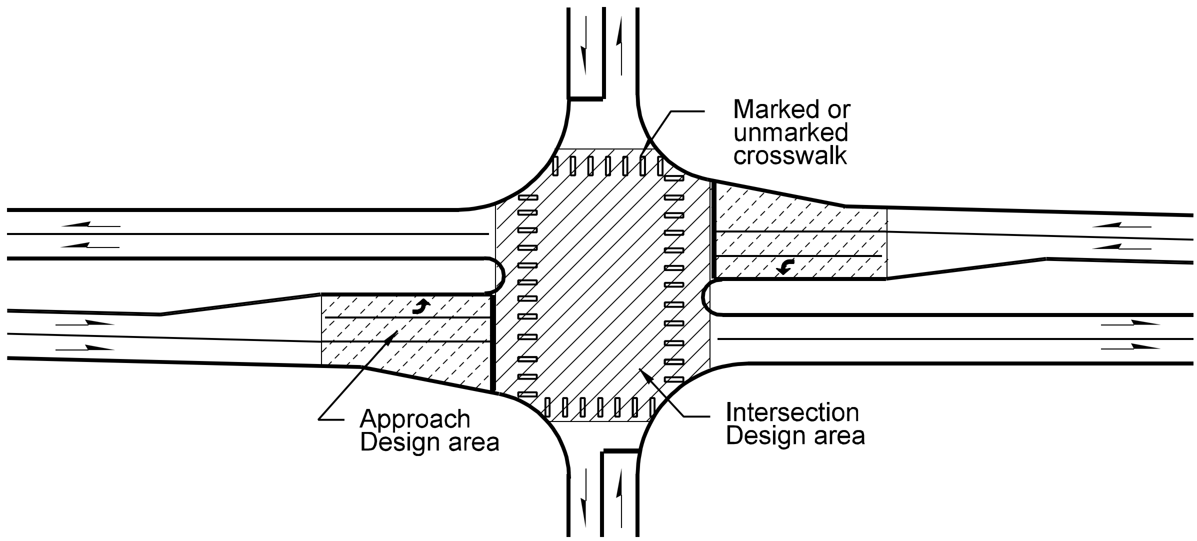


Unmarked Crosswalk Detail

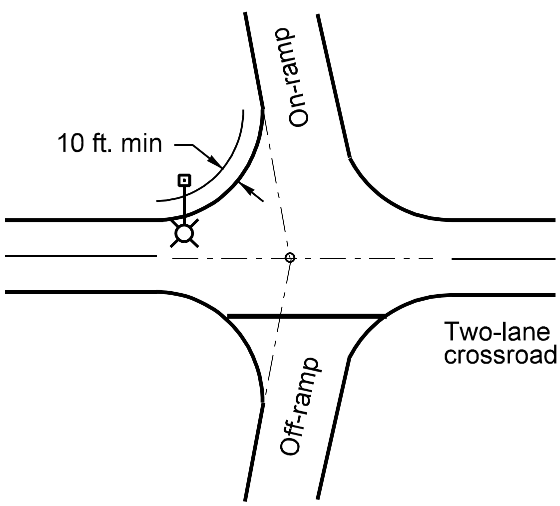


Alternate for Long Storage Lanes

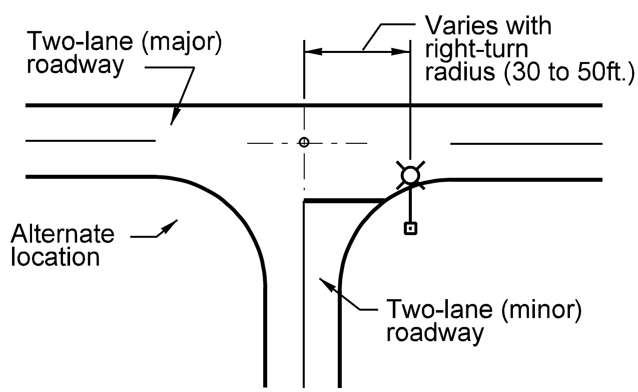
Roadway Lighting Applications
Figure 840-3



Divided Highway Intersection



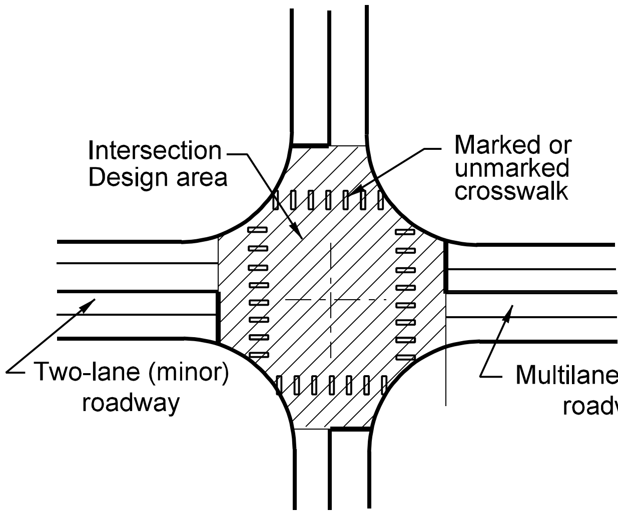
Ramp Terminals



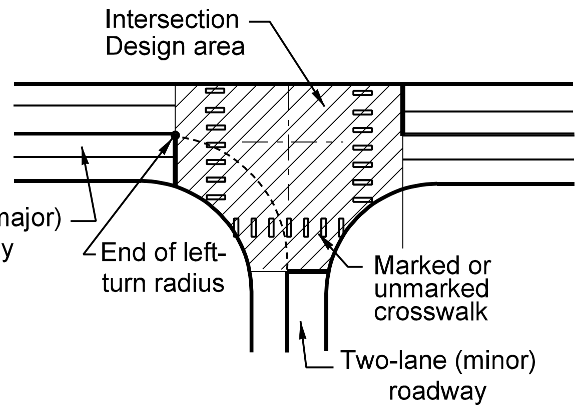
Tee Intersection Minor
(Without left-turn channelization)


Light standards with mast arm mounted luminaire. (Locations are typical and not mandatory.

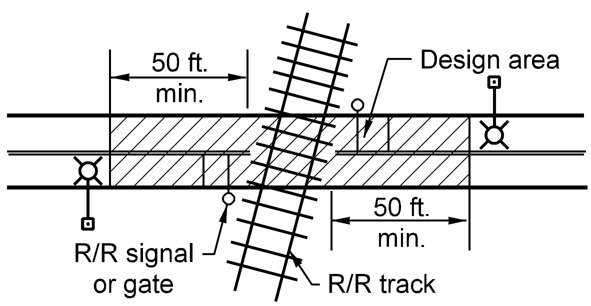
Roadway Lighting Applications
Figure 840-4



Four Way Intersection
(Without left-turn channelization)



Tee Intersection Major
(Without left-turn channelization)



Railroad Crossing

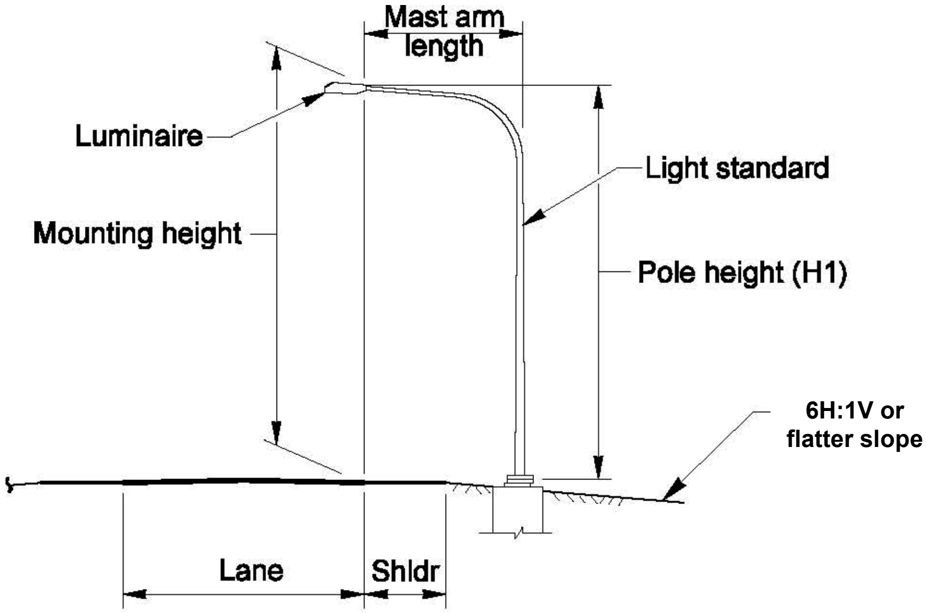
Roadway Lighting Applications
Figure 840-5

Light Level and Uniformity Ratio Chart					
Highway Design Class	**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 Limited 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	3 : 1	0.3 : 1
Intersections	1.2	0.9	0.9	3 : 1	0.3 : 1
Collectors					
Main Line	1.1	0.8	0.6	3 : 1	0.3 : 1
Intersections	1.1	1.0	0.9	3 : 1	0.3 : 1
Construction Lanes and Detours	1.0	1.0	1.0	3 : 1	0.3 : 1
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 and 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

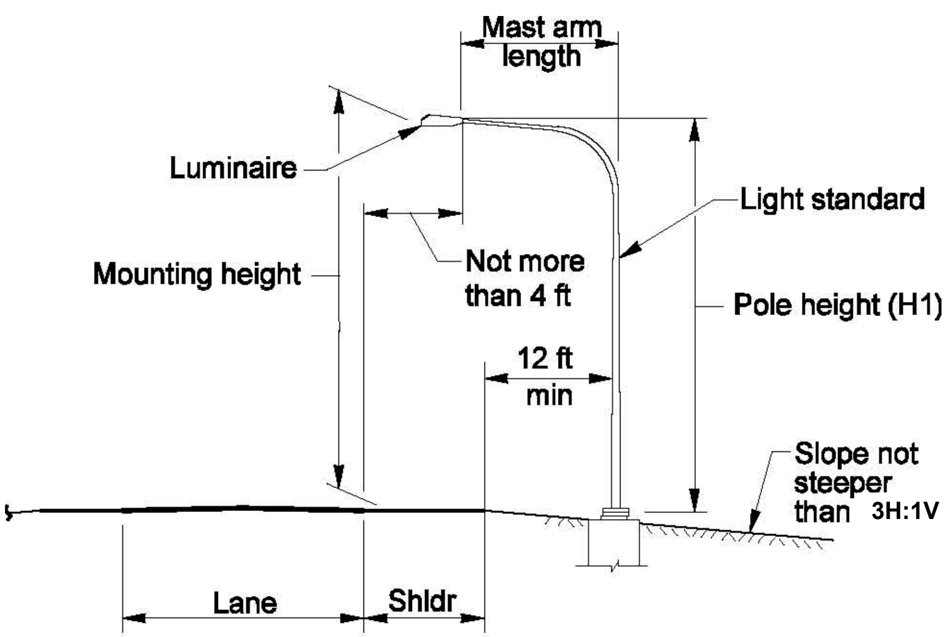
Notes

(1) The minimum light level is 0.2 fc for any application with an average 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 840.05 (6))
(5) Includes illumination at ramp on and off connections.
(6) $\frac{\text{Average Light Level}}{\text{Minimum Light Level}}$
(7) $\frac{\text{Maximum Veiling Luminance}}{\text{Average Luminance}}$
(8) Uniformity ratio is 3:1 when more than one light standard is justified.

Light Levels and Uniformity Ratios
Figure 840-6



Preferred Location
Embankment slope



Alternate Location

Light Standard Locations
Figure 840-7

Luminaire Wattage	Initial Lumens*	H1	Recommended Mounting Height	
			Maximum	Minimum
200	22,000	30 ft	32 ft	28 ft
250	28,000	35 ft	38 ft	32 ft
310	37,000	40 ft	44 ft	36 ft
400	50,000	40 ft	44 ft	36 ft
400	50,000	50 ft	54 ft	46 ft
1,000	140,000	100 ft	110 ft	90 ft

Note:
*Lumens are for high pressure sodium vapor luminaires

Luminaire Wattage, Lumens, and Mounting Heights
Figure 840-8

850 Traffic Control Signals

850.01 General

Traffic control signals are power-operated traffic control devices that warn or direct motorists to take some specific action. More specifically, signals are used to control the assignment of right of way at locations where conflicts exist or where passive devices, such as signs and markings, do not provide the necessary flexibility of control to move traffic in a safe and efficient manner.

850.02 References

The following references are used in the design, construction, and operation of traffic control signals installed on state highways. The Revised Codes of Washington (RCWs) noted below are specific state laws concerning traffic control signals and conformance to these statutes is required.

RCW 35.77, "Streets-Planning, establishment, construction, and maintenance."

RCW 46.61.085, "Traffic control signals or devices upon city streets forming part of state highways—Approval by department of transportation."

RCW 47.24.020 (6) and (13), "Jurisdiction, control."

RCW 47.36.020, "Traffic control signals."

RCW 47.36.060, "Traffic devices on county roads and city streets."

Washington Administrative Code (WAC) 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings."

Directive D 55-03, "Responsibility for Traffic Control Devices, Pavement Widening, and Channelization at Existing Intersections and Two-Way Left Turn Lanes in Cities"

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT, Washington DC, 1988, including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT, 1996

Plans Preparation Manual, M 22-31, WSDOT

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

850.03 Definitions

The various types of traffic control signals are defined below. Hazard identification beacons and ramp meter signals are energized only at specific times. All other signals remain in operation at all times.

conventional traffic signal A permanent or temporary installation providing alternating right of way assignments for conflicting traffic movements. At least two identical displays are required for the predominant movement on each approach.

emergency vehicle signal A special adaptation of a conventional traffic signal installed to allow for the safe movement of authorized emergency vehicles. Usually this type of signal is installed on the highway at the entrance into a fire station or other emergency facility. The signal assures protected entrance onto the highway for the emergency vehicle. When not providing for this movement, the signal either operates continuously, consistent with the requirements for a conventional traffic signal, or displays continuous green (allowed at nonintersection locations only). At least two identical displays are required per approach.

hazard identification beacon A beacon that supplements a warning or regulatory sign or marking. The display is a flashing yellow indication. These beacons are not used with "stop", "yield", or "do not enter" signs. A hazard identification beacon is energized only during those hours when the hazard or regulation exists.

intersection control beacon (flashing beacon) A secondary control device, generally suspended over the center of an intersection, that supplements intersection warning signs and stop signs. One display per approach may be used but two displays per approach are desirable. Intersection control beacons are installed only at an intersection to control two or more directions of travel.

lane control signal (reversible lanes) A special overhead signal that permits, prohibits, or warns of impending prohibition of lane use.

moveable bridge signal (drawbridge signal) A signal installed to notify traffic to stop when the bridge is opened for waterborne traffic. Moveable bridge signals display continuous green when the roadway is open to vehicular traffic.

overlapped displays Overlapped displays allow a nonconflicting traffic movement to run with another phase. Most commonly, a minor street's exclusive right-turn phase is overlapped with the nonconflicting major street's left-turn phase. An overlapped display can be terminated after the parent phase terminates. An overlapped display programmed for two or more parent phases continues to display until all of the parent phases have terminated.

pedestrian signal An adaptation of a conventional traffic signal installed at established pedestrian crossings. It is used to create adequate gaps in the vehicular movement to allow for safe pedestrian crossings. When not operating as a pedestrian signal, the system operates consistent with the requirements for an emergency vehicle signal.

portable traffic signal A type of conventional traffic signal used in work zones to control traffic. It is typically used on two-way, two-lane highways where one lane has been closed for roadwork. The traffic signal provides alternating right of way assignments for conflicting traffic movements. The signal has an adjustable vertical support with two three-section signal displays and is mounted on a mobile trailer with its own power source.

ramp meter signal A signal used to control the flow rate of traffic entering a freeway or similar facility. A minimum of two displays is required. When not in use, ramp meter signals are not energized.

speed limit sign beacon A beacon installed with a fixed or variable speed limit sign. The display is a flashing yellow indication.

stop sign beacon A beacon installed above a stop sign. The display is a flashing red indication.

temporary traffic signal A conventional traffic signal used during construction to control traffic at an intersection while a permanent signal system is being constructed. A temporary traffic signal is typically an inexpensive span-wire installation using timber strain poles.

850.04 Procedures

(1) Permit

State statutes (RCWs) require Department of Transportation approval for the design and location of all conventional traffic signals and some types of beacons located on city streets forming parts of state highways. Approval by the Department of Transportation for the design, location, installation, and operation of all other traffic control signals installed on state highways is required by department policy.

The Traffic Signal Permit (DOT Form 242-014 EF) is the formal record of the department's approval of the installation and type of signal. The permit is completed by the responsible agency and submitted to the Regional Administrator for approval. The region retains a record of the permit approval, complete with supporting data, and a copy is forwarded to the State Traffic Engineer at the Olympia Service Center (OSC). Permits are required for the following types of signal installations:

- Conventional traffic signals
- Emergency vehicle signals
- Hazard identification beacons, when installed overhead at an intersection

- Intersection control beacons
- Lane control signals
- Moveable bridge signals
- Portable signals
- Ramp meter signals
- Pedestrian signals
- Temporary signals

Emergency vehicle signals require annual permit renewal. The region's traffic office reviews the installation for compliance with standards. If satisfactory, the permit is renewed by the Regional Administrator by way of a letter to the operating agency. A copy of this letter is also sent to the State Traffic Engineer.

Permits are not required for hazard identification beacons that are not installed overhead at an intersection, speed limit sign beacons, stop sign beacons, and lane assignment signals at toll facilities.

When it is necessary to increase the level of control, such as changing from an intersection control beacon to a conventional traffic signal, a new permit application is required. If the change results in a reduction in the level of control, as in the case of converting a conventional signal to a flashing intersection beacon, or if the change is the removal of the signal, submit the "Report of Change" portion of the traffic signal permit to the Regional Administrator with a copy to the State Traffic Engineer.

(2) Responsibility for Funding, Construction, Maintenance, and Operation

Responsibility for the funding, construction, maintenance, and operation of traffic signals on state highways has been defined by legislative action and transportation commission resolutions. See Figure 850-3. Responsibilities vary depending on location, jurisdiction, and whether or not limited access control has been established. Limited access as used in this chapter refers to full, partial, or modified limited access control as identified in the "Master Plan for Limited Access Highways Route Listing".

(a) **Inside the corporate limits of cities with a population of less than 22,500.** The Department of Transportation is responsible for funding, construction, maintenance, and operation of traffic signals.

(b) **Inside the corporate limits of cities with a population of 22,500 or greater where there is no established limited access control.** The city is responsible for the funding, construction, maintenance, and operation of traffic signals.

(c) **Inside the corporate limits of cities with a population of 22,500 or greater where there is established limited access control.** The Department of Transportation is responsible for funding, construction, maintenance, and operation of traffic signals.

(d) **Outside the corporate limits of cities and outside established limited access control areas.** The Department of Transportation is responsible for funding, construction, maintenance, and operation of a signal when a new state highway crosses an existing county road. The Department of Transportation is responsible for only the maintenance and operation when a new county road intersects an existing state highway. The county is responsible for the construction costs of the signal and associated illumination. When it is necessary to construct a traffic signal at an existing county road and state highway intersection, the construction cost distribution is based on the volume of traffic entering the intersection from each jurisdiction's roadway. The county's share of the cost, however, is limited to a maximum of fifty percent. The state is responsible for maintenance and operation. See WAC 468-18-040 for details.

(e) **Outside the corporate limits of cities and inside established limited access control areas**. The Department of Transportation is responsible for funding, construction, maintenance, and operation of traffic signals.

(f) **Emergency Vehicle Signals**. The emergency service agency is responsible for all costs associated with emergency vehicle signals.

(g) **Third Party Agreement Signals**. At those locations where the Department of Transportation is responsible for signals and agrees that the proposed signal is justified but where funding schedules and priorities do not provide for the timely construction of the signal requested by others, the following rules apply:

- The third party agrees to design and construct the traffic signal in conformance with the Department of Transportation's standards.
- The third party agrees to submit the design and construction documents to the Department of Transportation for review and approval.
- The third party obtains a traffic signal permit.

850.05 Signal Warrants

The requirements for traffic signal warrants are in the MUTCD. A signal warrant is a minimum condition in which a signal may be installed. Satisfying a warrant does not mandate the installation of a traffic signal. The warranting condition indicates that an engineering study, including a comprehensive analysis of other traffic conditions or factors, is required to determine whether the signal or another improvement is justified. There are eleven warrants for conventional traffic signal installations. These warrants are as follows:

- Warrant 1 Minimum vehicular volume
- Warrant 2 Interruption of continuous traffic
- Warrant 3 Minimum pedestrian volume
- Warrant 4 School crossings
- Warrant 5 Progressive movement
- Warrant 6 Accident experience
- Warrant 7 Systems
- Warrant 8 Combination of warrants
- Warrant 9 Four Hour Volumes
- Warrant 10 Peak Hour Delay
- Warrant 11 Peak Hour Volume

Warrants 1, 2, 9, and 11 of the MUTCD allow a reduction in the major street vehicle volume requirements when the 85th percentile speed exceeds 40 mph. This provision only acknowledges a difference in driver behavior on higher speed roadways. It does not imply that traffic signals are always the most effective solution on these facilities. A proposal to install a traffic signal on any state route with a posted speed of 45 mph or higher requires an alternatives analysis. See Chapter 910. A proposal to install a traffic signal on a high speed highway requires Olympia Service Center Design Office review and concurrence.

Warrant 6, Accident experience, is used when the types of accidents are correctable by the installation of a traffic signal. Correctable accidents typically are angle and side impact collisions with turning or entering vehicles.

Rear-end, sideswipe, and single vehicle accidents are usually not correctable with the installation of a traffic signal and are only used in special circumstances to satisfy the requirements of the accident warrant. In the project file, include an explanation of the conditions justify using these types of accidents to satisfy the accident warrant.

850.06 Conventional Traffic Signal Design

(1) General

The goal of any signal design is to assign right of way in the most efficient manner possible and still be consistent with traffic volumes, intersection geometrics, and safety.

(2) Signal Phasing

As a general rule, although there are exceptions, the fewer signal phases the more efficient the operation of the traffic signal. The number of phases required for safe, efficient operation is related to the intersection geometrics, traffic volumes, the composition of the traffic flow, turning movement demands, and the level of driver comfort desired. The traffic movements at an intersection have been standardized to provide a consistent system for designing traffic signals. See Figure 850-4 for standard intersection movements, signal head numbering, and the standard phase operation. Figure 850-5 shows the phase diagrams for various signal operations.

(a) **Level of Service.** The efficiency of a traffic signal is measured differently than highways. While highways use the number and width of lanes and other factors to determine capacity and a level of service, traffic signals are measured or rated by the overall delay imposed on the motorists. Phase analysis is the tool used to find the anticipated delay for all movements. These delay values are then equated to a level of service. There are several computer-based programs for determining delay and level of service. Letter designations from “A” to “F” denote the level of service (LOS) with “F” being the worst condition.

In new construction or major reconstruction projects where geometric design can be addressed, a level of service of at least “D” in urban locations and “C” in rural areas is desirable on state highways. These levels of service are a projection of the conditions that will be present during the highest peak hour for average traffic volumes during the design year of the traffic signal’s operation. Special or seasonal events of short duration or holidays, which can generate abnormally high traffic volumes, are not considered in this determination. Provide an explanation in the project file when the desired level of service cannot be obtained.

Intersection level of service can be improved by either adding traffic lanes or eliminating conflicting traffic movements. Intersections can sometimes be redesigned to compress the interior of the intersection by eliminating medians, narrowing lanes, or reducing the design vehicle turning path requirements. This compression reduces the travel time for conflicting movements and can reduce overall delay.

(b) **Left-turn phasing.** Left-turn phasing can be either permissive, protected, or a combination of both that is referred to as protected/permissive.

1. **Permissive left-turn phasing** requires the left turning vehicle to yield to opposing through traffic. Permissive left-turn phasing is used when the turning volume is minor and adequate gaps occur in the opposing through movement. This phasing is more effective on minor streets where providing separate, protected turn phasing might cause significant delays to the higher traffic volume on the main street. On high speed approaches or where sight distance is limited, consider providing a separate left-turn storage lane for the permissive movement to reduce the frequency of rear end type accidents and to provide safe turning movements.

2. **Protected/permissive left-turn phasing** means that the left-turn movements have an exclusive nonconflicting phase followed by a secondary phase when the vehicles are required to yield to opposing traffic. Where left-turn phasing will be installed and conditions do not warrant protected-only operation, consider protected/permissive left-turn phasing. Protected/permissive left-turn phasing can result in increased efficiency at some types of intersections, particularly “Tee” intersections, ramp terminal intersections, and intersections of a two-way street with a one-way street where there are no opposing left movements. Due to the geometry of these types of intersections, neither the simultaneous display of a circular red indication with a green left-turn arrow nor the condition referred to as “yellow trap” occur.

“Yellow trap” occurs on a two-way roadway when the permissive left-turn display changes to protected-only mode on one approach, while the display remains in the permissive mode on the opposite approach where a left turning motorist sees a yellow indication on the adjacent through movement. The motorist believes the opposing through movement also has a yellow display, when, in fact, that movement’s display remains green. It is possible to prevent “yellow trap” by recalling the side street, however, this can lead to inefficient operation and is not desirable.

3. **Protected left-turn phasing** provides the left turning vehicle a separate phase and conflicting movements are required to stop.

Protected phasing is always required for multilane left-turn movements.

Use protected left-turn phasing when left turning type accidents on any approach equal 3 per year, or 5 in two consecutive years. This includes left turning accidents involving pedestrians.

Use protected left-turn phasing when the peak hour turning volume exceeds the storage capacity of the turn lane because of insufficient gaps in the opposing through traffic and one or more of the following conditions are present:

- The 85th percentile speed of the opposing traffic exceeds 45 mph.
- The sight distance of oncoming traffic is less than 250 ft when the 85th percentile speed is 35 mph or below or less than 400 ft if the 85th percentile speeds are above 35 mph.
- The left-turn movement crosses three or more lanes (including right-turn lanes) of opposing traffic.
- Geometry or channelization is confusing.

Typically, an intersection with protected left turns operates with leading left turns. This means that on the major street, the left-turn phases, phase 1 and phase 5, time before the through movement phases, phase 2 and phase 6. On the minor street, the left-turn phases, phase 3 and phase 7, time before phase 4 and phase 8. Lagging left-turn phasing means that the through phases time before the conflicting left-turn phases. In lead-lag left-turn phasing one of the left-turn phases times before the conflicting through phases and the other left-turn phase times after the conflicting through phases. In all of these cases, the intersection phasing is numbered in the same manner. Leading, lagging, and lead-lag left-turn phasing are accomplished by changing the order in which the phases time internally within the controller.

(c) **Multilane left-turn phasing.** Multilane left turns can be effective in reducing signal delay at locations with high left turning volumes or where the left-turn storage area is limited longitudinally. At locations with closely spaced intersections, a two-lane left-turn storage area might be the only solution to prevent the left-turn volume from backing up into the adjacent intersection. Consider the turning paths of the vehicles when proposing multilane left turns. At smaller intersections the opposing left turn might not be able to turn during the two-lane left-turn phase and it might be necessary to reposition this lane. If the opposing left turns cannot time together the reduction in delay from the two-lane left-turn phase might be nullified by the requirement for separate opposing left-turn phase. Figure 850-6 shows two examples of two-lane left with opposing single left arrangements.

A two-lane exit is required for the two-lane left-turn movements. In addition, this two-lane exit must extend well beyond the intersection. A lane reduction on this exit immediately beyond the intersection will cause delays and backups into the intersection because the left turning vehicles move in dense platoons and lane changes are difficult. See Chapter 910 for the restrictions on lane reductions on intersection exits.

(d) **Right-turn phasing.** Right-turn overlapped phasing can be considered at locations with a dedicated right-turn lane where the intersecting street has a complimentary protected left-turn movement and U-turns are prohibited. Several right-turn overlaps are shown in the Phase Diagrams in Figure 850-5. The display for this movement is dependent on whether a pedestrian movement is allowed to time concurrently with the through movement adjacent to the right-turn movement.

For locations with a concurrent pedestrian movement, use a five section signal head consisting of circular red, yellow, and green displays with yellow and green arrow displays. Connect the circular displays to the through phase adjacent to the right-turn movement and connect the arrow displays to the complimentary conflicting minor street left-turn phase.

For locations without a concurrent pedestrian movement, use a three section signal head with all arrow displays or visibility limiting displays (either optically programmed sections or louvered visors) with circular red, yellow arrow, and green arrow displays. This display is in addition to the adjacent through movement displays. Program this display as an overlap to both the left-turn phase and the adjacent through phase.

(e) **Two-lane right-turn phasing.** Two-lane right-turn phasing can be used for an extraordinarily heavy right-turn movement. They can cause operation problems when "right turn on red" is permitted at the intersection. Limited sight distance and incorrect exit lane selection are pronounced and can lead to an increase in accidents. In most cases, a single unrestricted "right turn only" lane approach with a separate exit lane will carry a higher traffic volume than the two-lane right-turn phasing.

(f) **Phasing at railroad crossings.** Railroad preemption phasing is required at all signalized intersections when the nearest rail of a railroad crossing is within 200 ft of the stop bar of any leg of the intersection, unless the railroad crossing is rarely used or is about to be abandoned. Preemption for intersections with the railroad crossing beyond 200 ft from the intersection stop line is only considered when the queue on that approach routinely occupies the crossing. Contact the railroad company to determine if this line still actively carries freight or passengers.

Railroad preemption has two distinct intervals; the clearance interval before the train arrives and the passage interval when the train is crossing the intersection leg. During the clearance interval, all phases are terminated and the movement on the railroad crossing leg is given priority. When this movement has cleared the crossing, it is then terminated. During the passage interval, the traffic signal cycles between the movements not affected by the train crossing. See Figure 850-7 for an example of railroad preemption phasing.

Arranging for railroad preemption requires a formal agreement with the railroad company. The region's Utilities Engineer's office handles this transaction. Contact this office early in the design stage as this process can be time consuming and the railroad company might require some modifications to the design.

(3) Intersection Design Considerations

Left turning traffic can be better accommodated when the opposing left-turn lanes are directly opposite each other. When a left-turn lane is offset into the path of the approaching through lane, the left turning driver might assume that the approaching vehicles are also in a left-turn lane and fail to yield. To prevent this occurrence, less efficient split phasing is necessary.

Consider providing an unrestricted through lane on the major street of a "T" intersection. This design allows for one traffic movement to flow without restriction.

Skewed intersections, because of their geometry, are difficult to signalize and delineate. When possible, modify the skew angle to provide more normal approaches and exits. The large paved areas for curb return radii at skewed intersections, in many cases, can be reduced when the skew angle is lessened. See Chapter 910 for requirements and design options.

If roadway approaches and driveways are located too close to an intersection, the traffic from these facilities can affect signal operation. Consider restricting their access to "Right In / Right Out" operation.

Transit stop and pull out locations can affect signal operation. See Chapter 1060 for transit stop and pull out designs. When possible, locate these stops and pull outs on the far side of the intersection for the following benefits:

- Minimizes overall intersection conflict, particularly the right-turn conflict.
- Minimizes impact to the signal operation when buses need preemption to pull out.
- Provides extra pavement area where U-turn maneuvers are allowed.
- Eliminates the sight distance obstruction for drivers attempting to turn right on red.
- Eliminate conflict with right-turn pockets.

Large right-turn curb radii at intersections sometimes have negative impacts on traffic signal operation. Larger radii allow faster turning speeds and might move the entrance point farther away from the intersection area. See Chapter 910 for guidance in determining these radii.

At intersections with large right-turn radii, consider locating signal standards on raised traffic islands to reduce mast arm lengths. These islands are primarily designed as pedestrian refuge areas. See Chapter 1025 for pedestrian refuge area and traffic island designs.

Stop bars define the point where vehicles must stop to not be in the path of the design vehicle's left turn. Check the geometric layout by using the turning path templates in Chapter 910 or a computerized vehicle turning path program to determine if the proposed phasing can accommodate the design vehicles. Also, check the turning paths of opposing left-turn movements. In many cases, the phase analysis might recommend allowing opposing left turns to run concurrently, but the intersection geometrics are such that this operation cannot occur.

(4) Crosswalks and Pedestrians

Provide pedestrian displays and push buttons at all signalized intersections unless the pedestrian movement is prohibited. Crosswalks, whether marked or not, exist at all intersections. See Chapter 1025 for additional information on marked crosswalks. If a pedestrian movement will be prohibited at an intersection, provide signing for this prohibition. This signing is positioned on both the near side and far side on the street to be visible to the pedestrians. When positioning these signs for visibility, consider the location of the stop bar where this crossing will be prohibited. Vehicles stopped at the stop bar might obstruct the view of the signing. There are normally three crosswalks at a "T" intersection and four crosswalks at "four legged" intersection. For pedestrian route continuity the minimum number of crosswalks is two at "T" intersections and three for "four legged" intersections.

If a crosswalk is installed across the leg where right or left turning traffic enters, the vehicle display cannot have a green turn arrow indication during the pedestrian "walk" phase. If this cannot be accomplished, provide a separate pedestrian or vehicle turn phase.

Locate crosswalks as close as possible to the intersection, this improves pedestrian visibility for the right-turning traffic. Locate the push buttons no more than five feet from the normal travel path of the pedestrian. Locate the push button no more than 15 ft from the center point at the end of the associated crosswalk. At curb and sidewalk areas, locate the pedestrian push buttons adjacent to the sidewalk ramps to make them accessible to people with disabilities. Figures 850-8a and 850-8b show examples of the push button locations at raised sidewalk locations. When the pedestrian push buttons are installed on the vehicle signal standard, provide a paved path, not less than 4 ft in width, from the shoulder or sidewalk to the standard. If access to the signal standard is not possible, install the push buttons on Type PPB push button posts or on Type PS pedestrian display posts. When pedestrian push buttons are installed behind guardrail, use Type PPB posts. Position these posts so that the push button is not more than 1.5 ft from the face of the guardrail.

(5) Control Equipment

Controller assemblies can be either Type 170 controllers or National Electrical Manufacturers Association (NEMA) controllers with dual ring; eight vehicle phase, four pedestrian phase, four overlap, operational capabilities. From a design perspective, identical operation can be obtained from either controller. Specify the Type 170 unless the region's policy is to use NEMA controllers.

In situations where it is necessary to coordinate the traffic movements with another agency, it is necessary for one of the agencies to be responsible for the operation of the traffic signal, regardless of which agency actually owns and maintains the signal. This is accomplished by negotiating an agreement with the other agency. At a new intersection, where the state owns the signal but another agency has agreed to operate the signal, the controller must be compatible with that agency's system.

When Type 170 controllers are used, but it is necessary to coordinate the state owned and operated signals with another jurisdiction’s system using NEMA controllers, use compatible NEMA controllers installed in Type 170/332 cabinets. Specify a C1 plug connected to a NEMA A, B, C, and D plug adapter for these installations. The Model 210 conflict monitor in the Type 170/332 cabinet can be used with a NEMA controller by changing a switch setting. The Type 12 NEMA conflict monitor is not used in this configuration. It does not fit in a Type 170/332 cabinet and the operation is not compatible. When a NEMA cabinet is used, specify rack-mountings for the loop detector amplifiers and the preemption discriminators.

Coordinate with the region’s electronics technician to determine the optimum controller cabinet location and the cabinet door orientation. The controller cabinet is positioned to provide maintenance personnel access. At this location, a clear view of the intersection is desirable. Avoid placing the controller at locations where it might block the view of approaching traffic for a motorist turning right on red. Avoid locating the controller where flooding might occur or where the cabinet might be hit by errant vehicles. If possible, position the controller where it will not be affected by future highway construction.

If a telephone line connection is desired for remote signal monitoring and timing adjustments by signal operations personnel, provide a modem in the controller cabinet and separate conduits and a junction box between the cabinet and the telephone line access point.

Vehicle and pedestrian movements are standardized to provide uniformity in signal phase numbering, signal display numbering, preemption channel identification, detection numbering, and circuit identification. The following are general guidelines for the numbering system:

- Assign phases 2 and 6 to the major street through movements, orienting phase 2 to the northbound or eastbound direction of the major street.
- Assign phases 1 and 5 to the major street protected left-turn movements.
- Assign phases 4 and 8 to the minor street through movements.
- Assign phases 3 and 7 to the minor street protected left-turn movements.
- At “Tee” intersections, assign the movement on the stem of the “Tee” to either phase 4 or phase 8.
- At intersections with four approaches and each minor street times separately, assign the minor streets as phase 4 and 8 and note on the phase diagram that these phases time exclusively.
- Signal displays are numbered with the first number indicating the signal phase. Signal displays for phase 2, for example, are numbered 21, 22, 23,and so on. If the display is an overlap, the designation is the letter assigned to that overlap. If the display is protected/permissive, the display is numbered with the phase number of the through display followed by the phase number of the left-turn phase. A protected/permissive signal display for phase 1 (the left-turn movement) and phase 6 (the compatible through movement), for example, is numbered 61/11. The circular red, yellow, green displays are connected to the phase 6 controller output and the yellow and green arrow displays are connected to the phase 1 controller output.
- Pedestrian displays and detectors are numbered with the first number indicating the signal phase and the second number as either an 8 or 9. Pedestrian displays and detectors 28 and 29, for example, are assigned to phase 2.
- Detection is numbered with the first number representing the phase. Detection loops for phase 2 detectors are numbered 21, 22, 23, and so on.
- Emergency vehicle detectors are designated by letters; phase 2 plus phase 5 operation uses the letter “A”, phase 4 plus phase 7 uses the letter “B”, phase 1 plus phase 6 uses the letter “C”, and phase 3 plus phase 8 uses the letter “D”.

(6) Detection Systems

The detection system at a traffic actuated signal installation provides the control unit with information regarding the presence or movement of vehicles, bicycles, and pedestrians. Vehicle detection systems perform two basic functions: queue clearance and the termination of phases. Depending on the specific intersection characteristics, either of these functions can take priority. The merits of each function are considered and a compromise might be necessary.

The vehicle detection requirements vary depending on the 85th percentile approach speed as follows:

- When the posted speed is below 35 mph, provide stop bar detection from the stop bar to a point 30 ft to 35 ft in advance of that location. Assign the stop bar loops to detection input “extension” channels. When counting loops are installed, calculate the distance traveled by a vehicle in two seconds at the 85th percentile speed and position the advance loops at this distance in advance of the stop bar.
- When the posted speed is at or above 35 mph, provide advance detection based on the “dilemma zone detection design”. Where installed, stop bar detection extends from the stop bar to a point 30 ft to 35 ft in advance of that location. Stop bar detection is required on minor streets. Assign stop bar detection to “call” channels and assign advance detection-to-detection input “extension” channels.

A dilemma occurs when a person is forced to make a decision between two alternatives. As applied to vehicle detection design, this situation occurs when two vehicles are approaching a traffic signal and the signal indications turn yellow. The motorist in the lead vehicle must decide whether to accelerate and risk being hit in the intersection by opposing traffic or decelerate and risk being hit by the following vehicle. Dilemma zone detection design has been developed to address this problem. This design allows the 90th percentile speed vehicle and the 10th percentile speed vehicle to either clear the intersection safely or decelerate to a complete stop before reaching the intersection. The method of calculating the dilemma zone and the required detection loops is shown in Figure 850-9.

A study of the approach speeds at the intersection is necessary to design the dilemma zone detection. Speed study data is obtained at the approximate location at or just upstream of the dilemma zone. Only the speed of the lead vehicle in each platoon is considered. Speed study data is gathered during off-peak hours in free-flow conditions under favorable weather conditions. Prior speed study information obtained at this location can be used if it is less than one and a half years old and driving conditions have not changed in the area.

When permissive left-turn phasing is installed on the major street with left-turn channelization, include provisions for switching the detector input for future protected left-turn phasing. Assign the detector a left-turn detector number and connect to the appropriate left-turn detector amplifier. Then specify a jumper connector between that amplifier output and the extension input channel for the adjacent through movement detector. The jumper is removed when the left-turn phasing is changed to protected in the future.

In most cases, electromagnetic induction loops provide the most reliable method of vehicle detection. Details of the construction of these loops are shown in the Standard Plans. Consider video detection systems for projects that involve extensive stage construction with numerous alignment changes. Video detection functions best when the detectors (cameras) are positioned high above the intersection. In this position, the effective detection area can be about ten times the mounting height in advance of the camera. When video detection is proposed, consider using Type III signal standards in all quadrants and install the cameras on the luminaire mast arms. High wind can adversely affect the video equipment by inducing vibration in the luminaire mast arms. Areas that experience frequent high winds are not always suitable for video detection.

(7) Preemption Systems

(a) **Emergency vehicle preemption.** Emergency vehicle preemption is provided if the emergency service agency has an operating preemption system. WSDOT is responsible for the preemption equipment that is permanently installed at the intersection for new construction or rebuild projects. The emergency service agency is responsible for preemption emitters in all cases. If the emergency agency requests additional preemption equipment at an existing signal, that agency is responsible for all installation costs for equipment installed permanently at the intersection. These same guidelines apply for a transit agency requesting transit preemption. The standard emergency vehicle system is optically activated to be compatible with all area emergency service agency emitters. Approval by the State Traffic Engineer is required for the installation of any other type of emergency vehicle preemption system.

Optically activated preemption detectors are positioned for each approach to the intersection. These detectors function best when the approach is straight and relatively level. When the approach is in a curve, either horizontal or vertical, it might be necessary to install additional detectors in or in advance of the curve to provide adequate coverage of that approach. Consider the approximate speed of the approaching emergency vehicle and the amount of time necessary for phase termination and the beginning of the preemption phase when positioning these detectors.

(b) **Railroad preemption.** An approaching train is detected either by electrical contacts under the railroad tracks or by motion sensors. The railroad company installs these devices. The region provides the electrical connections between the railroad signal enclosure (called a bungalow) and the preemption phasing in the traffic signal controller. A two-conductor cable is used for the electrical connection. The electrical circuit is connected to a closed “dry” contact using a normally energized relay. When a train is detected, the relay opens the circuit to the traffic signal controller. Contact the railroad to determine the voltage they require for this relay. This will determine the requirements for the isolator at the traffic signal controller. The railroad company’s signal equipment usually operates at 24 volt DC storage batteries charged by a 120 volt AC electrical system. Conduit crossings under railroad tracks are normally jacked or pushed because open excavation is rarely allowed. The usual depth for these crossings is four feet below the tracks but railroad company requirements can vary. Contact the company for their requirements. They, also, will need the average vehicle queue clearance time values in order to finalize the preemption agreement. These values are shown on Figure 850-10.

Flashing railroad signals are usually necessary when railroad preemption is installed at a signalized intersection. Automatic railroad gates are also necessary when train crossings are frequent and the exposure factor is high. Chapter 930 provides guidance on determining the railroad crossing exposure factor. Advance signals, signal supports with displays, are also only installed at locations with high exposure factors. See Figures 850-11a and 850-11b. When the nearest rail at a crossing is within 88 ft of an intersection stop bar on any approach, provide additional traffic signal displays in advance of the railroad crossing. The 88-foot distance provides storage for the longest vehicle permitted by statute (75 ft plus 3 ft front overhang and 4 ft rear overhang) plus a 6 ft down stream clear storage distance.

Light rail transit crossings at signalized intersections also use a form of railroad preemption. Light rail transit makes numerous stops along its route, sometimes adjacent to a signalized intersection. Because of this, conventional railroad preemption detection, which uses constant speed as a factor, is not effective. Light rail transit uses a type of preemption similar to that used for emergency vehicle preemption.

(c) **Transit priority preemption.** Signal preemption is sometimes provided at intersections to give priority to transit vehicles. The most common form of preemption is the optically activated type normally used for emergency preemption. This can be included in mobility projects, but the transit company assumes all costs in providing, installing, and maintaining this preemption equipment. The department's role is limited to approving preemption phasing strategies and verifying the compatibility of the transit company's equipment with the traffic signal control equipment.

(8) Signal Displays

Signal displays are the devices used to convey right of way assignments and warnings from the control mechanism to the motorists and pedestrians. When selecting display configurations and locations, the most important objective is the need to present these assignments and warnings to the motorists and pedestrians in a clear and concise manner. Typical vehicle signal displays are shown in Figures 850-12a through 850-12e. In addition to the display requirements contained in the MUTCD, the following also apply:

- Always provide two identical indications for the through (primary) or predominate movement, spaced a minimum of 8 ft apart when viewed from the center of the approach. At a tee intersection, select the higher volume movement as the primary movement and provide displays accordingly. A green left-turn arrow on a primary display and a green ball on the other primary display do not comply with this rule.
- Use arrow indications only when the associated movement is completely protected from conflict with other vehicular and pedestrian movements. This includes conflict with a permissive left-turn movement.
- Locate displays overhead whenever possible and in line with the path of the applicable vehicular traffic.
- Locate displays a minimum of 40 ft (60 ft desirable) ands a maximum of 150 ft from the stop line.
- Consider installation of a near-side display when the visibility requirements of Table 4-1 of the MUTCD cannot be met.
- Use vertical vehicle-signal display configurations. Horizontal displays are not allowed unless clearance requirements cannot be achieved with vertical displays. Approval by the State Traffic Engineer is required for the installation of horizontal displays.
- Use 12-inch signal sections for all vehicle displays except the lower display for a post-mount ramp-meter signal.
- Use all arrow displays for protected left turns when the left turn operates independently from the adjacent through movement.
- When green and yellow arrows are used in combination with circular red for protected left turns operating independently from the adjacent through movement, use visibility-limiting displays (either optically programmed sections or louvered visors). Contact the local maintenance superintendent, signal operations office, or traffic engineer to ensure correct programming of the head.
- Use either a five section cluster arrangement (dog house) or a five section vertical arrangement.
- Use either Type M or Type N mountings for vehicle display mountings on mast arms. Provide only one type of mounting for each signal system. Mixing mounting types at an intersection is not acceptable except for supplemental displays mounted on the signal standard shaft.
- Use backplates for all overhead mounted displays.
- Use Type E mountings for pedestrian displays mounted on signal standard shafts.
- Consider installing supplemental signal displays when the approach is in a horizontal or vertical curve and the intersection visibility requirements cannot be met.

The minimum mounting heights for cantilevered mast arm signal supports and span wire installations is 16.5 ft from the roadway surface to the bottom of the signal housing or back plate. There is also a maximum height for signal displays. The roof of a vehicle can obstruct the motorist's view of a signal display. The maximum heights from the roadway surface to the bottom of the signal housing with 12-inch sections are shown in Figure 850-1.

Distance	Signal Display	Maximum Height
Signal displays 40 feet from the stop bar	Vertical 3 section	17.3 feet
	Vertical 4 section	16.9 feet
	Vertical 5 section*	16.5 feet
Signal displays 45 feet from the stop bar	Vertical 3 section	19.1 feet
	Vertical 4 section	17.9 feet
	Vertical 5 section*	16.8 feet
Signal displays 50 feet from the stop bar	Vertical 3 section	20.9 feet
	Vertical 4 section	19.7 feet
	Vertical 5 section*	18.5 feet
Signal displays 53 to 150 feet from the stop bar	Vertical 3 section	21.9 feet
	Vertical 4 section	20.7 feet
	Vertical 5 section*	19.6 feet

* Note: The 5 section cluster display is the same height as a vertical 3-section signal display.

Signal Display Maximum Heights
Figure 850-1

Install an advanced signalized intersection warning sign assembly to warn motorists of a signalized intersection when either of the two following conditions exists:

- The visibility requirements in Table 4-1 of the MUTCD are not achievable.
- The 85th percentile speed is 55 mph or higher and the nearest signalized intersection is more than two miles away.

This warning sign assembly consists of a W3-3 sign, two continuously flashing beacons, and sign illumination. Locate the sign in advance of the intersection in accordance with Table II-1 (Condition A) of the MUTCD.

(9) Signal Supports

Signal supports for vehicle displays consist of metal vertical shaft standards (Type I), cantilevered mast arm standards (Type II, Type III, and Type SD Signal Standards), metal strain poles (Type IV and Type V Signal Standards), or timber strain poles. See the Standard Plans.
Mast arm installations are preferred because they provide greater stability for signal displays in high wind areas and reduce maintenance costs. Preapproved mast arm signal standard designs are available with arm lengths up to 65 ft. Use mast arm standards for permanent installations unless display requirements cannot be met. Metal strain poles are allowed when signal display requirements cannot be achieved with mast arm standards or the installation is expected to be in place less than 5 years. Timber strain pole supports are generally used for temporary installations that will be in place less than 2 years.

Pedestrian displays can be mounted on the shafts of vehicle display supports or on individual vertical shaft standards (Type PS). The push buttons used for the pedestrian detection system can also be mounted on the shafts of other display supports or on individual pedestrian push button posts. Do not place the signal standard at a location that blocks pedestrian or wheelchair activities. Locate the pedestrian push buttons so they are ADA accessible to pedestrians and persons in wheelchairs.

Terminal cabinets mounted on the shafts of mast arm standards and steel strain poles are recommended. The cabinet provides electrical conductor termination points between the controller cabinet and signal displays that allows for easier construction and maintenance. Terminal cabinets are usually located on the back side of the pole to reduce conflicts with pedestrians and bicyclists.

In the placement of signal standards, the primary consideration is the visibility of signal faces. Place the signal supports as far as practicable from the edge of the traveled way without adversely affecting signal visibility. The MUTCD provides additional guidance for locating signal supports. Initially, lay out the location for supports for vehicle display systems, pedestrian detection systems, and pedestrian display systems independently to determine the optimal location for each type of support. If conditions allow and optimal locations are not compromised, pedestrian displays and pedestrian detectors can be installed on the vehicular display supports.

Another important consideration that can influence the position of signal standards is the presence of overhead and underground utilities. Verify the location of these lines during the preliminary design stage to avoid costly changes during construction.

Mast arm signal standards are designed based on the total wind load moment on the mast arm. The moment is a function of the XYZ value and this value is used to select the appropriate mast arm fabrication plan. The preapproved mast arm fabrication plans are listed in the special provisions. To determine the XYZ value for a signal standard, the cross sectional area for each component mounted on the mast arm is determined. Each of these values is then multiplied by its distance from the vertical shaft. These values are then totaled to determine the XYZ value. All signal displays and mast arm mounted signs, including street name signs, are included in this calculation. The effect of emergency preemption detectors and any required preemption indicator lights are negligible and are not included. For mast arm mounted signs, use the actual sign area to determine the XYZ value. An example of this calculation is shown in Figure 850-13. Cross sectional areas for vehicle displays are shown in Figure 850-2.

Signal Display	Area
Vertical 3 section	8.7 sq ft
Vertical 4 section	11.0 sq ft
Vertical 5 section	13.1 sq ft
5 section cluster	14.4 sq ft

Signal Display Areas
Figure 850-2

Foundation design is a critical component of the signal support. A soils investigation is required to determine the lateral bearing pressure and the friction angle of the soil and whether ground water might be encountered. The XYZ value is used in determining the foundation depth for the signal standard. Select the appropriate foundation depth from Figure 850-13. A special foundation design for a mast arm signal standard is required if the lateral bearing pressure is less than 1000 psf or the friction angle is less than 26 degrees. The regional materials group determines if these unusual soil conditions are present and a special foundation design is required. They then send this information to the OSC Materials Office for confirmation. That office forwards the findings to the OSC Bridge and Structures Office and requests the special foundation design. The Bridge and Structures Office designs foundations for the regions and reviews designs submitted by private engineering groups performing work for the regions.

Steel strain poles are used in span wire installations and are available in a range of pole classes. A pole class denotes the strength of the pole. The loads and resultant forces imposed on strain poles are calculated and a pole class greater than that load is specified. Figures 850-14a and 850-14b show the procedure for determining the metal strain pole class and foundation. Figure 850-15 shows an example of the method of calculation. The foundation depth is a product of the pole class and the soil bearing pressure. A special design is required for metal strain pole or timber strain pole support systems if the span exceeds 150 ft, the tension on the span exceeds 7200 lbs, or the span wire attachment point exceeds 29 ft in height. Contact the OSC Bridge and Structures Office for assistance.

(10) Preliminary Signal Plan

Develop a preliminary signal plan for the project file. Include with the preliminary signal plan a discussion of the problem that is being addressed by the project. Provide sufficient level of detail on the preliminary signal plan to describe all aspects of the signal installation, including proposed channelization modifications. Use a plan scale of 1 inch = 20 feet and include the following information:

- Stop bars
- Crosswalks
- Left-turn radii, including beginning and ending points
- Corner radii, including beginning and ending points
- Vehicle detector locations

- Pedestrian detector locations
- Signal standard types and locations
- Vehicle signal displays
- Pedestrian signal displays
- Phase diagram including pedestrian movements
- Emergency vehicle preemption requirements
- Illumination treatment

Submit a copy of the preliminary signal plan to the State Traffic Engineer for review and comment. When the proposed traffic signal is on an NHS highway, also submit a copy of the preliminary signal plan to the Assistant State Design Engineer for review and concurrence. After addressing review comments, finalize the plan and preserve as noted in the documentation section of this chapter. Prepare the contract plans in accordance with the *Plans Preparation Manual*.

If HQ is preparing the contract plans, specifications, and estimates for the project, submit the above preliminary signal plan with the following additional items:

- Contact person.
- Charge numbers.
- Critical project schedule dates.
- Existing utilities, both underground and overhead.
- Existing intersection layout, if different from the proposed intersection.
- Turning movement traffic counts; peak hour for isolated intersections; and AM, Midday, and PM peak hour counts if there is another intersection within 500 ft.
- Speed study indicating 90th and 10th percentile speeds for all approaches.
- Electrical service location, source of power, and utility company connection requirements.

After the plans, specifications, and estimate are prepared, the entire package is transmitted to the region for incorporation into their contract documents.

(11) Electrical Design

(a) **Circuitry Layout.** Consider cost, flexibility, construction requirements, and ease of maintenance when laying out the electrical circuits for the traffic signal system. Minimize roadway crossings whenever possible.

(b) **Junction Boxes.** Provide junction boxes at each end of a roadway crossing, where the conduit changes size, where detection circuit splices are required, and at locations where the sum of the bends for the conduit run equals or exceeds 360°. Signal standard or strain pole bases are not used as junction boxes. In general, locate junction boxes out of paved areas and sidewalks. Placing the junction boxes within the traveled way is rarely an effective solution and will present long-term maintenance problems. If there is no way to avoid locating the junction box in the traveled way, use traffic-bearing boxes. Avoid placing junction boxes in areas of poor drainage. In areas where vandalism can be a problem, consider junction boxes with locking lids. The maximum conduit capacities for various types of junction boxes are shown in the Standard Plans.

(c) **Conduit.** Use galvanized steel conduit for all underground raceways for the traffic signal installation on state highways. Thick-walled polyvinyl chloride (Schedule 80 PVC) conduit is used by many local agencies for ease of installation. At existing intersections, where roadway reconstruction is not proposed, place these conduits beyond the paved shoulder or behind existing sidewalks to reduce installation costs. With the exception of the 1/2 inch conduit for the service grounding electrode conductor, the minimum size conduit is 1 inch. The minimum size conduit for installations under a roadway is $1^1/4$ inch. Size all conduits to provide 26% maximum conductor fill for new signal installations. A 40% fill area can be used when installing conductors in existing conduits. See Figure 850-16 for conduit and signal conductor sizes.

(d) **Electrical Service and other components.** Electrical service types, overcurrent protection, and other components are covered in Chapter 840.

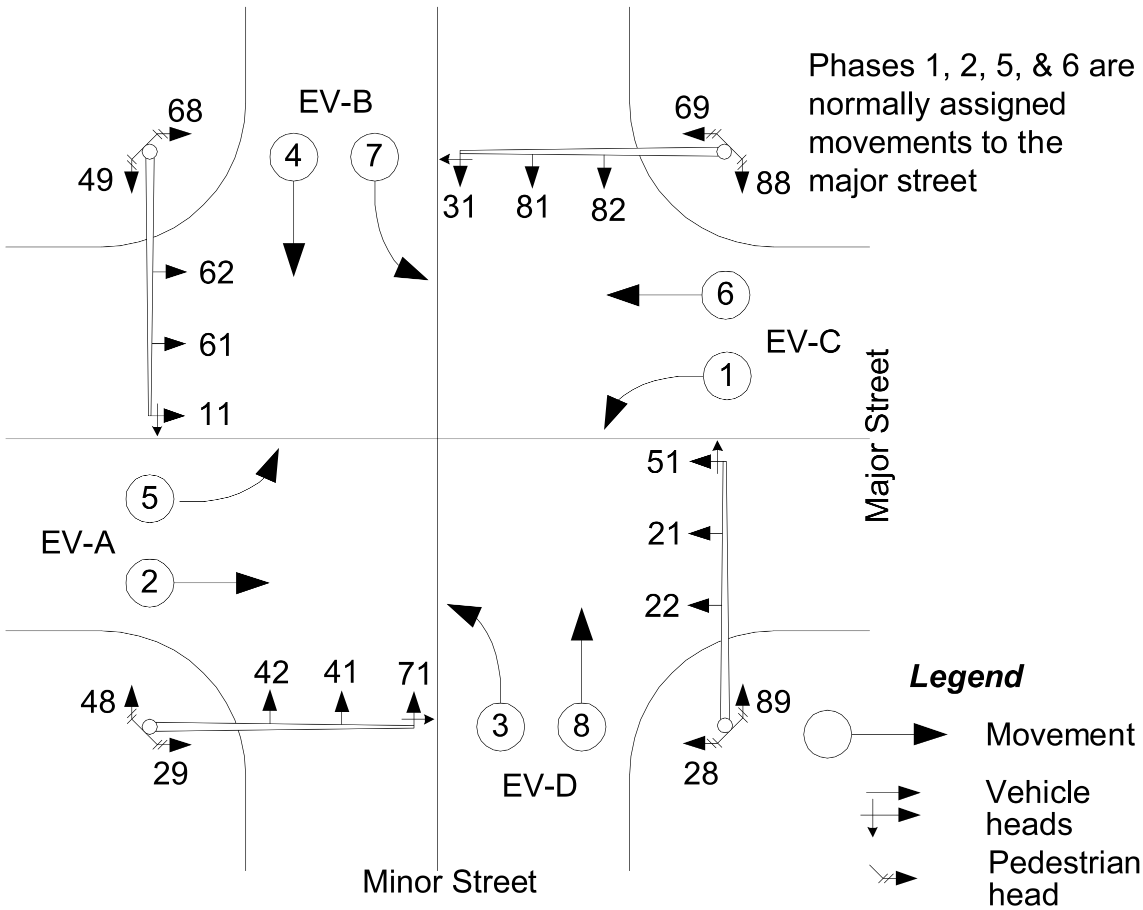
850.07 Documentation

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

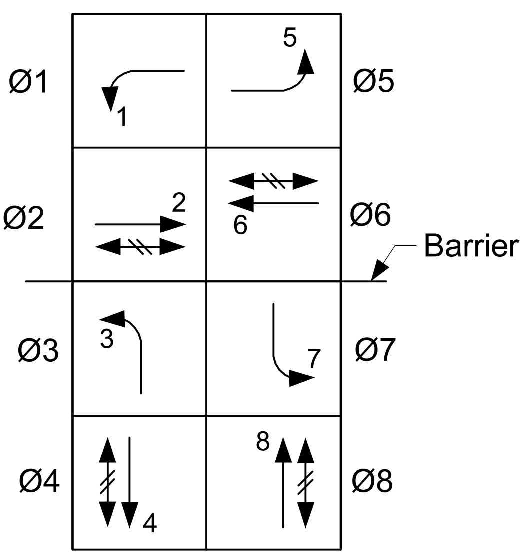
Responsibility for Various Types of Facilities on State Highways				
Area	Responsibility	Emergency vehicle signals	Traffic signals, school signals, & intersection control beacons	Reversible lane signals & moveable bridge signals
Cities with less than 22,500 population	Finance	ESD (1)	State	State
	Construct	ESD (1)	State	State
	Maintain	ESD (1)	State	State
	Operate	ESD (1)	State	State
Cities with 22,500 or greater population	Finance	ESD (1)	City (2)	City (2)
	Construct	ESD (1)	City (2)	City (2)
	Maintain	ESD (1)	City (2)	City (2)
	Operate	ESD (1)	City (2)	City (2)
Beyond corporate limits	Finance	ESD (1)	State Country (3)	State
	Construct	ESD (1)	State	State
	Maintain	ESD (1)	State	State
	Operate	ESD (1)	State	State
Access control	Finance	ESD (1)	State	State
	Construct	ESD (1)	State	State
	Maintain	ESD (1)	State	State
	Operate	ESD (1)	State	State

Notes:
(1) ESD refers to the applicable Emergency Service Department.
(2) State highways without established limited access control. See 850.04(2)b.
(3) See 850.04(2)d.

Responsibility for Facilities
Figure 850-3



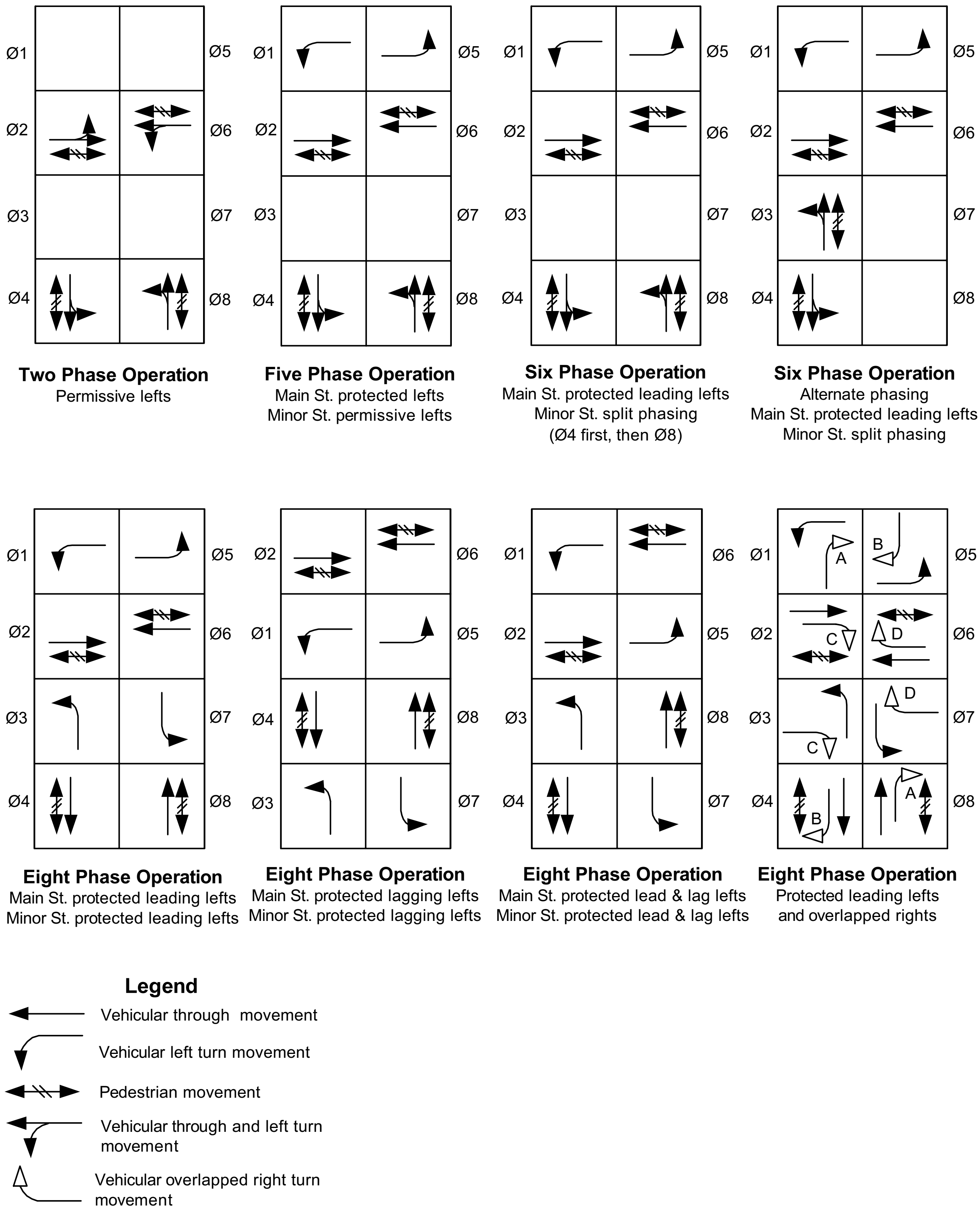
Standard Intersection Movements and Head Numbers



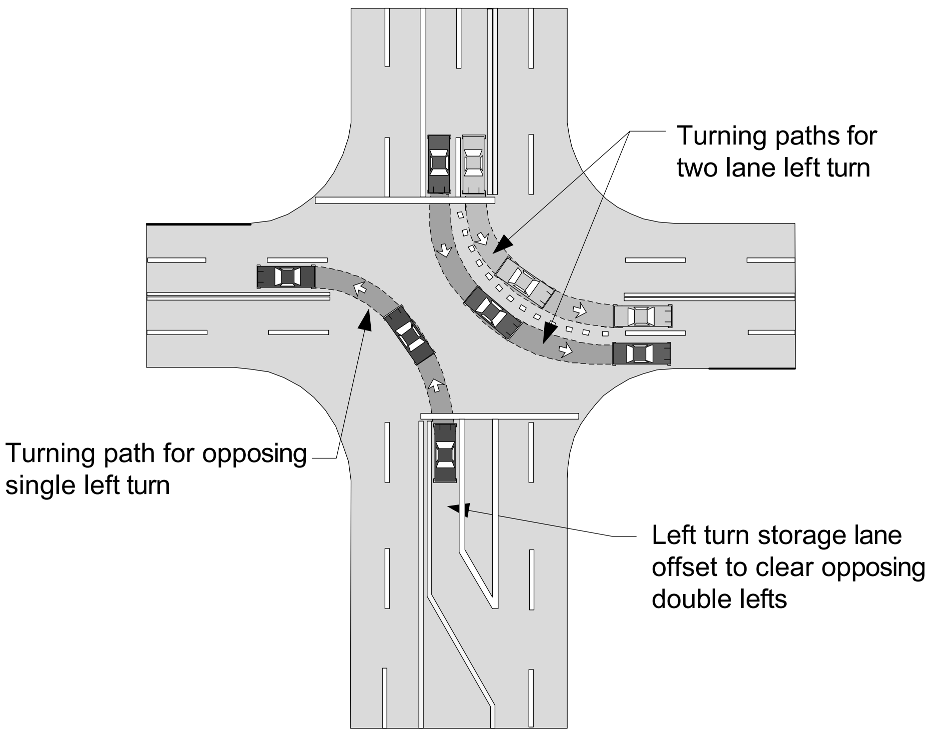
Standard Eight Phase Operation

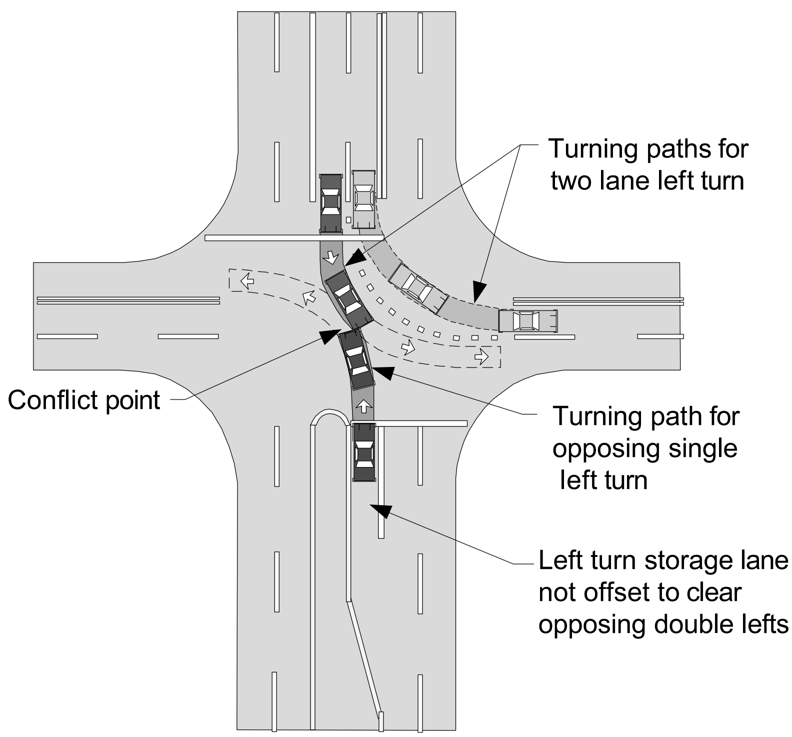
Standard Intersection Movements and Head Numbers

Figure 850-4

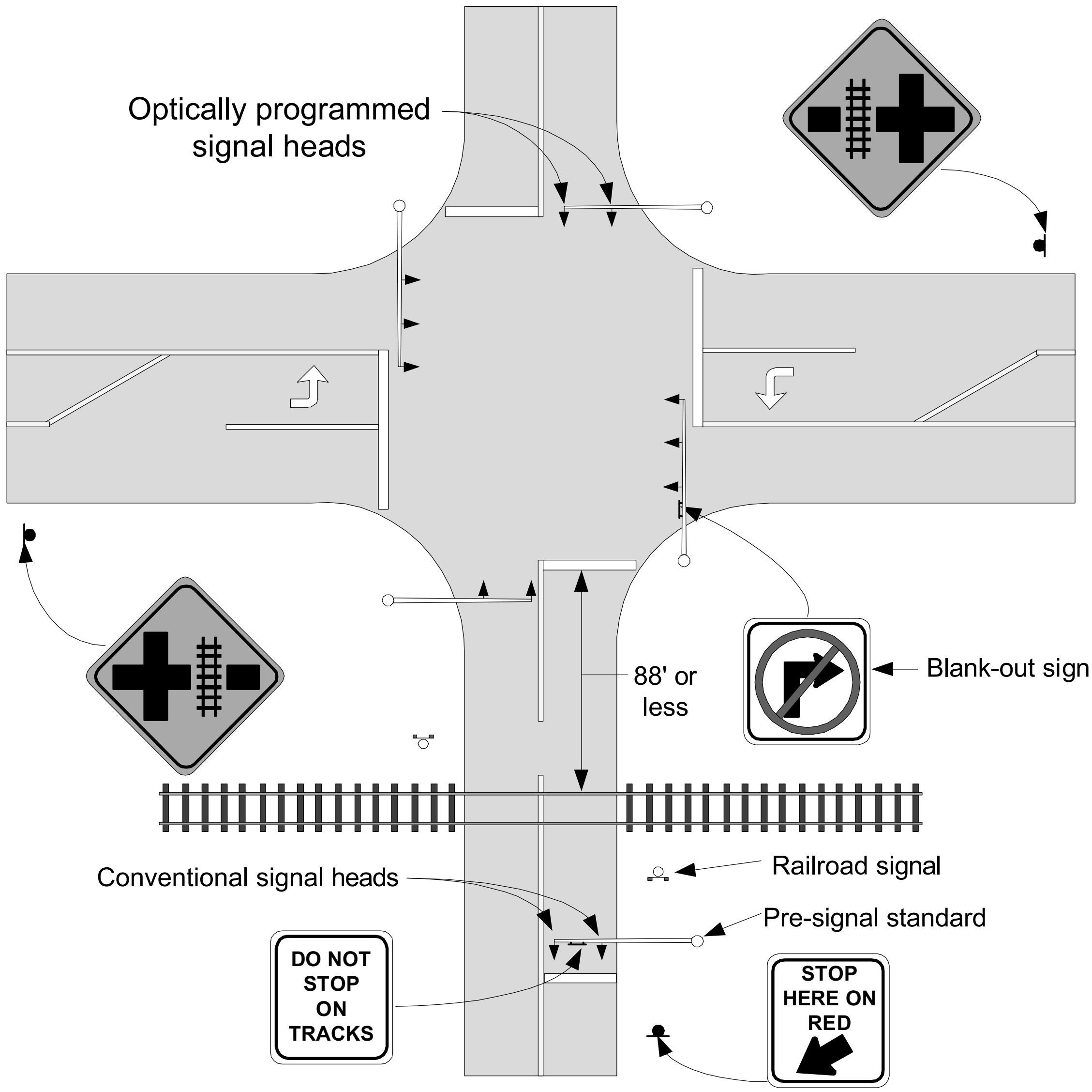


Phase Diagrams — Four Way Intersections
Figure 850-5

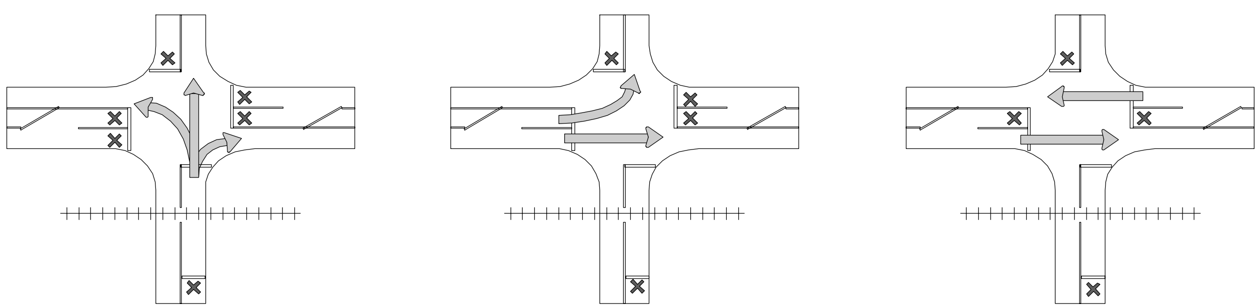




Turn Lane Configuration Preventing Concurrent Phasing
Double Left Turn Channelization
Figure 850-6



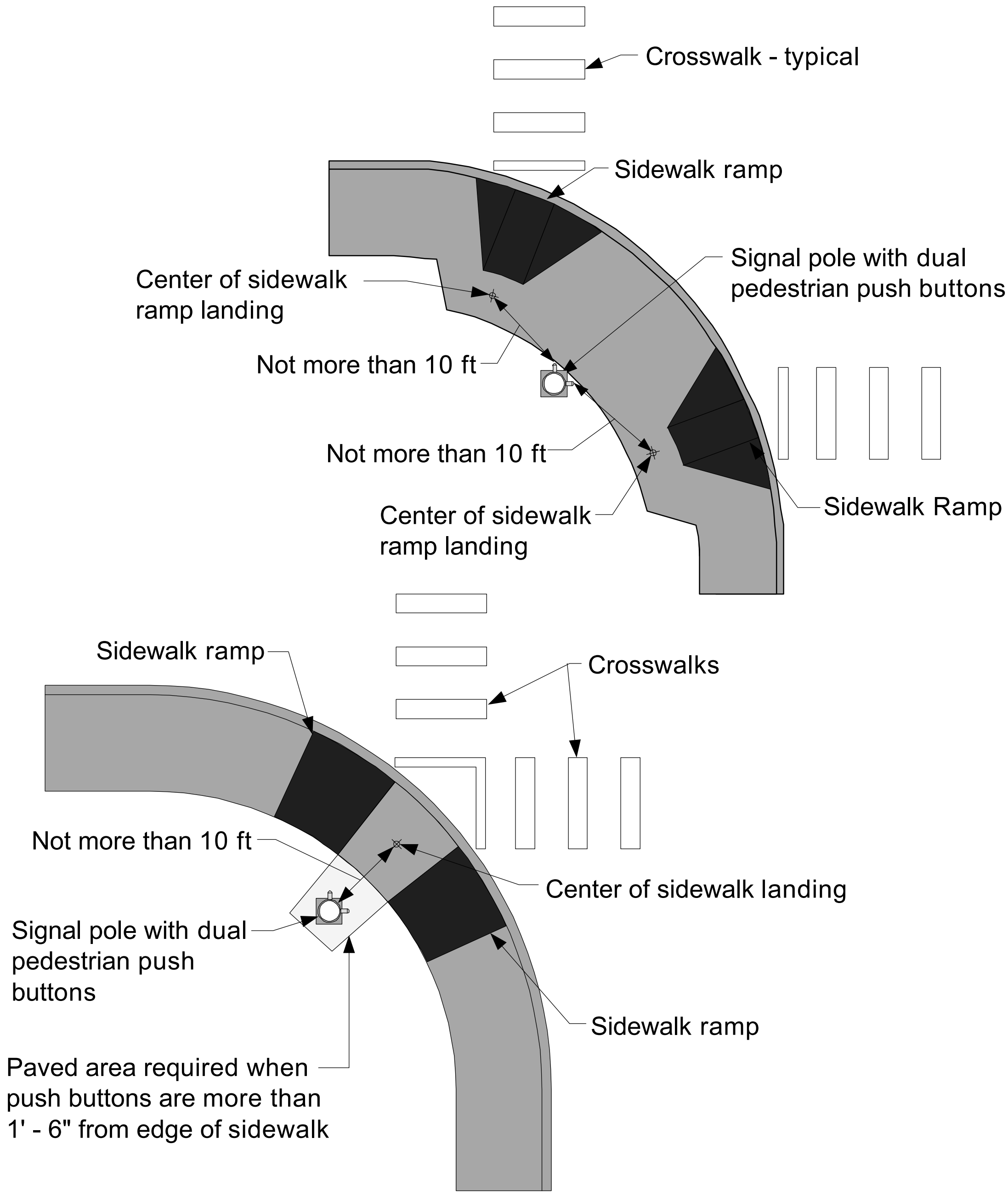
Typical Signal Installation
Adjacent to Railroad



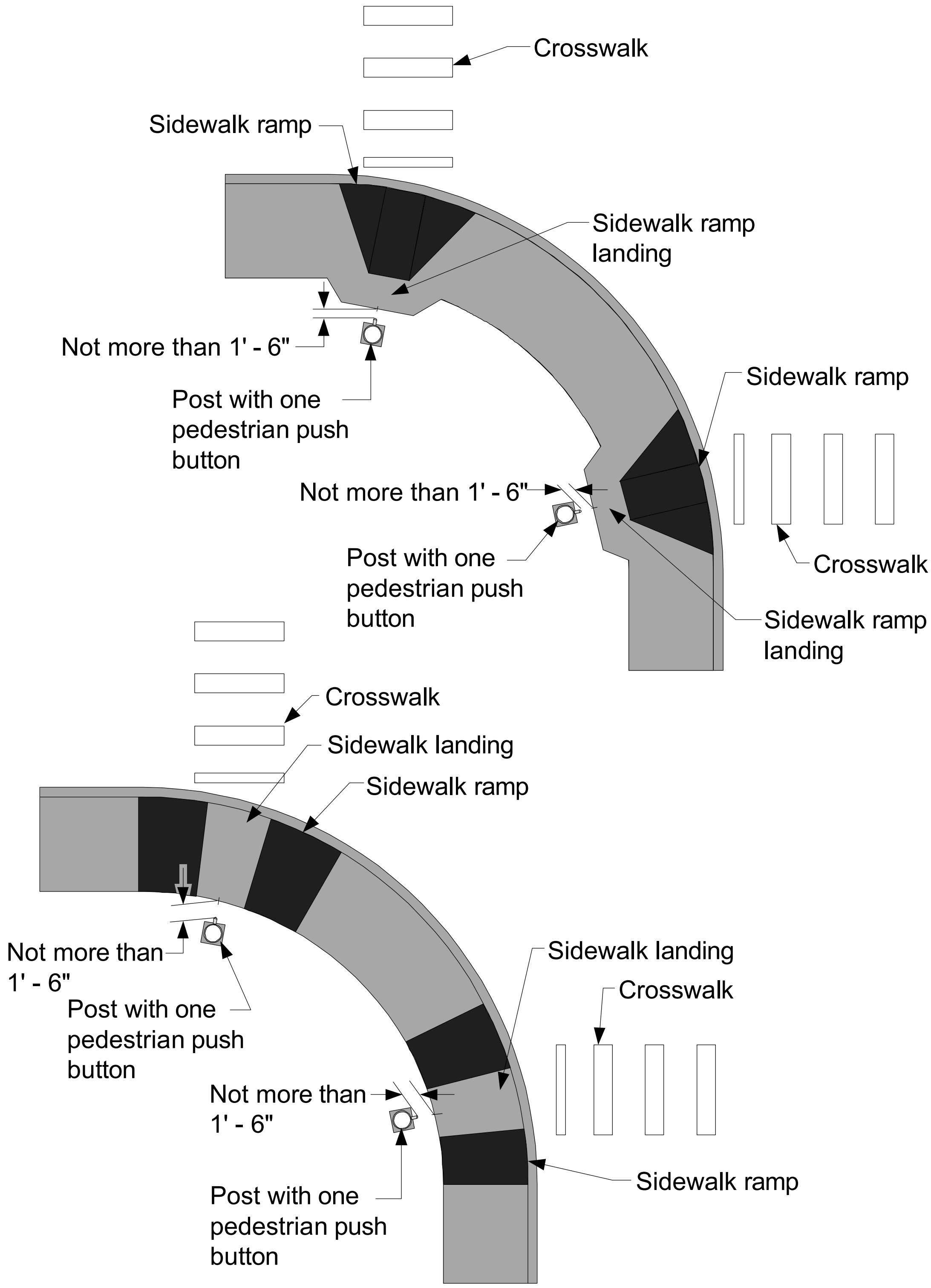
Clearance Phase before Train Arrival

Phase Sequence During Train Crossing

Railroad Preemption Phasing
Figure 850-7



Pedestrian Push Button Locations
Figure 850-8a



Pedestrian Push Button Locations
Figure 850-8b

Where: **V_{90}** = 90^{th} pecentile speed in feet per second

V_{10} = 10^{th} percentile speed in feet per second

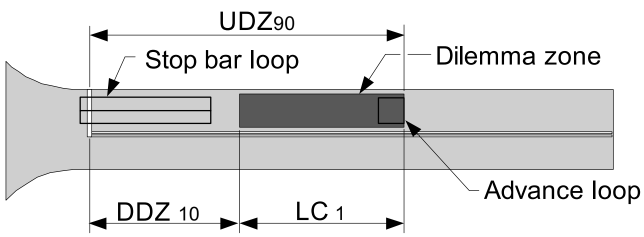
UDZ_{90} = Upstream end of dilemma zone for 90^{th} percentile speed

DDZ_{10} = Downstream end of dilemma zone for 10^{th} percentile speed

LC_1 = V_{10} travel time to downstream DDZ_{10}

LC_2 = V_{10} travel time from 1st loop to 2nd loop

LC_3 = V_{10} travel time from 3rd loop to DDZ_{10}



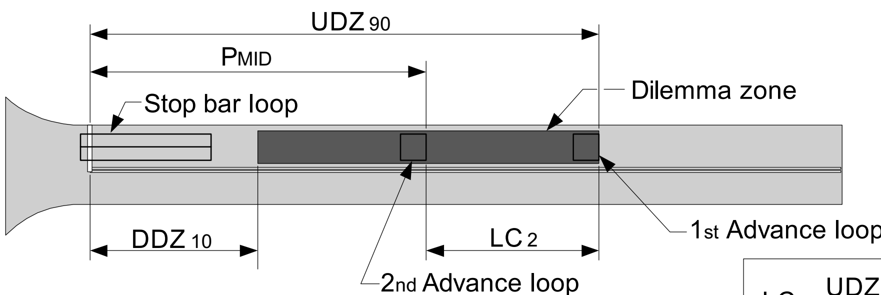
$$UDZ_{90} = \frac{V_{90}^2}{16} + V_{90}$$

$$DDZ_{10} = \frac{V_{10}^2}{40} + V_{10}$$

$$LC_1 = \frac{UDZ_{90} - DDZ_{10}}{V_{10}}$$

Single Advance Loop Design

When LC_1 is equal to or less than 3 seconds

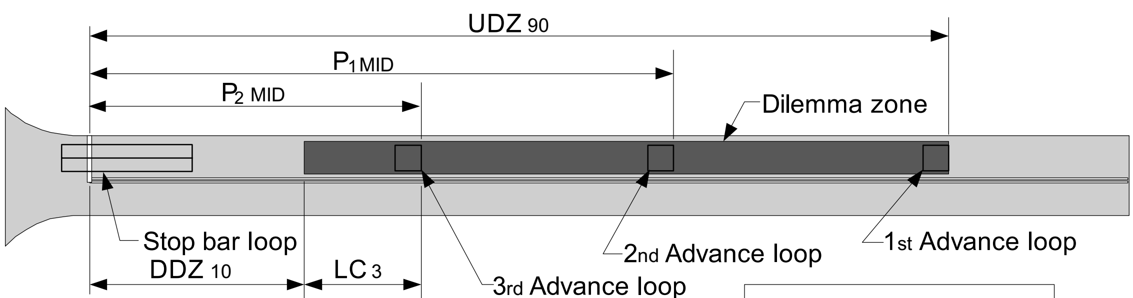


$$LC_2 = \frac{UDZ_{90} - P_{MID}}{V_{10}}$$

$$P_{MID} = \frac{UDZ_{90} + DDZ_{10}}{2}$$

Double Advance Loop Design

When LC_2 is equal to or less than 3 seconds



$$LC_3 = \frac{P_2MID - DDZ_{10}}{V_{10}}$$

$$P_1MID = UDZ_{90} - 3V_{10}$$

$$P_2MID = UDZ_{90} - 6V_{10}$$

Triple Advance Loop Design

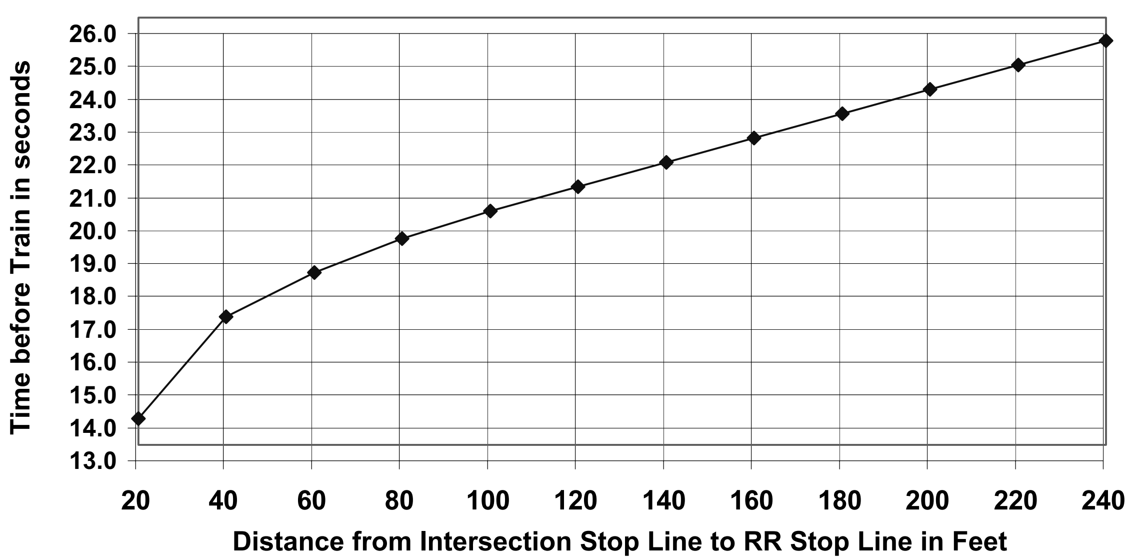
When LC_2 is greater than 3 seconds

Dilemma Zone Loop Placement

Figure 850-9

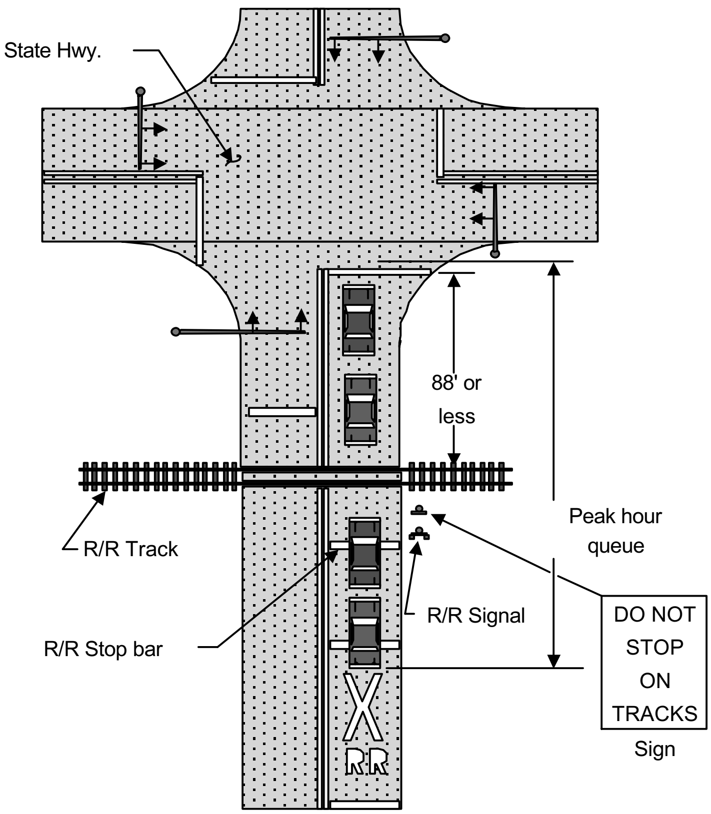
Traffic Signal Railroad Track Clearance Interval Table (Single Track)							
Queue	Start-Up Time	Queue Length	Intersection Clearance	Start-Up Time	Queue Clear Time	Time from PE start to Q	Time Before Train
Vehicles	Seconds	Feet	Seconds	Seconds	Seconds	Seconds	Seconds
A	B	C	D	E	F	G	H
1	3.8	20	10	3.8	3.8	13.8	13.8
2	3.1	40	10	3.1	6.9	16.9	16.9
3	2.7	60	10	2.7	9.6	19.6	18.2
4	2.4	80	10	2.4	12.0	22.0	19.3
5	2.2	100	10	2.2	14.2	24.2	20.1
6	2.1	120	10	2.1	16.3	26.3	20.9
7	2.1	140	10	2.1	18.4	28.4	21.6
8	2.1	160	10	2.1	20.5	30.5	22.3
9	2.1	180	10	2.1	22.6	32.6	23.1
10	2.1	200	10	2.1	24.7	34.7	23.8
11	2.1	220	10	2.1	26.8	36.8	24.6
12	2.1	240	10	2.1	28.9	38.9	25.3

A = Number of Vehicles in the queue.
B = Vehicle startup time.
C = Distance from intersection stop line to R/R gate or R/R stop line. For single track, the stop bar is 20' upstream from the nearest rail.
D = Worst Case intersection clearance (5 seconds mainline green/flashing "don't walk" + 5 seconds yellow/all red = 10 seconds).
E = Startup time for each vehicle by position in the queue.
F = Cumulative startup time, includes the track approach green time (7 seconds minimum).
G = Total time from railroad relay closure until last car in the queue has cleared the intersection stop bar. G = D + F
H = Total time from railroad relay closure until the last car in the queue is 20 ft beyond nearest rail. This assumes a departure speed of 10 MPH. H = G - ((C-40') ÷ 14.7)

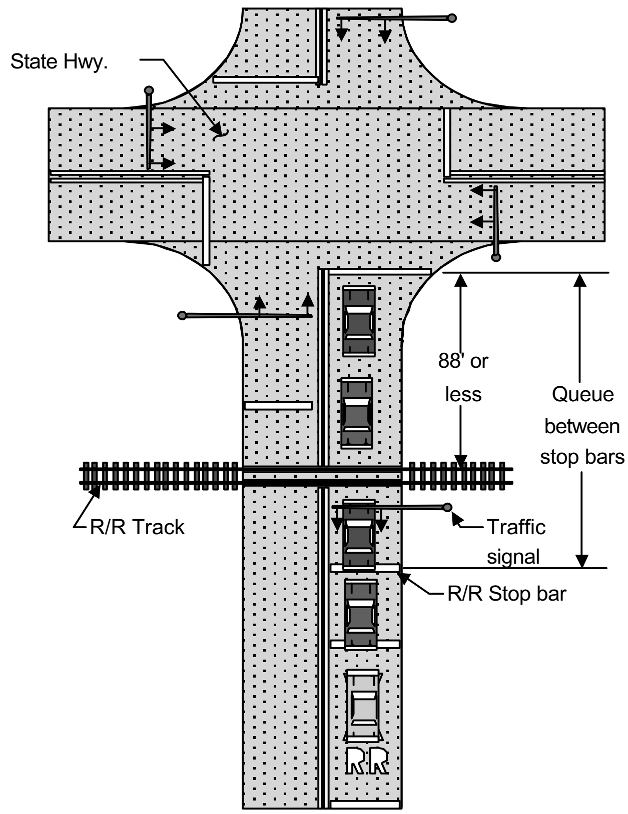


Example: A location where it is 60 ft from stop bar to nearest rail of a single track crossing.
Solution: Enter table at queue length of 80 ft (60 ft + 20 ft to R/R stop bar). Graph value is 19.3 seconds.

Railroad Queue Clearance
Figure 850-10

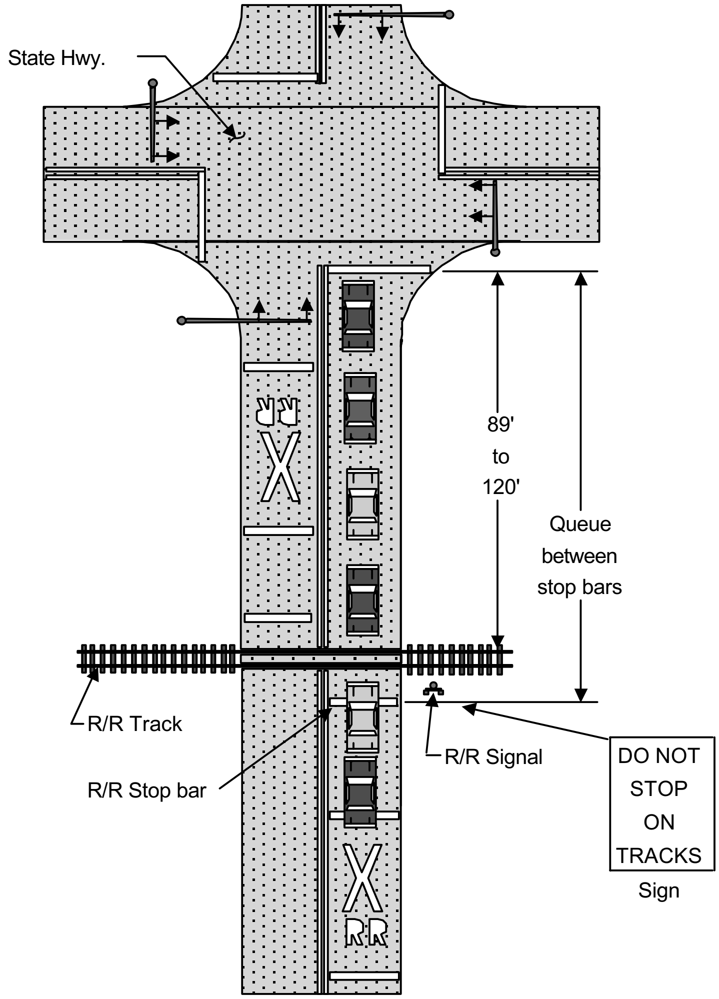


Railroad Crossing
with Low Exposure Factor
(See Chapter 930 for R/R crossing protection guidelines)



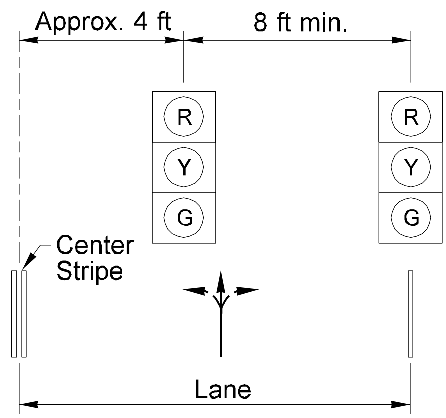
Railroad Crossing
with High Exposure Factor
(See Chapter 930 for R/R crossing protection guidelines)

Intersections With Railroad Crossings
Figure 850-11a

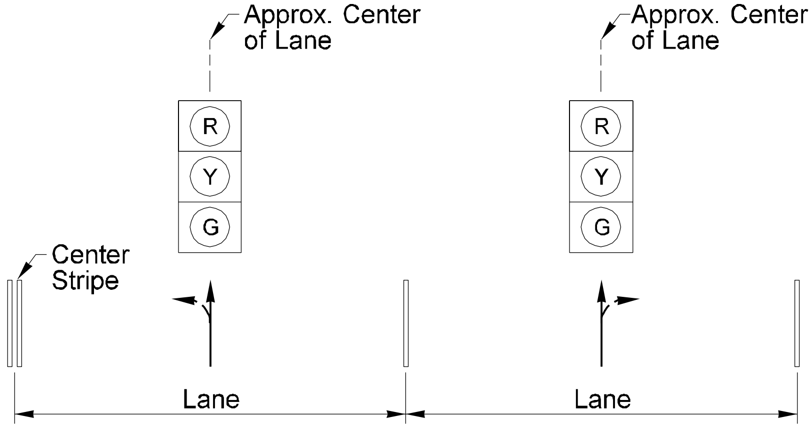


Railroad Crossing more than 88 Ft from Intersection

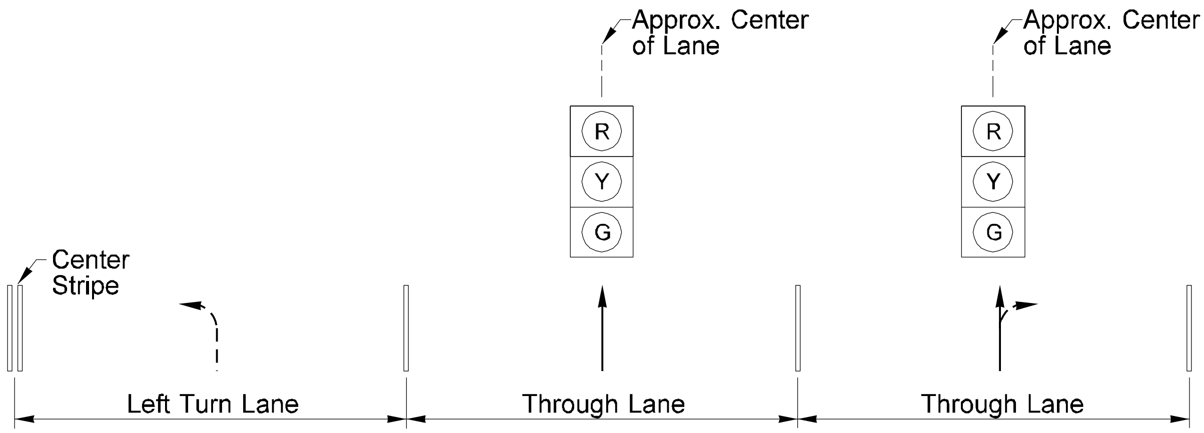
Intersections With Railroad Crossings
Figure 850-11b



One Through Lane
With Permissive Left Turn

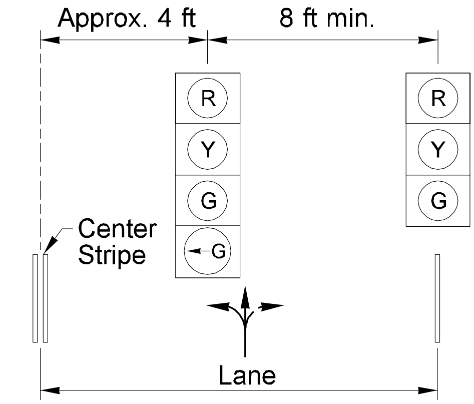


Two Through Lanes
With Permissive Left Turn

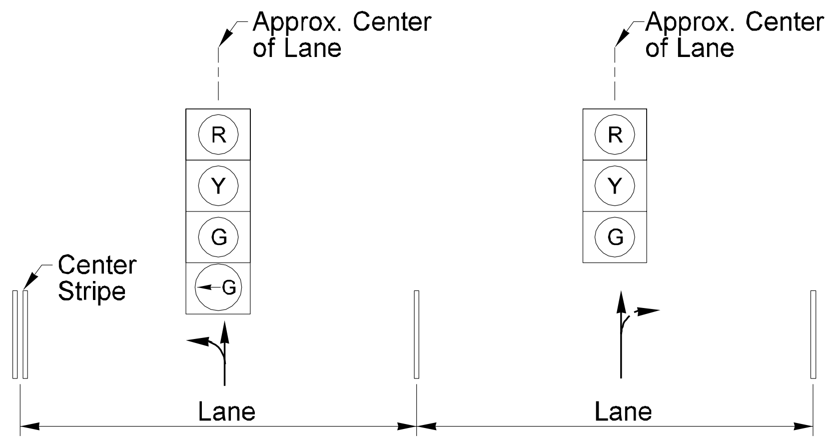


Two Through Lanes and One Left Turn Storage Lane
With Permissive Left Turn

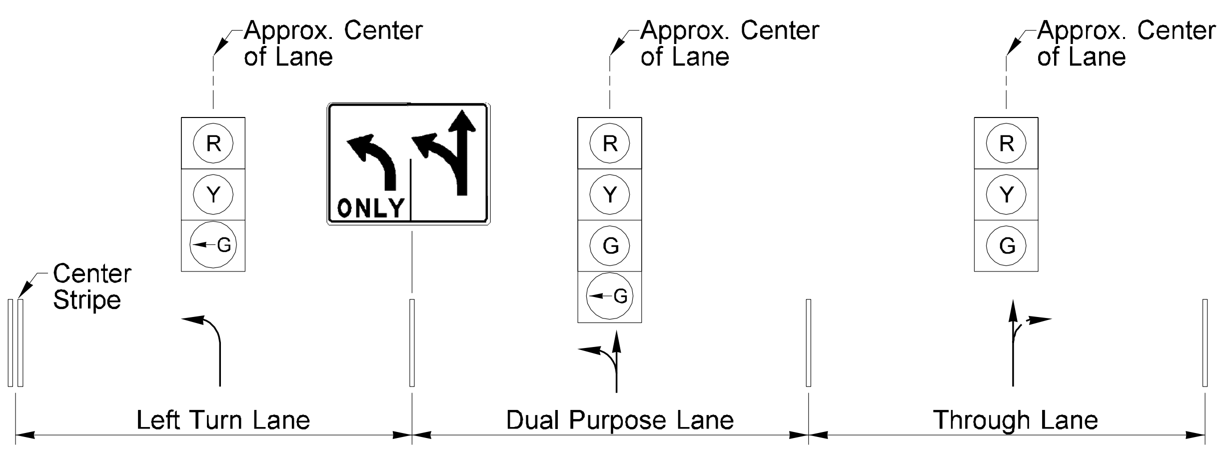
Traffic Signal Display Placements
Figure 850-12a



One Through Lane
With Protected Left Turn Phasing

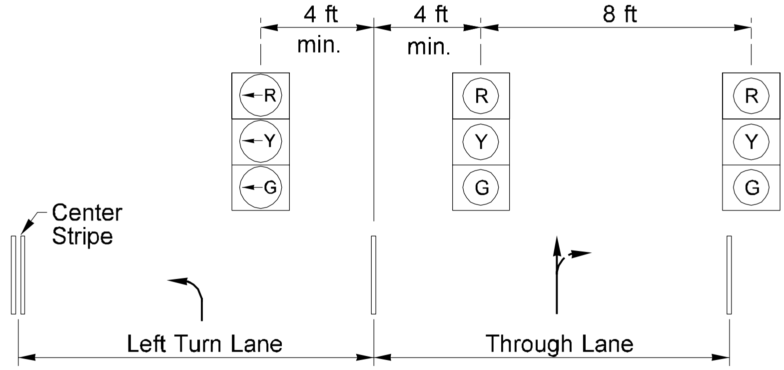


Two Through Lanes
With Split Phasing for Protected Left Turns
(Left turn and through movements terminate together.)



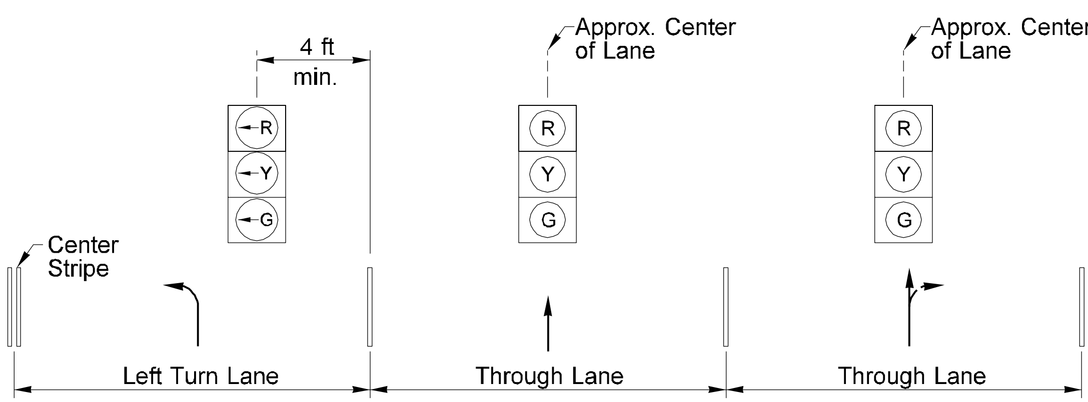
One Through Lane, a Dual Purpose (Left or Through) Lane
and One Left Turn Storage Lane With Split Phasing for Protected Left Turns
(Left turn and through movements terminate together.)

Traffic Signal Display Placements
Figure 850-12b



One Through Lane and One Left Turn Storage Lane With Protected Left Turn Phasing

(Left turn and through movements terminate independently.)

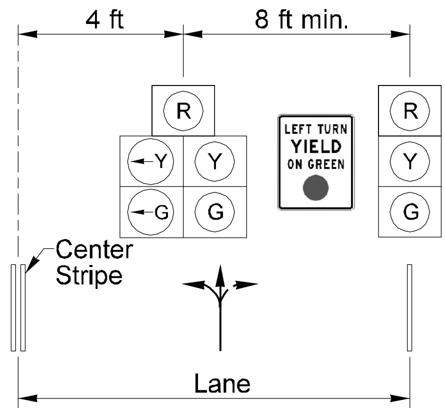


Two Through Lanes and One Left Turn Storage Lane With Protected Left Turn Phasing

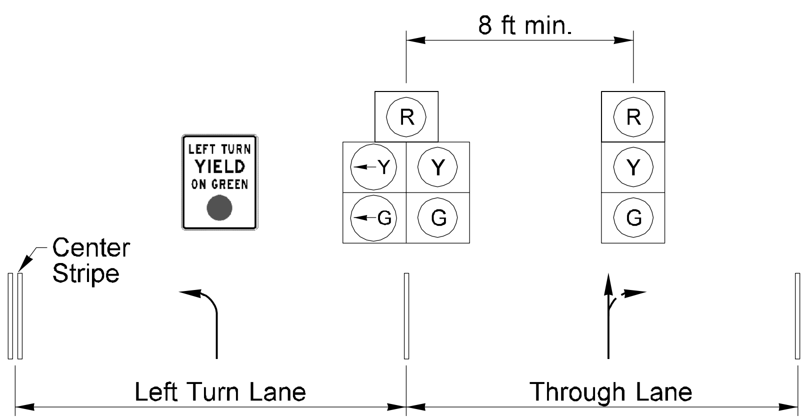
(Left turn and through movements terminate independently.)

Traffic Signal Display Placements

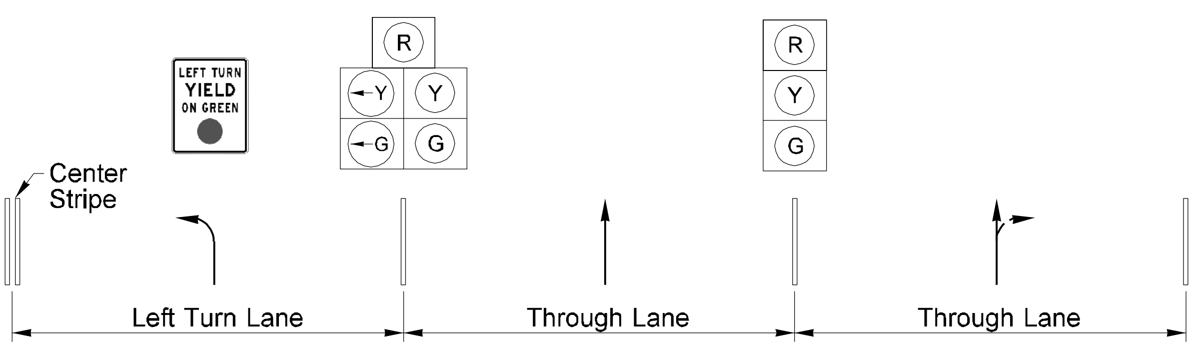
Figure 850-12c



One Through Lane
With Protected / Permissive Left Turn Phasing

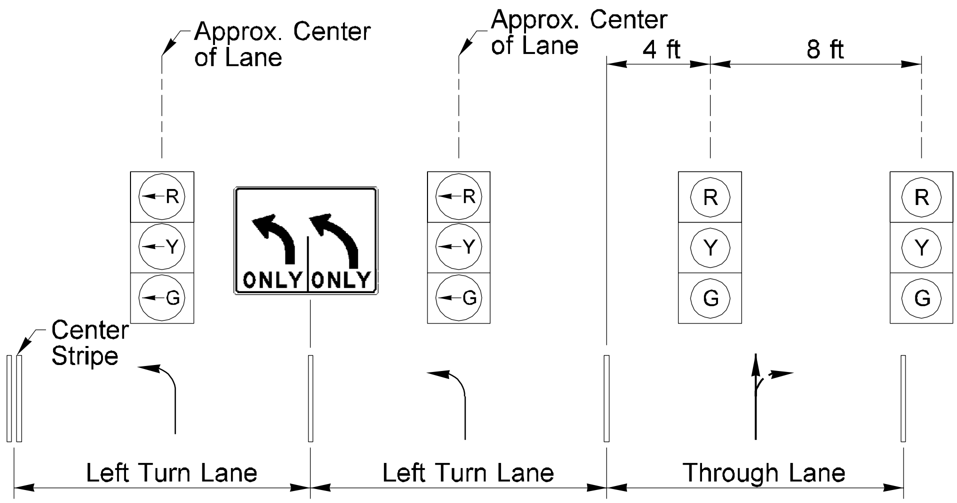


One Through Lane and One Left Turn Storage Lane
With Protected / Permissive Left Turn Phasing



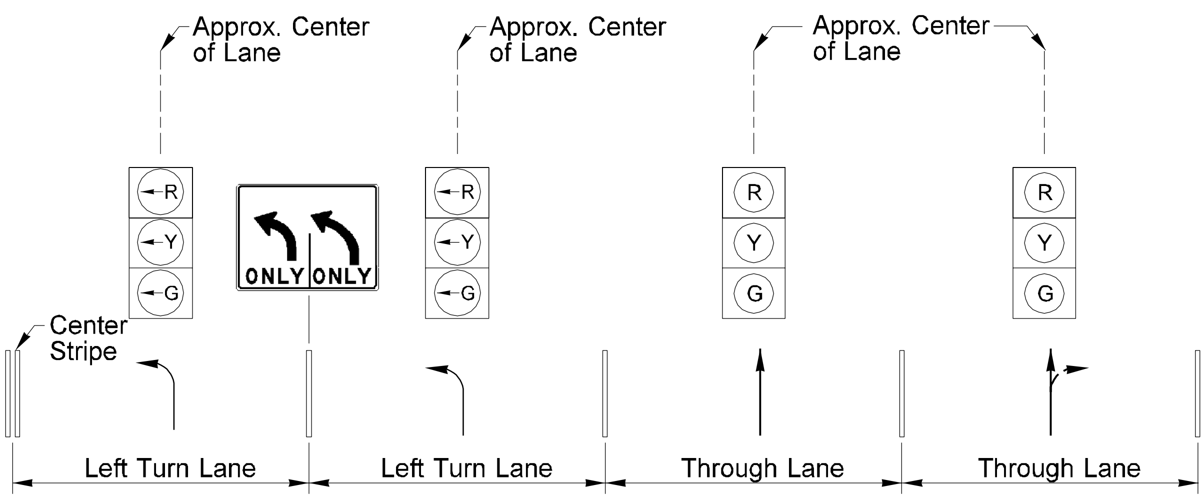
Two Through Lanes and One Left Turn Storage Lane
With Protected / Permissive Left Turn Phasing

Traffic Signal Display Placements
Figure 850-12d



One Through Lane and Two Left Turn Storage Lanes With Protected Left Turn Phasing

(Left Turn and Through Movements Terminate Independently.)

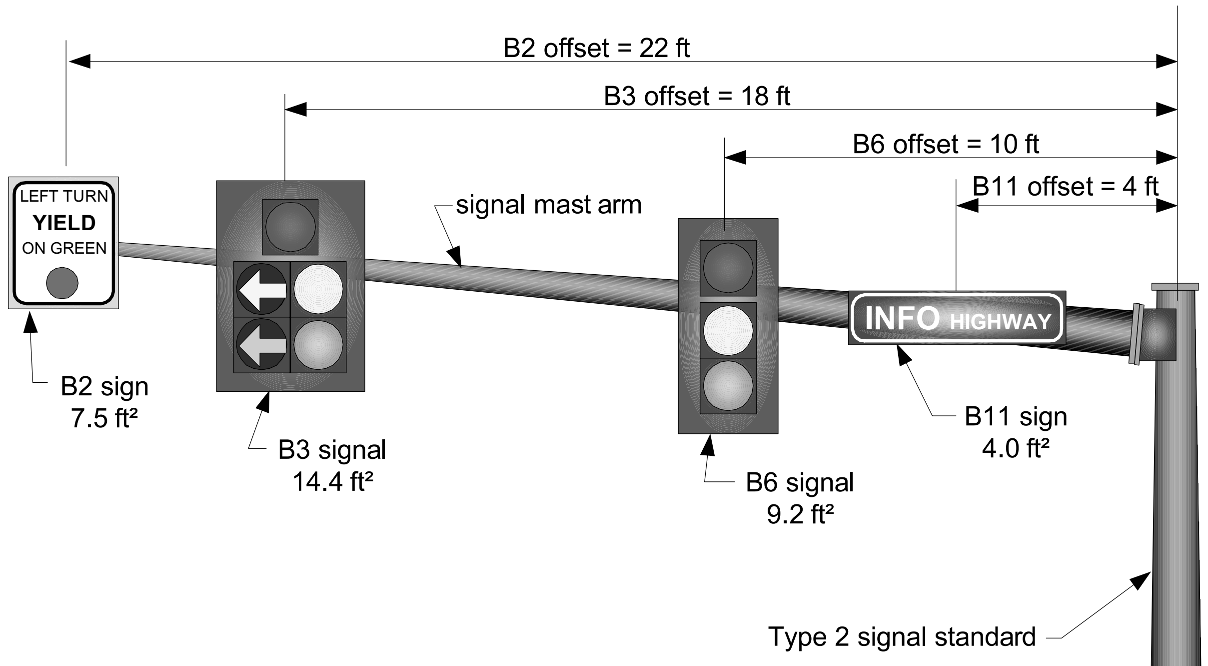


Two Through Lanes and Two Left Turn Storage Lanes With Protected Left Turn Phasing

(Left turn and through movements terminate independently.)

Traffic Signal Display Placements

Figure 850-12e



First

Total windload calculation (XYZ)

B2 area X B2 offset

$7.5\ ft^2 \times 22\ ft = 165.0$

B3 area X B3 offset

$14.4\ ft^2 \times 18\ ft = 259.2$

B6 area X B6 offset

$9.2\ ft^2 \times 10\ ft = 92.0$

B11 area X B11 offset

$4.0\ ft^2 \times 4\ ft = 16.0$

Total XYZ = $532.2\ ft^3$

Then

Determine foundation depth from chart

If the lateral bearing pressure is 1500 psf and the XYZ is $532\ ft^3$,

Then the foundation depth is:

8 ft ~ 3 ft round foundation type
7 ft ~ 3 ft square foundation type
7 ft ~ 4 ft round foundation type

FOUNDATION DEPTH TABLE							
Lateral Bearing Pressure	Foundation Type	XYZ (cubic feet) Type II, III, and SD mast arm standards					
		$600\ ft^3$	$900\ ft^3$	$1200\ ft^3$	$1500\ ft^3$	$1900\ ft^3$	$2300\ ft^3$
1000 psf	3' Round	10'	10'	11'	11'	13'	15'
	3' Square	8'	8'	9'	9'	10'	11'
	4' Round	8'	8'	9'	9'	10'	11'
1500 psf	3' Round	8'	8'	9'	11'	13'	15'
	3' Square	7'	7'	7'	8'	8'	9'
	4' Round	7'	7'	7'	8'	8'	9'
2500 psf	3' Round	6'	6'	7'	11'	13'	15'
	3' Square	6'	6'	6'	6'	7'	7'
	4' Round	6'	6'	6'	6'	7'	7'

Mast Arm Signal Moment and Foundation Depths

Figure 850-13

Selection Procedure

1. Determine span length
.
2. Calculate the total dead load (P) per span. Use 40 pounds per signal section and 6.25 pounds per square foot of sign area.

3. Calculate the average load (G) per span. G = P/n where (n) is the number of signal head assemblies plus the number of signs.

4. Determine cable tension (T) per span. Enter the proper chart with the average load (G) and number of loads (n). If (n) is less than minimum (n) allowed on chart, use minimum (n) on chart.

5. Calculate the pole load (PL) per pole. If only one cable is attached to the pole, the pole load (PL) equals the cable tension (T). If more than one cable is attached, (PL) is obtained by

computing the vector resultant of the (T) values.

6. Select the pole class from the "Foundation Design Table". Choose the pole class closest to but greater than the (PL) value.

7. Calculate the required foundation depth (D).

   Use the formula: $D = a\frac{DT}{\sqrt{S}}$

   Select the table foundation depth (DT) from the "Foundation Design Table". Lateral soil bearing pressure (S) is measured in pounds per square foot (psf). The formula value (a) is a variable for the cross-sectional shape of the foundation. The values for these shapes are:
   a = 50 for a 3' round foundation
   a = 43 for a 4' round foundation
   a = 41 for a 3' square foundation
   Round (D) upwards to nearest whole number if 0.10 foot or greater,

8. Check vertical clearance (16.5' minimum) assuming 29' maximum cable attachment height and 5% minimum span sag.

Notes:
A special design by the Bridge and Structures Office is required if:
The span length exceeds 150 ft.
The (PL) value exceeds 7200 lbs
The vertical distance between the base plate and the first cable attachment exceeds 29 feet.

1. Charts are based on a cable weight of 3 pounds per foot (1.25 lbs/ft, cable and conductors, 1.75 lbs/ft ice). Total dead load (P) includes weight of ice on sign and signal section.
2. On timber strain pole designs, specify two down guy anchors when the (PL) value exceeds 4500 Lbs.

Foundation Design Table	
Pole Class (Pounds)	Foundation Depth (DT)
1900	6' - 0"
2700	7' - 0"
3700	8' - 0"
4800	9' - 6"
5600	10' - 0"
6300	11' - 0"
7200	12' - 0"

Strain Pole and Foundation Selection Procedure
Figure 850-14a

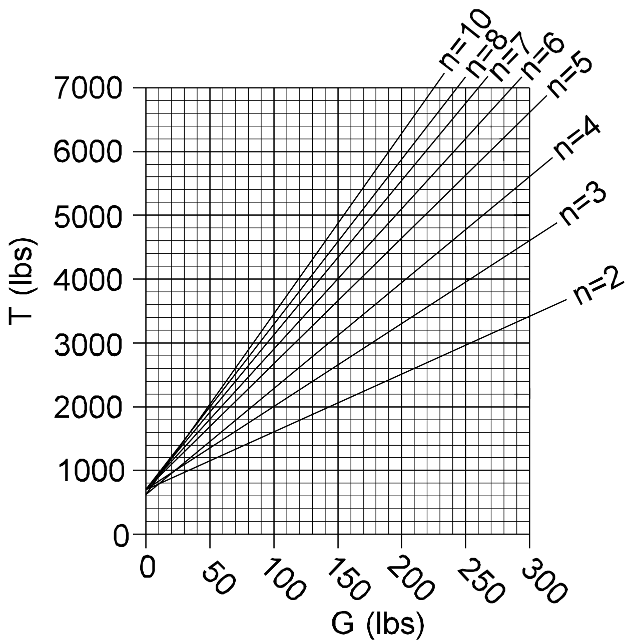


Chart 1 - Span Length 90' and Less

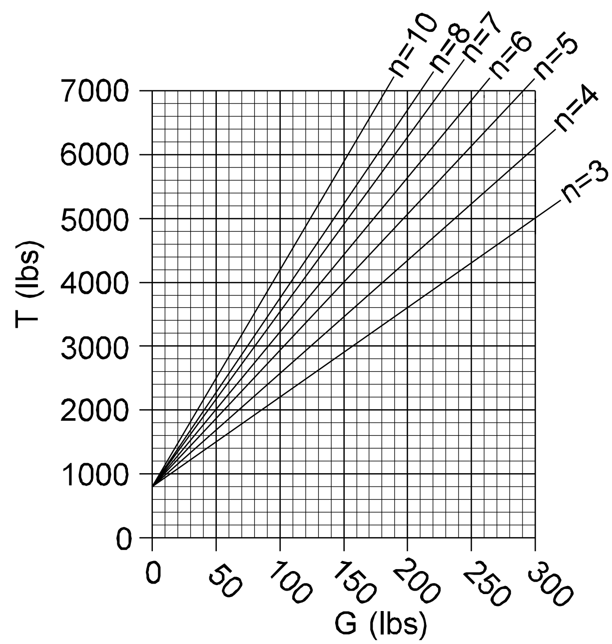


Chart 2 - Span Length 91' to 120'

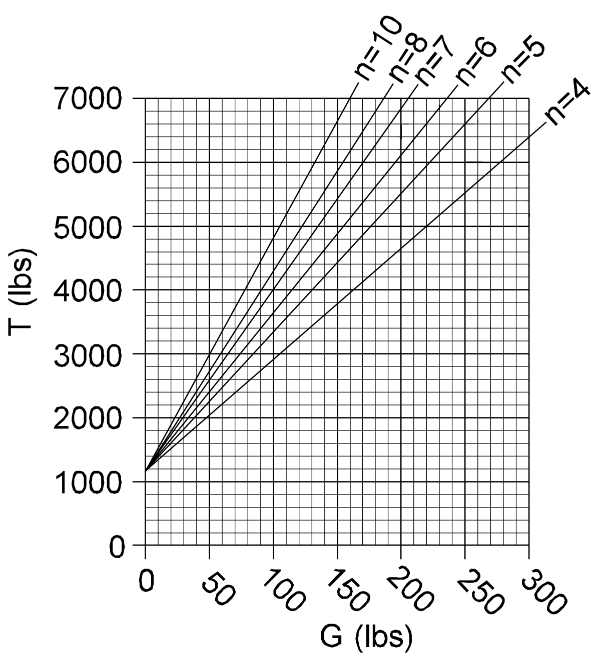
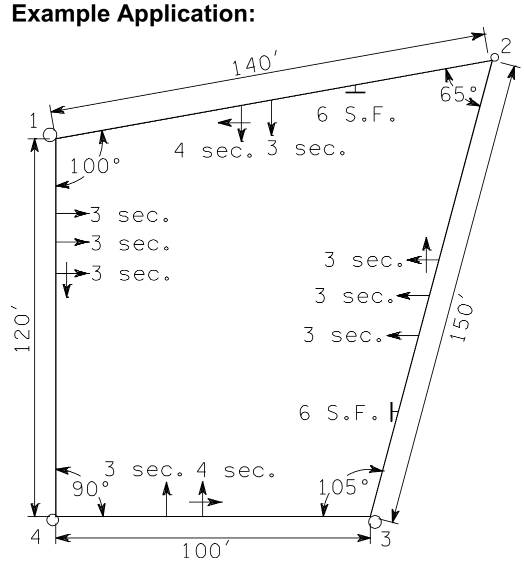


Chart 3 - Span Length 121' to 150'

Strain Pole and Foundation Selection Procedure

Figure 850-14b

Example Application:



Determine the following:

- Cable Tensions (T)
- Pole Loads (PL)
- Pole Classes
- Foundation Depths (D)

Step 1.
Span lengths given above.
Step 2.
Calculate (P) and (G) values.

Span 1-2, n = 3
7 sections x 40 lbs/sec = 280 pounds
6 s.f. sign x 6.25 lbs/s.f. = 38 pounds
Total (P) = 318 pounds
G = P/n = 318/3 = 106 pounds

Span 2-3, n = 4
9 sections x 40 lbs/sec = 360 pounds
6 s.f. sign x 6.25 lbs/s.f. = 38 pounds
Total (P) = 398 pounds
G = P/n = 398/4 = 100 pounds

Span 3-4, n =2
7 sections x 40 lbs/sec = 280 pounds
Total (P) = 280 pounds
G = P/n = 280/2 = 140 pounds

Span 4-1, n = 3
9 sections x 40 lbs/sec = 360 pounds
Total (P) = 360 pounds
G = P/n = 360/3 = 120 pounds

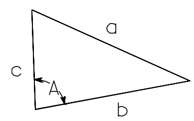
Step 3.
Determine (T) values.

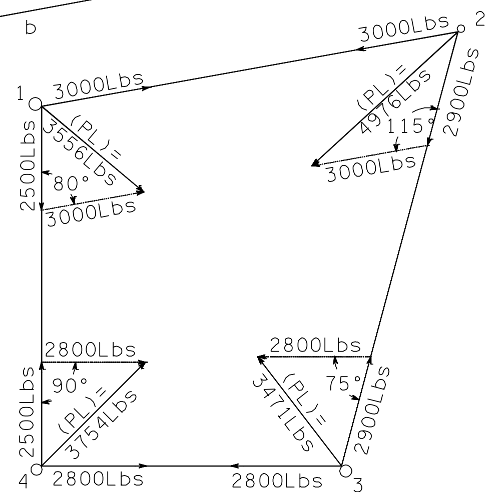
Span	Length	G	Chart	n	min n	T
1-2	140'	106 lbs	III	3	4	3000 lbs
2-3	150'	100 lbs	III	4	4	2900 lbs
3-4	140'	140 lbs	II	2	3	2800 lbs
4-1	120'	120 lbs	II	3	3	2500 lbs

Step 4.

Calculate (PL) values by computing the vector resultant of the (T) values.

$$a = \sqrt{b^2 + c^2 - 2bc(\cos A)}$$





Step 5.
Select the pole class from the Design Table (Figure 850-14b).

Pole Number	(PL)	Pole Class
1	3556 lbs	3700 lbs
2	4976 lbs	5600 lbs
3	3471 lbs	3700 lbs
4	3754 lbs	4800 lbs

Step 6.
Calculate the required foundation depths.
Given: (S) = 1000 psf.

$$D = a\frac{DT}{\sqrt{S}}$$

Pole No.	Pole Class	DT	Foundation Depths (D) 3' Rd (a=50)	4' Rd (a=43)	3' Sq (a=41)
1	3700 lbs	8'	13'	11'	11'
2	5600 lbs	10'	16'	14'	13'
3	3700 lbs	8'	13'	11'	11'
4	4800 lbs	9'-6"	15'	13'	13'

Strain Pole and Foundation Selection Example
Figure 850-15

Conduit Sizing Table			
Trade Size	Inside Diam. (inches)	Maximum Fill (inch^2)	
		26%	40%
1/2”	0.632	0.08	0.13
3/4”	0.836	0.14	0.22
1”	1.063	0.23	0.35
1 1/4”	1.394	0.40	0.61
1 1/2”	1.624	0.54	0.83
2”	2.083	0.89	1.36
2 1/2”	2.489	1.27	1.95
3”	3.09	1.95	3.00
3 1/2”	3.57	2.60	4.00
4”	4.05	3.35	5.15

Conductor Size Table			
Size (AWG)	Area (inch^2)	Size (AWG)	Area (inch^2)
# 14 USE	0.021	2cs (# 14)	0.090
# 12 USE	0.026	3cs (# 20)	0.070
# 10 USE	0.033	4cs (# 18)	0.060
# 8 USE	0.056	5c (# 14)	0.140
# 6 USE	0.073	7c (# 14)	0.170
# 4 USE	0.097	10c (# 14)	0.290
# 3 USE	0.113	6pcc (# 19)	0.320
# 2 USE	0.133		

Conduit and Conductor Sizes
Figure 850-16

860.01 General

Intelligent Transportation Systems (ITS) apply advanced technologies in communications and computer science to optimize the safety and efficiency of the existing surface transportation network. In highway design, this goal is achieved by collecting and using traffic data to develop predictive models, regulating access to the freeway system, and providing timely information on traffic conditions to motorists. Previously, this technology was called Surveillance, Control, and Driver Information (SC&DI). In the context of highway design, ITS and SC&DI are synonymous.

The Transportation Equity Act (TEA-21) requires ITS projects to comply with the standards being developed in association with the federal government and private industry. These standards will be known as the National ITS Architecture. These standards are intended to ensure interoperability and efficiency to the maximum extent practicable for the many different types of ITS devices under development. The National ITS Architecture organizes a "system of subsystems" and makes managing ITS deployment easier. The Architecture helps agencies communicate complex ideas by providing a common language and definitions. One benefit of using the National ITS Architecture is that it helps identify all agencies and jurisdictions that should be included in ITS projects.

The ITS program in Washington State is known as "Venture Washington." It focuses on five areas within Washington State. These areas were chosen because they each have unique characteristics and problems associated with traffic. These five areas are:

- The Greater Puget Sound Region
- The Spokane Area
- The Vancouver Area
- Other Statewide Urban Areas
- Rural Areas and Intercity Corridors

An intelligent transportation system can be implemented in stages, starting with a small project for immediate benefit and then expanding the system as needed. Consider installing an ITS at any of the following locations:

- Where congestion frequently causes accidents.
- At freeway on-ramps where merging problems routinely occur.
- Where heavy traffic volumes occur between closely spaced on-ramps.
- Where the motorist would benefit from information on traffic conditions or alternative routes.

The initial stage of an intelligent transportation system can be as simple as installing a dynamic message sign that warns motorists of unusual driving conditions. Appropriate messages can be displayed on the sign using information obtained by direct observation of road conditions or by reports from law enforcement agencies.

Automated systems incorporate a traffic data collection system. The data collection system provides basic data to determine traffic volumes, vehicular speeds, and levels of congestion. The traffic data can be analyzed and used to verify the locations of traffic problems. This data can also be used in freeway computer models to predict the impacts of proposed improvements.

Design each stage of the system so that the associated technology can be used in subsequent, more sophisticated stages. For example, the stage following data collection could be the installation of closed circuit television cameras (CCTV) to monitor freeway locations where congestion is commonplace. The CCTV monitoring is used to detect or confirm incidents noted by other forms of data collection. The installation of motorist information devices such as dynamic message signs or highway advisory radio provides a means of transmitting this information to the motorist. Eventually, as traffic congestion increases, ramp meters are installed to control the traffic flow entering the facility.

When planning a staged system, attempt to determine the ultimate communication system to the degree that underground conduit size and quantity are known and can be installed in the initial construction. Consider long-term maintenance issues and component standardization.

The Northwest Region Traffic Systems Management Center (TSMC) is an example of a traffic operations center (TOC). Because a TOC usually works best with existing radio communication, it is located adjacent to or as part of a radio communication office. In addition to the location of a TOC, consider the work force and equipment costs required to operate and maintain the entire system. The size of a TOC is dependent on the complexity of the system and can vary from a single person at a desk to a large room with advanced equipment requiring continuous staffing.

860.02 References

Transportation Equity Act (TEA-21) of 1998

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT,

SC&DI Design Guide, WSDOT Northwest Region

SC&DI Operations Guide, WSDOT Northwest Region

I-90 Seattle to Spokane, ITS Corridor Study, WSDOT Advanced Technology Branch

I-5 Seattle to Vancouver, BC, ITS Corridor Study, WSDOT Advanced Technology Branch

Portland/Vancouver to Boise, ITS Corridor Study Plan, WSDOT Advanced Technology Branch

Application of Advanced Transportation Technology Within Washington State: Discussion and Policy Recommendations, WSDOT Advanced Technology Branch

State-Wide Communications Strategic Plan, WSDOT Advanced Technology Branch

Seattle to Portland Inter-City ITS Corridor Study and Communications Plan, WSDOT Advanced Technology Branch

Venture Washington, WSDOT Advanced Technology Branch

860.03 Traffic Data Collection

Loop detectors, placed in traffic lanes, are the most common devices used to collect traffic data. In general, data stations are spaced at 1/2 mile intervals between interchanges. Alternative methods of detection include video detection cameras, microwave detectors, and other newer technologies. This information can be augmented with cellular phone calls from motorists, Washington State Patrol (WSP) reports, and commercial traffic reporters.

The loops sense the amount of time a vehicle is over them. This is called *occupancy* and is recorded by a data station in a nearby roadside cabinet. The data station periodically transmits the data to a central computer. The information from the detection system is transmitted over leased phone lines, WSDOT phone lines, fiber optic lines, or microwave transmitters to a traffic operations center. A spread spectrum radio is another method of transmitting data. The central computer translates these data into an indication of traffic congestion for incident detection and traffic flow information.

A single loop provides traffic volumes and lane occupancy from which, given some basic assumptions, speeds can be computed. Two loops spaced a known distance apart, longitudinally, provide better determinations of traffic speeds.

CCTV is used by the department to manage the freeway system. It is not usually used as a traffic law enforcement tool. The primary function of CCTV is to confirm or detect incidents. As a secondary function, this information can be provided to the WSP, incident response teams, maintenance forces, and the local media.

860.04 Traffic Flow Control

During peak traffic volume periods, freeway on-ramps are metered with either roadside or overhead traffic signals. These ramp meters control or regulate the flow of traffic entering the freeway. The metering prevents the entering traffic from exceeding freeway capacity by limiting the number of vehicles that enter within a specific time period. The meters also keep long platoons of cars from merging onto the freeway. This process makes on-ramp merges safer and allows freeway traffic to move at a more efficient speed.

Ramp meters are traffic control signals and an approved traffic signal permit is required. The approval procedures for traffic signal permits are noted in Chapter 850.

Consider the available area for vehicle storage on the ramp when locating a ramp meter. If the arrival rate of the entering traffic exceeds the metered flow rate, traffic queues will develop. A common concern is that this queue might extend onto the crossroads and interfere with local traffic. Chapter 1050 provides guidance on the placement of the ramp meter. This guidance, however, only addresses the required acceleration needed to merge onto the freeway. The storage area needed at the meter varies at each location and is determined separately. If it is not possible to provide an adequate storage length on the ramp, consider alternate methods of addressing the problem.

(1) Adjust the ramp metering rate to temporarily increase the rate.

(2) Allow two vehicles to pass the meter at a time.

(3) Widen to two metered lanes.

(4) Provide storage lanes on the crossroad.

(5) Provide alternate routes for local traffic.

(6) Provide HOV bypass lanes.

(1) **Adjust Rate.** Ramp metering uses information from the detection loops to determine freeway congestion adjacent to and downstream from the ramps. Data from the loops are sent to a central computer or a local computer that adjusts the metering rate for the traffic congestion and transmits this rate to the ramp meter controllers. The ramp controllers implement the metering rate and control the signal. A ramp metering rate can be determined in two ways: remote metering and standby metering.

For remote metering, the metering rates of all ramp meter locations are determined by the local controller and adjusted by the central computer at the TOC. This is the normal mode of operation for the Seattle system. The central computer is capable of adjusting upstream metering rates on the basis of downstream conditions. A metering rate at an upstream location is decreased if traffic congestion develops downstream. Metering start and end times, as well as metering rates, can be remotely adjusted from the TOC with an override function.

Standby metering, also called local control, is used when communications with the central computer are interrupted or when that computer is not in service. In these cases, each ramp meter determines a metering rate for its on-ramp according to local traffic conditions or by a pre-determined rate based on a time of day table. These time of day tables are developed to predict averages of the actual traffic volume peaking characteristics of the on-ramp. In standby metering, each ramp meter operates independently without coordinating with other controllers.

Single lane metering rates normally vary between 4 and 15 vehicles per minute (240 and 900 vehicles per hour). If a ramp has heavier traffic volumes and queue storage is not adequate, several actions can be taken.

(2) **Two Vehicles**. The metering capacity can be increased by allowing two vehicles to enter during each green cycle. This can increase a single lane ramp meter maximum capacity to about 1,100 vehicles per hour. This procedure is a temporary, operational solution and is not a recommended design practice.

(3) **Widen**. The metering capacity can be increased by widening the ramp to install additional lanes. Widening a single-lane on-ramp to create two lanes can double the metered traffic volume to 1,800 vehicles per hour, provided no downstream traffic congestion develops. Changes in ramp access to the freeway might require an access point decision report. (See Chapter 1425.)

(4) **Storage Lanes**. If adequate storage length cannot be provided on the ramp, it might be possible to provide storage as turn lanes on the crossroad and adjust the ramp terminal traffic signal timing to limit freeway access movements.

(5) **Diversion**. Diversion of some ramp traffic to local arterial streets might can be desirable, assuming a suitable alternate route is available. When diversion occurs, modification of traffic signal timing and coordination plans on the alternative routes might be necessary. Coordinate efforts with the local agency and, if appropriate, initiate public meetings to identify needs and impacts.

(6) **HOV Bypass.** Wherever possible, provide bypass lanes for high occupancy vehicles (HOV) around the traffic queue at the ramp meter. The HOV bypass allows transit vehicles to maintain schedules and indirectly provides an incentive for carpooling. (See Chapter 1050.)

860.05 Motorist Information

Motorist information includes dynamic message signs, highway advisory radio, telephone traffic information lines, commercial radio and television messages, and Internet access for personal computers. These are all used to transmit traffic conditions to freeway users. The motorist information system is also used to alert drivers to short term construction and maintenance activities that might affect normal travel patterns. It can also be used to suggest alternative travel routes.

(1) Dynamic Message Signs

Dynamic message signs (DMS) are used to provide motorists with current road and traffic conditions. Accidents, incidents, construction and maintenance activities, reversible lane status, traffic congestion, and traction device requirements are examples of this information. Because motorists receive many distractions while driving, consider the location of the DMS. The best location for a DMS is on a tangent section of roadway with few roadside distractions. Overhead installations have more visual impact. When possible, use sign bridges, cantilever sign structures, or bridge mounts on existing overcrossings for DMSs. Use the message displays and sign location requirements contained in the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) and Chapter 820.

(2) Highway Advisory Radio

The highway advisory radio (HAR) system uses car radios to provide information to motorists. Warning signs, usually with flashing beacons, direct motorists to select a specific AM radio station for information. HAR has an advantage over DMS because longer messages with more detailed information can be relayed to the motorist. The major disadvantages are that not all vehicles have radios that can receive HAR frequencies, and some motorists might not use the radio for this information. HAR works best when used in conjunction with DMS.

HAR locations and assigned radio frequencies are restricted to prevent interference with other frequencies in use. HAR message content is restricted by federal regulations and WSDOT restricts HAR messages to noncommercial voice information pertaining to roadway and mountain pass conditions, major incidents, traffic hazards, and travel advisories.

(3) Additional Public Information Components

A telephone number can be provided to give the same prerecorded messages as the HAR and can also include transit and carpool information. A computer generated flow map can be developed, using the data collection system, to graphically depict actual traffic flows within a geographical area. The flow map can be made accessible to the public by providing links to a WSDOT web site.

860.06 Documentation

Preserve the following documents in the project file: See Chapter 330.

- ☐ Justification for the installation of ramp meters.
- ☐ Approved traffic signal permit for ramp meters.
- ☐ All correspondence and coordination with local agencies.
- ☐ Designs for the ultimate system when staged implementation is used.

P65:DP/DMM

910.01 General

Intersections are a critical part of highway design because of increased conflict potential. Traffic and driver characteristics, bicycle and pedestrian needs, physical features, and economics are considered during the design stage to develop channelization and traffic control to enhance safe and efficient multimodal traffic flow through intersections.

This chapter provides guidance for designing intersections at grade, including at-grade ramp terminals. See the following chapters for additional information:

Chapter	Subject
915	Roundabouts
920	Road Approaches
940	Interchanges

If an intersection design situation is not covered in this chapter, contact the Headquarters (HQ) Design Office, for assistance.

910.02 References

Americans with Disabilities Act of 1990 (ADA)

Washington Administrative Code (WAC) 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings"

WAC 468-52, "Highway access management—Access control classification system and standards"

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

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT (MUTCD)

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

Roundabouts: An Informational Guide, FHWA-RD-00-067, USDOT, FHWA

Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians, FHWA-RD-01-051, USDOT, FHWA, May 2001

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

Highway Capacity Manual (HCM), Special Report 209, Transportation Research Board, National Research Council

NCHRP 279
Intersection Channelization Design Guide

Highway Research Record No. 211
Aspects of Traffic Control Devices, pp 1-18, "Volume Warrants for Left-Turn Storage Lanes at Unsignalized Grade Intersections." Harmelink, M. D.

910.03 Definitions

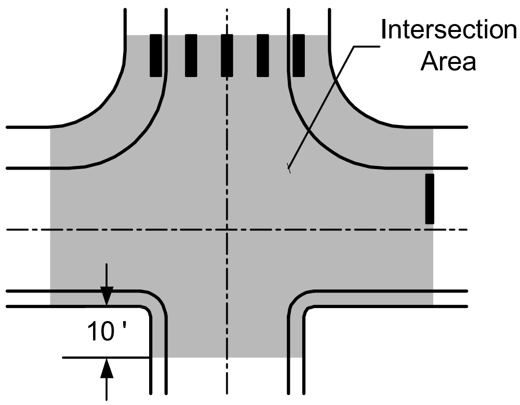
bulb out A curb and sidewalk bulge or extension out into the roadway used to decrease the length of a pedestrian crossing. (See chapter 1025.)

conflict An event involving two or more road users, in which the action of one user causes the other user to make an evasive maneuver to avoid a collision.

crossroad The minor roadway at an intersection. At a stopped controlled intersection, the crossroad has the stop.

intersection angle The angle between any two intersecting legs at the point that the center lines intersect.

intersection area The area of the intersecting roadways bounded by the edge of traveled ways and the area of the adjacent roadways to the end of the corner radii, any marked crosswalks adjacent to the intersection, or stop bar, but not less than 10 ft from the edge of shoulder of the intersecting roadway. See Figure 910-1.



Intersection Area
Figure 910-1

intersection at grade The general area where a state route or ramp terminal is met or crossed at a common grade or elevation by another state route, a county road, or a city street.

four leg intersection An intersection with four legs, as where two highways cross.

tee (T) intersection An intersection with three legs in the general form of a "T."

split tee A four leg intersection with the cross road intersecting the through roadway at two tee intersections. The crossroad must be offset at least the width of the roadway.

wye (Y) intersection An intersection with three legs in the general form of a "Y" and the angle between two legs is less than 60°.

intersection leg Any one of the roadways radiating from and forming part of an intersection.

entrance leg The lanes of an intersection leg for traffic entering the intersection.

exit leg The lanes of an intersection leg for traffic leaving the intersection.

Whether an intersection leg is an entrance leg or an exit leg depends on which movement is being analyzed. For two way roadways, each leg is an entrance leg for some movements and an exit leg for other movements.

intersection sight distance The distance that the driver of a vehicle on the crossroad can see along the through roadway, as compared to the distance required for safe operation.

island A defined area within an intersection, between traffic lanes, for the separation of vehicle movements or for pedestrian refuge. It may be outlined with pavement markings or delineated by curbs. Within an intersection, a median is considered an island.

channelization island An island that separates traffic movements into definite paths of travel and guides traffic into the intended route.

divisional island An island introduced, on an undivided roadway, at an intersection to warn drivers of the crossroad ahead and regulate traffic through the intersection.

refuge island An island at or near a crosswalk or bicycle path to aid and protect pedestrians and bicyclists crossing the roadway.

median crossover An opening in a median provided for crossings by maintenance, law enforcement, emergency, and traffic service vehicles. (See Chapter 960.)

roundabout A circular intersection at which all traffic moves counterclockwise around a central island. (See Chapter 915)

rural intersection An intersection in a nonurban area.

urban intersection An intersection that is in one of the following areas:

- The area within the federal urban area boundary as designated by FHWA.
- An area characterized by intensive use of the land for the location of structures and receiving such urban services as sewers, water, and other public utilities and services normally associated with urbanized areas.

- An area with not more than twenty-five percent undeveloped land.

910.04 Design Considerations

Intersection design requires consideration of all potential users of the facility. This involves addressing the needs of a diverse mix of user groups including passenger cars, heavy vehicles of varying classifications, bicycles, and pedestrians. Often, meeting the needs of one user group requires a compromise in service to others. Intersection design balances these competing needs, resulting in appropriate levels of operation for all users.

In addition to reducing the number of conflicts, minimize the conflict area as much as possible while still providing for the required design vehicle (910.05). This is done to control the speed of turning vehicles and reduce vehicle, bicyclist, and pedestrian exposure.

(1) Traffic Analysis

Conduct a traffic analysis and an accident analysis to determine the design characteristics of each intersection. Include recommendations for channelization, turn lanes, acceleration and deceleration lanes, intersection configurations, illumination, bicycle and pedestrian accommodations, ADA requirements, and traffic control devices in the traffic analysis.

(2) Intersection Configurations

(a) **Intersection angle.** An important intersection design characteristic is the intersection angle. The desirable intersection angle is 90°, with 75° to 105° allowed for new, reconstructed, or realigned intersections.

Existing intersections with an intersection angle between 60° and 120° may remain. Intersection angles outside this range tend to restrict visibility, increase the area required for turning, increase the difficulty to make a turn, increase the crossing distance and time for vehicles and pedestrians, and make traffic signal arms difficult or impossible to design.

(b) **Lane alignment.** Design intersections with entrance lanes aligned with the exit lanes. Do not put angle points on the roadway alignments within intersection areas or on the through roadway alignment within 100 ft of the edge of traveled way of a crossroad. This includes short radius curves where both the PC and PT are within the intersection area. However, angle points within the intersection are allowed at intersections with a minor through movement, such as at a ramp terminal (Figure 910-18).

When practical, locate intersections so that curves do not begin or end within the intersection area. It is desirable to locate the PC and PT at least 250 ft from the intersection so that a driver can settle into the curve before the gap in the striping for the intersection area.

(c) **Split Tee.** Avoid split tee intersections where there is less than the required intersection spacing. See 910.04(4). Split tee intersections with an offset distance to the left greater than the width of the roadway, but less than the intersection spacing, may be designed with justification. Evaluate the anticipated benefits against the increased difficulty in driving through the intersection and a more complicated traffic signal design.

Split tee intersections with the offset to the right have the additional disadvantages of overlapping main line left-turn lanes, increased possibility of wrong way movements, and traffic signal design that is even more complicated. Do not design a split tee intersection with an offset to the right less than the required intersection spacing [see 910.04(4)] unless traffic is restricted to right-in right-out only.

(d) **Other Nonstandard Configurations.** Do not design intersections with nonstandard configurations such as:

- Intersections with offset legs, except for split tee intersections [910.04(2)(c)].
- Intersections with more than four legs.
- Tee intersections with the major traffic movement making a turn.
- Wye intersections that are not a one-way merge or diverge.

A roundabout might be an alternative to these nonstandard configurations. (See 910.08 and Chapter 915.)

With justification and approval from the region's Traffic Engineer existing intersections with nonstandard configurations may remain in place when an analysis shows no accident history related to the configuration.

(3) Crossroads

When the crossroad is a city street or county road, design the crossroad beyond the intersection area according to the applicable design criteria given in Chapter 440 for a city street or county road.

When the crossroad is a state facility, design the crossroad according to the applicable design level and functional class (Chapters 325, 430, and 440). Continue the cross slope of the through roadway shoulder as the grade for the crossroad. Use a vertical curve that is at least 60 ft long to connect to the grade of the crossroad.

Consider the profile of the crossroad in the intersection area. To prevent operational problems, the crown slope of the main line might need to be adjusted in the intersection area.

In areas that experience accumulations of snow and ice and for all legs that will require traffic to stop, design a maximum grade of ±4 percent for a length equal to the anticipated queue length for stopped vehicles.

(4) Intersection Spacing

Adequate intersection spacing is required to provide for safety and the desired operational characteristics for the highway. The minimum spacing for highways with limited access control is covered in Chapter 1430. For other highways, the minimum spacing is dependent on the Highway Access Management Class. See Chapter 1435 for minimum intersection spacing on Managed Access highways.

As a minimum, provide enough space between intersections for left-turn lanes and storage length. Space signalized intersections, and intersections expected to be signalized, to maintain efficient signal operation. It is desirable to space intersections so that queues will not block an adjacent intersection.

910.05 Design Vehicle

The physical characteristics of the design vehicle control the geometric design of the intersection. The following design vehicle types are commonly used:

Design Symbol	Vehicle Type
P	Passenger car, including light delivery trucks.
BUS	Single unit bus
A-BUS	Articulated bus
SU	Single unit truck
WB-40	Semitrailer truck, overall wheelbase of 40 ft
WB-50	Semitrailer truck, overall wheelbase of 50 ft
WB-67	Semitrailer truck, overall wheelbase of 67 ft
MH	Motor home
P/T	Passenger car pulling a camper trailer
MH/B	Motor home pulling a boat trailer

Design Vehicle Types
Figure 910-2

The geometric design of an intersection requires identifying and addressing the needs of all intersection users. There are competing design objectives when considering the turning requirements of the larger design vehicles and the crossing requirements of pedestrians. To reduce the operational impacts of large design vehicles, larger turn radii are used. This results in increased pavement areas, longer pedestrian crossing distances, and longer traffic signal arms.

To reduce the intersection area, a smaller design vehicle is used or encroachment is allowed. This reduces the potential for vehicle/pedestrian conflicts, decreases pedestrian crossing distance, and controls speeds of turning vehicles. The negative impacts include possible capacity reductions and greater speed differences between turning vehicles and through vehicles.

Select a design vehicle that is the largest vehicle that normally uses the intersection. The primary use of the design vehicle is to determine radii requirements for each leg of the intersection. It is possible for each leg to have a different design vehicle. Figure 910-3 shows the minimum design vehicles. As justification to use a smaller vehicle, include a traffic analysis showing that the proposed vehicle is appropriate.

Intersection Type	Design Vehicle
Junction of Major Truck Routes	WB-67
Junction of State Routes	WB-50
Ramp Terminals	WB-50
Other Rural	WB-50
Industrial	WB-40
Commercial	SU(1)(2)
Residential	SU(1)(2)

(1) To accommodate pedestrians, the P vehicle may be used as the design vehicle if justification, with a traffic analysis, is documented.

(2) When the intersection is on a transit or school bus route, use the BUS design vehicle as a minimum. See Chapter 1060 for additional guidance for transit facilities.

Intersection Design Vehicle
Figure 910-3

To minimize the disruption to other traffic, design the intersection to allow the design vehicles to make each turning movement without encroaching on curbs, opposing lanes, or same-direction lanes at the entrance leg. Use turning path templates (Figures 910-6a through 6c, templates from another published source, or computer generated templates) to verify that the design vehicle can make the turning movements.

Encroachment on same-direction lanes of the exit leg and the shoulder might be necessary to minimize crosswalk distances; however, this might negatively impact vehicular operations. Document and justify the operational tradeoffs associated with this encroachment. When encroachment on the shoulder is required, increase the pavement structure to support the anticipated traffic.

In addition to the design vehicle, often a larger vehicle must be considered. When vehicles larger than the design vehicle are allowed and are anticipated to occasionally use the intersection make certain that they can make the turn without leaving the paved shoulders or encroaching on a sidewalk. The amount of encroachment allowed is dependent on the frequency of the vehicle and the resulting disruption to other traffic. Use the WB-67 as the largest vehicle at all state route to state route junctions. Document and justify any required encroachment into other lanes, and any degradation of intersection operation.

910.06 Right-Turn Corners

The geometric design of an intersection requires identifying and addressing the needs of all intersection users. For the design of right-turn corners, there can be competing design objectives when considering the turning requirements of the design vehicle and the crossing requirements of pedestrians. To reduce the operational impacts of large trucks, right-turn radii are designed so that the truck can complete its turn without encroaching on the adjacent lanes at either the entrance or the exit legs of the turn. This results in larger corner radii, increased pavement area and pedestrian crossing distance, a larger conflict area, and higher vehicle turning speeds.

When pedestrian issues are a primary concern, the design objectives become one of reducing the potential for vehicle/pedestrian conflicts. This is done by minimizing pedestrian crossing distance and controlling the speeds of turning vehicles. This normally leads to right-corner designs with smaller turning radii. The negative impacts include possible capacity reductions and greater speed differences between turning vehicles and through vehicles.

Pedestrian refuge islands can also improve pedestrian safety. Pedestrian refuge islands minimize the crossing distance, reduce the conflict area, and minimize the impacts on vehicular traffic. When designing islands, speeds can be reduced by designing the turning roadway with a taper or large radius curve at the beginning of the turn and a small radius curve at the end. This allows larger islands while forcing the turning traffic to slow down.

Figure 910-7 shows right-turn corner designs for the design vehicles. These are considered the minimum pavement area to accommodate the design vehicles without encroachment on the adjacent lane at either leg of the curve.

With justification, right-turn corner designs given in Figure 910-7 may be modified. Document the benefits and impacts of the modified design including: changes to vehicle pedestrian conflicts, vehicle encroachment on the shoulder or adjacent same direction lane at the exit leg, capacity restrictions for right-turning vehicles or other degradation of intersection operations, and the effects on other traffic movements. To verify that the design vehicle can make the turn, include a plot of the design showing the design vehicle turning path template.

910.07 Channelization

Channelization is the separation or regulation of traffic movements into delineated paths of travel to facilitate the safe and orderly movement of vehicles, bicycles, and pedestrians.

Painted or plastic pavement markings are normally used to delineate travel paths. (See Chapter 830 and the standard plans for details.)

(1) Left-Turn Lanes

Left-turn lanes provide storage, separate from the through lanes, for left-turning vehicles waiting for a signal to change or for a gap in opposing traffic. (See 910.07(3) for a discussion on speed change lanes.)

Design left-turn channelization to provide sufficient operational flexibility to function under peak loads and adverse conditions.

(a) **One-Way Left-Turn Lanes** are separate storage lanes for vehicles turning left from one roadway onto another. When recommended, one-way left-turn lanes may be an economical way to lessen delays and accident potential involving left-turning vehicles. In addition, they can allow deceleration clear of the through traffic lanes. When considering left-turn lanes, consider impacts to all intersection movements and users.

At signalized intersections, use a traffic signal analysis to determine if a left-turn lane is needed and what the storage requirements are. (See Chapter 850.)

At unsignalized intersections, use the following as a guide to determine whether or not to provide one-way left-turn lanes:

- A traffic analysis indicates that a left-turn lane will reduce congestion. On two-lane highways, use Figure 910-8a, based on total traffic volume (DHV) for both directions and percent left-turn traffic, to determine if further investigation is needed. On four-lane highways, use Figure 910-8b to determine if a left-turn lane is recommended.
- An accident study indicates that a left-turn lane will reduce accidents.
- Restrictive geometrics require left-turning vehicles to slow greatly below the speed of the through traffic.
- There is less than decision sight distance at the approach to the intersection.

An HCM analysis may also be used to determine if left-turn lanes are necessary to maintain the desired level of service.

Determine the storage length required on two-lane highways by using Figures 910-9a through 9c. On four-lane highways use Figure 910-8b. These lengths do not consider trucks. Use Figure 910-4 for storage length when trucks are present.

Storage* Length (ft)	% Trucks in Left-Turn Movement				
	10	20	30	40	50
100	125	125	150	150	150
150	175	200	200	200	200
200	225	250	275	300	300
250	275	300	325	350	375
300	350	375	400	400	400
*Length from Figures 910-8b, 9a, 9b, or 9c.					

Left-Turn Storage With Trucks (ft)
Figure 910-4

Design opposing left-turn vehicle paths with a minimum 4 ft (12 ft desirable) clearance between opposing turning paths. Existing signalized intersections that do not meet the 4 ft clearance may remain with split signal phasing, an evaluate upgrade, and concurrence from the HQ Traffic Office.

Where one-way left-turn channelization with curbing is to be provided, ensure that surface water will drain.

Provide illumination at left-turn lanes in accordance with the guidelines in Chapter 840.

At signalized intersections with high left-turn volumes, double left-turn lanes may be needed to maintain the desired level of service. A throat width of 30 to 36 ft is desirable on the exit leg of the turn to offset vehicle offtracking and the difficulty of two vehicles turning abreast. Use turning path templates to verify that the design vehicle can complete the turn. Where the design vehicle is a WB-40 or larger it is preferred to provide for the design vehicle and an SU turning abreast rather than two design vehicles turning abreast.

Figures 910-10a through 10e show one-way left-turn geometrics. Figure 910-10a shows widening to accommodate the new lane. Figures 910-10c and 10d show the use of a median. Figure 910-10e shows the minimum protected left-turn with a median.

1. **Widening (Figure 910-10a).** It is desirable that offsets and pavement widening be symmetrical about the center line or base line. Where right of way or topographic restrictions, crossroad alignments, or other circumstances preclude symmetrical widening, pavement widening may be on one side only.

2. **Divided Highways (Figure 910-10b through 10d).** Widening is not required for left-turn lane channelization where medians are 11 ft wide or wider. For medians between 13 ft and 23 ft or where the acceleration lane is not provided, it is desirable to design the left-turn lane adjacent to the opposing lane, as shown on Figure 910-10b, to improve sight distance.

   A median acceleration lane, shown on Figures 910-10c and 10d, may be provided where the median is 23 ft or wider. The median acceleration lane might not be necessary at a signalized intersection. When a median acceleration lane is to be used, design it in accordance with 910.07(3) Speed Change Lanes. Where medians have sufficient width, provide a 2 ft shoulder adjacent to a left-turn lane.

3. **Minimum Protected Left-Turn with a Median (Figure 910-10e).** At intersections on divided highways where channelized left-turn lanes are not provided, consider the minimum protected storage area.

   With justification, left-turn lane designs given in Figures 910-10a through 10d may be modified. Document the benefits and impacts of the modified design including: changes to vehicle pedestrian conflicts, vehicle encroachment, deceleration length, capacity restrictions for turning vehicles or other degradation of intersection operations, and the effects on other traffic movements. The modified design must be able to accommodate the design vehicle and provide for the striping requirements of the Standard Plans and the MUTCD. To verify that the design vehicle can make the turn, include a plot of the design showing the design vehicle turning path template.

(b) **Two-Way Left-Turn Lanes** (TWLTL) are located between opposing lanes of traffic. They are used by vehicles making left turns from either direction, either from or onto the roadway.

Use TWLTLs only on managed access highways where there are no more than two through lanes in each direction. Consider installation of TWLTLs where:

- An accident study indicates that a TWLTL will reduce accidents.
- There are existing closely spaced access points or minor street intersections.
- There are unacceptable through traffic delays or capacity reductions because of left turning vehicles.

TWLTL can reduce delays to through traffic, reduce rear-end accidents, and provide separation between opposing lanes of traffic. However, they do not provide a safe refuge for pedestrians and can encourage strip development with additional closely spaced access points. Consider other alternatives, before using TWLTL, such as prohibiting midblock left-turns and providing for U-turns. See Chapters 440 and 1435 for additional restrictions on the use of TWLTLs.

The basic design for a TWLTL is illustrated on Figure 910-10f. Additional criteria are:

- The desirable length of a TWLTL is not less than 250 ft.
- Provide illumination in accordance with the guidelines in Chapter 840.
- Pavement markings, signs, and other traffic control devices must be in accordance with the MUTCD and the Standard Plans.
- Provide clear channelization when changing from TWLTL to one-way left-turn lanes at an intersection.

(2) Right-Turn Lanes and Drop Lanes

Right-turn movements influence intersection capacity even though there is no conflict between right-turning vehicles and opposing traffic. Right-turn lanes might be needed to maintain efficient intersection operation. Use the following as guidelines to determine when to consider right-turn lanes at unsignalized intersections:

- Recommendation from Figure 910-11 based on same direction approach and right-turn traffic volumes for multilane roadways with a posted speed 45 mph or above and for all two-lane roadways.
- An accident study indicates that a right-turn lane will result in an overall accident reduction.
- Presence of pedestrians who require right-turning vehicles to stop.
- Restrictive geometrics that require right-turning vehicles to slow greatly below the speed of the through traffic.
- Less than decision sight distance at the approach to the intersection.

For unsignalized intersections, see 910.07(3) Speed Change Lanes for guidance on right-turn lane lengths. For signalized intersections, use a traffic signal analysis to determine if a right-turn lane is needed and the length requirement. (See Chapter 850.)

A capacity analysis may be used to determine if right-turn lanes are necessary to maintain the desired level of service.

Where adequate right of way exists, providing right-turn lanes is relatively inexpensive and can provide increased safety and operational efficiency.

The right-turn pocket or the right-turn taper (Figure 910-12) may be used at any minor intersection where a deceleration lane is not required and turning volumes indicate a need as set forth in Figure 910-11. These designs will cause less interference and delay to the through movement by offering an earlier exit to right-turning vehicles.

If the right-turn pocket is used, Figure 910-12 shows taper lengths for various posted speeds.

A lane may be dropped at an intersection with a turn-only lane or beyond the intersection with an acceleration lane (Figure 910-14). Do not allow a lane-reduction taper to cross an intersection or end less than 100 ft before an intersection.

When a lane is dropped beyond a signalized intersection, provide a lane of sufficient length to allow smooth merging. For facilities with a posted speed of 45 mph or higher, use a minimum length of 1500 ft. For facilities with a posted speed less than 45 mph, provide a lane of sufficient length so that the advanced lane reduction warning sign will be placed not less than 100 ft beyond the intersection area.

(3) Speed Change Lanes

A speed change lane is an auxiliary lane primarily for the acceleration or deceleration of vehicles entering or leaving the through traveled way. Speed change lanes are normally provided for at-grade intersections on multilane divided highways with access control. Where roadside conditions and right of way allow, speed change lanes may be provided on other through roadways. Justification for a speed change lane depends on many factors such as speed, traffic volumes, capacity, type of highway, the design and frequency of intersections, and accident history.

A deceleration lane is advantageous because, if a deceleration lane is not provided the driver leaving the highway must slow down in the through lane regardless of following traffic.

An acceleration lane is not as advantageous because entering drivers can wait for an opportunity to merge without disrupting through traffic.

When either deceleration or acceleration lanes are to be used, design them in accordance with Figures 910-13 and 14. When the design speed of the turning traffic is greater than 20 mph, design the speed change lane as a ramp in accordance with Chapter 940. When a deceleration lane is used with a left-turn lane, add the deceleration length to the storage length.

(4) Shoulders

Shoulder width requirements adjacent to turn lanes and speed change lanes at intersections are reduced. For roadways without curb sections, the shoulder adjacent to turn lanes and speed change lanes may be reduced to 2 ft on the left and 4 ft on the right. When a curb and sidewalk section is used with a turn lane 400 ft or less in length, the shoulder adjacent to the turn lane may be eliminated. The design of the intersection might need to be adjusted to allow for vehicle tracking. On routes where provisions are made for bicycles, continue the bicycle facility between the turn lane and the through lane. (See Chapter 1020 for information on bicycle facilities.)

Reducing the shoulders for turn and speed change lanes reduces the pavement widening for the lane and discourages drivers from using the shoulder to bypass the other turning vehicles.

(5) Islands

An island is a defined area within an intersection between traffic lanes for the separation of vehicle movements or for pedestrian refuge. Within an intersection, a median is considered an island. Design islands to clearly delineate the traffic channels to drivers and pedestrians.

Traffic islands perform these functions:

- Channelization islands control and direct traffic movement.
- Divisional islands separate traffic movements.
- Refuge islands provide refuge for pedestrians.
- Islands can provide for the placement of traffic control devices and luminaires.
- Islands can provide areas within the roadway for landscaping.

(a) **Size and Shape.** Divisional and refuge islands are normally elongated and at least 4 ft wide and 20 ft long. (Mountable curb, used to discourage turn movements, is not a divisional island.)

Channelization islands are normally triangular. In rural areas, 75 ft^2 is the minimum island area and 100 ft^2 is desirable. In urban areas where posted speeds are 25 mph or less, smaller islands are acceptable. Use islands with at least 200 ft^2 if pedestrians will be crossing or traffic control devices or luminaires will be installed.

Design triangular shaped islands as shown on Figure 910-15a through 15c. The shoulder and offset widths illustrated are for islands with vertical curbs 6 in or higher. Where painted islands are used, such as in rural areas, these widths are desirable but may be omitted. See Chapter 641 for turning roadway widths.

Island markings may be supplemented with reflective raised pavement markers.

Barrier-free access must be provided at crosswalk locations where raised islands are used. See Chapter 1025.

(b) **Location.** Design the approach ends of islands to provide adequate visibility to alert the motorist of their presence. Position the island so that a smooth transition in vehicle speed and direction is attained. Begin transverse lane shifts far enough in advance of the intersection to allow gradual transitions. Avoid introducing islands on a horizontal or vertical curve. If the use of an island on a curve cannot be avoided, provide adequate sight distance, illumination, or extension of the island.

(c) **Compound Right-Turn Lane.** To design large islands, the common method is to use a large radius curve for the turning traffic. While this does provide a larger island, it also encourages higher turning speeds. Where pedestrians are a concern, higher turning speeds are undesirable. An alternative is a compound curve with a large radius followed by a small radius (Figure 910-15b). This design forces the turning traffic to slow down.

(d) **Curbing.** Provide vertical curb 6 in or higher for:

- Islands with luminaires, signals, or other traffic control devices.
- Pedestrian refuge islands.

In addition consider curbing for:

- Divisional and channelizing islands.
- Landscaped islands.

In general, unless required for the uses listed above, it is preferred not to use curbs on facilities with a posted speed of 45 mph or greater.

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

See Chapter 440 for additional information and requirements on the use of curbs.

910.08 Roundabouts

Modern roundabouts are circular intersections. They can be an effective intersection type.

Modern roundabouts differ from the old rotaries and traffic circles in two important respects: they have a smaller diameter, which lowers speeds; and they have splitter islands that provide entry constraints, slowing down the entering speeds.

When well designed, roundabouts are an efficient form of intersection control. They have fewer conflict points, lower speeds, easier decision making, and they require less maintenance. When properly designed and located, they have been found to reduce injury accidents, traffic delays, fuel consumption, and air pollution. Roundabouts also permit U-turns.

Consider roundabouts at intersections with the following characteristics:

- Where stop signs result in unacceptable delays for the cross road traffic. Roundabouts reduce the delays for the cross road, but increase the delays for the through roadway.
- With a high left-turn percentage. Unlike most intersection types, roundabouts can operate efficiently with high volumes of left-turning traffic.
- With more than four legs. When the intersection cannot be modified by closing or relocating legs, a roundabout can provide a solution.
- Where a disproportionately high number of accidents involve crossing or turning traffic.
- Where the major traffic movement makes a turn.
- Where traffic growth is expected to be high and future traffic patterns are uncertain.
- Where it is not desirable to give priority to either roadway.

There are some disadvantages with roundabouts. Roundabouts do not allow for a primary roadway to have priority because all legs entering a roundabout are treated the same. Also, all traffic entering a roundabout is required to reduce speed. Therefore, roundabouts are not appropriate on high speed facilities, where traffic flows are unbalanced, or where an arterial intersects a collector or local road.

See Chapter 915 for information and requirements on the design of roundabouts.

910.09 U-Turns

For divided highways without full access control that have access points where a median prevents left turns, consider providing locations designed to allow U-turns. Normally, the U-turn opportunities are provided at intersections; however, where intersections are spaced far apart, consider median openings between intersections to accommodate U-turns. Use the desirable U-turn spacing (Figure 910-5) as a guide to determine when to consider U-turn locations between intersections. When the U-turning volumes are low, use longer spacing.

	U-Turn Spacing	
	Desirable	Minimum
Urban(1)	1,000 ft	(2)
Suburban	1/2 mi	1/4 mi(3)
Rural	1 mi	1/2 mi

(1) For design speeds greater than 45 mph use suburban spacing.

(2) The minimum spacing is the acceleration lane length from a stop (Figure 910-14) plus 300 ft.

(3) For design speeds 60 mph or greater, the minimum spacing is the acceleration lane length from a stop (Figure 910-14) plus 300 ft.

U-Turn Spacing
Figure 910-5

When designing U-turn locations, use Figure 910-16 as a guide. Where the median is less than 40 ft wide and a large design vehicle is required, consider the use of a U-turn roadway (jug handle).

Document the need for U-turn locations, the spacing used, and justify the selected design vehicle.

U-turns at signal controlled intersections do not require the acceleration lanes shown in Figure 910-16. At new U-turn locations at signal controlled intersections, ensure that right-turning vehicles from side streets will not conflict with U-turning vehicles. Warning signs on the cross street might be appropriate.

910.10 Sight Distance at Intersections

For traffic to move safely through intersections, drivers need to be able to see stop signs, traffic signals, and oncoming traffic in time to react accordingly.

Provide decision sight distance, where practical, in advance of stop signs, traffic signals, and roundabouts. See Chapter 650 for guidance.

The driver of a vehicle that is stopped, waiting to cross or enter a through roadway, needs obstruction-free sight triangles in order to see enough of the through roadway to safely complete all legal maneuvers before an approaching vehicle on the through roadway can reach the intersection. Use Figure 910-17a to determine minimum sight distance along the through roadway.

The sight triangle is determined as shown in Figure 910-17b. Within the sight triangle, lay back the cut slopes and remove, lower, or move hedges, trees, signs, utility poles, and anything else large enough to be a sight obstruction. Consider eliminating parking so sight distance is not obstructed. In order to maintain the sight distance, the sight trianlge must be within the right of way or a state maintenance easement (see Chapter 1410).

The minimum setback distance for the sight triangle is 18 ft from the edge of traveled way. This is for a vehicle stopped 10 ft from the edge of traveled way. The driver is almost always 8 ft or less from the front of the vehicle; therefore, 8 ft is added to the setback. When the stop bar is placed more than 10 ft from the edge of traveled way, consider providing the sight triangle to a point 8 ft back of the stop bar.

Provide a clear sight triangle for a P vehicle at all intersections. In addition to this, provide a clear sight triangle for the SU vehicle for rural highway conditions. If there is significant combination truck traffic, use the WB-50 or WB-67 rather than the SU. In areas where SU or WB vehicles are minimal, and right of way restrictions prohibit adequate sight triangle clearing, only the P vehicle need be considered.

At existing intersections, when sight obstructions within the sight triangle cannot be removed due to limited right of way, the intersection sight distance may be modified. A driver that does not have the desired sight distance will creep out until the sight distance is available; therefore, the 10 ft stopping distance from the edge of traveled way may be reduce to 2 ft, reducing the setback to 10 ft. Also, the time gap (t_g) may be reduced by the 2 sec perception/reaction time. Document the right of way width and provide a brief analysis of the intersection sight distance clarifying the reasons for reduction. Verify and document that there is not an accident problem at the intersection. Document as a design exception.

If the intersection sight distance cannot be provided using the reductions in the preceding paragraph, the calculated sight distance may be reduced, with HQ Design Office approval. Provide as much sight distance as practical, but not less than the stopping sight distance required for the major roadway, with visibility at the 10 ft setback point. (For required stopping sight distance, see Chapter 650.) Document the right of way width and provide a brief analysis of the intersection sight distance clarifying the reasons for reduction. Verify and document that there is not an accident problem at the intersection. Document as a design exception.

In some instances intersection sight distance is provided at the time of construction, but subsequent vegetative growth has degraded the sight distance available. The growth may be seasonal or occur over time. In these instances, the intersection sight distance will be restored through periodic scheduled maintenance of vegetation in the sight triangle within the WSDOT right of way or state maintenance easement.

At intersections controlled by traffic signals, provide sight distance for right-turning vehicles.

Designs for movements that cross divided highways are influenced by the median widths. If the median is wide enough to store the design vehicle, with 3 ft clearance at both ends of the vehicle, sight distances are determined in two steps. The first step is for crossing from a stopped position to the median storage; the second step is for the movement, either across, or left into the through roadway.

Design ramp terminal sight distance as at-grade intersections considering only left- and right- turning movements. An added element at ramp terminals is the grade separation structure. Figure 910-17b gives the sight distance considerations in the vicinity of a structure. In addition, when the crossroad is an undercrossing, check the sight distance under the structure graphically using a truck eye height of 6 ft and an object height of 1.5 ft.

Document a brief description of the intersection area, sight distance restrictions, and traffic characteristics to support the design vehicle and sight distances chosen.

910.11 Traffic Control at Intersections

Intersection traffic control is the process of moving traffic safely through areas of potential conflict where two or more roadways meet. Signs, signals, channelization, and physical layout are the major tools used to establish intersection control.

There are three objectives to intersection traffic control that can greatly improve intersection operations.

- **Maximize Intersection Capacity.** Since two or more traffic streams cross, converge, or diverge at intersections, capacity of an intersection is normally less than the roadway between intersections. It is usually necessary to assign right of way through the use of traffic control devices to maximize capacity for all users of the intersection. Turn prohibitions may be used to increase intersection capacity.
- **Reduce Conflict Points.** The crossing, converging, and diverging of traffic creates conflicts which increase the potential for accidents. Establishing appropriate controls can reduce the possibility of two cars attempting to occupy the same space at the same time. Pedestrian accident potential can also be reduced by appropriate controls.
- **Priority of Major Streets.** Traffic on major routes is normally given the right of way over traffic on minor streets to increase intersection operational efficiency.

If a signal is being considered or exists at an intersection that is to be modified, a preliminary signal plan is required (Chapter 850). If a new signal permit is required, it must be approved before the design is approved.

A proposal to install a traffic signal or a roundabout on a state route, either NHS or Non-NHS, with a posted speed limit of 45 mph or higher requires an analysis of alternatives, approved by the region's Traffic Engineer with review and comment by the Headquarters Design Office, prior to proceeding with the design. Include the following alternatives in the analysis:

- Channelization, providing deceleration lanes, storage, and acceleration lanes for left- and right-turning traffic.
- Right-off /right-on with U-turn opportunities.
- Grade separation.
- Roundabouts.
- Traffic control signals.

Include a copy of the analysis with the preliminary signal plan or roundabout justification.

910.12 Interchange Ramp Terminals

The design to be used or modified for use on one-way ramp terminals with stop or traffic signal control at the local road is shown on Figure 910-18. Higher volume intersections with multiple ramp lanes are designed individually.

Due to probable development of large traffic generators adjacent to an interchange, width for a median on the local road is desirable whenever such development is believed imminent. This allows for future left-turn channelization. Use median channelization when justified by capacity determination and analysis, or by the need to provide a smooth traffic flow.

Determine the number of lanes for each leg by capacity analysis methods assuming a traffic signal cycle, preferably 45 or 60 seconds in length, regardless of whether a signal is used or not. Consider all terminals in the analysis.

Adjust the alignment of the intersection legs to fit the traffic movements and to discourage wrong way movements. Use the allowed intersecting angles of 75° to 105° (60° to 120° for modified design level) to avoid broken back or reverse curves in the ramp alignment.

910.13 Procedures

Document design considerations and conclusions in accordance with Chapter 330. For highways with limited access control, see Chapter 1430 for requirements.

(1) Approval

An intersection is approved in accordance with Chapter 330. When required, the following items must be completed before an intersection may be approved:

- Traffic analysis.
- Deviations approved in accordance with Chapter 330.
- Preliminary traffic signal plan approved by the HQ Traffic Office. (See Chapter 850.)
- HQ Design Office approval for intersections with roundabouts. See Chapter 915 for approval procedures.

(2) Intersection Plans

Intersection plans are required for any increases in capacity (turn lanes) of an intersection, modification of channelization, or change of intersection geometrics. Support the need for intersection or channelization modifications with history, school bus and mail route studies, hazardous materials route studies, pedestrian use, public meeting comments, and so forth.

Include the following as applicable:

- Drawing of the intersection showing existing and new alignment of the main line and crossroad.
- Main line stationing of the intersection and angle between intersection legs.
- Curve data on main line and crossroads.
- Profiles for the main line and crossroad.
- ADA considerations.
- Right of way lines.
- Location and type of channelization.
- Width of lanes and shoulders on main line and crossroads (Chapter 440, 640 and 641).
- Proposed access control treatment (Chapters 1420, 1430, and 1435).
- Traffic data including volumes for all movements and vehicle classifications.
- Classes of highway and design speeds for main line and crossroads (Chapter 440).

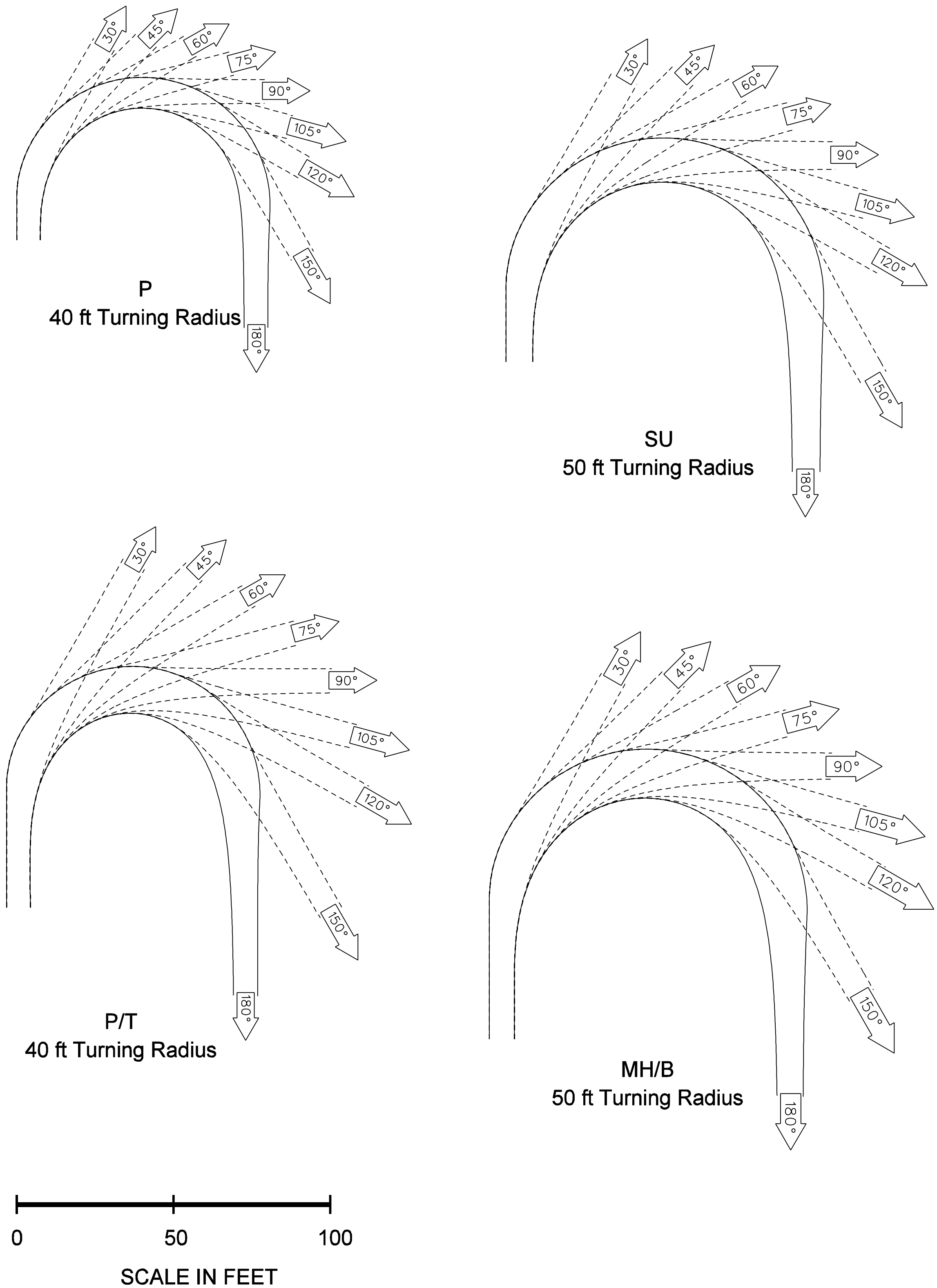
- Whether or not the intersection will be signalized or illuminated.
- A copy of all deviations and justifications, if any.

(3) Local Agency or Developer Initiated Intersections

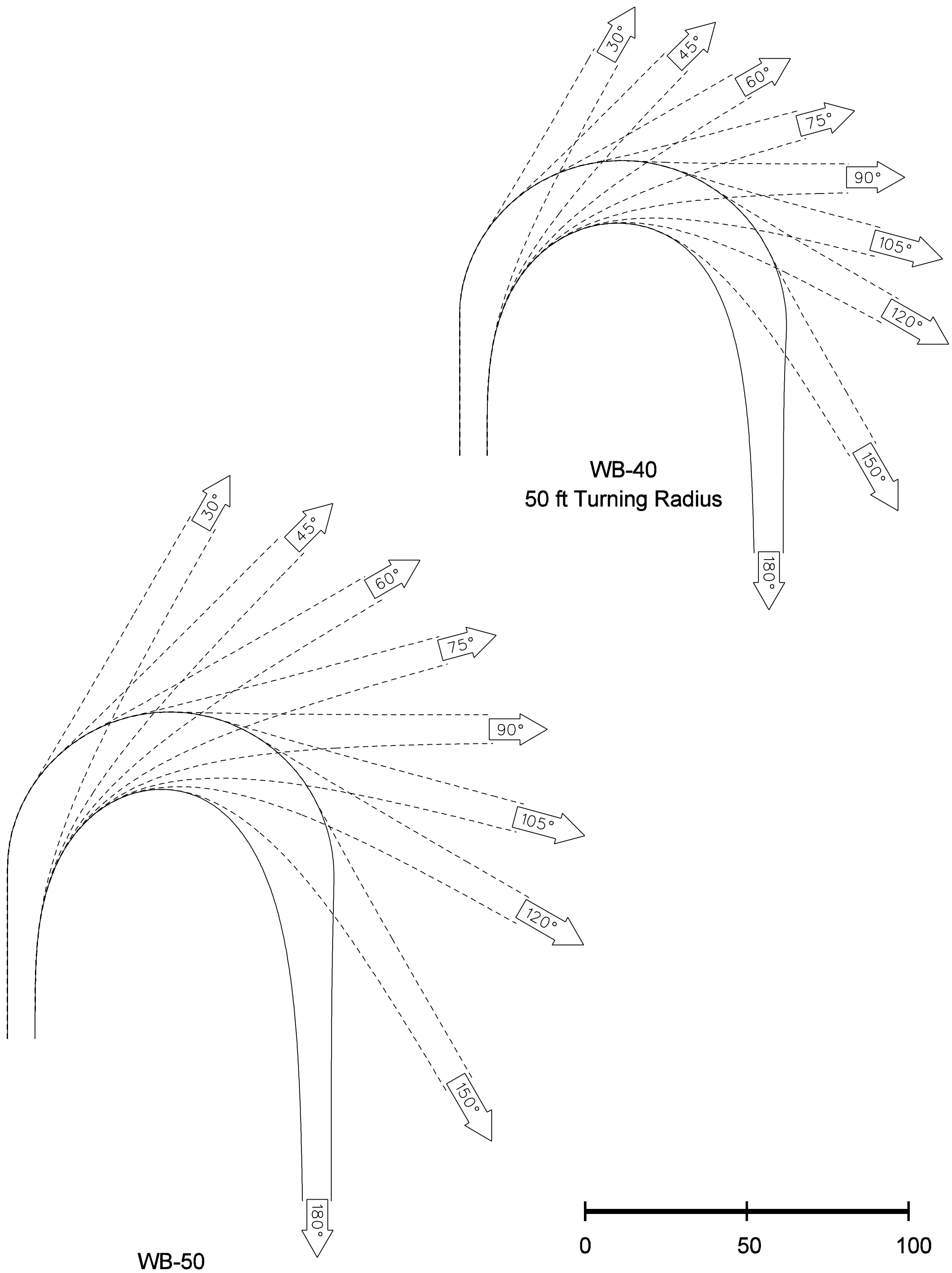
There is a separate procedure for local agency or developer-initiated projects at intersections with state routes. The project initiator submits an intersection plan, and the documentation of design considerations that led to the plan, to the region for approval. For those plans requiring a deviation, the deviation must be approved in accordance with Chapter 330 prior to approval of the plan. After the plan approval, the region prepares a construction agreement with the project initiator. (See the *Utilities Manual*.)

910.14 Documentation

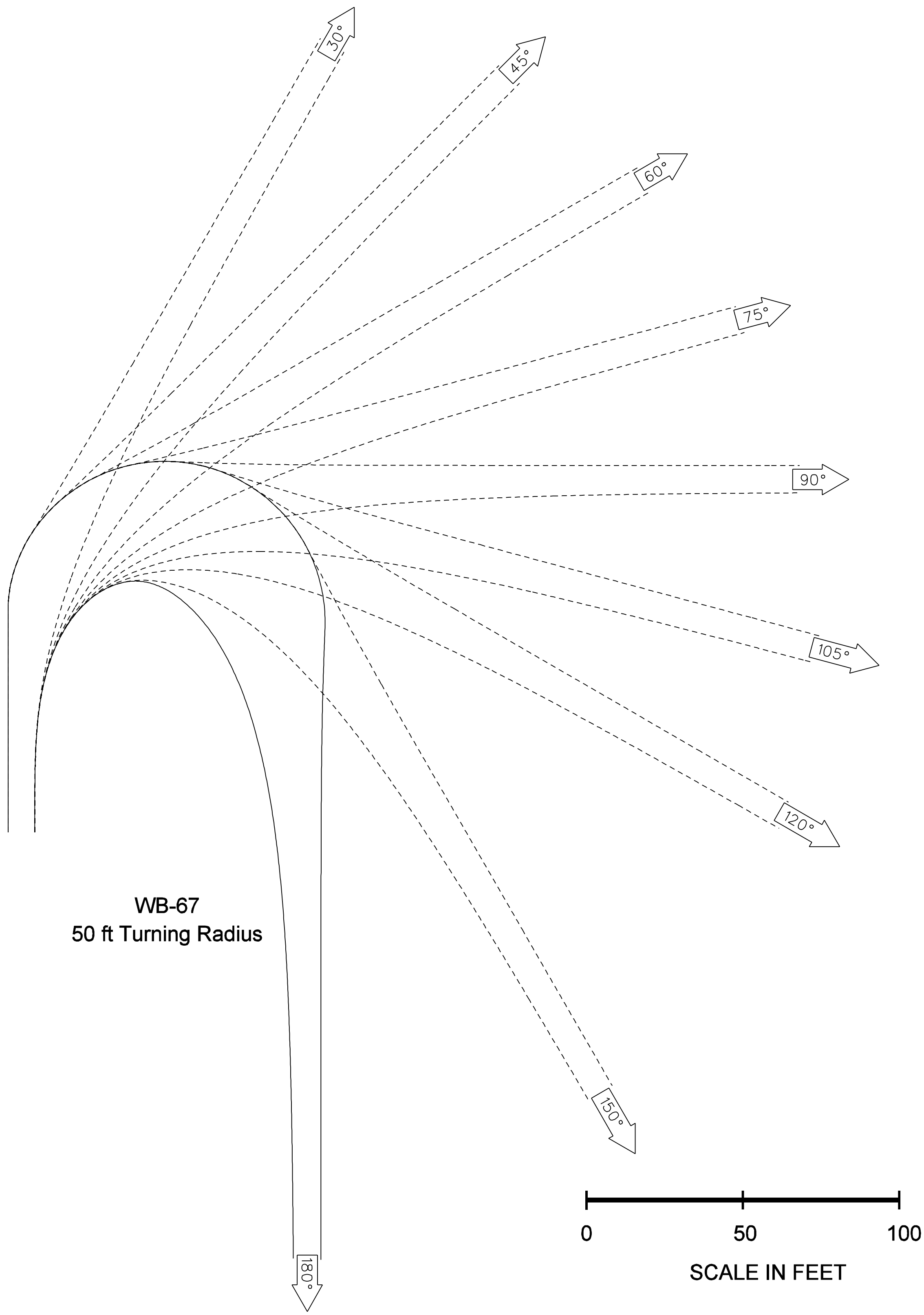
A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/



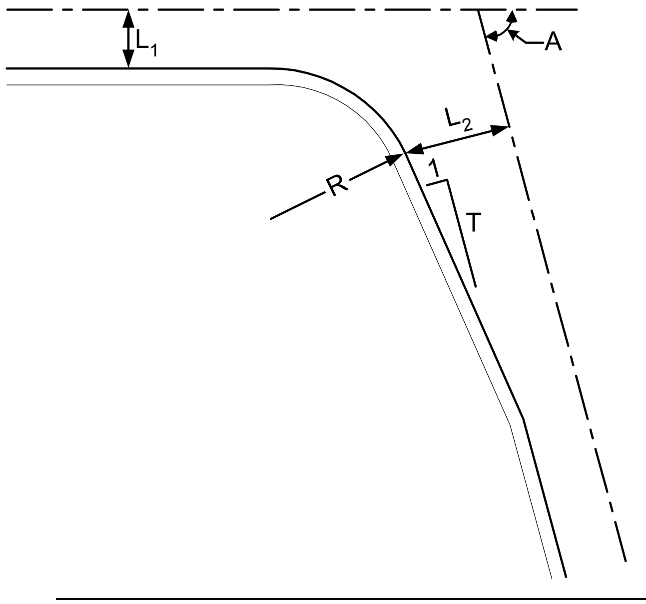
Turning Path Template
Figure 910-6a



Turning Path Template
Figure 910-6b



Turning Path Template
Figure 910-6c



L_1 = Minimum available roadway width (2) that the vehicle is turning from.

L_2 = Minimum available roadway width (2) that the vehicle is turning into.

R = Radius to the edge of traveled way.

T = Taper rate (length per unit of width of widening)

A = Delta angle of the turning vehicle

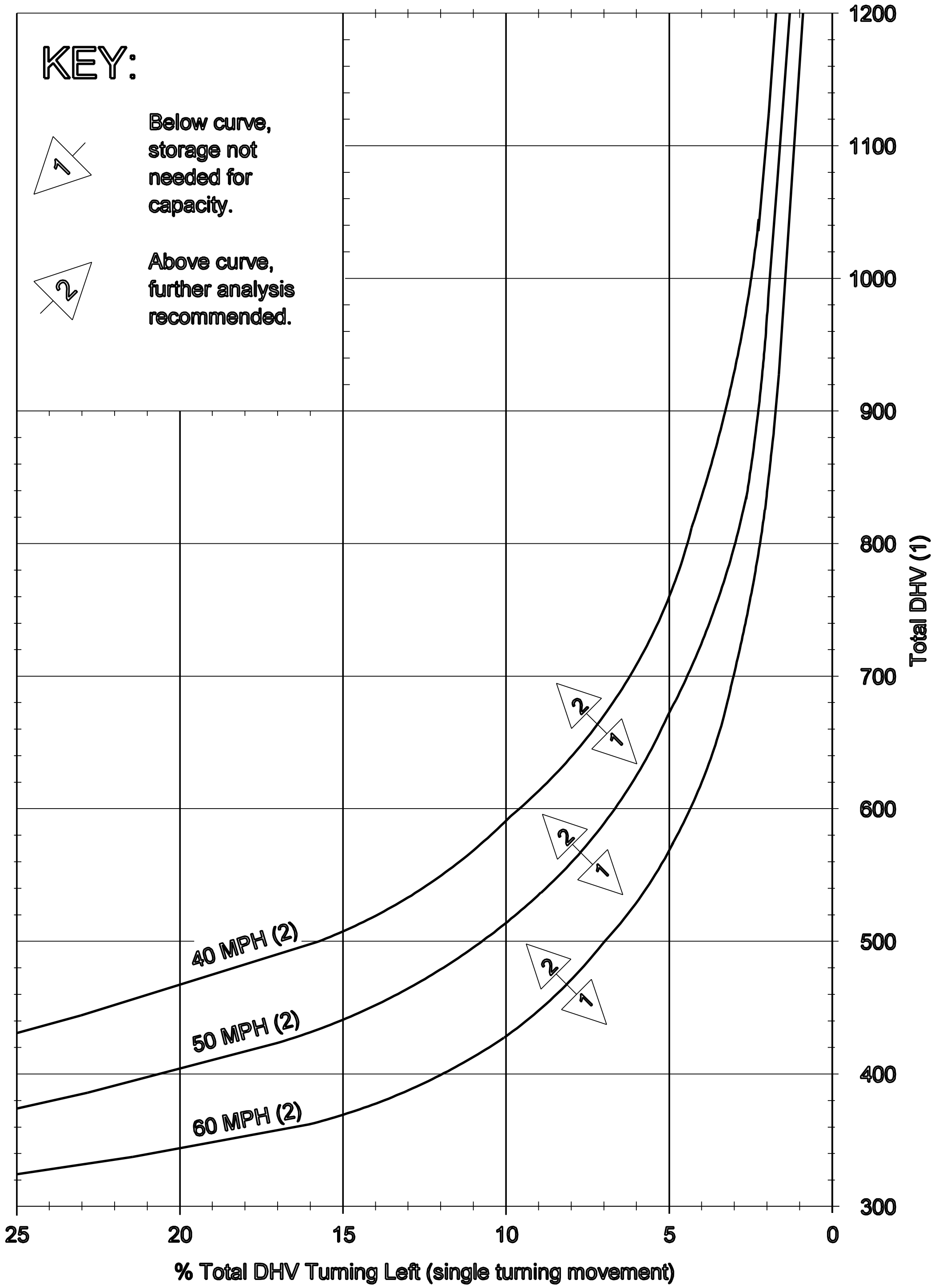
Vehicle	A	R	L_1 (1)	L_2 (1)	T	Vehicle	A	R	L_1 (1)	L_2 (1)	T
WB-67	60	85	11	22	7	WB-40	60	55	11	15	7.5
	75	75	11	21	8		75	55	11	15	7.5
	90	70	11	21	8		90	55	11	14	7.5
	105	55	11	24	7		105	45	11	16	7.5
	120	50	11	24	7		120	45	11	15	7.5
WB-50	60	55	11	19	6	SU & BUS	All	50	11	11	25
	75	55	11	18	6	P	All	35	11	11	25
	90	55	11	17	6						
	105	50	11	17	6						
	120	45	11	18	6						

(1) When available roadway width is less than 11 ft, widen at 25:1.

(2) Available roadway width includes the shoulder, less 2 ft clearance to a curb, and all same direction lanes of the exit leg at signalized intersections.

(3) All distances given in feet and angles in degrees.

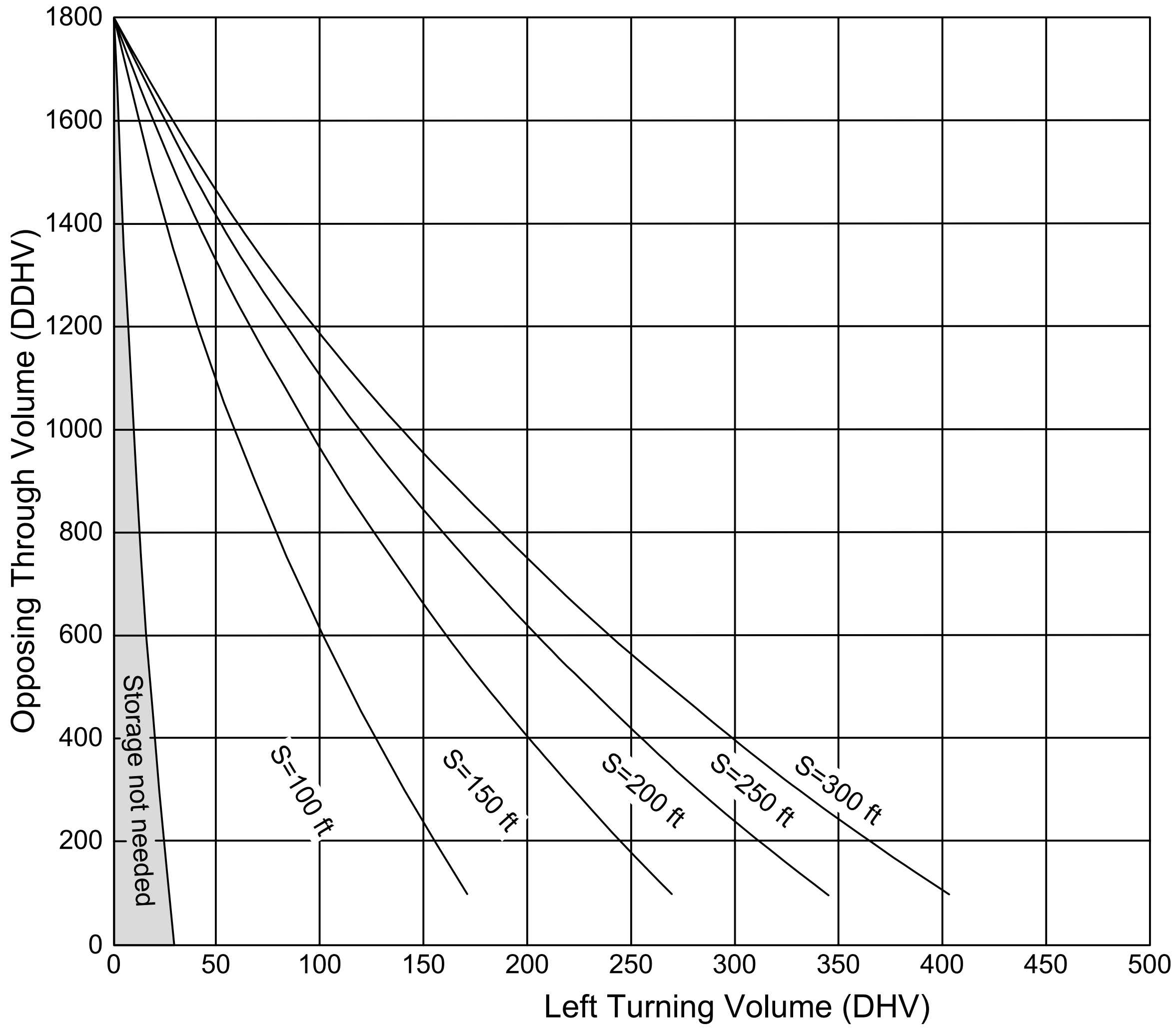
Right-Turn Corner
Figure 910-7



(1) DHV is total volume from both directions.

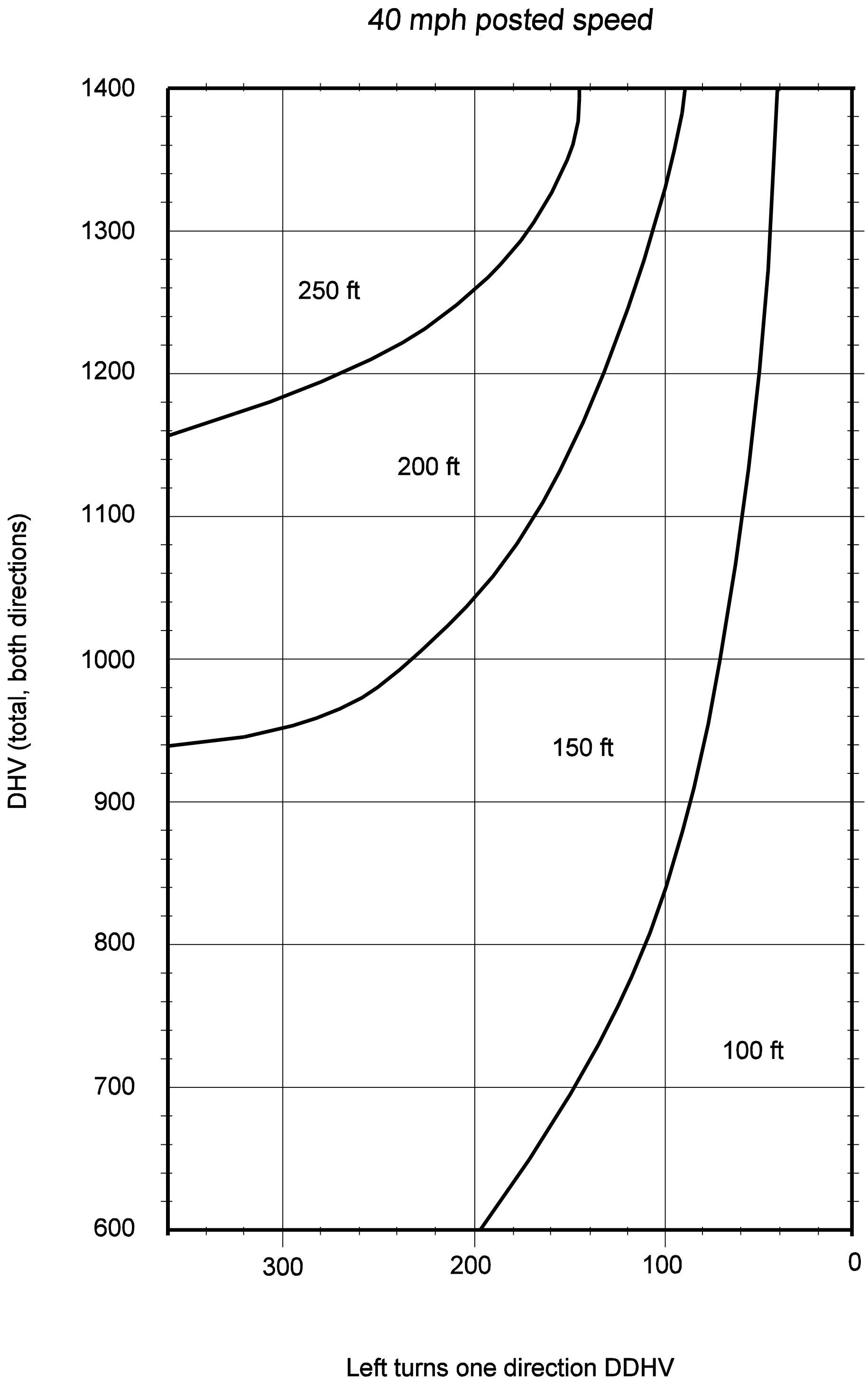
(2) Speeds are posted speeds.

Left-Turn Storage Guidelines (Two-Lane, Unsignalized)
Figure 910-8a

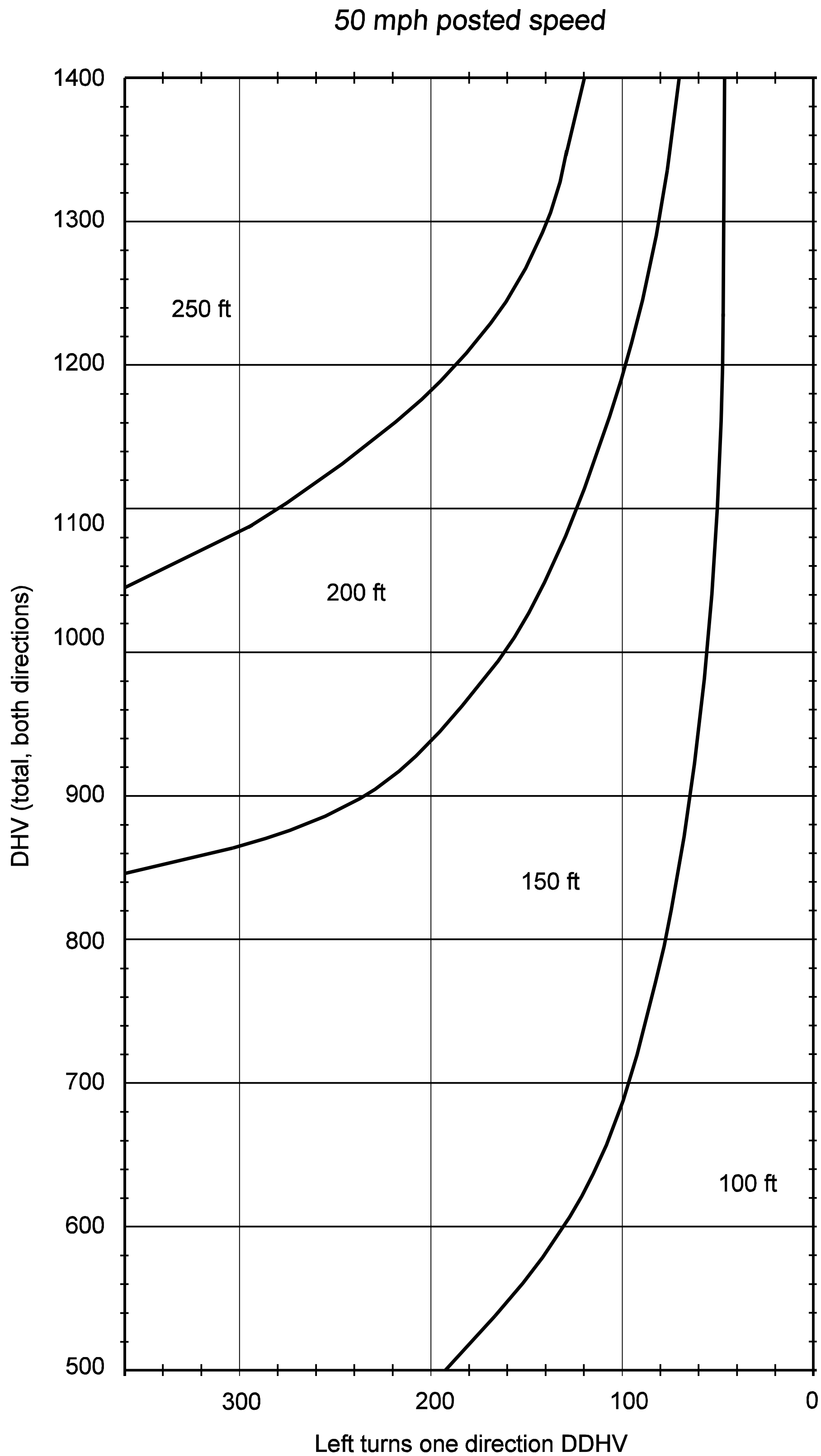


S = Left-Turn storage length

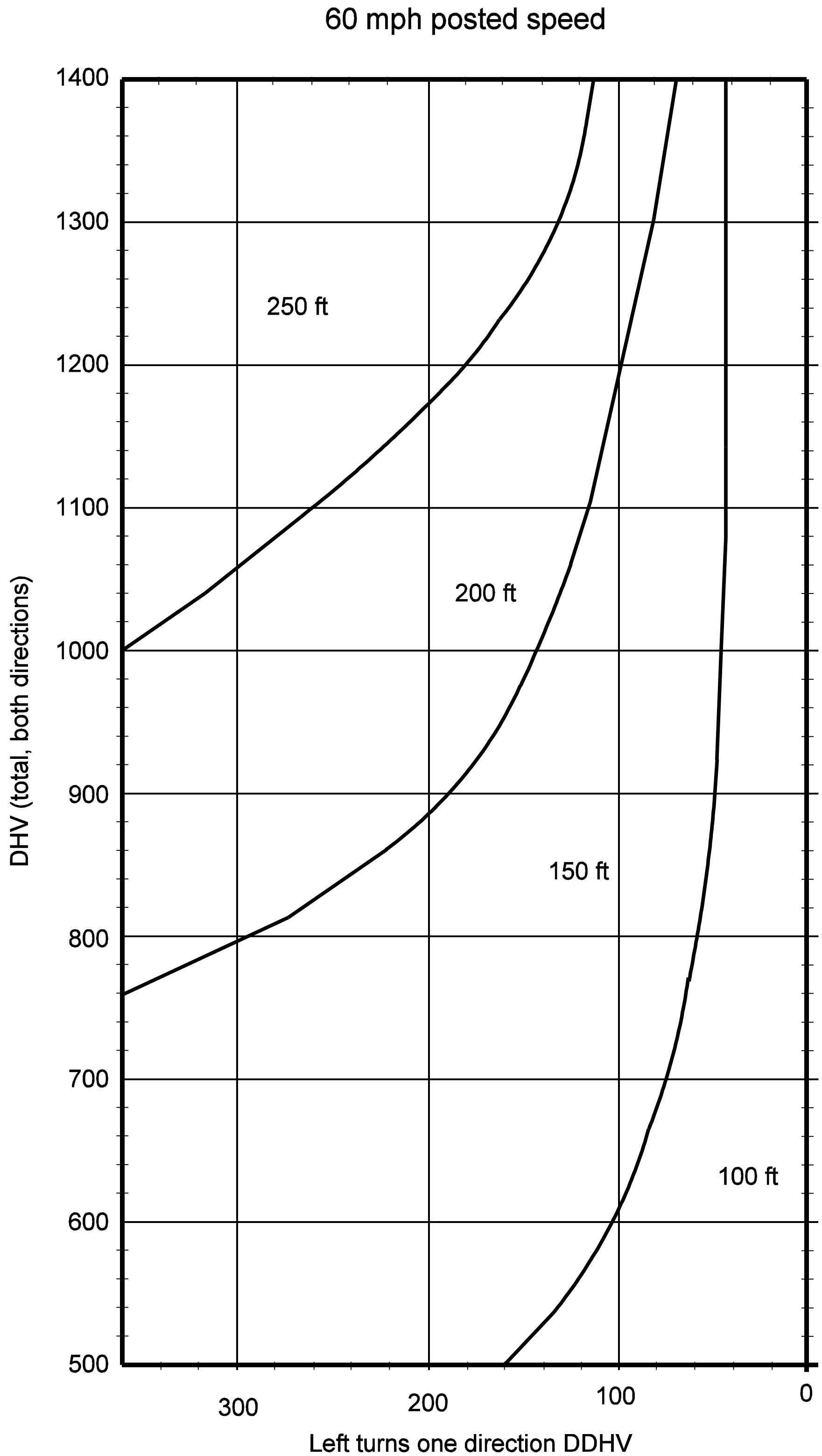
Left-Turn Storage Guidelines (Four-Lane, Unsignalized)
Figure 910-8b



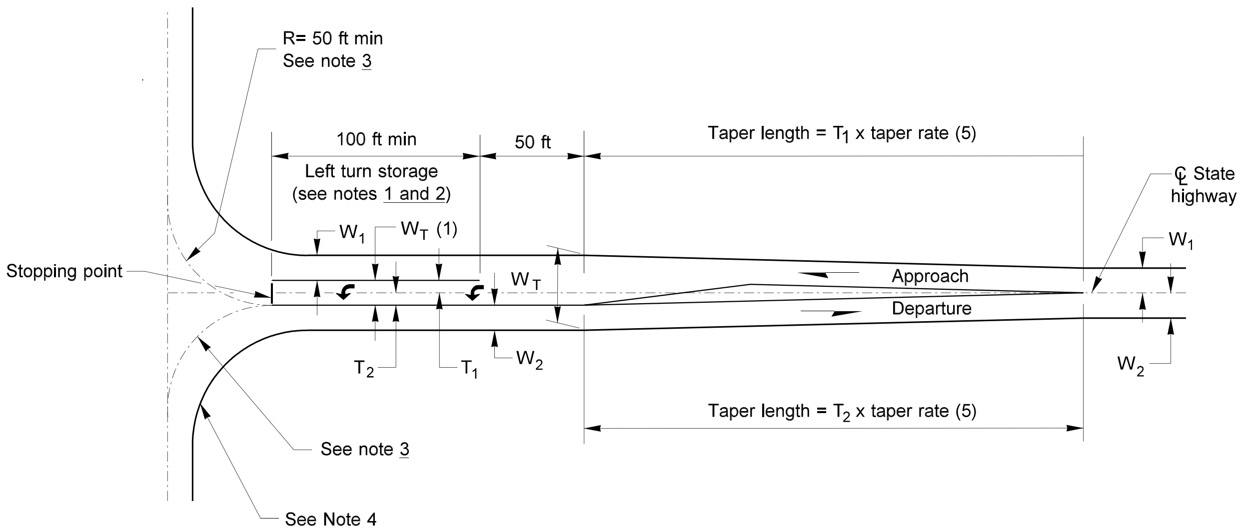
Left-Turn Storage Length (Two-Lane, Unsignalized)
Figure 910-9a



Left-Turn Storage Length (Two-Lane, Unsignalized)
Figure 910-9b



Left-Turn Storage Length (Two-Lane, Unsignalized)
Figure 910-9c



Notes:

(1) The minimum width of the left-turn storage lane (T_1+T_2) is 11 ft. The desirable width is 12 ft.

(2) For left-turn storage length, see Figures 910-8b for 4-lane roadways or 9a through 9c for 2-lane roadways.

(3) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.

(4) See Figure 910-7 for right-turn corner design.

(5) See Table 1 for desirable taper rates. With justification, taper rates from Table 2, Figure 910-10c, may be used.

(6) See Standard Plans and MUTCD for pavement marking details.

W_1 = Approaching through lane.

W_2 = Departing lane.

T_1 = Width of left-turn lane on approach side of center line.

T_2 = Width of left-turn lane on departure side of center line.

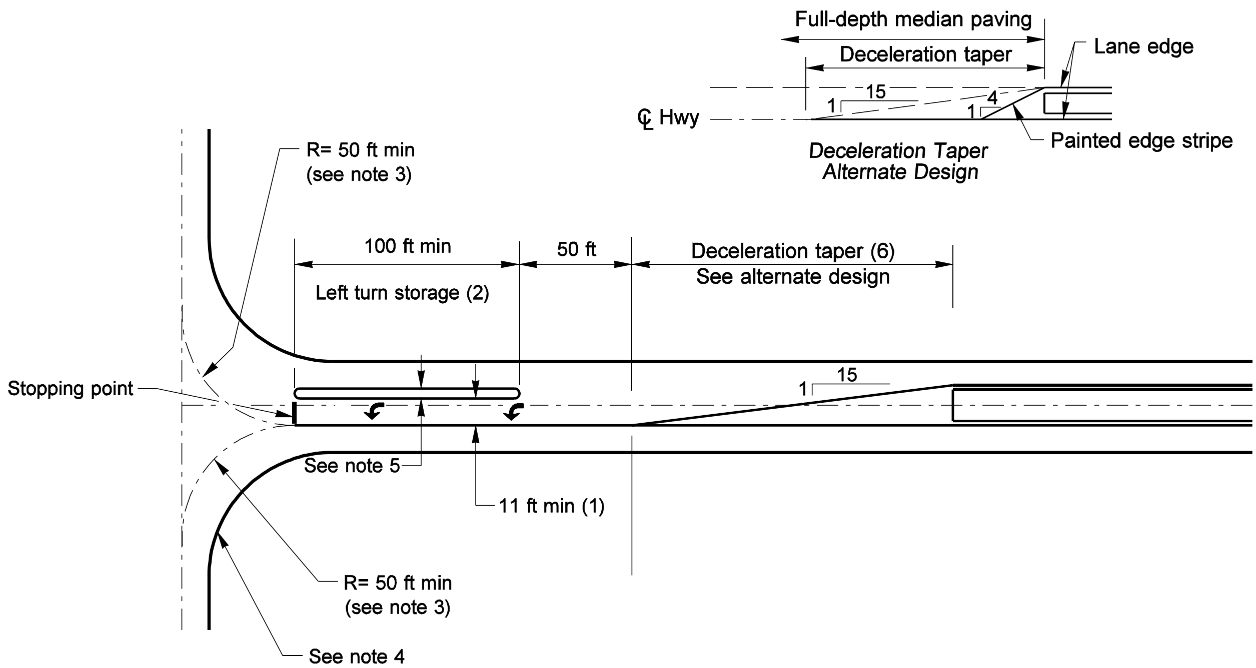
W_T = Total width of channelization. (W_1+W_2+T_1+T_2)

Posted Speed	Taper Rate
55 mph	55:1
50 mph	50:1
45 mph	45:1
40 mph	40:1
35 mph	35:1
30 mph	30:1
25 mph	25:1

Table 1

Median Channelization (Widening)

Figure 910-10a



Notes:

(1) Lane width of 13 ft is desirable.

(2) For left-turn storage length, see Figures 910-8b for 4-lane roadways or 9a through 9c for 2-lane roadways.

(3) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.

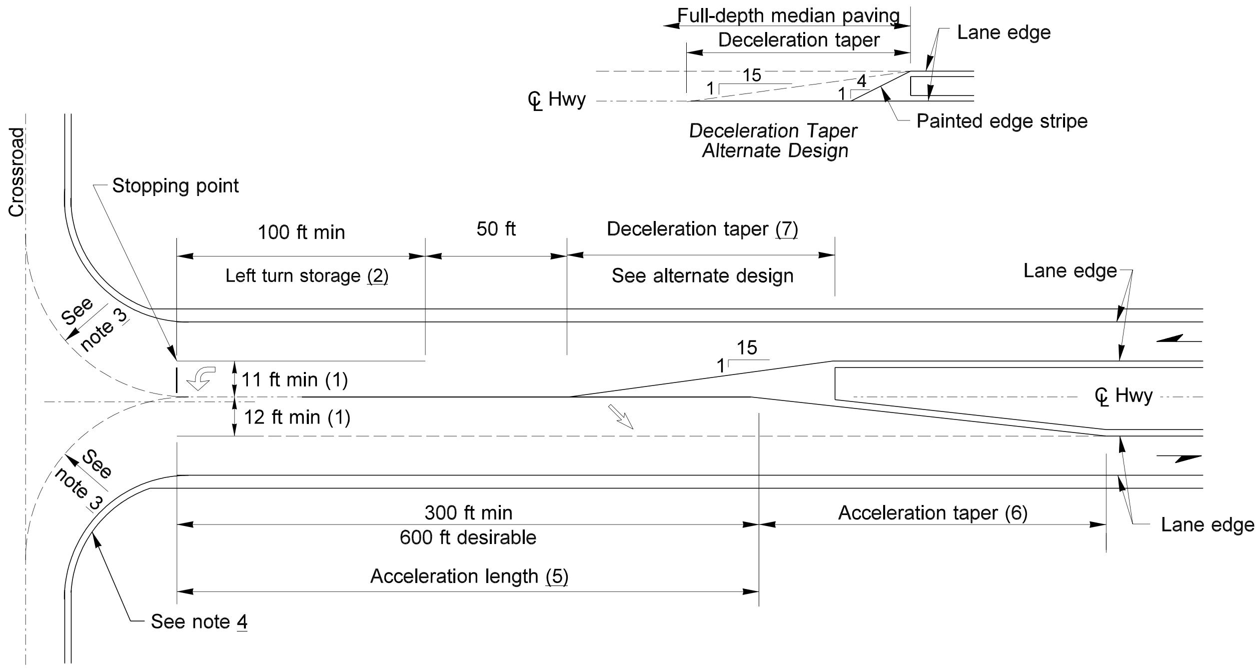
(4) See Figure 910-7 for right-turn corner design.

(5) For median widths greater than 13 ft, it is desirable to locate the left-turn lane adjacent to the opposing through lane with excess median width between the same direction through lane and the turn lane.

(6) For increased storage capacity, consider the left-turn deceleration taper alternate design.

(7) See Standard Plans and MUTCD for pavement marking details.

Median Channelization (Median Width 11 ft or more)
Figure 910-10b



Notes:

(1) Lane widths of 13 ft are desirable for both the left-turn storage lane and the median acceleration lane.

(2) For left-turn storage length, see Figures 910-8b for 4-lane roadways or 9a throug9c for 2-lane roadways.

(3) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.

(4) See Figure 910-7 for right-turn corner design.

(5) The minimum total length of the median acceleration lane is shown in Figure 910-14.

(6) See Table 2, for acceleration tape rate.

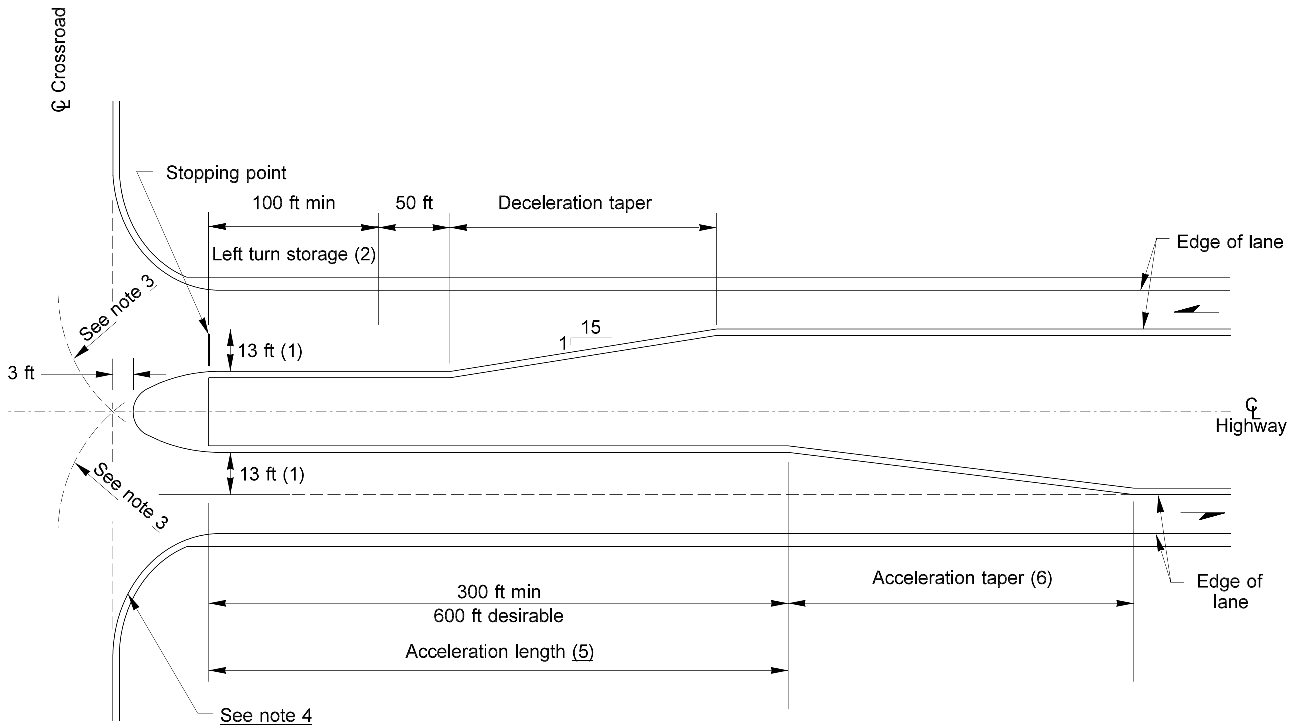
(7) For increased storage capacity, consider the left-turn deceleration taper alternate design.

(8) See Standard Plans and MUTCD for pavement marking details.

Posted Speed	Taper Rate
55 mph	55:1
50 mph	50:1
45 mph	45:1
40 mph	27:1
35 mph	21:1
30 mph	15:1
25 mph	11:1

Table 2

Median Channelization (Median Width 23 ft to 26 ft)
Figure 910-10c



Notes:

(1) May be reduced to 11 ft, with justification.

(2) For left-turn storage length, see Figures 910-8b for 4-lane roadways or 9a through 9c for 2-lane roadways.

(3) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.

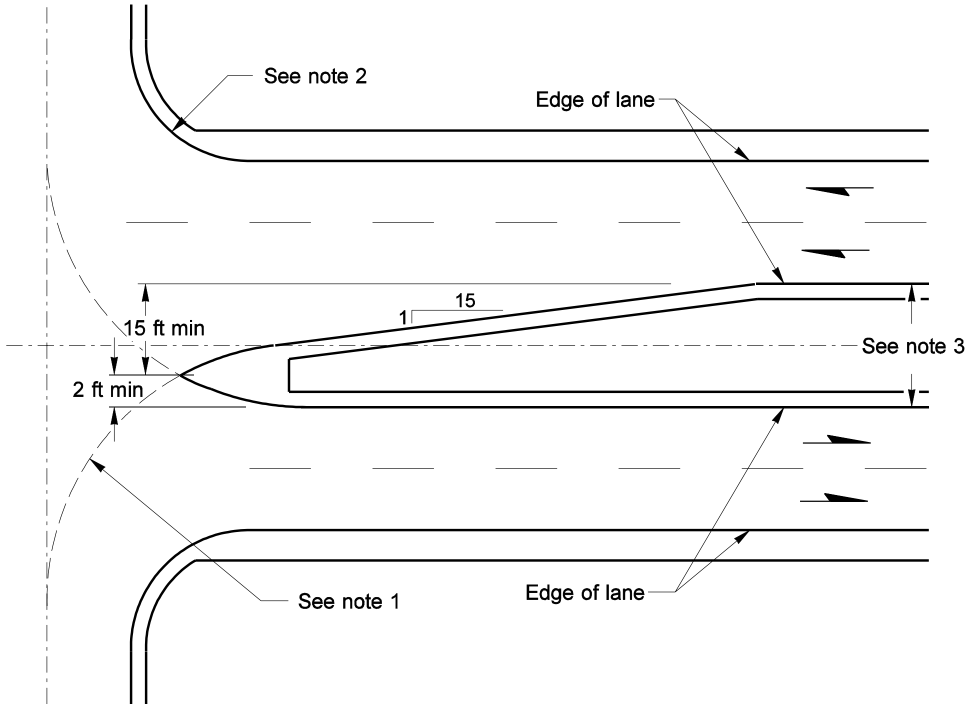
(4) See Figure 910-7 for right-turn corner design.

(5) The minimum length of the median acceleration lane is shown in Figure 910-14.

(6) See Table 2 Figure 910-10c for acceleration tape rate.

(7) See Standard Plans and MUTCD for pavement marking details.

Median Channelization (Median Width of More Than 26 ft)
Figure 910-10d



Notes:

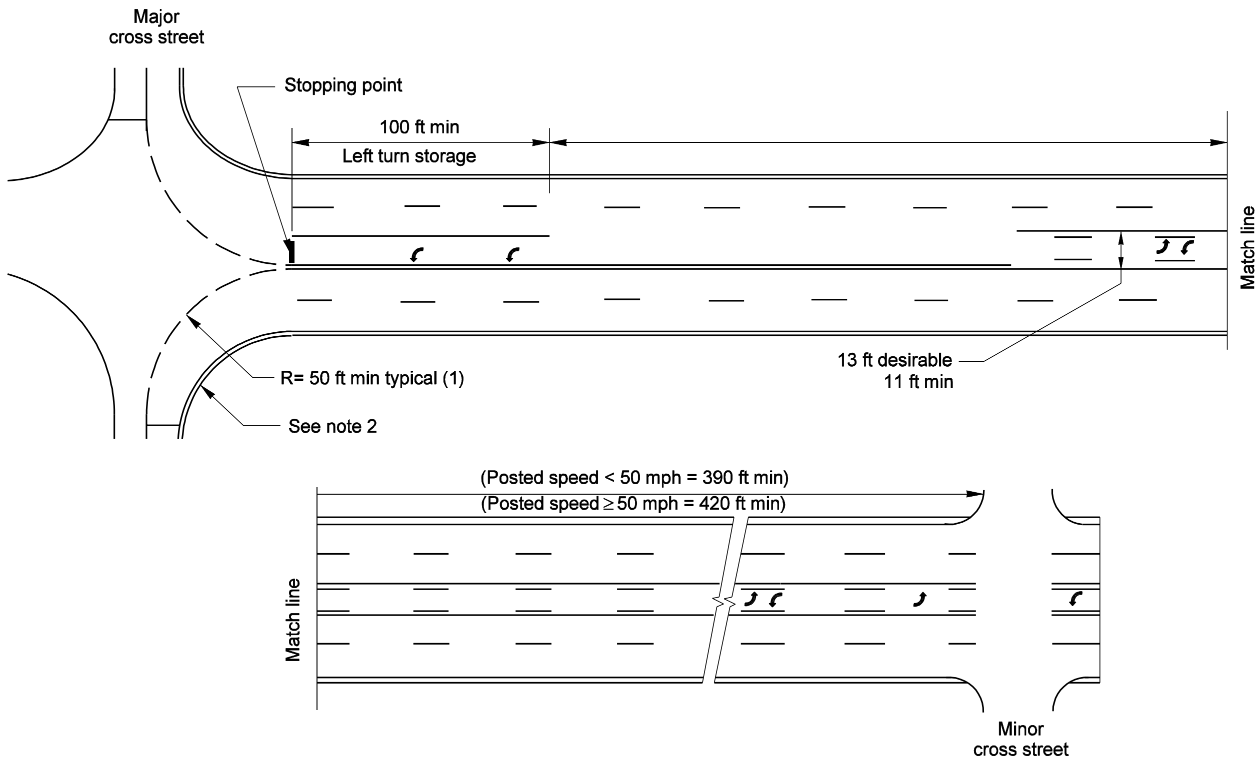
(1) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.

(2) See Figure 910-7 for right-turn corner design.

(3) For median width 17 ft or more. For median width less than 17 ft, widen to 17 ft or use Figure 910-10b.

(4) See Standard Plans and MUTCD for pavement marking details.

Median Channelization (Minimum Protected Storage)
Figure 910-10e



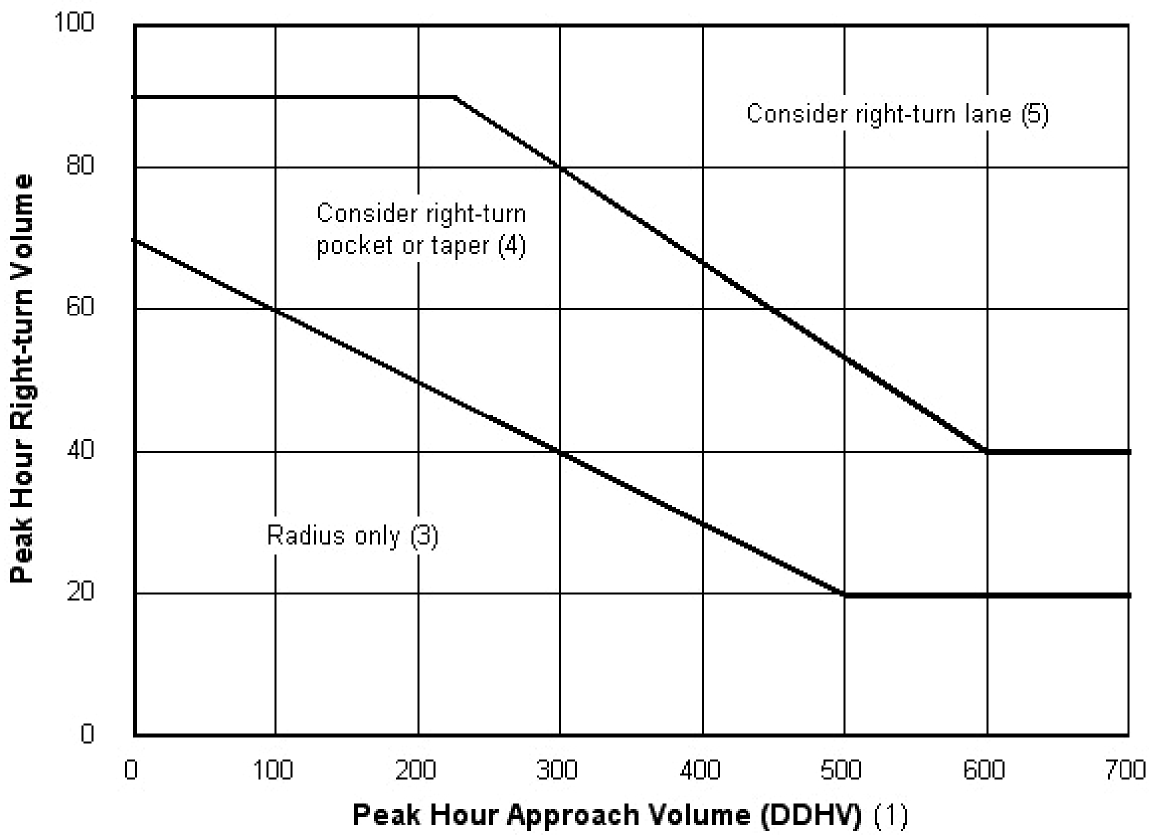
Notes:

(1) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.

(2) See Figure 910-7 for right-turn corner design.

(3) See the Standard Plans and the MUTCD for pavement marking details and signing criteria.

Median Channelization (Two-way Left-Turn Lane)
Figure 910-10f



Notes:

(1) For two-lane highways, use the peak hour DDHV (through + right-turn).

For multilane, high speed highways (posted speed 45 mph or above), use the right-lane peak hour approach volume (through + right-turn).

(2) When all three of the following conditions are met, reduce the right-turn DDHV by 20.

- The posted speed is 45 mph or less.
- The right-turn volume is greater than 40 VPH.
- The peak hour approach volume (DDHV) is less than 300 VPH.

(3) See Figure 910-7 for right-turn corner design.

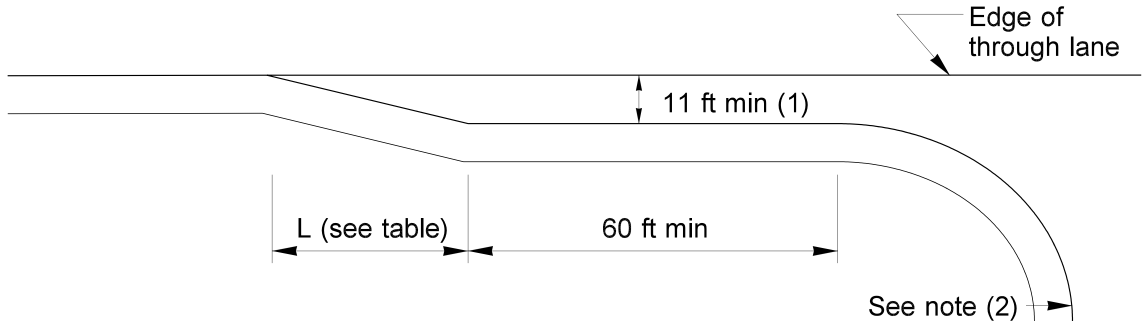
(4) See Figure 910-12 for right-turn pocket or taper design.

(5) See Figure 910-13 for right-turn lane design.

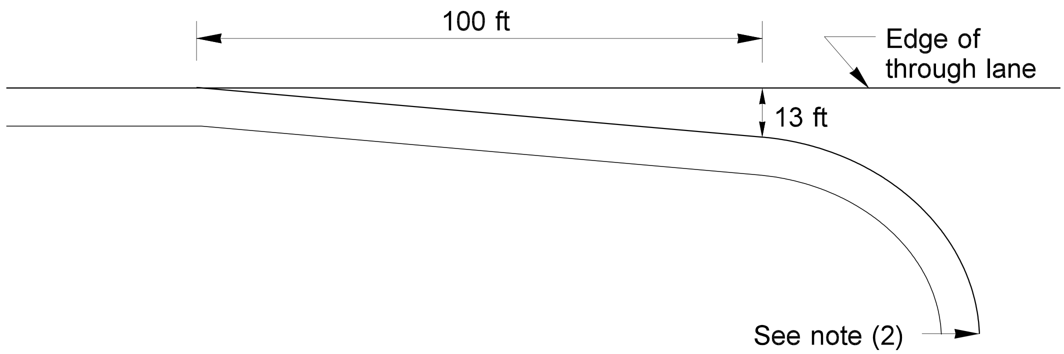
(6) For additional guidance, see 910.07(2) in the text.

Right-Turn Lane Guidelines (6)

Figure 910-11



Right-Turn Pocket



Right-Turn Taper

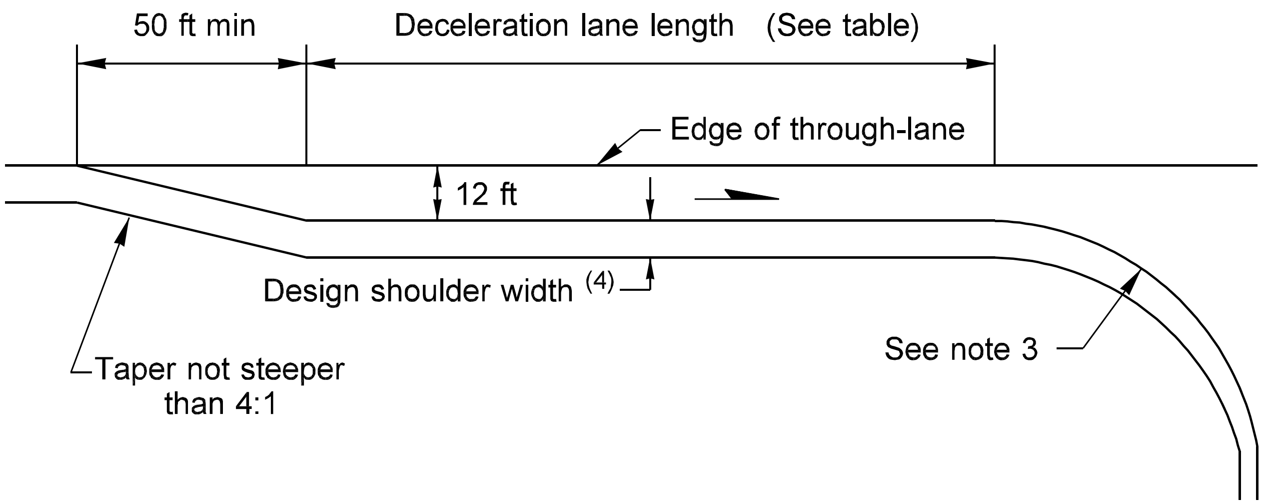
Posted speed limit	L
Below 40 mph	40 ft
40 mph or above	100 ft

Notes:

(1) 12 ft desirable.

(2) See Figure 910-7 for right-turn corner design.

Right-Turn Pocket and Right-Turn Taper
Figure 910-12



Highway Design Speed (mph)	Turning Roadway design speed (mph)		
	Stop(1)	15	20
30	235	200 (2)	170 (2)
35	280	250	210
40	320	295	265
45	385	350	325
50	435	405	385
55	480	455	440
60	530	500	480
65	570	540	520
70	615	590	570

Minimum Deceleration Lane Length (ft)

Grade	Upgrade	Downgrade
3% to less than 5%	0.9	1.2
5% or more	0.8	1.35

Adjustment Multiplier for Grades 3% or Greater

Notes:

(1) For use when the turning traffic is likely to stop before completing the turn. (For example, where pedestrians are present.)

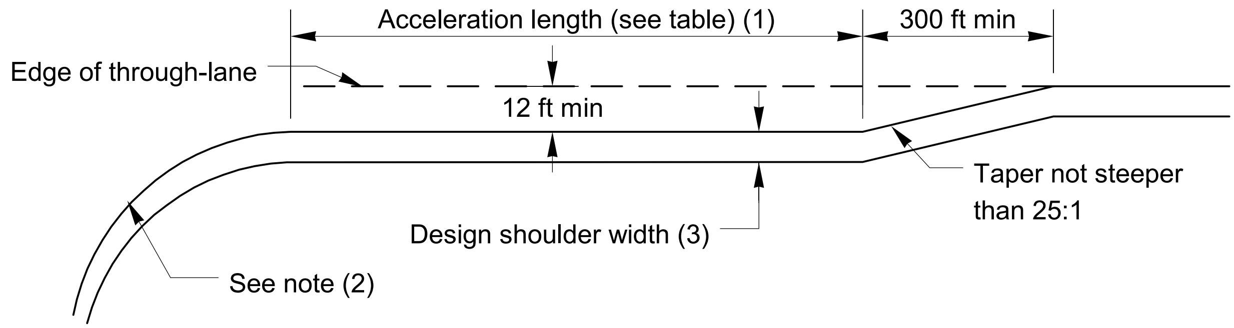
(2) When adjusting for grade, do not reduce the deceleration lane to less than 150 ft.

(3) See Figure 910-7 for right-turn corner design.

(4) May be reduced, see 910.07(4) in the text.

(5) See the Standard Plans and the MUTCD for pavement marking details.

Right-Turn Lane
Figure 910-13



Highway Design Speed (mph)	Turning Roadway Design Speed (mph)		
	Stop	15	20
30	180	140	
35	280	220	160
40	360	300	270
45	560	490	440
50	720	660	610
55	960	900	810
60	1200	1140	1100
65	1410	1350	1310
70	1620	1560	1520

Minimum Acceleration Lane Length (ft) (1)

Highway Design Speed (mph)	% Grade	Upgrade	Downgrade
40	3% to less than 5%	1.3	0.7
50		1.3	0.65
60		1.4	0.6
70		1.5	0.6
40	5% or more	1.5	0.6
50		1.5	0.55
60		1.7	0.5
70		2.0	0.5

Adjustment Multiplier for Grades 3% or Greater

Notes:

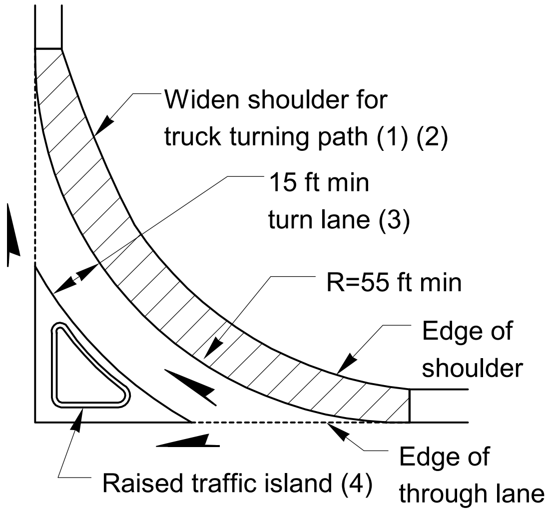
(1) At free-right turns (no stop required) and all left-turns, the minimum acceleration lane length is not less than 300 ft.

(2) See Figure 910-7 for right-turn corner design.

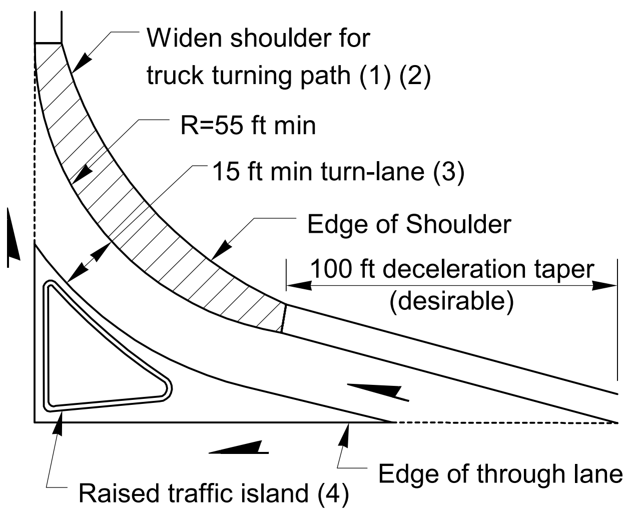
(3) May be reduced, see 910.07(4) in the text.

(4) See the Standard Plans and the MUTCD for pavement marking details.

Acceleration Lane
Figure 910-14



Small Traffic Island Design (5)



Large Traffic Island Design (5)

Notes:

(1) Widen shoulders when adequate right-turn radii or roadway width cannot be provided for large trucks. Design widened shoulder pavement the same depth as the right-turn lane.

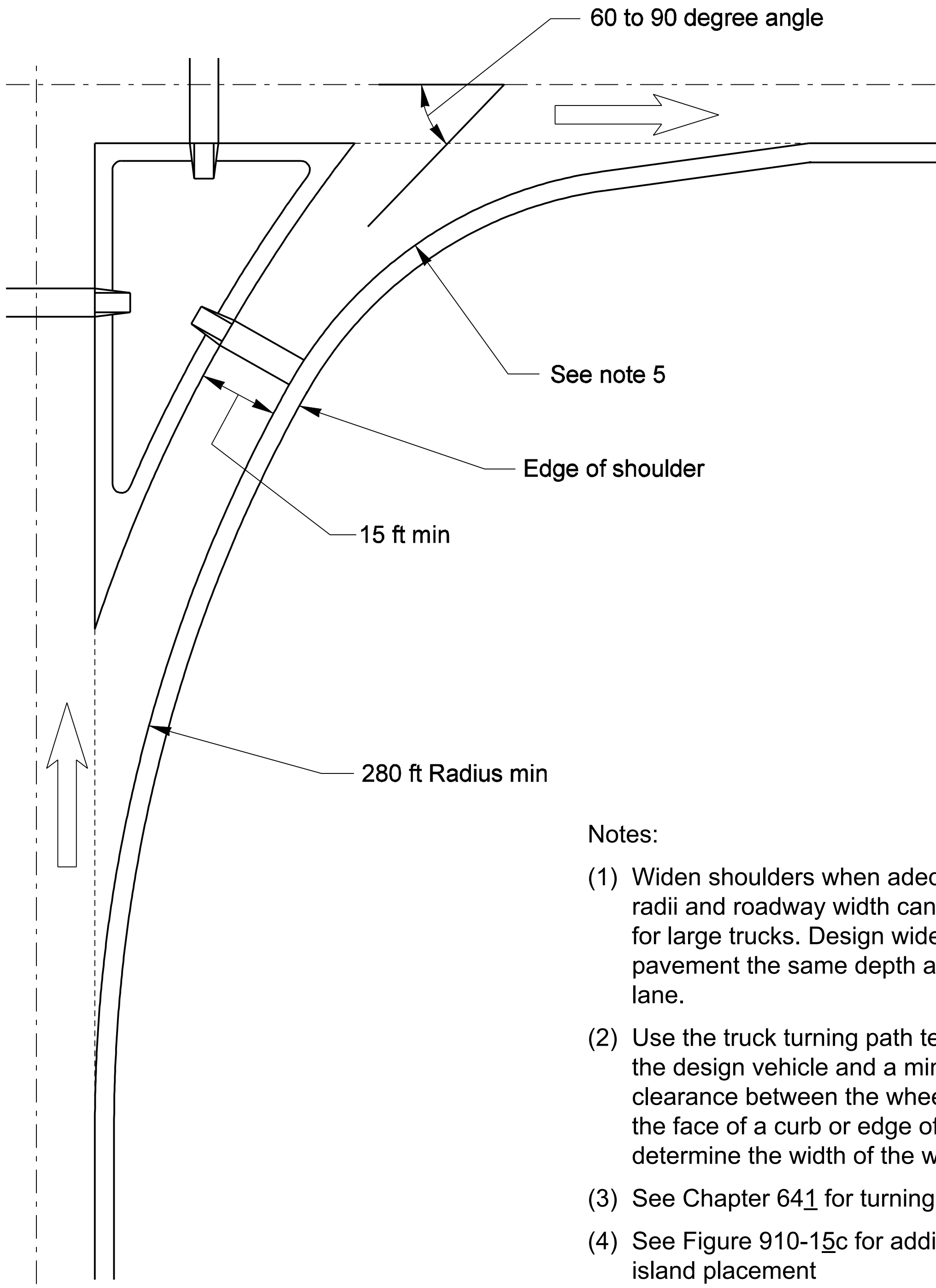
(2) Use the truck turning path templates for the design vehicle and a minimum of 2 ft clearance between the wheel paths and the face of a curb or edge of shoulder to determine the width of the widened shoulder.

(3) See Chapter 641 for turning roadway widths.

(4) See Figure 910-15c for additional details on island placement

(5) Small traffic islands have an area of 100 ft^2 or less; large traffic islands have an area greater than 100 ft^2.

Traffic Island Designs
Figure 910-15a



Notes:

(1) Widen shoulders when adequate right-turn radii and roadway width cannot be provided for large trucks. Design widened shoulder pavement the same depth as the right-turn lane.

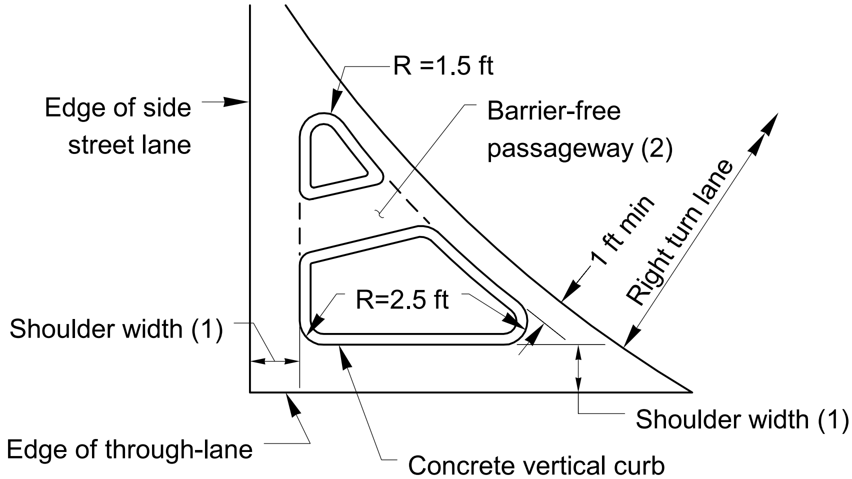
(2) Use the truck turning path templates for the design vehicle and a minimum of 2 ft clearance between the wheel paths and the face of a curb or edge of shoulder to determine the width of the widened shoulder.

(3) See Chapter 641 for turning roadway widths.

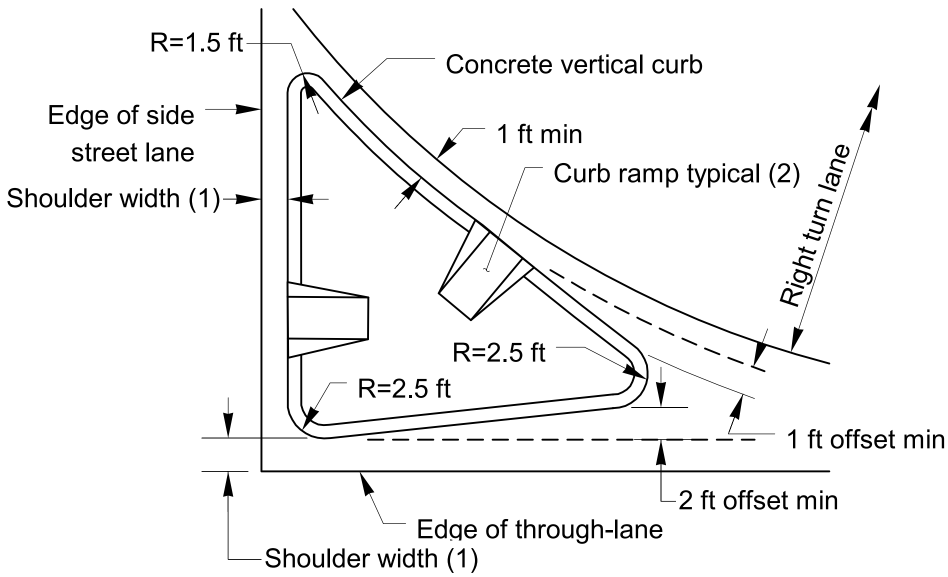
(4) See Figure 910-15c for additional details on island placement

(5) See Figure 910-7 for right-turn corner design.

Traffic Island Designs (Compound Curve)
Figure 910-15b



Small Raised Traffic Island (3)



Large Raised Traffic Island

Notes:

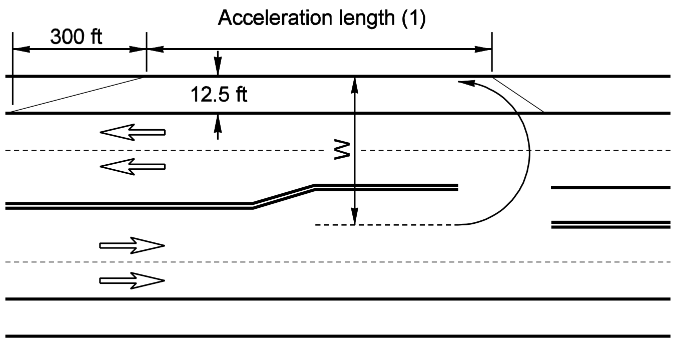
(1) See Chapter 440 for minimum shoulder width. See the text for additional information on shoulders at islands.

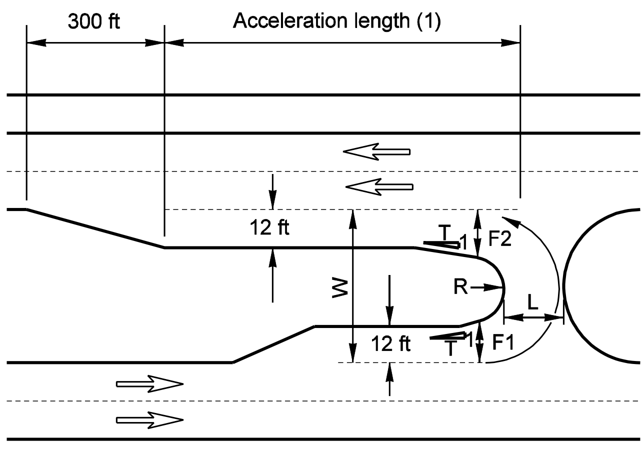
(2) Provide barrier-free passageways or curb ramps when required, see Chapter 1025.

(3) Small traffic islands have an area of 100 ft^2 or less; large traffic islands have an area greater than 100 ft^2.

Traffic Island Designs

Figure 910-15c





Vehicle	W	R	L	F1	F2	T
P	52	14	14	12	12	—
SU	87	30	20	13	15	10:1
BUS	87	28	23	14	18	10:1
WB-40	84	25	27	15	20	6:1
WB-50	94	26	31	16	25	6:1
WB-67	94	22	49	15	35	6:1
MH	84	27	20	15	16	10:1
P/T	52	11	13	12	18	6:1
MH/B	103	36	22	15	16	10:1

U-Turn Design Dimensions

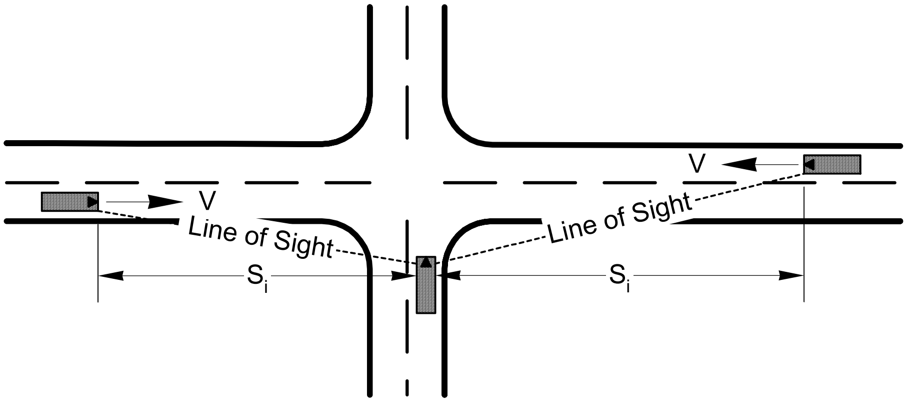
Notes:

(1) The minimum length of the acceleration lane is shown in Figure 910-14. Acceleration lane may be eliminated at signal controlled intersections.

(2) All dimensions in feet.

(3) When U-turn uses the shoulder, provide 12.5 ft shoulder width and shoulder pavement designed to the same depth as the through lanes for the acceleration length and taper.

U-Turn Locations
Figure 910-16



$\underline{S_i} = 1.47Vt_g$
Where:
S_i = Intersection Sight Distance (ft)
V = Design speed of the through roadway (mph)
t_g = Time gap for the minor roadway traffic to enter or cross the through roadway (s)

Intersection Sight Distance Equation
Table 1

Design Vehicle	Time Gap (t_g) in seconds
Passenger car (P)	9.5
Single unit trucks and buses (SU & BUS)	11.5
Combination trucks (WB-40, WB-50, & WB-67)	13.5
Note: Values are for a stopped vehicle to turn left onto a two-lane two-way roadway with no median and grades 3% or less. Includes 2 sec for perception/reaction time.	

Intersection Sight Distance Gap Times (t_g)
Table 2

The t_g values listed in Table 2 require the following adjustments:

Crossing or right-turn maneuvers:

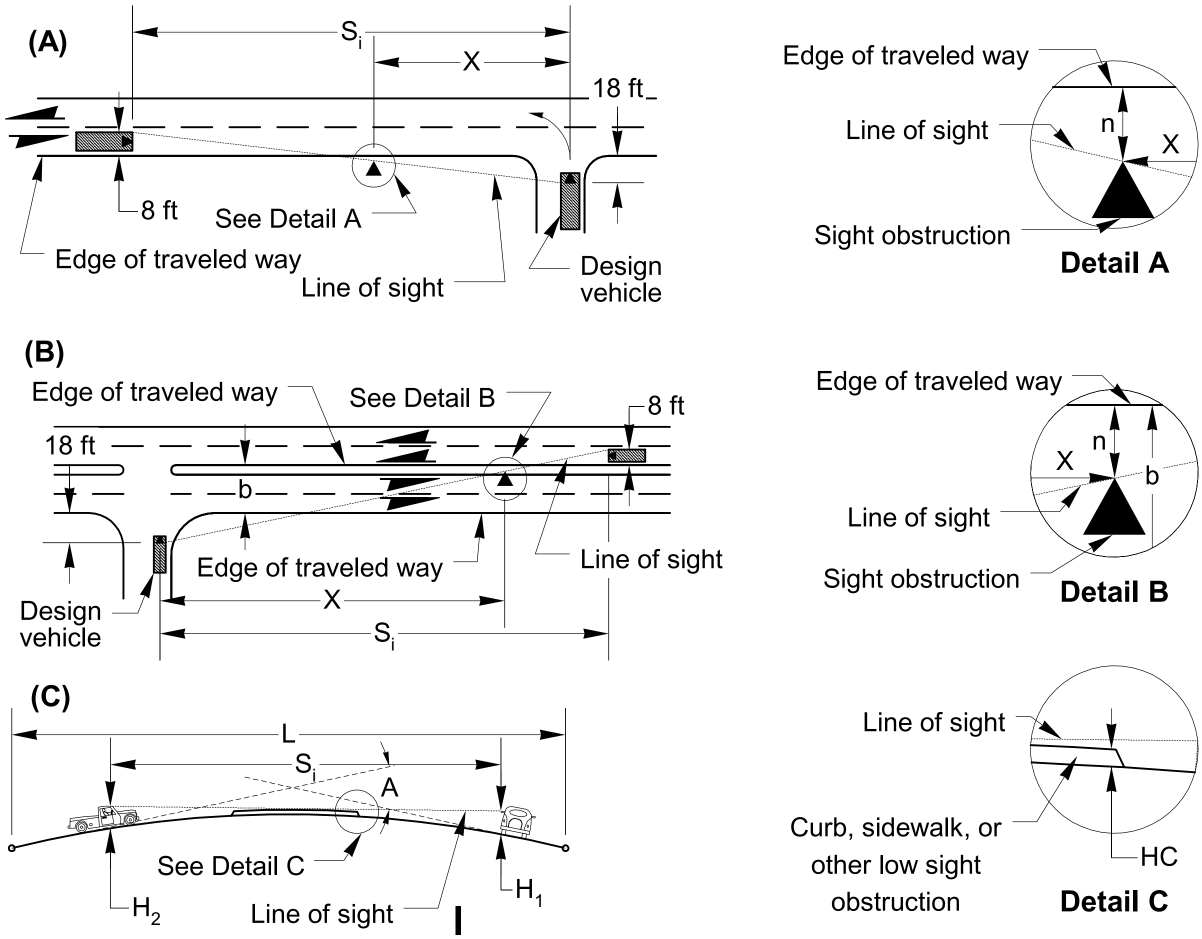
All vehicles subtract 1.0 s

Multilane roadways:

Left-turns, for each lane in excess of one to be crossed and for medians wider than 4 ft:
Passenger cars add 0.5 s
All trucks and buses add 0.7 s
Crossing maneuvers, for each lane in excess of two to be crossed and for medians wider than 4 ft:
Passenger cars add 0.5 s
All trucks and buses add 0.7 s
Note: Where medians are wide enough to store the design vehicle, determine the sight distance as two maneuvers.

Crossroad grade greater than 3%:
All movements upgrade, for each percent that exceeds 3%:
All vehicles add 0.2 s

Sight Distance at Intersections
Figure 910-17a



For sight obstruction driver cannot see over:

$$S_i = \frac{(26 + b)(X)}{(18 + b - n)}$$

Where:

S_i = Available intersection sight distance (ft).

n = Offset from sight obstruction to edge of lane (ft).

b = Distance from near edge of traveled way to near edge of lane approaching from right (ft). (b=0 for sight distance to the left.)

X = Distance from center line of lane to sight obstruction (ft).

For crest vertical curve over a low sight obstruction where S<L:

$$S = \sqrt{\frac{100L\left[\sqrt{2(H_1 - HC)} + \sqrt{2(H_2 - HC)}\right]^2}{A}}$$

$$L = \frac{AS^2}{100\left[\sqrt{2(H_1 - HC)} + \sqrt{2(H_2 - HC)}\right]^2}$$

Where:

S = Available sight distance (ft).

H_1 = Eye height (3.5 ft for passenger cars; 6 ft for all trucks).

H_2 = Object height (4.25 ft).

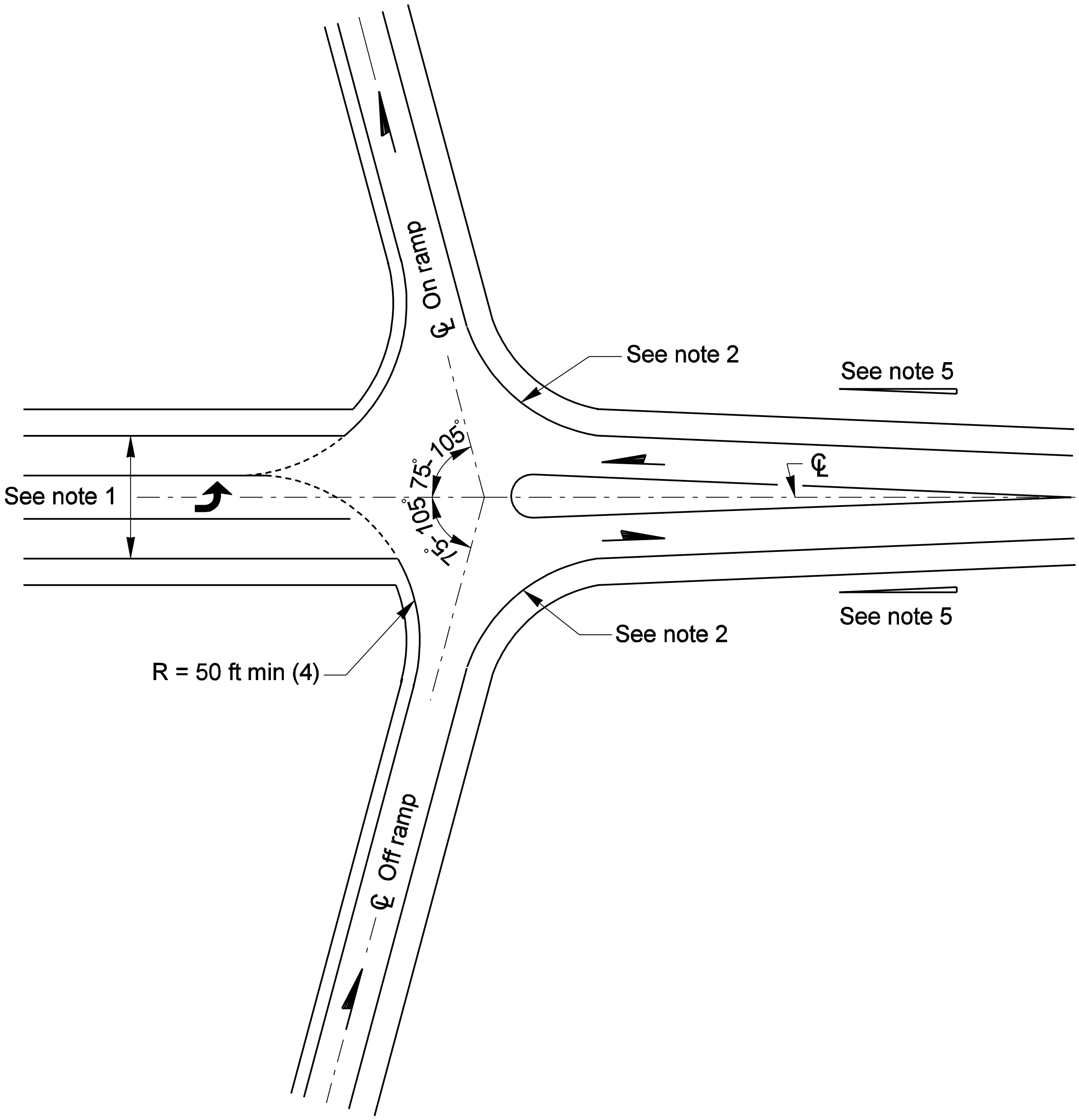
HC = Sight obstruction height (ft).

L = Vertical curve length (ft).

A = Algebraic difference in grades (%).

Sight Distance at Intersections

Figure 910-17b



Notes:

(1) 12 ft through-lanes and 13 ft left-turn lane desirable.

(2) For right-turn corner design see Figure 910-7.

(3) Intersections may be designed individually.

(4) Use templates to verify that the design vehicle can make the turn.

(5) See Figure 910-10a, Table 1 for taper rates.

Interchange Ramp Details
Figure 910-18

915.01 General

Modern roundabouts are circular intersections at grade. They can be an effective intersection type with fewer conflict points, lower speeds, and provide for easier decision making than conventional intersections. They require less maintenance than traffic signals. When well designed, they have been found to reduce fatal and severe injury accidents, traffic delays, fuel consumption, and air pollution. They also can have a traffic calming effect. For additional information and details on roundabouts, see *Roundabouts: An Informational Guide*.

Selection of a roundabout as the preferred intersection type is based on several factors including traffic volume, pedestrian and bicycle volume, space requirements, right of way availability, and traffic speeds. The safety benefits of a roundabout decrease with higher traffic volumes, particularly when pedestrians and bicycles are considered. Select a roundabout only when it is clearly the best intersection type.

Modern roundabouts differ from the old rotaries and traffic circles in three important respects: they have a smaller diameter that constrains circulating speeds; they have raised splitter islands that provide entry deflection, slowing down the entering vehicles; and they have yield at entry, which requires entering vehicles to yield, thus allowing circulating traffic free flow.

Old rotaries and traffic circles are characterized by a large diameter, often in excess of 300 ft. This large diameter typically results in travel speeds within the circulating roadway that exceed 30 mph. They typically provide little or no horizontal deflection of the paths of through traffic. These large diameters also create weaving areas that increase accidents in the circulating roadway. At times, traffic control was imposed on the circulating traffic, such as yield or stop signs that required circulating traffic to yield to entering traffic. In some cases, each entry was controlled with a traffic signal. Circular intersections with any of these features are not an approved intersection type.

(1) Locations Recommended for Roundabouts

Consider roundabouts at intersections:

- Where stop signs result in unacceptable delays for the crossroad traffic.
- With a high left-turn percentage on one or more legs.
- Where a disproportionately high number of accidents involve crossing or turning traffic.
- Where the major traffic movement makes a turn, for example where a state route or city arterial makes a turn.
- Where traffic growth is expected to be high and future traffic patterns are uncertain.
- Where it is not desirable to give priority to either roadway.
- Where major roads intersect at a wye (Y) or tee (T) intersection or with unusual geometry.

(2) Locations Where Roundabouts Need Additional Evaluation

The following conditions raise concerns that might make a roundabout less than desirable over other intersection types. With an evaluation that gives equal consideration to other intersection types, roundabouts may be considered:

- On a facility with a functional class of collector or above where any leg has a posted speed of 45 mph or higher.
- Where the grade for any leg exceeds 4%.
- Where traffic flows are unbalanced with higher volumes on one or more approaches.
- Where a major road intersects a minor road and a roundabout would result in unacceptable delays to the major road traffic.
- Where there is considerable pedestrian activity and, due to high traffic volumes, it would be difficult for pedestrians to cross either road. This includes special-need pedestrians such as large numbers of children or elderly.
- Where there is inadequate sight distance.
- Where there is considerable bicycle traffic.
- Where a downstream traffic control device could cause a queue that extends into the roundabout. Examples include traffic signals, signalized pedestrian crossings, railroad crossings, and drawbridges.
- Where a railroad will cross through the roundabout.
- With more than six approach legs.

(3) Locations Not Recommended for Roundabouts

Roundabouts are not recommended at intersections:

- Where a satisfactory geometric design (deflection, diameter, roadway width, or grade for example) cannot be provided.
- Where peak period reversible lanes are required.
- At a single intersection in a network of coordinated traffic signals and spacing prevents progression of the traffic signals.
- Where a signal interconnect system would provide a better level of service.
- Where it is desirable to be able to modify traffic movements via signal timings.
- Where volumes on the major roadway does not provide sufficient gaps for the minor roadway drivers, based on gap acceptance analysis model.

915.02 References

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ADA Accessibility Guidelines (ADAAG), US Access Board, http://www.access-board.gov/adaag/html/adaag.htm

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

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The Design of Roundabouts. State of the Art Review; Brown, Mike; Transportation Research Laboratory, Department of Transport. London, HMSO, 1995.

Crash Reductions Following Installation of Roundabouts in the United States, Insurance Institute for Highway Safety, March 2000.

ARCADY (Assessment of Roundabout CApacity and DelaY) program, developed by MVA Systematica under contract to Transport Road Research Laboratory (TRRL).

RODEL (ROundabout DELay) program, developed by the Highway Department of Staffordshire County Council in the UK.

aaSIDRA (Signalized Intersection Design and Research Aid) program, developed by The Australian Road Research Board (ARRB).

915.03 Definitions

approach roadway The lane or set of lanes for traffic approaching the roundabout. (See Figure 915-1.)

central island The area of the roundabout surrounded by the circulating roadway.

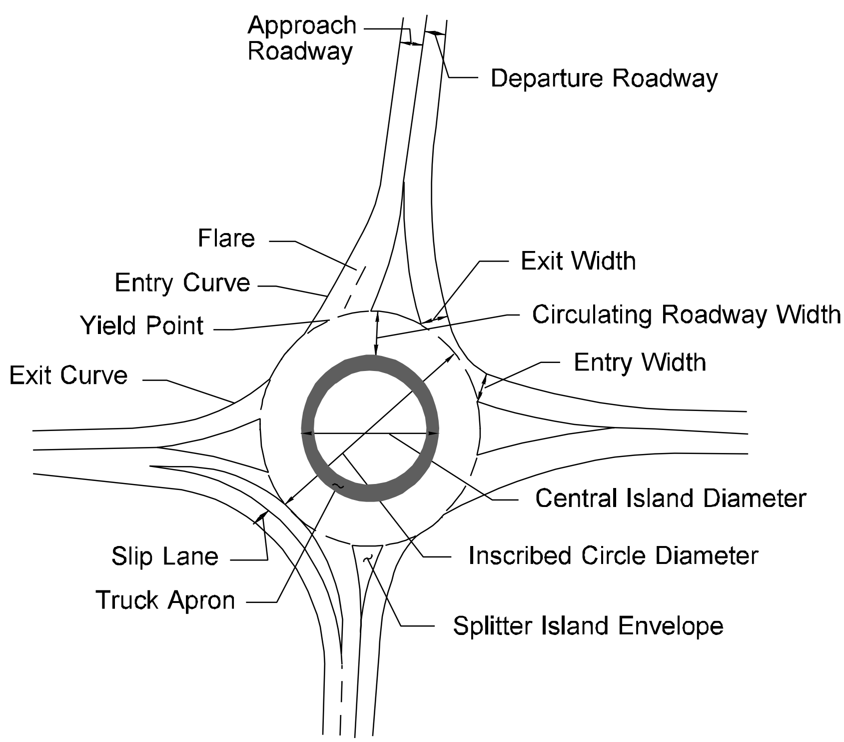
central island diameter The diameter of the central island, including the truck apron. (See Figure 915-1.)

circulating lane A lane used by vehicles circulating in the roundabout.

circulating roadway width The width of the area within the inscribed circle for vehicular movement measured from inscribed circle to the central island. (See Figure 915-1.)

conflict An event involving two or more road users in which the action of one user causes the other user to make an evasive maneuver to avoid a collision.

curb bulb A bulge in a curb line that reduces the width of the roadway.



Roundabout Elements
Figure 915-1

deflection The change in the path of a vehicle imposed by geometric features of a roundabout resulting in a slowing of vehicles. (See Figures 915-9a and 9b.)

departure roadway The lane or set of lanes for traffic leaving the roundabout. (See Figure 915-1.)

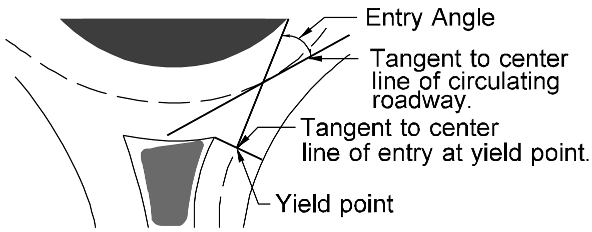
design speed The speed used to determine the various geometric design features of the roadway.

design vehicle A vehicle, the dimensions and operating characteristics of which are used to establish the layout geometry.

detectable warning surface A feature of a walking surface to warn visually impaired pedestrians of a hazard. Truncated domes are specified by The ADAAG.

double-lane roundabout A roundabout with the circulating roadway and one or more entry or exit legs designed as two lanes.

entry angle The angle between the entry roadway and the circulating roadway measured at the yield point. (See Figure 915-2.)



Entry Angle
Figure 915-2

entry curve The curve of the right curb that leads vehicles into the circulating roadway. (See Figure 915-1.)

entry width The width of an entrance leg at the inscribed circle. (See Figure 915-1.)

exit curve The curve of the right curb that leads vehicles out of the circulating roadway. (See Figure 915-1.)

exit width The width of an exit leg at the inscribed circle. (See Figure 915-1.)

flare The widening of the approach to the roundabout to increase capacity. (See Figure 915-1.)

functional classification The grouping of streets and highways according to the character of the service they are intended to provide as provided in RCW 47.05.021.

inscribed circle The entire area within a roundabout between all of the approaches and exits.

inscribed circle diameter The diameter of the inscribed circle. (See Figure 915-1.)

intersection angle The angle between any two intersection legs at the point that the center lines intersect.

intersection at grade The general area where a roadway or ramp terminal is met or crossed at a common grade or elevation by another roadway.

intersection leg Any one of the roadways radiating from and forming part of an intersection.

intersection sight distance The sight distance for the driver of a vehicle on the crossroad along the main roadway, as compared to the distance required for safe operation.

island A defined area within an intersection, between traffic lanes, for the separation of vehicle movements or for pedestrian refuge.

lane A strip of roadway used by 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. The width of an existing lane is measured from the edge of traveled way to the center of the lane line or between the centers of successive lane lines.

roadway The portion of a state highway; a federal, county, or private road; or a city street, including shoulders, for vehicular use.

roundabout A circular intersection with yield control of all entering traffic, channelized approaches with raised splitter islands, counter-clockwise circulation, and appropriate geometric curvature to ensure that travel speeds on the circulating roadway are typically less than 30 mph.

sight distance The length of roadway visible to the driver.

single-lane roundabout A roundabout with the circulating roadway and all entry and exit legs designed as one lane.

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 and bicycles.

slip lane A lane that separates heavy right turn movements from the roundabout circulating traffic. (See Figure 915-1.)

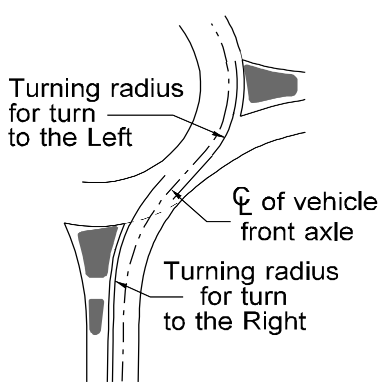
splitter island The raised island at each two-way leg between entering vehicles and exiting vehicles, designed primarily to deflect entering traffic.

splitter island envelope The raised splitter island and the painted channelization surrounding it. (See Figure 915-1.)

stopping sight distance The sight distance, as compared to the distance required to detect a hazard and safely stop a vehicle traveling at design speed.

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.

rural area A nonurban area.



Turning Radius (R)
Figure 915-3

truck apron The optional, outer, mountable portion of the central island of a roundabout between the raised, nontraversable area of the central island and the circulating roadway. (See Figure 915-1.)

turning radius The radius that the front wheel of the design vehicle on the outside of the curve travels while making a turn. (See Figure 915-3.)

urban area One of the following areas:

- Within the federal urban area boundary as designated by FHWA.
- Characterized by intensive use of the land for the location of structures and receiving such urban services as sewers, water, and other public utilities and services normally associated with urbanized areas.
- With not more than twenty-five percent undeveloped land.

yield-at-entry The requirement that vehicles on all approaches yield to vehicles within the circulating roadway.

yield point The point of entry from an approach into the circulating roadway. If necessary, entering traffic must yield to circulating traffic at this point before entering the circulating roadway. (See Figure 915-1.)

915.04 Roundabout Categories

Roundabouts have been categorized according to size and environment to facilitate discussion of specific performance or design issues. There are six basic categories based on environment, number of lanes, and size:

- Mini roundabouts
- Urban compact roundabouts
- Urban single-lane roundabouts
- Urban double-lane roundabouts
- Rural single-lane roundabouts
- Rural double-lane roundabouts

Characteristics of the different roundabout categories are summarized on Figure 915-7. These categories and Figure 915-7 represent general characteristics of roundabouts, not design limits. Final design values may vary.

Separate categories have not been identified for suburban environments. Suburban settings combine higher approach speeds common in rural areas with multimodal activity that is more similar to urban settings. Therefore, generally, design suburban roundabouts as urban roundabouts but with the high-speed approach treatments recommended for rural roundabouts.

(1) Mini Roundabouts

Mini roundabouts are small roundabouts used in low-speed urban environments and are not suitable for use on a state route. They can be useful in low-speed urban environments, with average operating speeds of 35 mph or less, where a conventional roundabout is precluded by right of way constraints. In retrofit applications, mini roundabouts are relatively inexpensive because they typically require minimal additional pavement at the intersecting roads. They are mostly recommended when there is insufficient right of way for an urban compact roundabout. Because they are small, mini roundabouts are perceived as pedestrian friendly with short crossing distances and very low vehicle speeds on approaches and exits. The mini roundabout is designed to accommodate passenger cars without requiring them to drive over the central island. A mountable central island is recommended because larger vehicles might be required to cross over it. Provide speed control around the mountable central island in the design by requiring horizontal deflection. Capacity for this type of roundabout is expected to be similar to that of the urban compact roundabout. Permeable pavement might be appropriate in the mountable center island to offset any storm water impacts.

(2) Urban Compact Roundabouts

Urban compact roundabouts are also intended to be pedestrian and bicyclist friendly. Because of the smaller design vehicle, they are normally not suitable for use on a state route. Their perpendicular approach legs require very low vehicle speeds. All legs have single-lane entries. However, the urban compact treatment meets all the design requirements of effective roundabouts. The principal objective of this design is to enable pedestrians to have safe and effective use of the intersection. Consider urban compact roundabouts only where capacity is not a critical issue. The geometric design includes raised splitter islands that incorporate at-grade pedestrian storage areas, and a nonmountable central island. There is usually a truck apron surrounding the compact central island to accommodate large vehicles.

(3) Urban Single-Lane Roundabouts

Urban single-lane roundabouts are characterized as having single-lane entries at all legs and one circulating lane. They are distinguished from urban compact roundabouts by their larger inscribed circle diameters and more tangential entries and exits, resulting in higher capacities. Their design allows slightly higher speeds at the entry, on the circulating roadway, and at the exit. This roundabout design is focused on achieving consistent entering and circulating vehicle speeds. The geometric design includes raised splitter islands, a nonmountable central island, and (preferably) no apron. However, a truck apron might be necessary to allow large trucks to make left turns. When a truck apron is used, design the roundabout so that a bus will not need to use it.

(4) Urban Double-Lane Roundabouts

Urban double-lane roundabouts include all roundabouts in urban areas that have at least one entry with two lanes. They include roundabouts with entries on one or more approaches that flare from one to two lanes. These require wider circulating roadways to accommodate two vehicles traveling side by side. The speeds at the entry, on the circulating roadway, and at the exit are similar to those for the urban single-lane roundabouts. It is important that the vehicular speeds be consistent throughout the roundabout. Geometric design includes raised splitter islands, a nonmountable central island, and appropriate horizontal deflection.

Alternate routes may be provided for bicyclists who choose to bypass the roundabout. Delineate bicycle and pedestrian pathways clearly. Use sidewalks and landscaping to direct users to the appropriate crossing locations and alignment. Urban double-lane roundabouts located in areas with high pedestrian or bicycle volumes might have special design requirements.

When a double-lane roundabout is required for the design year but traffic projections indicate that one lane will be sufficient for 10 years or more, consider restricting it to one lane until traffic volumes require a double-lane roundabout.

(5) Rural Single-Lane Roundabouts

Rural single-lane roundabouts generally have high approach speeds. They require supplementary geometric and traffic control device treatments on approaches to encourage drivers to slow to an appropriate speed before entering the roundabout. Rural roundabouts may have larger diameters than urban roundabouts to allow slightly higher speeds at the entries, on the circulating roadway, and at the exits. This is possible if current and anticipated future pedestrian volumes are low.

Design rural roundabouts that might become part of an urban area with slower speeds and pedestrian treatments. However, in the interim, provide supplementary approach and entry features to achieve safe speed reduction. Supplemental geometric design elements include extended and raised splitter islands, a nonmountable central island, and adequate horizontal deflection.

The central island needs to have "target value" to give cues to approaching drivers that there is something that they must drive around. Designers will need to mound the planting area and plant native materials that are out of clear zone and provide "target value".

The geometric design includes a truck apron where necessary for WB-50 and larger trucks to use the roundabout. Design the roundabout so that a WB-40 will not be required to use the truck apron.

(6) Rural Double-Lane Roundabouts

Rural double-lane roundabouts have speed characteristics similar to rural single-lane roundabouts. They differ in having two entry lanes, or entries flared from one to two lanes, on one or more approaches. Consequently, many of the characteristics and design features of rural double-lane roundabouts mirror those of their urban counterparts. The main design differences are higher entry speeds and larger diameters, and recommended supplementary approach treatments. Design rural roundabouts that might become part of an urban area for slower speeds, with design details that fully accommodate pedestrians and bicyclists. However, in the interim, design approach and entry features to achieve safe speed reduction.

The central island needs to have "target value" to give cues to approaching drivers that there is something that they must drive around. Designers will need to mound the planting area and plant native materials that are out of clear zone and provide "target value".

When a double-lane roundabout is required for the design year but traffic projections indicate that one lane will be sufficient for at least 5 to 10 years, consider restricting it to one lane until traffic volumes require a double-lane roundabout.

915.05 Capacity Analysis

A capacity analysis is required for each proposed roundabout to compare it to other types of intersection control.

Design roundabouts so that the demand volume to capacity ratio is 0.85 or less and the anticipated delays are comparable to other types of intersection control.

There are two methods of performing the capacity analysis:

- An analysis based on gap acceptance (the Australian method). Use the method given in the *Austroad Guide* or the *Highway Capacity Manual*.
- An empirical formula based on measurements at a saturated roundabout (the British method). Use the method given in TRRL Report 942.

While each method has advantages, it is felt there is currently not enough United States performance data on which to base the empirical method analysis. Therefore, the gap acceptance method is preferred.

Figure 915-8 may be used to estimate the entry capacity of each roundabout entry leg; however, perform a capacity analysis using other methods to verify roundabout capacity.

915.06 Geometric Design

(1) Design Vehicle

The physical characteristics of the design vehicle are one of the elements that control the geometric design of a roundabout. See Chapter 910 for guidance on the selection of a design vehicle. As with other intersections, the design vehicle may differ for each movement. Use the largest vehicle selected for any movement as the design vehicle for the circulating roadway. For a roundabout on a state highway, this is the WB-50 vehicle. Design a roundabout so that the design vehicle can use it with 2 ft clearance from the turning radius to any curb face. The rear wheel of a semitrailer may encroach on the truck apron.

It is desirable to design the circulating roadway so that a BUS design vehicle in urban areas and a WB-40 in rural areas can use the roundabout without encroaching on the truck apron.

Design roundabouts on state routes so the WB-67 can use it without leaving the truck apron or encroaching on a curb. Use vehicle turning path templates to verify that this vehicle can make all state highway to state highway movements.

The vehicle path through a roundabout will normally contain reverse or compound curves. To check the roundabout for the design vehicles, a computer generated template for each path is recommended.

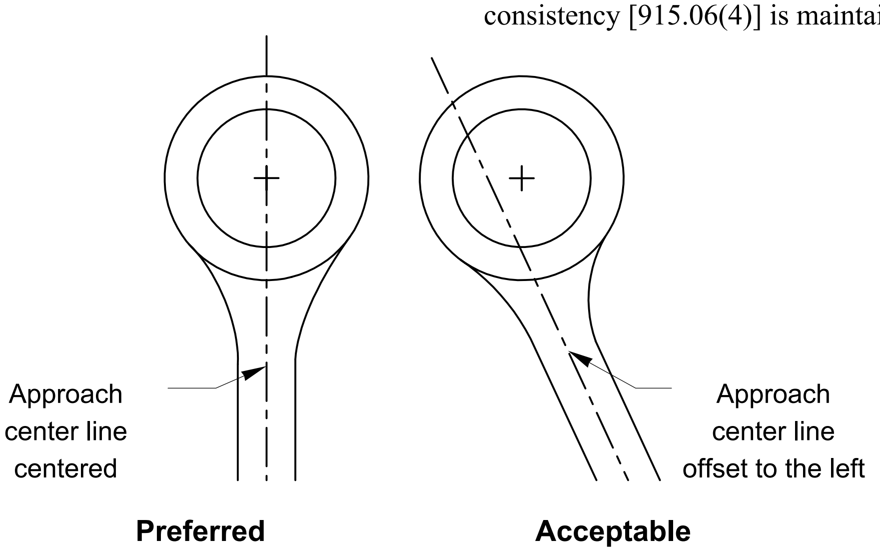
(2) Approach Alignment

The preferred alignment of an approach leg to a roundabout is with the centerline passing through the center of the inscribed circle. (See Figure 915-4.) This allows the roundabout to be designed so that vehicles will maintain slow speeds at both the entries and the exits. This alignment makes the central island more conspicuous to approaching drivers.

Where it is not possible to align an approach leg through the center of the inscribed circle, a slight offset to the left is acceptable. (See Figure 915-4.) This will allow adequate curvature at the entry, which is of greatest importance. In some cases, it may be beneficial to offset the approach slightly to the left to enhance the entry curvature. However, this will create a more tangential exit with increased exit speed and might increase the risk for pedestrians.

Approach alignment offset to the right of the roundabout's center point is unacceptable. This alignment <u>results in a more tangential approach allowing vehicles to enter the roundabout at a higher speed. This will normally result in a reduction in safety.</u>

It is desirable to equally space the angles between entries. This will optimize the separation between successive entries and exits. When site conditions make equal spacing impractical, spacing may be varied to a minimum of 40°. When reducing the angle between approaches, ensure that speed consistency [915.06(4)] is maintained.



Approach Leg Alignment
Figure 915-4

(3) Deflection and Design Speed

For a roundabout to work properly, it must be designed to reduce the relative speeds between conflicting traffic streams. The most significant feature that will control the speed is adequate deflection. The deflection is expressed as the radius of the center line of a vehicle path through the roundabout. Figures 915-9a and 9b illustrate the vehicle paths for determining deflection.

The vehicle path can be adjusted by:

- Changing the alignment and width of the entry and the shape, size, and position of the approach splitter island.
- Changing the central island size.
- Staggering alignment between entrance and exit.

The deflection design speed is controlled by the path radius and cross slope of the roadway. Figure 915-5 gives the deflection radii for design speeds for roadways that slope down to the outside of the curve (-2%), that are level (0%), and that slope down to the inside of the curve (2%). Use the following equation to make the final adjustments for speeds between those given:

$$V = \sqrt{\frac{R(c+f)}{6.69}}$$

Where:

V	=	Design speed in mph
R	=	The deflection radius in feet.
c	=	Slope of the roadway in percent
f	=	Side friction factor from Figure 915-5

Design roundabouts so that deflection limits the entry speed to 30 mph or less and achieves speed consistency. In areas with a large number of pedestrians or bicyclists, design roundabouts for a maximum speed of 15 to 20 mph.

Design Speed (mph)	Deflection Radius (ft) Cross Slope			Side Friction actor f
	-2%	0%	2%	
10	20	20	20	38
15	50	50	45	32
20	110	100	95	27
25	200	185	170	23
30	335	300	275	20
35	515	455	410	18

Deflection
Figure 915-5

(4) Speed Consistency

Speed consistency for all movements is an important element of roundabout design. Speed consistency is achieved when the differences between speeds of paths that merge, cross, or parallel each other do not exceed 12 mph.

Figure 915-10 shows five critical path radii to be checked for each leg. The entry path (R_1) is the minimum radius for through traffic approaching the yield point. The circulating path (R_2) is the minimum radius for through traffic around the central island. The exit path (R_3) is the minimum radius for through traffic into the exit. The left-turn path (R_4) is the minimum radius for the conflicting left-turn movement. The right-turn path (R_5) is the minimum radius for a right-turning vehicle. These vehicular path radii are determined as shown on Figures 915-9a and 9b.

Make R_1 smaller than or equal to R_2, and R_2 smaller than or equal to R_3 ($R_1 \leq R_2 \leq R_3$). This ensures that speeds will be reduced to their lowest at the roundabout entry reducing the likelihood of problems in the roundabout.

(5) Inscribed Diameter

The inscribed diameter is controlled by the space available, the design speed, design vehicle and the number of legs. The size of the inscribed diameter is a balance between designing for large vehicles and providing adequate deflection for the design speed. Select a diameter that will result in a speed at or below the desired design speed.

To meet the need to provide an adequate turning radius, the right-turn movement might require that the inscribed diameter be increased for roundabouts with more than four legs or with high skew angles. On state routes, make the turning radius 50 ft minimum with 2 ft clearance to the face of a curb.

The inscribed circle is not always circular, with a constant-radius circulating roadway; ovals and tear drops have been used. Noncircular shapes are allowed when the smaller turning radius is at least 50 ft. When a noncircular roundabout is used, where possible align it so that the heavier traffic uses the larger radius.

(6) Entry

Design the entry width to accommodate the design vehicles and required entry lanes while providing adequate deflection. Design the entry so that the entry angle is between 20° and 60°, preferably between 30° and 40°. Figure 915-11 provides additional guidance for entry design.

When the approach width, including shoulders and parking lanes, is wider than needed for the entry width, consider curb bulbs to reduce the width. For information on parking limitation at roundabouts, see 915.11.

When the roundabout is on a state route, the minimum turning radius is 50 ft to provide for large trucks. It is desirable for the entry radius to be smaller than both the circulating radius and the exit radius. This makes the speeds the lowest at the roundabout entry. It also helps to reduce the speed differential between entering and circulating traffic.

Design the entry radius, R_1 on Figure 915-10, to limit entry speeds to not more than 25 mph in urban areas and 30 mph in rural area.

At single-lane roundabouts, it is not difficult to reduce the value of the entry radius. The curb radius at the entry can be reduced or the alignment of the approach can be shifted to the left to achieve a slower entry speed. This is more difficult at double-lane roundabouts. When entry and exit curve radii are too small, the natural path of adjacent traffic can overlap. Path overlap occurs when the geometry leads a vehicle in the left lane to cross into the right lane to avoid the central island. (See Figure 915-12.) Path overlap can reduce capacity and increase accidents. Take care when designing double-lane roundabouts to avoid path overlap. For more information on path overlap, see *Roundabouts: An Informational Guide*.

Flaring is an effective means of introducing a double-lane roundabout without requiring as much right of way as a full lane addition. 130 ft is the optimum flare length to add a second lane at a double-lane roundabout. However, if right of way is constrained, shorter flare lengths may be used with decreased capacity.

At rural locations, consider the speed differential between the approaches and entries. If the posted speed of the approach is greater than 15 mph above the design speed of the entry curve, consider introducing speed reduction measures before the entry curve.

(7) Circulating Roadway

Keep the circulating width constant throughout the roundabout with the minimum width equal to or slightly wider (120%) than the maximum entry width.

At single-lane roundabouts, provide a circulating roadway width plus truck apron to just accommodate the design vehicle. Use appropriate vehicle-turning templates or a computer program to determine the swept path of the design vehicle through each turning movement. Provide a minimum clearance of 2 ft between the vehicle's tire track and all vertical curbs with a height of 6 in or more.

Design the circulating radius, R_2 on Figure 915-10, to be larger than the entry radius. In some cases where capacity is not a concern, it might not be possible for the circulating radius to be greater than the entry radius. In such cases, the entry radius may be greater than the circulating radius, provided the difference in speeds is less than 12 mph and preferably less than 6 mph.

(8) Exit

Design the exit width to accommodate the design vehicles while providing adequate deflection. Figure 915-11 provides additional guidance for exit design.

Generally, design the exit radius, R_3 on Figure 915-10, larger than both the entry radius (R_1) and the circulating radius (R_2). The larger exit curve radii improve the ease of exit and minimize the likelihood of congestion at the exits. This, however, is balanced by the need to maintain low speeds at the pedestrian crossing on exit. If the exit path radius is smaller than the circulating path radius, vehicles might be traveling too fast to negotiate the exit and crash into the splitter island or into oncoming traffic.

At single-lane roundabouts with pedestrian activity, design exit radii the same as or slightly larger than the circulating radius to minimize exit speeds. However, at double-lane roundabouts, additional care must be taken to minimize the likelihood of exit path overlap. Exit path overlap can occur when a vehicle on the left side of the circulating roadway exits into the right exit lane. Where no pedestrians are expected, make the exit radii large enough to minimize the likelihood of exiting path overlap. Where pedestrians are present, tighter exit curvature might be necessary to ensure low speeds at the pedestrian crossing.

When the departure roadway width, including shoulders and parking lanes, is wider than needed for the exit width, consider curb bulbs to reduce the width.

(9) Turning movements

Evaluate the left- and right-turn radii, R_4 and R_5 on Figure 915-10, to ensure that the maximum speed differential between entering and circulating traffic is no more than 12 mph. The left-turn movement is the lowest circulating speed. The left-turn radius can be determined by adding 5 ft to the central island radius.

(10) Sight Distance

The operator of a vehicle approaching a roundabout needs to have an unobstructed view of the splitter island, central island, yield point, and sufficient lengths of the intersecting roadways to permit recognition of the roundabout and to initiate the required maneuvers to maintain control of the vehicle and to avoid collisions. To do this, two aspects of the sight distance are necessary:

- **Stopping Sight Distance.** Provide the stopping sight distance given on Figure 915-6 at all points on the approach roadways, the circulating roadway, and the departure roadways. Check each vehicle path using the deflection speed. See Chapter 650 for additional information on stopping sight distance.

Speed (mph)	Stopping Sight Distance (ft)
10	47
15	77
20	113
25	153
30	198
35	248

Stopping Sight Distance for Roundabouts
Figure 915-6

- **Intersection Sight Distance.** For intersection sight distance at roundabouts, provide a clear view of traffic on the circulating roadway and approaching the roundabout on the leg to the left for a distance equal to that traveled in 4.5 seconds. The required gap is also a function of capacity and, at lower volumes, a larger gap may be required. However, do not use an intersection sight distance (Figure 915-13) less than the stopping sight distance (Figure 915-6).

  Because traffic is approaching a yield condition and might not be required to stop before entering a roundabout, provide the sight distance along the approach for 50 ft. Momentary sight obstructions that do not hide a vehicle, such as poles, sign posts, and narrow trees, are acceptable in the sight triangles including the central island. Guidance for intersection sight distance at a roundabout is shown on Figure 915-13.

Providing adequate sight distance will also provide clear zone for the central island.

(11) Islands

Raised islands are important for effective operation of a roundabout. Their primary purpose is to control deflection.

(a) **Central Island**. The central island is a raised, nontraversable area and may include a truck apron (Figure 915-14). The truck apron is the outer part of the central island, designed to allow for encroachment by the rear wheels of large trucks.

The primary control of the central island size is the inscribed diameter, the required circulating width, and the required deflection. When the required circulating width for the large vehicles results in a deflection radius larger than the maximum for the design speed, increase the central island diameter to achieve the desired deflection radius and provide a truck apron. Make the surfacing of the truck apron different from the circulating roadway. However, make the surfacing of the apron different from the sidewalks so that pedestrians are not encouraged to cross the circulating roadway. Use a 3 in mountable curb between the circulating roadway and the truck apron.

Use a 6 in or higher vertical curb between the truck apron and the nontraversable area. Landscape or mound the raised, nontraversable area to improve the visual impact of the roundabout to approaching drivers. When designing landscaping, consider sight distance and roadside safety. Also, consider maintenance needs for access to the landscaping in the central island.

When designing the landscaping for the central island, do not use items that might tempt people to take a closer look. Do not place street furniture or other objects that may attract pedestrian traffic to the central island, such as benches or monuments with small text. Design fountains or monuments in the central island in a way that will enable proper viewing from the perimeter of the roundabout. In addition, design and locate all objects in the center island to maintain sight distance, minimize driver distraction, and minimize the possibility of impact from an errant vehicle.

(b) **Splitter Island**. Splitter islands are built at each two-way leg. They serve to:

- Control the entry and exit speeds by providing deflection.
- Prevent wrong way movements.
- Provide pedestrian refuge.
- Provide a place to mount signs.

The desirable length of a splitter island envelope is equal to the stopping sight distance for the design speed of the roadway approaching the roundabout. (See Chapter 650.) Make the extensions of the curves that form the splitter islands tangent to the outside edge of the central island. The minimum width of the island at any crosswalk is 6.5 ft. Figure 915-15 gives guidance on the design of splitter islands.

For information on shoulders at islands, island nose radii, nose offsets, and other details, see Chapter 910.

(12) Grades and Superelevation

It is preferred that the grade on all of the intersecting roadways at a roundabout is 4% or flatter and that the grades be constant through the roundabout or that the roundabout be in a sag vertical curve. Grade in excess of 4% can result in reduces sight distance, increased difficulty slowing or stopping, and higher possibility of vehicle rollover.

When a roundabout must be built at or near the crest of a vertical curve on one of the roadways, pay special attention to the sight distances. For additional information on grades at roundabouts, see *Roundabouts: An Informational Guide*.

Do not use superelevation for the circulating roadway. It is desirable to maintain the normal 2% cross slope from the central island to the outside of the circle. (See Figure 915-5) This will improve drainage and help reduce the speed of circulating traffic.

(13) Right-Turn Slip Lane

Right-turn slip lanes may be used, with justification, when a right-turn movement is heavy enough to lead to a breakdown in roundabout operation and the radius produces a speed comparable to the speed through the roundabout.

For additional information on channelization for right-turn slip lanes, see right turn lanes at islands in Chapter 910 and *Roundabouts: An Informational Guide*.

(14) Design Clear Zone

For the right side of the circulating roadway, see Chapter 700 using the R_2 speed for the required design clear zone. Do not place light standards or other poles without breakaway features in splitter islands or on the right side just downstream of an exit point. When any approach leg has a posted speed of 45 mph or higher, place no fixed object, water features with a depth of 2 ft or more, or other hazards in the central island. At roundabouts with all approach legs posted at 40 mph or less, avoid water features with a depth of 2 ft or more in the central island. Avoid fixed objects in central islands when the island diameter is less than 65 ft. Within the central island, clear zone is desirable to provide both a recovery area for errant vehicles and sight distance. When necessary to protect features in the central island, provide a central island low profile barrier 18 in high or higher.

915.07 Pedestrians

Pedestrian crossings are unique at roundabouts in that the pedestrian is required to cross at a point behind the vehicles entering the roundabout. The normal crossing point at intersections is in front of these vehicles. For this reason, mark all pedestrian crosswalks at urban roundabouts and at rural roundabouts when pedestrian activity is anticipated. Position the crosswalk one car length, approximately 20 ft, from the yield point and use the raised splitter island as a pedestrian refuge. (See Figures 915-15 and 16.) Consider landscaping strips to discourage pedestrians crossing at undesirable locations.

Provide a barrier-free passageway at least 6 ft wide, 10 ft desirable, through this island for persons with disabilities. Whenever a raised splitter island is provided, also provide pedestrian refuge. This facilitates the pedestrian crossing in two separate movements.

Give special attention to assisting pedestrians who are visually impaired through design elements such as providing tactile cues through the installation of truncated domes at curb ramps, splitter islands, and any other pedestrian facility that might lead to conflicts with pedestrians and vehicular traffic. These pedestrians typically attempt to maintain their approach alignment to continue across a street in the crosswalk. A roundabout requires deviation from that alignment. Provide appropriate informational cues to pedestrians regarding the location of the sidewalk and the crosswalk.

See Chapter 1025 for sidewalk ramps and additional information on pedestrian needs.

915.08 Bicycles

The operating speed of vehicles within smaller low speed roundabouts is, in most cases, the same speed as that of bicyclists and both can use the same roadway without conflict or special treatment. Larger roundabouts with higher operating speeds can present problems for the bike rider and an alternate bike path, a shared use sidewalk, or warning signs might be necessary. If the bike riders are children, as in the case of a nearby elementary school, consider signing and pavement markings directing them to use the adjacent sidewalk. End all bicycle lanes before they enter a roundabout, with the bicycles either entering traffic to use the circulating roadway or leaving the roadway on a separate path or a shared use sidewalk. See Figure 915-16 for the recommended design for ending a bicycle lane with a shared use sidewalk at a roundabout.

915.09 Signing and Pavement Marking

Roundabouts, being a new concept in Washington State, require consistent signing and pavement markings to familiarize motorists with their intended operation.

Roundabout signing is shown on Figure 915-17. Locate signs where they have maximum visibility for road users but a minimal likelihood of obscuring other signs, pedestrians, or bicyclists. Use only signs contained in the MUTCD. A diagrammatic guide sign, as shown in the figure, can be used to provide the driver with destination information. Provide a route confirmation sign on all state routes shortly after exiting the roundabout.

Pavement markings are shown in the MUTCD. Optional lane lines between lanes within the circulating roadway may be used on multilane roundabouts. When evaluating whether or not to provide lane lines within the circulating roadway, consider the following potential impacts:

- Reduce confusion
- Reduce flexibility
- Improve lane alignment
- Reduce capacity
- Provide a more normal situation
- Might require advanced signing for proper lane usage at the entry

When lane lines are to be used, include the striping plan with the roundabout approval request.

915.10 Illumination

For a roundabout to operate satisfactorily, a driver must be able to enter, move through, and exit the roundabout in a safe and efficient manner. To accomplish this, a driver must be able to see the layout and operation in time to make the appropriate maneuvers. Adequate lighting is needed for this at night.

Provide illumination for roundabouts with any one of the following:

- At least one leg is a state route or ramp terminal.
- It is necessary to improve the visibilityof pedestrians and bicyclists.
- One or more of the legs are illuminated.
- An illuminated area in the vicinity can distract the driver's view.
- Heavy nighttime traffic is anticipated.

Provide illumination for each of the conflict points between circulating and entering traffic in the roundabout and at the beginning of the raised splitter islands. Figure 915-18 depicts the light standard placement for a four-legged roundabout. See Chapter 840 for additional information and requirements on illumination. A single light source located in the central island is not acceptable. When one or more of the legs are illuminated, provide a light level within the roundabout approximately 50% higher than the highest level on any leg. Use a high pressure sodium vapor luminaire with a medium or short cut-off light distribution for the light source. Position the luminaire over the outside edge of the roundabout to use the "house side" lighting to illuminate the pedestrian crosswalks.

915.11 Access, Parking, and Transit Facilities

No road approach connections to the circulating roadway are allowed at roundabouts, unless it is designed as a leg to the roundabout appropriate for the traffic volume using the approach. Road approach connections to the circulating roadway are allowed only when no other reasonable access is available. It is preferred that road approaches not be located on the approach or departure legs within the length of the splitter island. The minimum distance from the circulating roadway to a road approach is controlled by the corner clearance using the circulating roadway as the crossroad. (See Chapter 1435.)

Parking is not allowed in the circulating roadway or on the approach roadway past the crosswalk. It is also desirable that no parking be allowed on the approach or departure legs for the length of the splitter island. See Chapter 1025 for additional information on parking limitations near a crosswalk.

Transit stops are not allowed in the circulating roadway or on the approach roadway past the crosswalk. Locate transit stops on departure legs in a pullout or where the pavement is wide enough that a stopped bus will not block the through movement of traffic. Locate transit stops on approach or departure legs where they will not obstruct sight distance.

915.12 Procedures

(1) Selection

Use the following steps when selecting a roundabout for intersection control:

(a) Consider the context. Are there constraints that must be addressed? Are there site-specific and community impact reasons why a roundabout of a particular size would not be a good choice?

(b) Determine the roundabout category (Figure 915-7) and a preliminary lane configuration (Figure 915-8) based on capacity requirements.

(c) Identify the justification category. See 915.12(2). This establishes why a roundabout might be the preferred choice and determines the need for specific information.

(d) Perform the analysis appropriate to the selection category. If the selection is to be based on operational performance, use the appropriate comparisons with alternative intersections

(e) Determine the right of way requirements and feasibility.

(f) If additional right of way must be acquired or alternative intersection forms are viable, an economic evaluation will be useful.

(g) Contact all approving authorities to obtain concurrence that a roundabout is an acceptable concept at the proposed location. On state routes this includes the HQ Design Office.

(2) Justification

Consider roundabouts only when fulfilling one or more of the following justification categories:

(a) **Safety Improvement.** At high accident location intersections, a roundabout might be a method of reducing accidents by reducing the number of conflict points. At conventional intersections, many accidents involve left-turning or crossing vehicles; with roundabouts these movements are eliminated. With the low operating speeds and low entry angles, accidents at roundabouts are generally less severe.

Roundabouts in this category require an accident analysis that shows high accidents of a type that a roundabout can reduce in number or severity. In the analysis, consider any potential shift of accidents to another accident type.

(b) **Improve Intersection Capacity.** A roundabout may be analyzed as an alternative to traditional traffic control options to increase the capacity of an intersection. With traffic signals, alternating traffic streams through the intersection can cause a loss of capacity when the intersection clears between phases. In a roundabout, vehicles may enter available gaps simultaneously from multiple approaches. This can result in an advantage in capacity. This advantage becomes greater when the volume of left turning vehicles is high.

Justify roundabouts in this category with a capacity analysis showing that it can provide the required capacity comparable to the optimum design for a conventional intersection. Discuss the effects on “off-peak” traffic.

(c) **Queue Reduction.** Roundabouts can improve operations at locations where the space for queuing is limited. Roadways are often widened for queuing at traffic signals, but the reduced delays and continuous flows at roundabouts allow the use of fewer lanes. Possible applications are at interchanges where left turn volumes are high. Roundabouts at ramp terminals can improve capacity without widening a structure.

Roundabouts in this category require an analysis showing that the roundabout will eliminate the need to build additional lanes or widen a structure without additional impacts to the main line operations.

(d) **Special Conditions.** The special conditions where a roundabout might be preferred over a conventional intersection include locations with unusual geometrics; right of way limitations; closely spaced intersections; wye (Y) intersections; and, on nonstate routes, for traffic calming. Roundabouts might be better suited for intersections with unusual geometrics; such as high skew angle and offset legs. Roundabouts can provide adequate levels of operation without significant realignment or complicated signing or signal phasing.

Roundabouts can avoid the need to obtain additional right of way along the intersection legs. Roundabouts can shift any required right of way from the roadway between the intersections to the area of the intersection.

Roundabouts can eliminate closely spaced intersections, and any associated operational problems, by combining them into one intersection. The ability of roundabouts to serve high turning volumes make them a practical design at wye (Y) or tee (T) intersections.

Roundabouts proposed for a special condition require documentation indicating what the condition is and how the roundabout will address it.

(3) Approval

A proposal to install a roundabout on any route, either NHS or non-NHS, with a posted speed limit of 45 mph or higher requires an analysis of alternatives. See Chapter 910 for requirements.

HQ Design Office approval of the design is required when a roundabout is to be used on a state highway. Submit to the HQ Design Office:

- Supporting engineering data.
- Concurrence that a roundabout is an acceptable concept 915.12(1)(g).
- An intersection plan.
- Roundabout justification from 915.12 (2).
- A comparison of the roundabout to alternative intersection types with an explanation as to why the roundabout is the preferred alternative.
- A traffic analysis of the roundabout and alternative intersection types, including a discussion of any loss in level of service or increase in delay. Include the effects on "off-peak" traffic and discuss any adverse impacts of the roundabout.
- An analysis of pedestrian and bicycle activities.
- An approved analysis of alternatives for roundabouts on any state route with a posted speed of 45 mph or higher.
- The approval of the State Design Engineer or designee for roundabouts within the limits of limited access control.
- The calculated design speeds for the entry path, the circulating path, the exit path, the left-turn path, and the right-turn path for each leg of the roundabout.
- A corridor and network analysis.
- Current or projected traffic control or safety problems at the roundabout.
- Demonstration that the proposed configuration can be implemented and that it will provide adequate capacity on all approaches.
- All potential complicating factors, their relevance to the location, and any mitigation efforts that might be required.
- An economic analysis, indicating that a roundabout compares favorably with lternative control modes from a benefit-cost perspective.

915.13 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/

	Design Element	Mini (1)	Urban (2) Compact	Urban Single-Lane	Urban Double-Lane	Rural Single-Lane	Rural Double-Lane
General	Number of Lanes	1	1	1	2	1	2
	Typical max. (3) ADT	12,000	15,000	20,000	40,000	20,000	40,000
	Splitter Island Treatment	Painted, raised if possible	Raised	Raised	Raised	Raised extended	Raised extended
	Max. Design(4) Vehicle	SU	SU/BUS	WB-50	WB-50	WB-67	WB-67
Circulating	Inscribed Circle Diameter	45'-80'	80'-100'(5)	100'-130'(6)	150'-180'	115'-130'(6)	180'-200'
	Circulating Roadway Design Speed	15-18 mph	16-20 mph	20-25 mph	22-28 mph	22-27 mph	25-30 mph
	Circulating Roadway Width	14'-19'	14'-19'	14'-19'	29'-32'	14'-19'	29'-32'
Entry	Max. Entry Design Speed	15 mph	15 mph	20 mph	25 mph	25 mph	30 mph
	Entry Radius	25'-45'	25'(7)-100'	35'(7)-100'	100'-200'	40'(7)-120'	130'-260'
	Entry Lane Widths	14'-16'	14'-16'	14'-16'	25'-28'	14'-16'	25'-28'

(1) Mini roundabouts are not suitable for use on a state route.

(2) Urban compact roundabouts are normally not suitable for use on a state route.

(3) Total ADT entering a 4-leg roundabout with 33% of the volume on the minor roadway. Multiply by 1.2 for 4-leg roundabouts with equal volume on both roadways. Multiply by 0.9 for 3-leg roundabouts.

(4) See Chapter 910 for selecting a design vehicle on a state route.

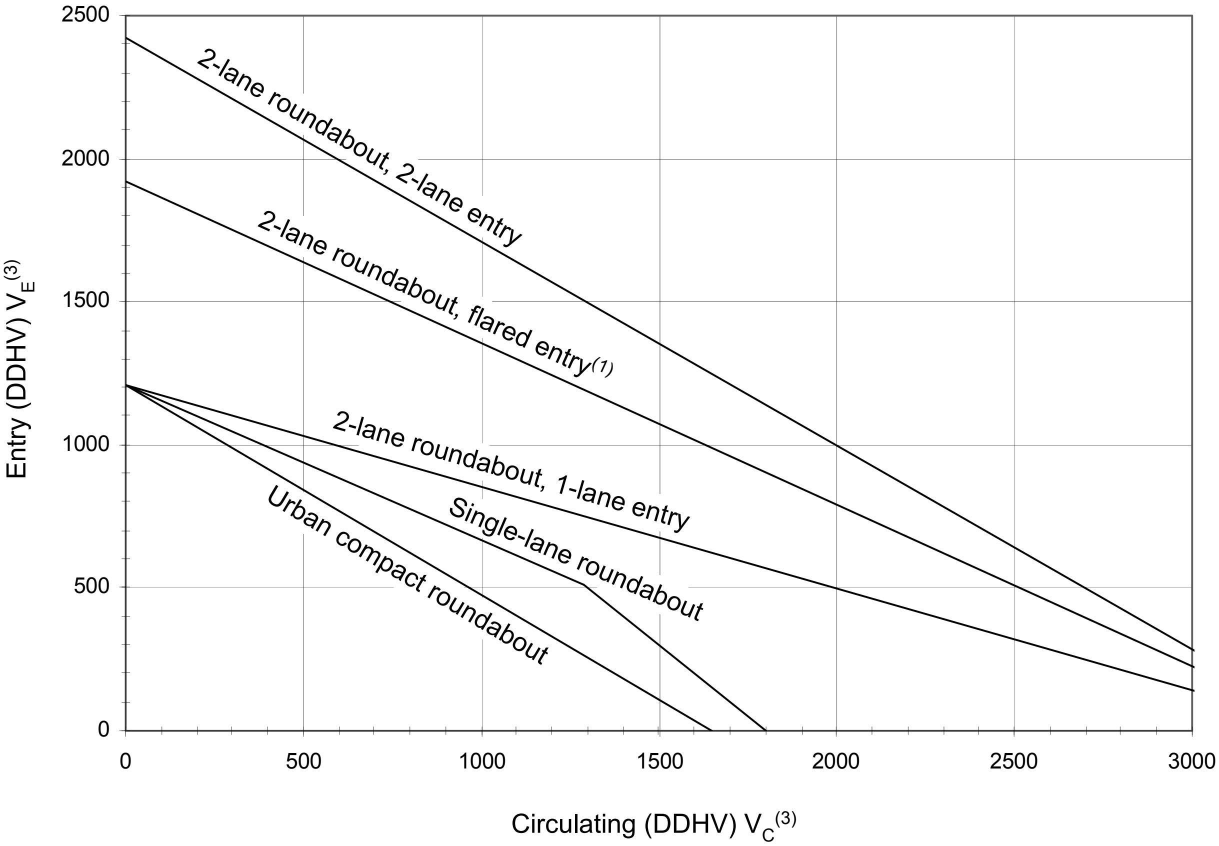
(5) Use 100 ft minimum on state routes.

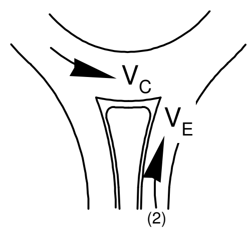
(6) When roundabout might be expanded to a double-lane roundabout, consider using a double-lane roundabout diameter.

(7) Use 50 ft minimum on state routes.

Note:
The values given in this figure are approximate. They are intended for planning and preliminary design. Final design values may vary.

Roundabout Categories Design Characteristics
Figure 915-7





Note:

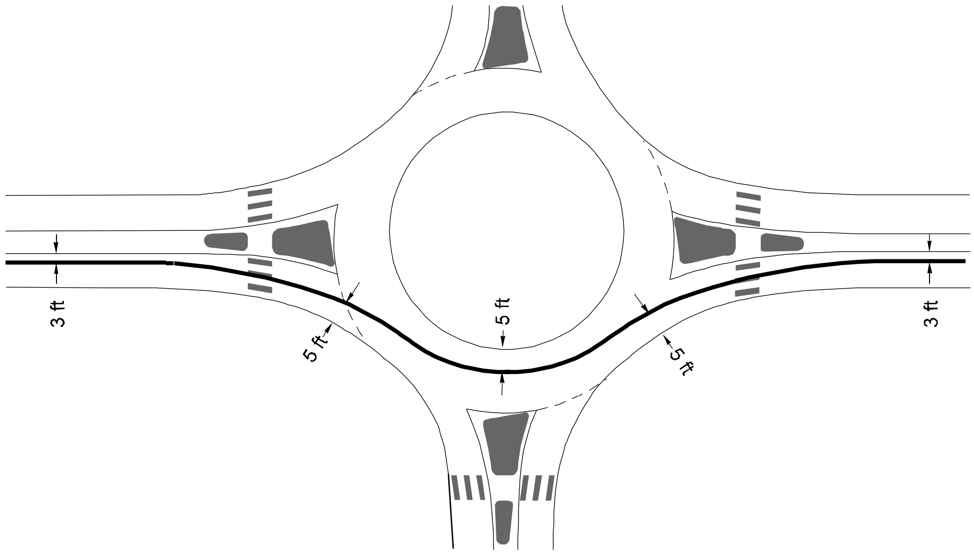
(1) Entry flared with 2 vehicle storage lane.

(2) Check for each entry.

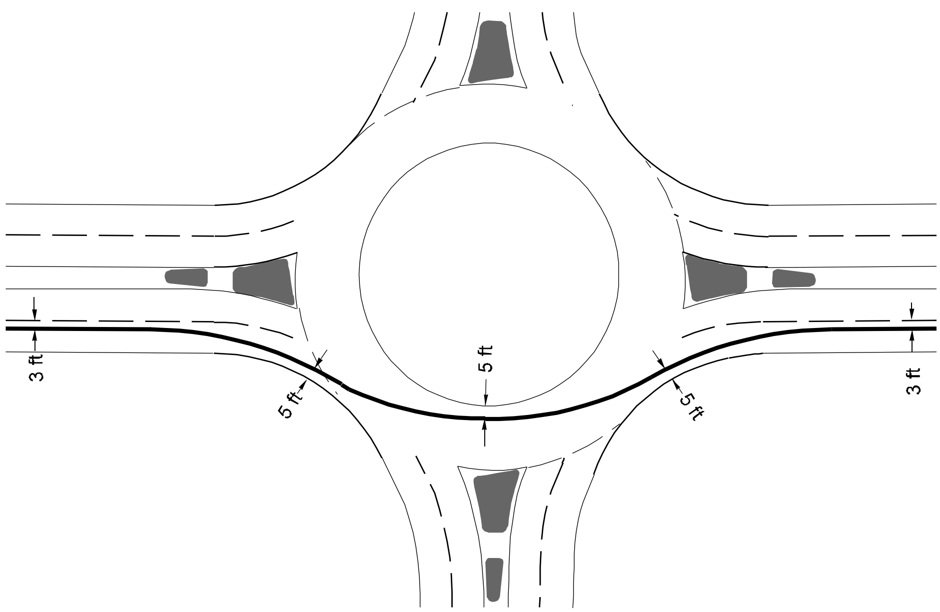
(3) DDHV in passenger car equivalents.

Vehicle Type	Passenger Car Equivalent
Car	1.0
SU or BUS	1.5
Other truck	2.0
Bicycle or Motorcycle	0.5

Approximate Entry Capacity
Figure 915-8



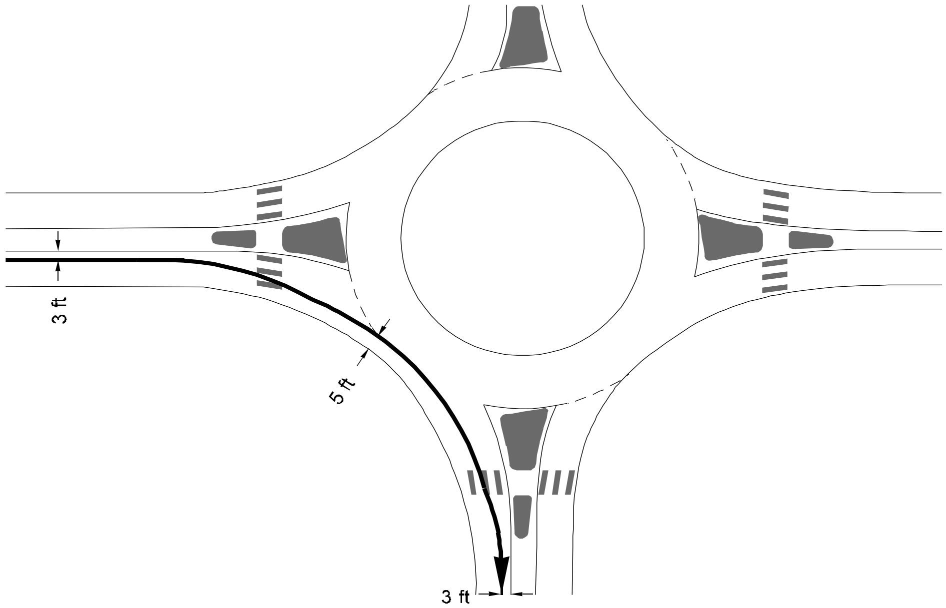
Single-Lane Roundabout



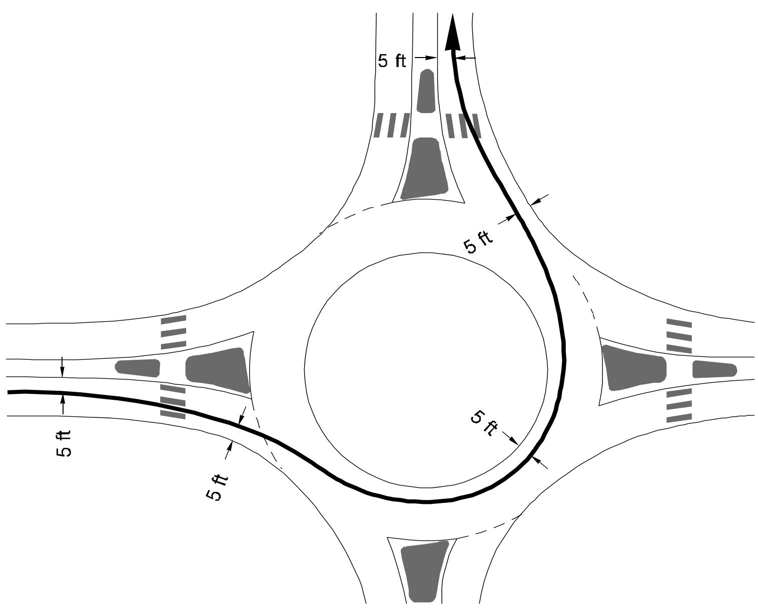
Double-Lane Roundabout

Deflection Path

Figure 915-9a

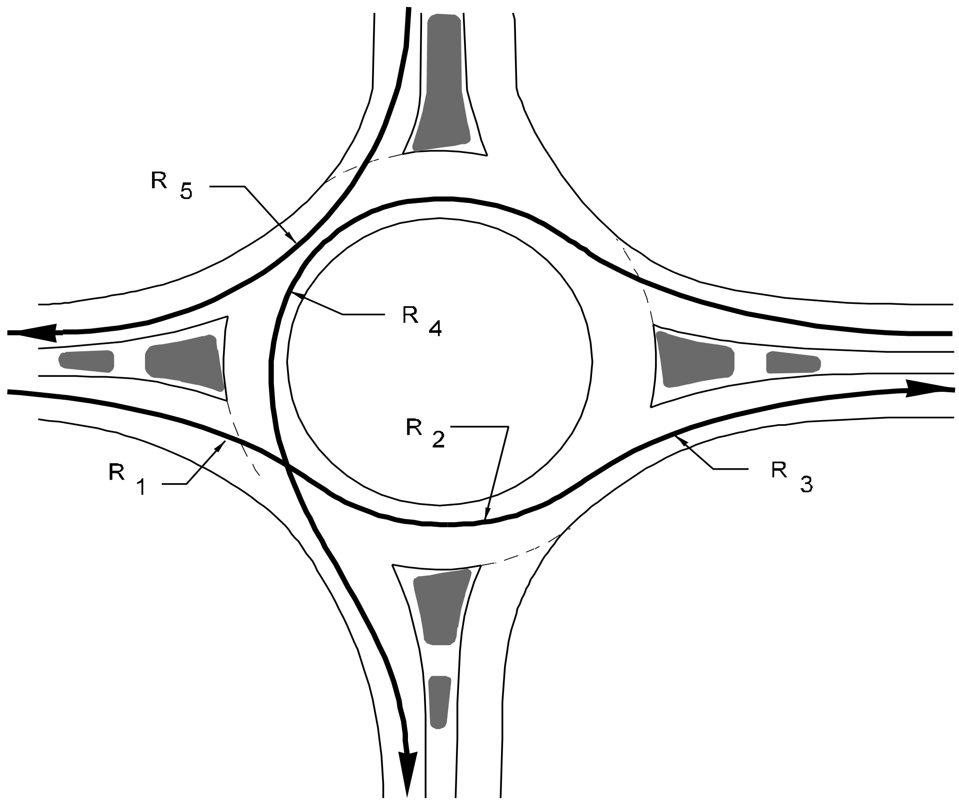


Right-Turn Movement



Left-Turn Movement

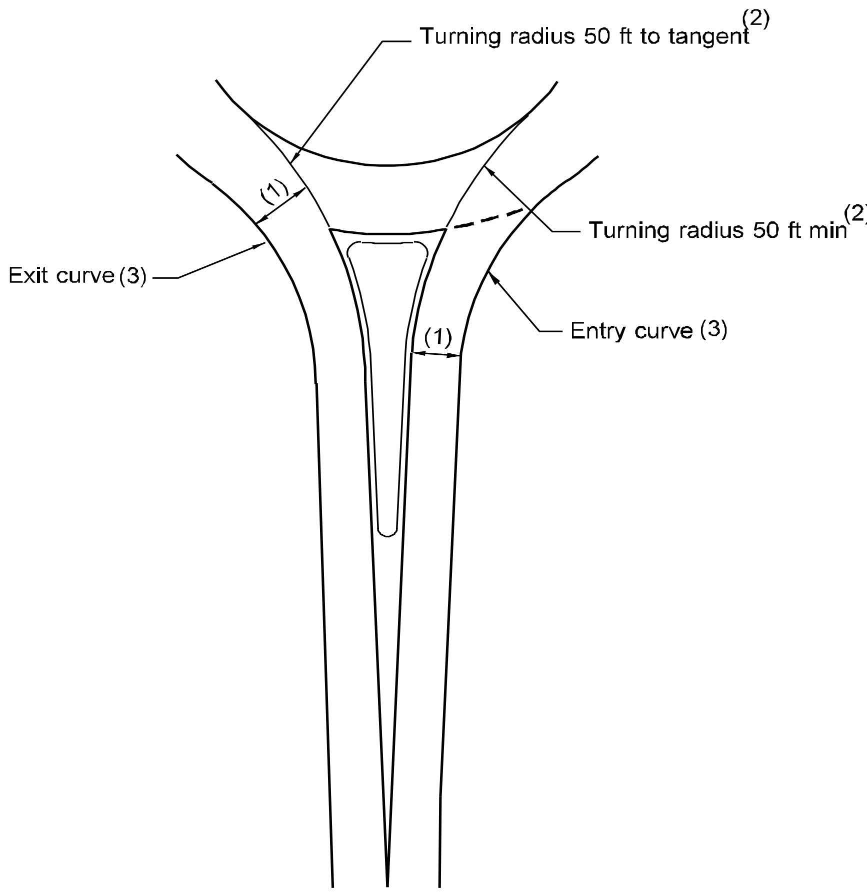
Deflection Path
Figure 915-9b



Where:

- R_1 = entry path radius.
- R_2 = circulating path radius.
- R_3 = exit path radius.
- R_4 = left-turn path radius.
- R_5= right-turn path radius.

Deflection Path Radius
Figure 915-<u>10</u>



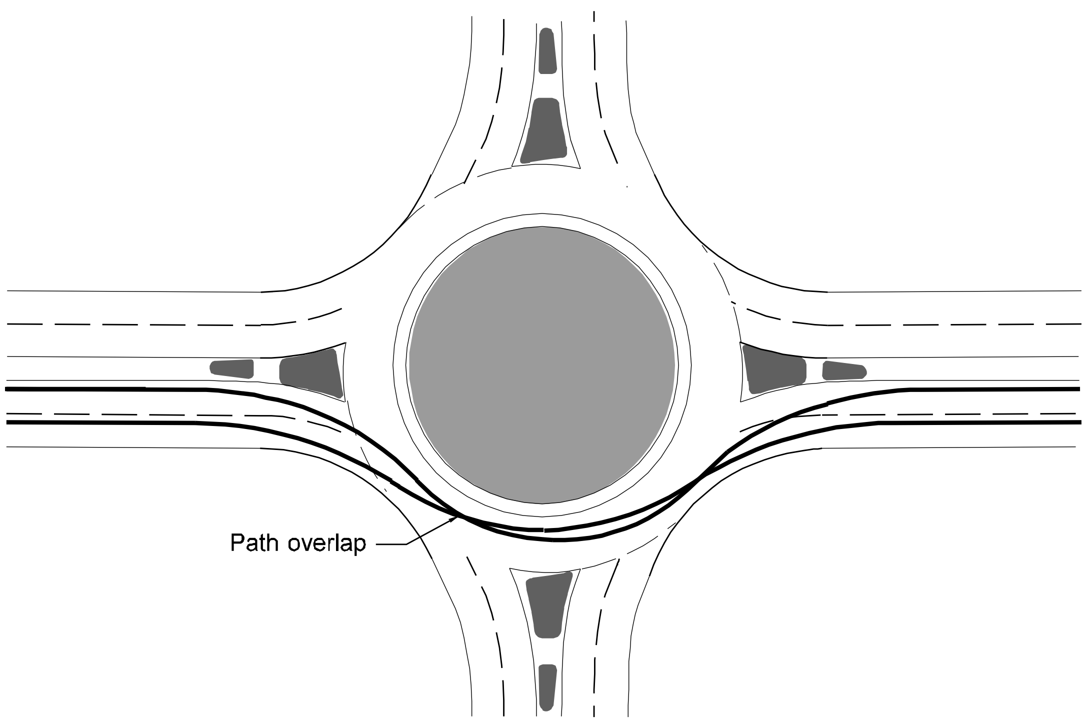
Notes:

(1) Minimum width is 15 ft for 1-lane and 25 ft for 2-lane. Entry and exit widths based on capacity needs (see Figure 915-8) and design vehicle requirements (see Chapter 641 or use templates).

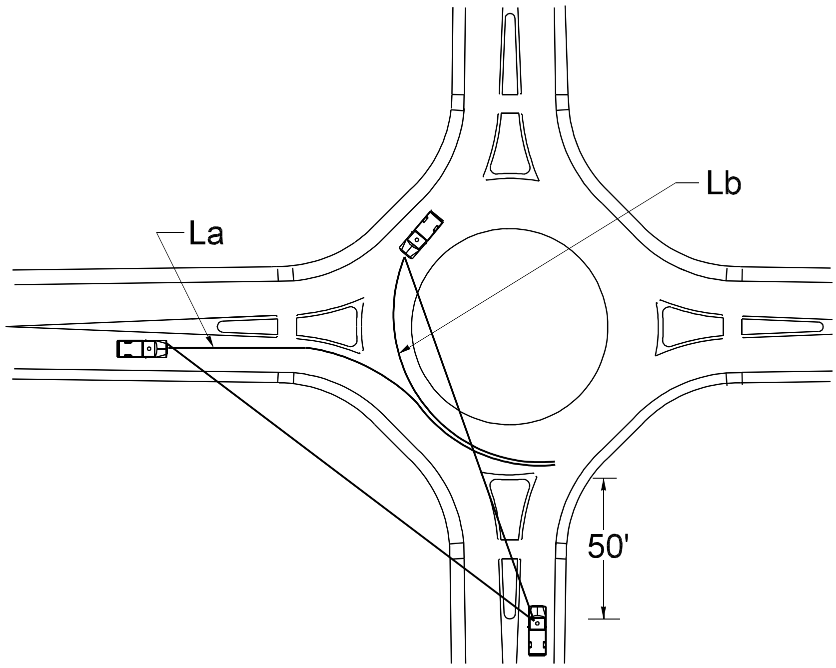
(2) Continuation of splitter island envelope curve tangential to central island.

(3) Entry and exit curves tangential to outside edge of circulating roadway.

Entry and Exit
Figure 915-11



Path Overlap
Figure 915-12



Speed (mph)	Gap Acceptance Length (min), L (ft)
15	115
20	150
25	185
30	225
35	260

Where:

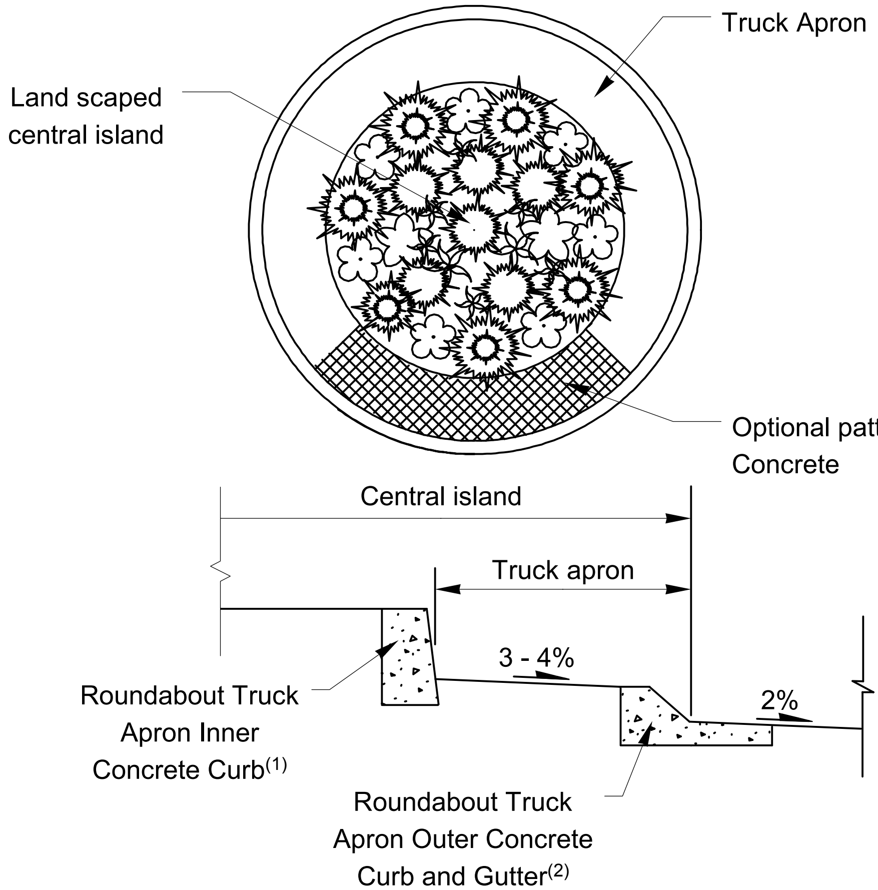
La = Sight distance, measured from the yield point, along approach roadway to the left, the minimum gap acceptance length (L) using the average of the entry speed (R_1) and the circulating speed (R_2).

Lb = Sight distance, from the yield point, along the circulating roadway, the minimum gap acceptance Length (L) using the left-turning vehicle speed (R_4).

Note:

See 915.06(2) and Figures 915-9a and 9b for information on determining R_1, R_2, and R_4 speeds.

Roundabout Intersection Sight Distance
Figure 915-13

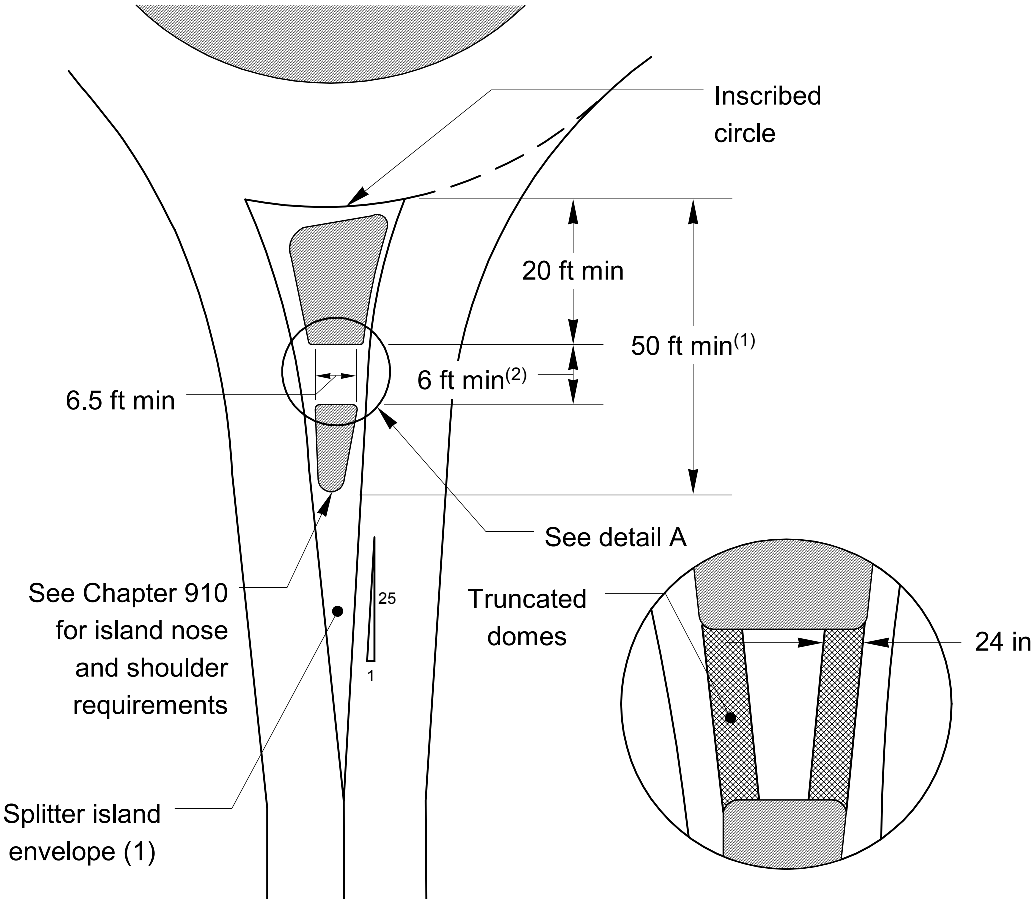


Notes:

(1) See Standard Plans for Roundabout Truck Apron Inner Concrete Curb details.

(2) See Standard Plans for Roundabout Truck Apron Outer Concrete Curb details. Other mountable curbs, with a maximum height of 3 in, may be used.

Central Island
Figure 915-14

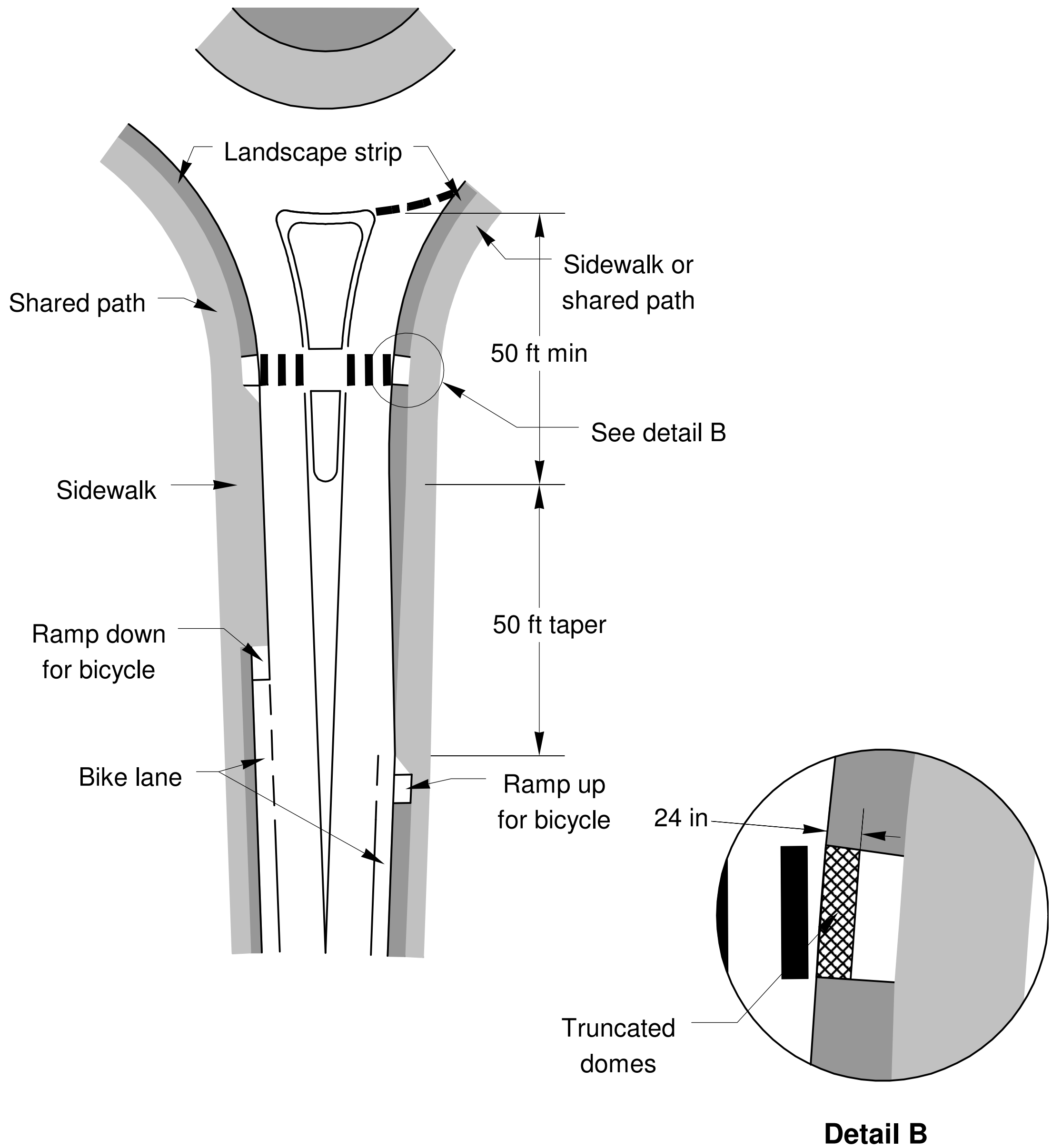


Notes:

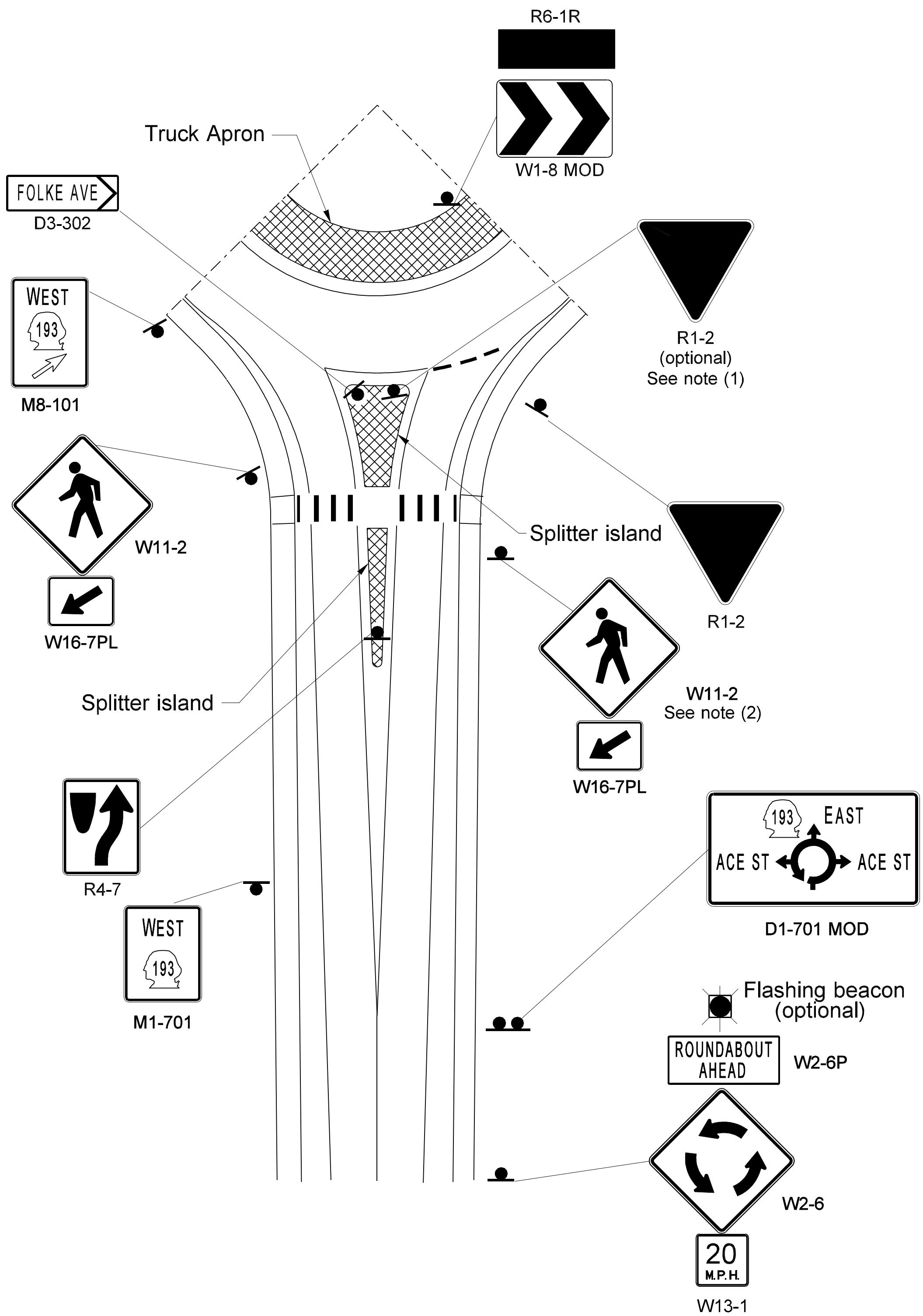
(1) Stopping sight distance desirable for length of splitter island envelop.

(2) A 10 ft width to accommodate full crosswalk width is desirable.

Splitter Island
Figure 915-15



Shared Use Sidewalk
Figure 915-16



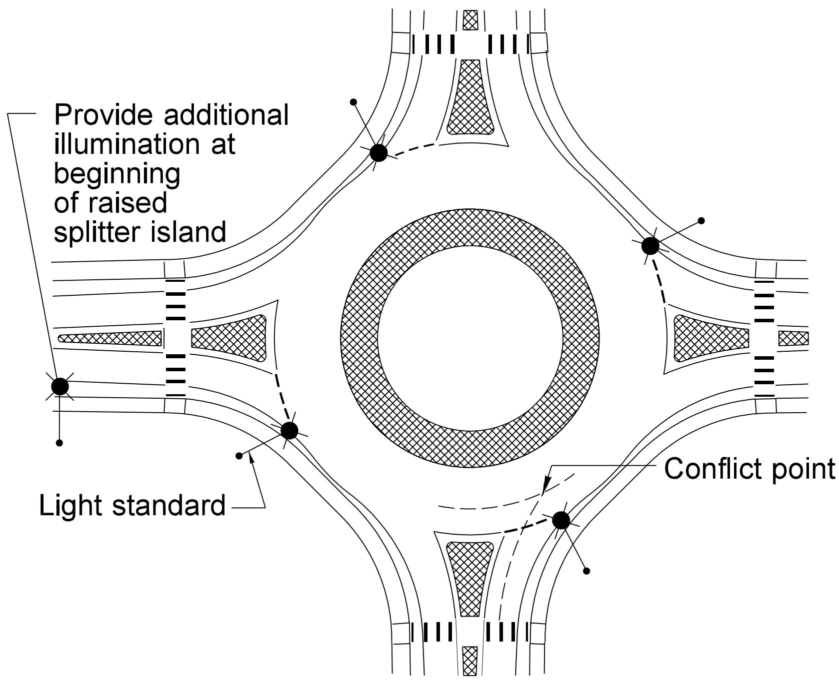
Notes:

(1) Required on two-lane entries, consider when view of right side sign might become obstructed.

(2) Locate in such a way as to not obstruct view of yield sign.

(3) See Chapter 820 for additional information on sign installation.

Roundabout Signing
Figure 915-17



Note:

Consider additional lighting for walkways and crosswalks to provide visibility for pedestrians.

Roundabout Illumination
Figure 915-18

920.01 General

Every owner of property that abuts the state highway system where limited access rights have not been acquired has a right to reasonable access to the state highway system. For considerations, requirements, and restrictions concerning road approaches on state highways where limited access rights have not been acquired, see Chapters 1420 and 1435.

For considerations, requirements, and restrictions concerning road approaches on state highways where limited access rights have been acquired from the abutting property owners, see Chapters 1420 and 1430.

Road approaches are designed and built on the state highway system to provide access at the locations provided for in Chapters 1430 and 1435. This chapter applies to road approaches on state highways in unincorporated areas and within incorporated areas where limited access rights have been acquired. Road approaches on state highways within incorporated areas where limited access rights have not been acquired are the jurisdiction of the local agency, but conformance to the requirements of this Chapter is required by statute (RCW 47.50.030).

920.02 References

Revised Code of Washington (RCW) 47.32.150, “Approach roads, other appurtenances — Permit”

RCW 47.32.160, “Approach roads, other appurtenances — Rules — Construction, maintenance of approach roads”

RCW 47.32.170, “Approach roads, other appurtenances — Removal of installations from right of way for default”

RCW 47.50, “Highway Access Management”

Washington Administrative Code (WAC) 468-51, “Highway Access Management Access Permits — Administrative Process”

WAC 468-52, “Highway Access Management — Access Control Classification System And Standards”

WAC 468-58, “Limited Access Highways”

Right of Way Manual, M 26-01, WSDOT

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

920.03 Definitions

access connection An access point, other than a public road/street, that permits access to or from a managed access highway on the state highway system.

approach An access point, other than a public road/street, that allows access to or from a limited access highway on the state highway system.

average weekday vehicle trip ends (AWDVTE) The estimated total of all trips entering plus all trips leaving a road approach on a weekday for the final stage of development of the property served by the road approach.

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.

legal road approach A road approach that complies with the requirements of Chapter 1430 for limited access facilities and Chapter 1435 for managed access facilities.

limited access highway All highways where the rights of direct access to or from abutting lands have been acquired from the abutting land owners.

managed access highway All highways where the rights of direct access to or from abutting lands have not been acquired from the abutting land owners.

nonconforming road approach A road approach that does not meet current requirements for location, quantity, spacing, sight distance, or geometric elements.

road approach A road or driveway providing private access to or from the state highway system.

road approach design template The design geometric standards for a road approach based on the usage, types of vehicles, and the traffic volume.

920.04 Design Considerations

Review all existing road approaches within the limits of a project to verify their legality. (See Chapters 1420, 1430, and 1435.) Restore or replace all legal road approaches impacted by a highway project. Evaluate road approaches that will not comply with access control requirements for ways to bring them into compliance.

New road approaches or upgrades to existing road approaches, requested by the property owner, may be included in the project at the expense of the property owner.

Design road approaches at transit facilities in accordance with Chapter 1060.

920.05 Road Approach Design Template

The road approach design template is dependent upon the usage, types of vehicles, and the traffic volume.

Figure 920-1 lists the road approach design templates, the road approach usage, and the design vehicle that Figures 920-3 through 5 provide for. When a larger design vehicle is required, use the turning path templates in Chapter 910, or from another source, to determine what adjustments to make.

Design Template	Property Usage	Design Vehicle
A	Residential	P
B	Farm	SU & BUS
C	Utility and special use	SU & BUS
D	Commercial	varies*
* See Figure 920-5.		

Road Approach Design Templates
Figure 920-1

The road approach templates are divided by allowable access movement. Figure 920-2 gives the movements allowed for each road approach access design.

Category	Access Allowed
1	Full access
2	Right in right out
3	Right in only
4	Right out only

Road Approach Access Category
Figure 920-2

When designating a road approach template include the access category. For example, a residential road approach with full access would be Design Template A1.

(1) Road Approach Design Template A – Residential

A Road Approach Design Template A is used for a noncommercial road approach to provide access for residential units. It is designed for low traffic volumes of primarily passenger cars. Design road approaches to fit the conditions within the limits shown in Figure 920-3.

(a) **Limited Access Facilities** Use Road Approach Design Template A when a Type A approach is specified.

(b) **Managed Access Facilities** Use Road Approach Design Template A for connections to single family residences, duplexes, or other small multifamily complexes. When the connection provides access to more than 10 dwelling units, consider a commercial road approach (Design Template D).

(2) Road Approach Design Template B – Farm

A Road Approach Design Template B is used for a road approach for the normal operation of a farm, but not for retail marketing. It is designed for the larger vehicles normal for farm operations. If there is a predominance of semitrailer traffic, modify the design to accommodate larger vehicles. Design road approaches to fit the conditions within the limits shown in Figure 920-4.

(a) **Limited Access Facilities** Use Road Approach Design Template B when a Type B approach is specified.

(b) **Managed Access Facilities** Use Road Approach Design Template B for connections to farms and other agricultural facilities that do not include retail marketing.

(3) Road Approach Design Template C – Utility and Special Use

A Road Approach Design Template C is used to provide access to facilities owned by a utility for the purpose of maintenance of that facility and operation of the utility. Template C may also be used for other special agreed upon uses. If there is a predominance of semitrailer traffic, modify the design to accommodate larger vehicles. Design road approaches to fit the conditions within the limits shown in Figure 920-4.

(a) **Limited Access Facilities** Use Road Approach Design Template C when a Type C or Type F approach is specified.

(b) **Managed Access Facilities** Use Road Approach Design Template C for connections to utility facilities, wireless communication sites, and other locations where an agreement has been reached for a special purpose.

(4) Road Approach Design Template D – Commercial

A Road Approach Design Template D is used for all commercial road approaches to provide access to businesses, farms with retail marketing, and other high volume road approaches.

Determine the predominant type of vehicle and design the commercial road approach in accordance with Figure 920-5. If the width of the frontage precludes such a road approach, use the turning path templates in Chapter 910, or from another source, to determine what adjustments may be made to provide safe and efficient access and to avoid encroachment upon the frontage of abutting property.

Commercial road approaches must not cause undue interference or hazard to the free movement of highway traffic and, when not joint use road approaches, they must not infringe on the frontage of adjoining property.

Where traffic volumes are heavy, such as for a shopping center or an industrial park, design the road approach as an intersection. (See Chapter 910.)

(a) **Limited Access Facilities** Use Road Approach Design Template D when a Type D approach is specified.

(b) **Managed Access Facilities** Use Road Approach Design Template D for businesses, farms with retail marketing, and other high volume road approaches.

920.06 Sight Distance

The driver of a vehicle entering a roadway from a road approach needs obstruction-free sight triangles in order to see enough of the roadway to safely enter before an approaching vehicle can reach the road approach.

Locate the road approach where the sight distances shown on Figure 920-6 are available.

920.07 Road Approach Location

Locate road approaches as determined in Chapter 1430 for limited access facilities and Chapter 1435 for managed access facilities.

920.08 Drainage Requirements

In a roadway section with a drainage ditch, a culvert pipe is placed under the road approach. The road approach is graded as shown in Figure 920-5. Be careful that roadway runoff is not a problem.

Design foreslopes not steeper than 6H:1V. Bevel the culvert ends in accordance with Chapter 700.

Locate culverts as far from the traveled way as possible. Minimum distances are shown in Figures 920-3 through 5.

A turnpike section (a standard roadway section with a shallow V-shaped paved gutter at the shoulder edge) may be used. Consider continuing the turnpike section throughout the area between the shoulder and the backslope. In the profile controls on Figure 920-5, if the grade from the edge of shoulder to the right of way line is a flat or minus grade and roadway runoff is a consideration, curb may be placed as shown.

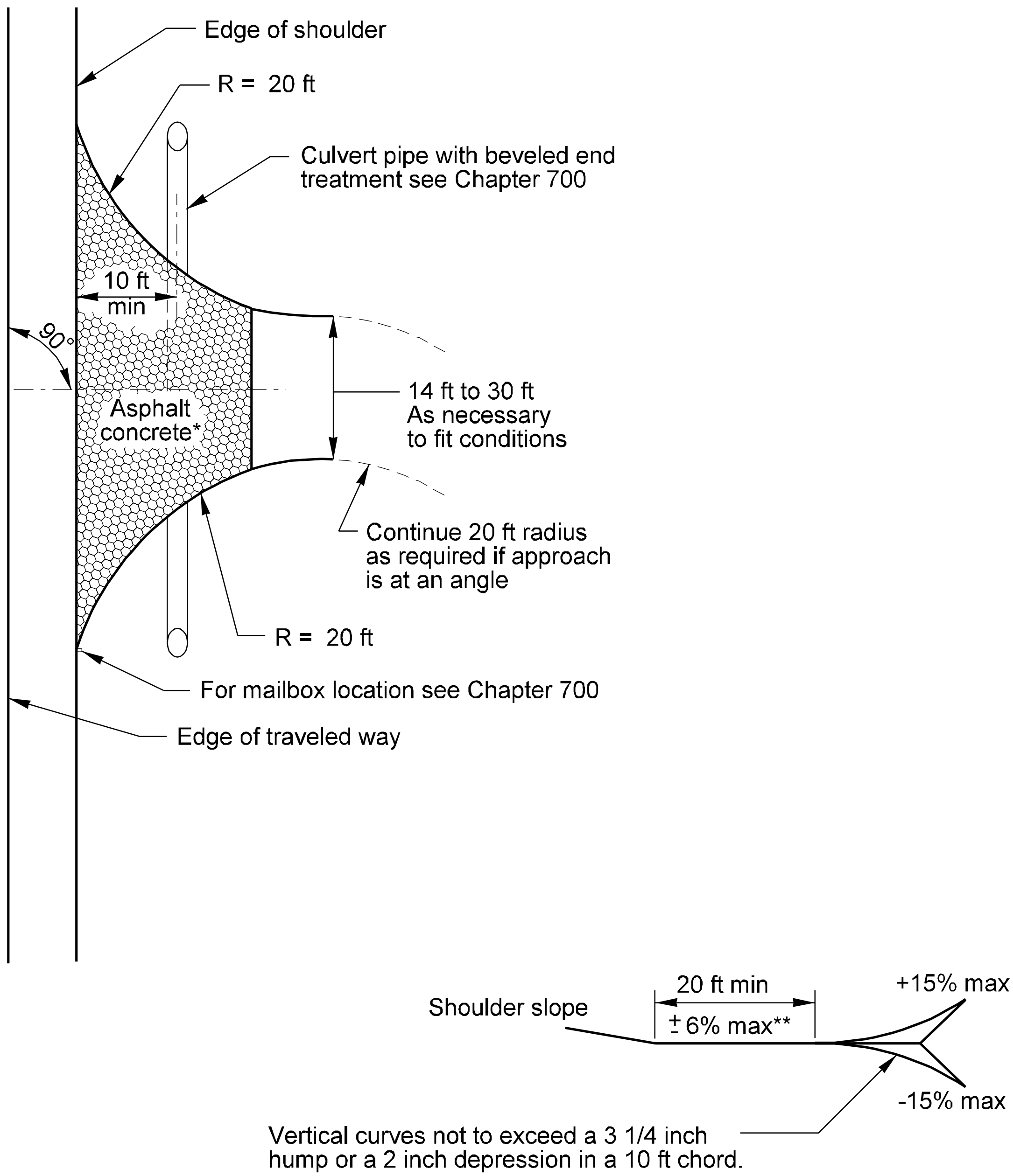
Road approaches and related areas must be constructed so they do not impair drainage within the right of way or alter the stability of the roadway subgrade.

920.09 Procedures

Verify the legality of all road approaches. (See Chapters 1420, 1430, and 1435.) Show on a plan or a list the location and template, for all road approaches. Where road approaches are to be included in a project, consider location and function as early as possible, preferably in the preliminary planning stage.

920.10 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/

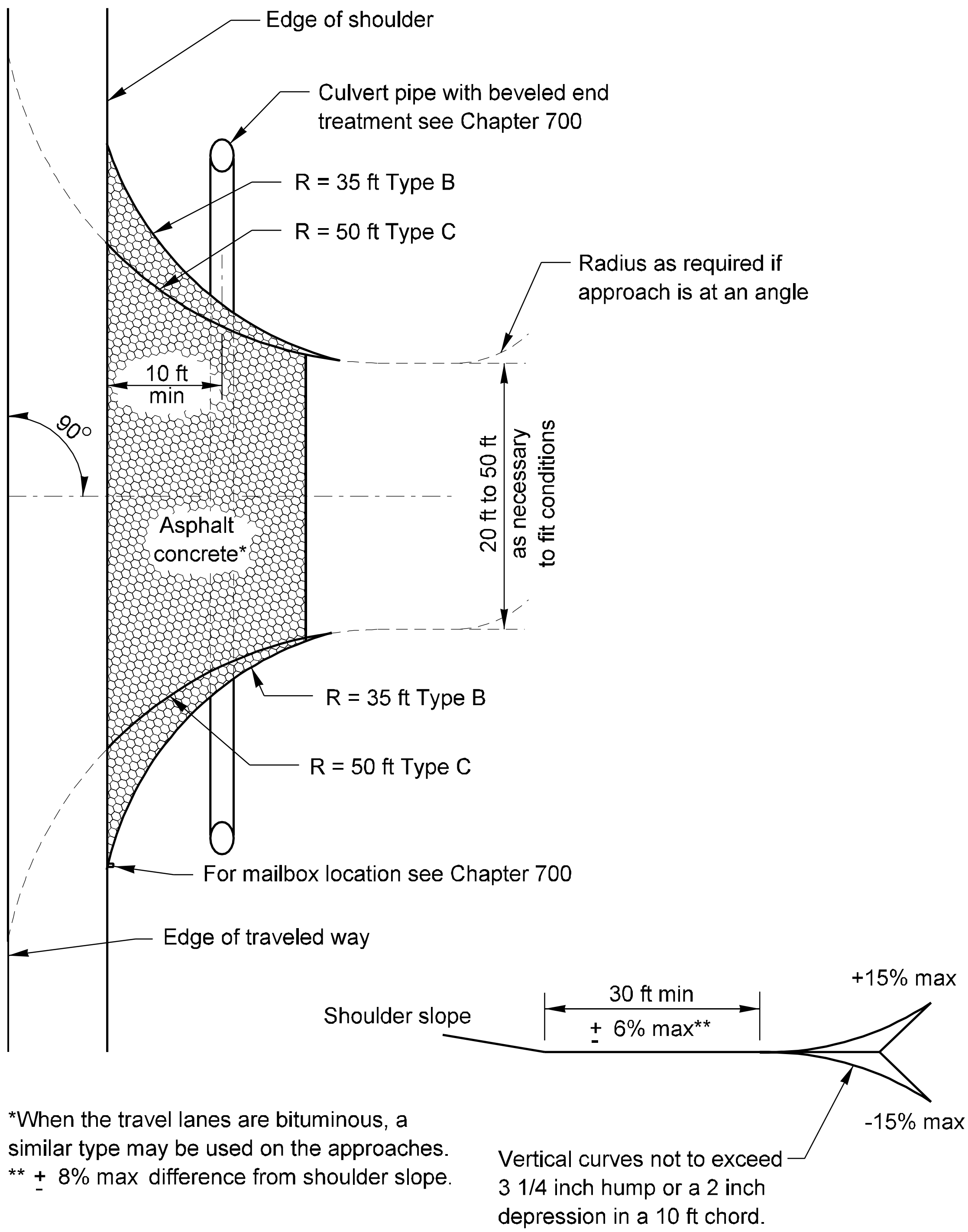


*When the travel lanes are bituminous, a similar type may be used on the approaches.

** ± 8% max difference from shoulder slope.

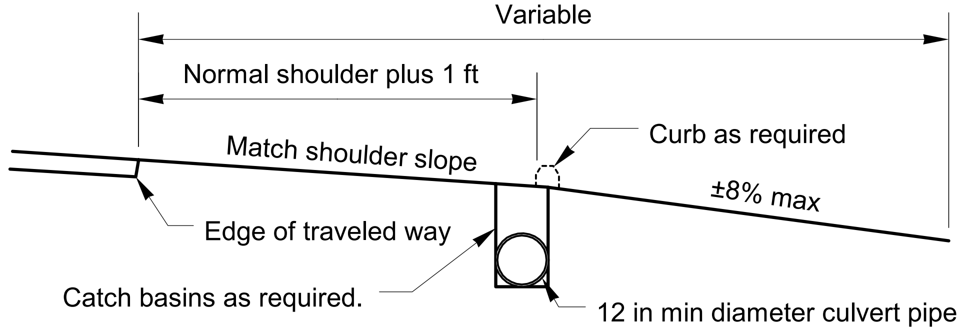
Road Approach Design Template A1

Figure 920-3

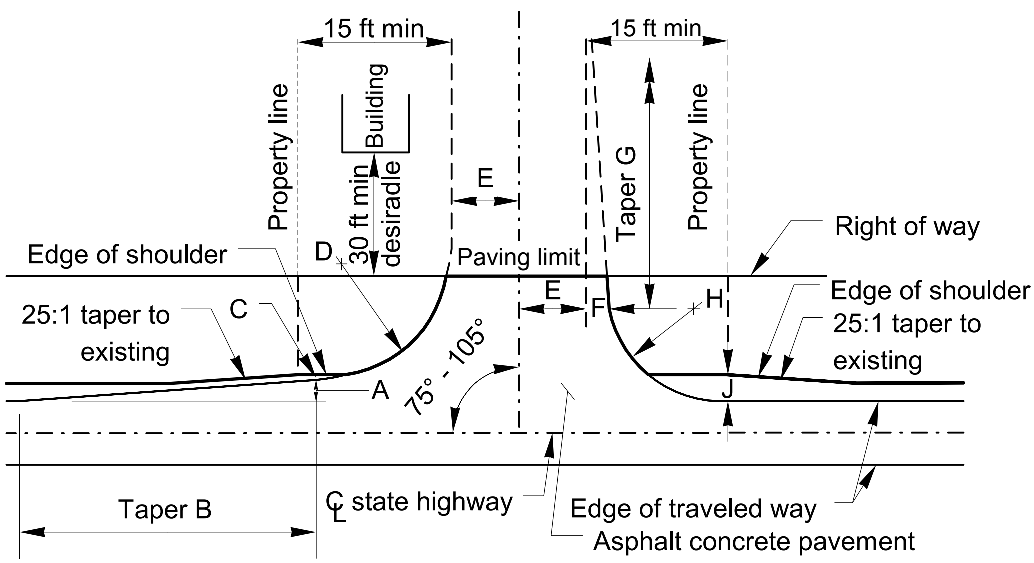


*When the travel lanes are bituminous, a similar type may be used on the approaches.
** ± 8% max difference from shoulder slope.

Road Approach Design Templates B1 and C1
Figure 920-4



Profile Controls



Condition	A	B	C	D	E	F	G	H	J
Primary SU and less	—	—	(2)	30	15	—	—	30	(2)
Primary combination Vehicle WB 40	—	—	(2)	65	15	—	—	55	(2)
	4	25	(3)	50	15	7	25	45	(2)
Primary combination Vehicle WB 50 and doubles	—	—	(2)	70	20	—	—	50	(2)
	4	25	(3)	55	20	—	—	50	(2)

Notes:

(1) All values in ft.

(2) Normal shoulder width. (See Chapter 440.)

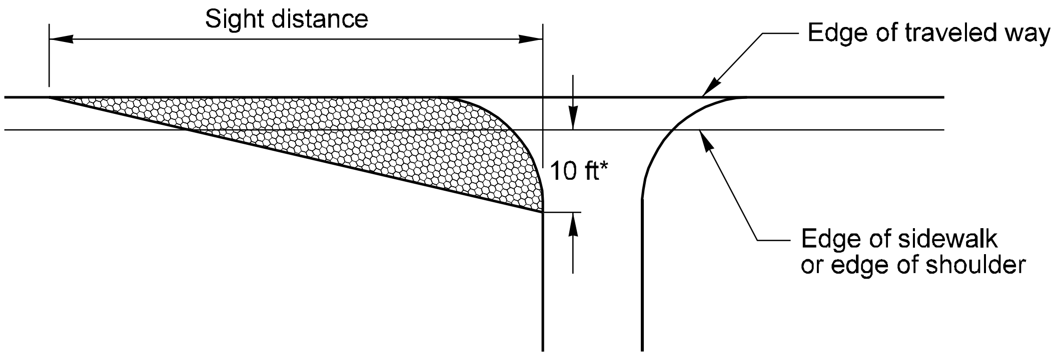
(3) Normal shoulder width less A.

(4) For larger vehicles, use turning templates. (See Chapter 910.)

(5) Vertical curves between the shoulder slope and the road approach grade not to exceed a 3¼ in hump or a 2 in depression in a 10 ft cord.

Road Approach Design Template D1

Figure 920-5



* Not to exceed 18 ft from the edge of traveled way.

Posted Speed Limit (mph)	25	30	35	40	50	60	70
AWDVTE 100 or less	155	200	230	295	395	525	625
AWDVTE 100 to 1500	155	200	250	305	425	570	645
Road Approach Sight Distance (ft)							

These distances require an approaching vehicle to reduce speed or stop to prevent a collision.

Design road approach sight distance for road approaches with AWDVTE over 1500 as an intersection, see Chapter 910.

Provide decision sight distance (Chapter 650) for through traffic at all utility and special use road approaches on facilities with full access control.

For road approaches where left turns are not allowed, a sight triangle need only be provided to the left, as shown.

For road approaches where left turns are allowed, provide a sight triangle to the right in addition to the one to the left. The sight distance to the right is measured along the center line of the roadway.

For additional information on calculating the sight triangle, see Chapter 910.

Road Approach Sight Distance
Figure 920-6

930.01 General

Most railroads in Washington were in operation long before our system of roads was developed and generally have prescriptive rights and underlying property interests that supersede those of road authorities. In general, right of way is not acquired in fee from a railroad company. Rather than selling property, railroads typically convey easements, access rights, and construction permits. Therefore, most roads exist on railroad property by easement from the railroads. Any widening or realignment of an existing roadway, construction upon, over or under, or installation of wires or pipes on railroad property requires permission from the railroad in the form of a permit or an agreement.

Projects that require the railroad to do work, or for which they are to be reimbursed or compensated will require an agreement. It is not unusual for a railroad agreement to take 6 months or more to be developed, reviewed and executed, therefore, it is important for the designer to establish early contact with the HQ WSDOT Railroad Liaison in the Design Office.

Agreements are developed and negotiated by the WSDOT Railroad Liaison. Permits are typically acquired directly from the railroad or its property manager by the Region. Contact your Regional Utilities Engineer or the HQ Railroad Liaison for assistance. Include copies of any executed permits or agreements in the Design Documentation Package. Include a copy of the "Notice to Proceed" (required in the agreement to authorize the railroad to commence work) in the Project file.

Railroad grade crossings are, in effect, intersections with two legs of rail traffic that never stop. Due consideration must be given by the roadway designer to the traffic control for the rail crossing. Grade crossing traffic controls (railroad signals, gates, pavement markings, signs, and controllers) are typically located within the area of railroad property. Railroad signal and gate maintenance is the responsibility of the railroad. Railroads are also responsible for the maintenance of crossing surfaces for the 12 inches outside the edge of rail (WAC 480-62-225). Most railroads will insist on designing and constructing their own signals, gates, and crossing surfaces.

The Washington Utilities and Transportation Commission (WUTC) has statutory authority over grade crossing safety in Washington State. Any changes to a grade crossing or the associated safety appurtenances require initial approval by the WUTC. This is accomplished by submitting a Petition to the WUTC. The Railroad Liaison has copies of WUTC forms and can help with their preparation. The WUTC will review the Petition and issue an Order granting or denying the Petition with or without conditions, depending on situation. Include a copy of any Petition or Order in the Design Documentation Package.

930.02 References

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA, including the *Washington State Modifications to the MUTCD*, WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Railroad-Highway Grade Crossing Handbook, FHWA TS-86-215

Guidance On Traffic Control Devices At Highway-Rail Grade Crossings, HIGHWAY/RAIL GRADE CROSSING TECHNICAL WORKING GROUP (TWG), FHWA, November 2002 (http://safety.fhwa.dot.gov/media/twgreport.htm#2)

Agreements Manual, WSDOT M22-99

Traffic Control Devices Handbook, ITE, 2001.

A Policy on Geometric Design of Highways and Streets, AASHTO, 2001

Revised Code of Washington (RCW) 81.53 Railroad Crossings

Washington Administrative Code (WAC) 480-62-150 Grade crossing petitions

930.03 Plans

Include plans for state constructed improvements to existing crossings and any new crossings within the normal process. In addition to basic roadway dimensions, signs, and markings, indicate angle of the crossing, number of tracks, location of signals and other railway facilities (e.g., electrical and communications lines, control boxes). Also indicate railroad stationing at the point where highway centerline crosses the center of the tracks.

For any project proposing to alter the horizontal or vertical alignment at a grade crossing (including grade separations), show the alignment and profile for both the railroad and the roadway for a minimum of 500 feet on all legs of the crossing. Show all other important features that might affect the safety, operation, and design of the crossing such as nearby crossroads, driveways or entrances, buildings, and highway structures on the plans.

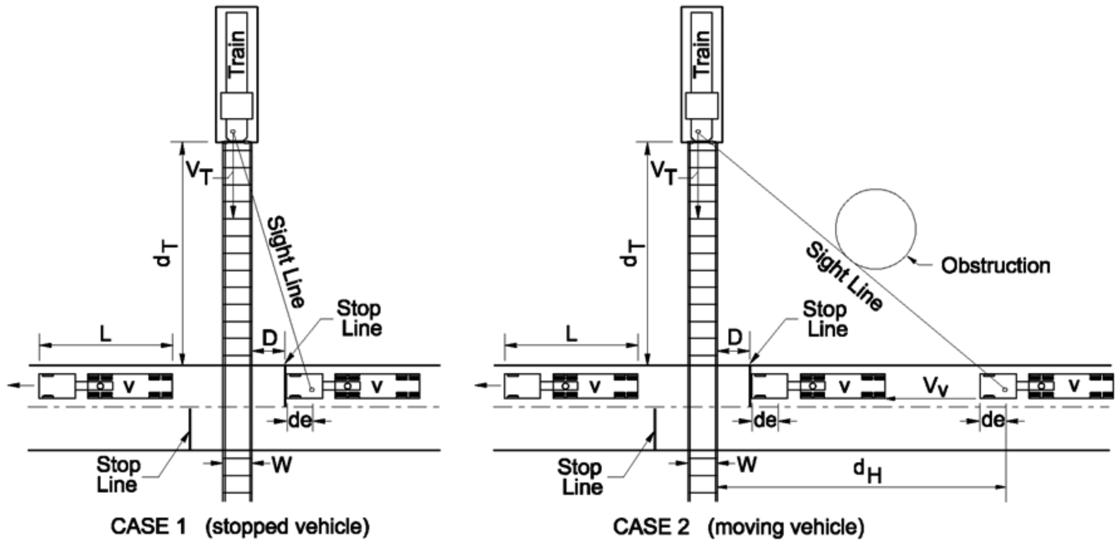
Sight distance is a primary consideration at grade crossings. A railroad grade crossing is comparable to the intersection of two highways where a sight triangle must be kept clear of obstructions or it must be protected by a traffic control device. The desirable sight distance allows an approaching driver to see an approaching train at such a distance that the vehicle can stop well in advance of the crossing if signals or gates and signals are not present. See Figures 930-1, Case 2 and 930-2. Sight distances of the order shown are desirable at any railroad grade crossing not controlled by railroad signal lights or gates (active warning devices).. Their attainment, however, is often difficult and impracticable due to topography and terrain. Even in flat open terrain, the growth of crops or other seasonal vegetation can create a permanent or seasonal sight distance obstruction. Furthermore, the properties upon which obstructions might exist are commonly owned by the railroad or others. Evaluate installation of active devices at any location where adequate sight distances cannot be assured. Include communication with the railroad and Washington Utilities and Transportation Commission in your evaluation.

The driver of a vehicle stopped at a crossing with signal lights but no gates needs to be able to see far enough down the tracks from the stop bar to be able to safely cross the tracks before a train, approaching at maximum allowable speed, reaches the crossing. See Figures 930-1, Case 1 and 930-2.

In some cases lights and gates alone will not provide adequate safety for motorists whose impatience may encourage them to drive around a gate. Evaluate train and traffic volumes and accident history to assess the feasibility of installing a median separator to prevent vehicles from driving around gates. Close call incident logs are sometimes available from the railroad or WUTC, these too can provide an indication of need for additional active control devices. Consult with the railroad or the HQ Railroad Liaison since the railroad may have information on numbers of gate violators at the crossing. Where sufficient space is available, median separators should be at least 60 feet in length.

Construct highway grades so that low-slung vehicles will not hang-up on tracks or damage them. See Chapter 630 for information on vertical alignment at railroad grade crossings. Whenever possible design the roadway to cross grade crossings at right angles. If bicycle traffic uses the crossing (this can be assumed for most roads), provide a shoulder through the grade crossing at least as wide as the approach shoulder width. If a skew is unavoidable, wider shoulders may be necessary to permit bicycles to maneuver to cross the tracks at right angles. See Chapter 1020 for information on bikeways crossing railroad tracks.. Consider installation of advance warning signs indicating the presence of a skewed crossing for crossings where engineering judgment suggests a benefit.

Include any engineering studies or sight distance measurements in the Design Documentation Package.



d_T = Sight distance along railroad tracks
d_H = Sight distance along highway
d_e = Distance from driver to front of vehicle (assumed 8 ft.)
D = Distance from stop line to nearest rail (assumed 15 ft.)
W = Distance between outer rails (single track W=5 ft.)

V_V = Velocity of vehicle
f = Coefficient of friction
V_T = Velocity of train
L = Length of vehicle (assumed 65 ft.)

Adjustments must be made for skew crossings.
Assumed flat highway grades adjacent to and at crossings.

Sight Distance at Railroad Crossing
Figure 930-1

Case 1 Departure from stop		Case 2 Moving Vehicle						
Train Speed (mph) V_T	0	Vehicle Speed (mph) V_V						
		10	20	30	40	50	60	70
		F=0.40	0.40	0.35	0.32	0.30	0.29	0.28
		Distance Along Railroad from Crossing d_T(ft)						
10	240	150	100	100	100	110	120	130
20	480	290	210	200	210	220	240	270
30	720	440	310	300	310	340	370	400
40	960	580	410	390	410	450	490	540
50	1200	730	520	490	520	560	610	670
60	1440	870	620	590	620	670	730	810
70	1880	1020	720	690	720	790	860	940
80	1920	1160	830	790	830	900	980	1070
90	2160	1310	930	890	930	1010	1100	1210
		Distance Along Highway from Crossing d_H(ft)						
		69	135	220	324	447	589	751
Required design sight distance for combination of highway and train vehicle speeds; 65 ft truck crossing a single set of tracks at 90°. (AASHTO)								

Sight Distance at Railroad Crossing
Figure 930-2

930.04 Traffic Control Systems

Traffic control systems permit safe and efficient operation of railroad-highway traffic crossings. These systems may include one or more of the following:

(a) Passive Elements

(1) Signing elements are shown in Part 8, *Traffic Control for Highway-Rail Grade Crossings*, of the MUTCD and include one or more of the following:

a. Railroad Crossing Sign (crossbuck). The railroad is responsible for maintenance of the crossbucks.

b. Railroad Crossing Auxiliary Sign (Inverted "T" sign). This sign is mounted below the crossbuck to indicate the number of tracks when 2 or more tracks are involved -- Railroad Responsibility.

c. Railroad Advance Warning Sign. Road Authority installs and maintains.

d. Exempt Crossing Sign. This is a supplemental sign that, when authorized by the WUTC, may be mounted below the crossbuck. When this sign is approved, certain classes of vehicles, otherwise required to stop before crossing the tracks, may proceed without stopping, provided no train is approaching. Road Authority installs and maintains.

e. Do Not Stop On Tracks Sign. Road Authority Responsibility.

(2) Pavement Markings on all paved approaches are the responsibility of the road authority and consist of RR Crossing markings per the Standard Plans, no passing markings and pullout lanes as appropriate.

(3) Consider the installation of illumination at and adjacent to railroad crossings where an engineering study determines that better nighttime visibility of the train and the grade crossing is needed. For example:

- where a substantial amount of railroad operations are conducted at night.
- where grade crossings are blocked for long periods at night by slow speed trains.
- where crash history indicates that drivers experience difficulty seeing trains during hours of darkness.

(b) Active Elements

(1) Railroad Signals and gates. Maintenance of these devices is the responsibility of the railroad. Funding for installation and upgrades to these devices, commonly comes from the road authority.

(2) Repeater Signals (also known as "pre-signals"). These are traffic signals installed in advance of a railroad grade crossing when the grade crossing is adjacent to a parallel roadway with a far side traffic signal. They are installed and maintained by the road authority and used to discourage traffic from stopping on the tracks.

(3) Locomotive Horn. By law, trains are required to sound their horn in advance of grade crossings. In some locations this can be a problem for adjacent residents or businesses. This requirement may be waived provided current Federal Railroad Administration (FRA) requirements are met. (See Federal Register Vol 68, Number 243, Dec. 18, 2003) and (http://www.fra.dot.gov/Content3.asp?P=1318).

(4) Traffic signal interconnects (also known as "railroad pre-emption") provide linkage between the railroad signals and adjacent traffic signals to prevent vehicles from getting trapped at a traffic signal as a train approaches. These are typically funded by the road authority and require cooperation with the railroad for installation. Include copies of any signal pre-emption timings or calculations in the Project File.

In general, passive controls notify drivers that they are approaching a grade crossing and should be on the lookout for trains. Passive controls are typically found at low (train) volume and (train) speed crossings.

For crossings of state highways with low to moderate train speeds and volumes or for crossings with limited sight distance per Figure 930-1 Case 2 consider active controls. For crossings without adequate stopped vehicle sight distance per Figure 930-2, Case 1, consider including gates.

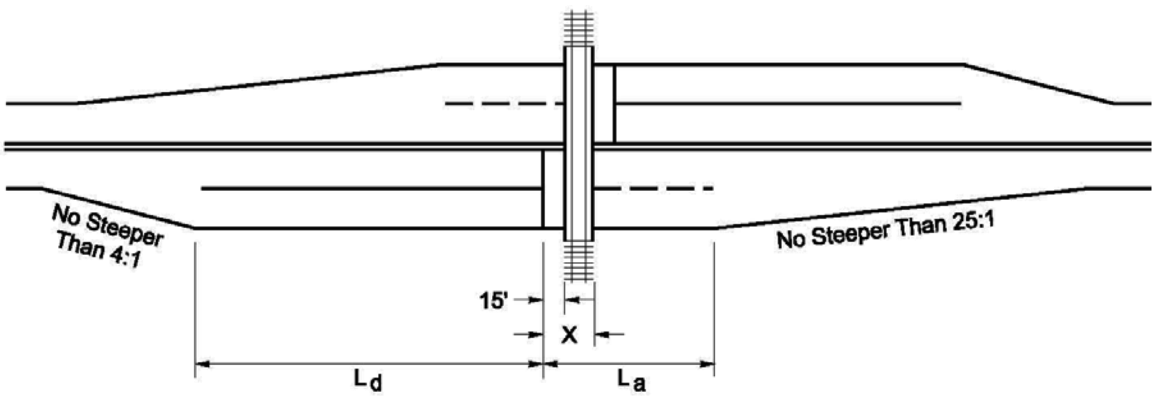
At the time of this writing no National or State warrants have been developed for installation of traffic controls at grade crossings. Furthermore, due to the large number of significant variables that must be considered, there is no single standard system of active traffic control devices universally applicable for grade crossings. Base the determination of the appropriate type of traffic control system on an engineering and traffic investigation including input from the railroad and the WUTC. Significant factors to consider are train and highway volumes and speeds, pedestrian volume, accident history, and sight distance restrictions.

Evaluate railroad signal supports and gate mechanisms as roadside hazards. Use traffic barrier or impact attenuators as appropriate per Division 7 of this manual.

930.05 Pullout Lanes

Per RCW 46.61.350 certain vehicles are required to stop at all railroad crossings without signals or not posted with an “Exempt” sign. Consider the installation of "pullout lane" when grade crossings have no active protection. Some school districts have a policy that school buses must stop at all grade crossings regardless of the type of control. Consider the installation of pullout lanes at any public grade crossing used regularly by school buses and for which the school buses must stop.

Design pullout lane geometrics in accordance with Figure 930-3. The minimum shoulder width adjacent to the pullout lane is 3 feet.



L_d = Total length of pullout lane, approach
L_a = Total length of pullout lane, exit
X = Distance from stopping point to downstream side of crossing surface

Approach Length of Pullout Lane, L_d		Downstream Length of Pullout Lane, L_a	
Vehicle Speed (mph)	Length (ft)	Vehicle Speed (mph)	Length (ft)
30	175	30	0
40	265	40	80
50	385	50	460
60	480	60	870

Typical Pullout Lane at Railroad Crossing
Figure 930-3

930.06 Crossing Surfaces

Railroads are responsible for the maintenance of crossing surfaces up to 12 inches outside the edge of rail (WAC 480-62-225). Crossing surfaces can be constructed of a number of different materials including asphalt, concrete, steel, timber, rubber, or plastic. The most common surface types used on state highway crossings are asphalt, precast concrete, and rubber. Timbered crossings are frequently used for low volume roads and temporary construction crossings.

The life of a crossing surface depends on the volume and weight of highway and rail traffic using it. Highway traffic not only dictates the type of crossing surface but also has a major influence on the life of the crossing. Rough crossing surfaces impact the motoring public far more than the railroad. Therefore, when a highway project passes through a railroad grade crossing consider the condition of the crossing surface. While the existing condition might not warrant railroad investment in replacing it, the surface might have deteriorated sufficiently to increase vehicle operating costs and motorist inconvenience. In such cases it may be effective to partner with the railroad to replace the crossing as part of the highway project. Such partnerships typically consist of the state reimbursing the railroad for all or a portion of the cost of the work.

930.07 Crossing Closure

The MUTCD states, "Any highway-rail grade crossing which cannot be justified should be eliminated". Coordination with the appropriate railroad and the Washington Utilities and Transportation Commission is required before any changes can be made to track structure or railroad signal systems. If a state route grade crossing appears unused, consult the Headquarters Railroad Liaison Engineer before taking any action. At-grade crossings which are replaced by grade separations should be closed.

930.08 Traffic Control During Construction And Maintenance

Work Zone Traffic Control at highway-rail grade crossings is required as in any other project with the addition of the need to provide protection from train traffic. When highway construction or maintenance activities will affect a railroad crossing, the railroad company must be notified at least ten days before performing the work (WAC 480-62-305 (4)). Furthermore, any time highway construction or maintenance crews or equipment are working within 25 feet of an active rail line or grade crossing, consult the railroad to determine if a railroad flagger is required to ensure work zone safety. Current contact numbers for railroads may be obtained by contacting your Regional Utilities Engineer. Railroad flaggers differ from highway flaggers in that they have information on train schedules and can generally communicate with trains by radio. When flaggers are required, the railroad generally sends the road authority a bill for the cost of providing this service.

Work zone traffic must never be allowed to stop or queue up on a nearby rail-highway grade crossing unless railroad flaggers are present. Without proper protection, vehicles might be trapped on the tracks when a train approaches. See the MUTCD for more detailed guidance.

For projects requiring temporary access across a set of railroad tracks, contact the Headquarters Railroad Liaison Engineer early in the design process since a Railroad Agreement will likely be required.

930.09 Railroad Grade Crossing Petitions And WUTC Orders

The Washington Utilities and Transportation Commission (WUTC) is authorized by statute (Title 81 RCW) with regulatory authority over railroad safety at grade-crossings. Any modifications to grade crossings or safety equipment including grade separations, widening, realignment, and profile must be approved by the WUTC (WAC 480-62-150). This is accomplished by submitting a formal Petition to the WUTC for which they will issue a formal Order. Provide Section, Township, & Range; posted speed limit;

ADT, percentage of trucks; number of daily school bus trips; and a 20 year projection of the ADT, truck percentage, and school bus trips. The Headquarters Railroad Liaison Engineer can help in the preparation and submittal of this petition. Include a copy of the Petition and WUTC Findings and Order in the Design Documentation Package.

930.10 Section 130 Grade Crossing Improvement Projects

WSDOT Highway and Local Programs administers the Section 130 Grade Crossing safety improvement program. Project proposals are submitted by local agencies, railroads, and WSDOT. Funding is provided from the Surface Transportation 10 percent "Safety Set Aside" authorized by the TEA-21.

Eligibility: All public railroad grade crossing safety improvements are eligible for funding. Project types include signing and pavement markings; active warning devices; illumination; crossing surfaces; grade separations (new and reconstructed); sight-distance improvements; geometric improvements to the roadway approaches; and closing and/or consolidating crossings. Section 130 funds are generally available at a 90 percent Federal share and up to 100% for signing; pavement markings; active warning devices; elimination of hazards; and crossing closures.

Most Section 130 projects on state highways are low cost grade crossing signal upgrades entirely within existing railroad right of way. Work is typically done by the railroad under agreement and generally takes a very short time. Consider Section 130 grade crossing signal upgrade projects, constructed by the railroad or its contractor, which are not part of a larger state highway project to be Minor Operational Enhancements funded under Program Q barring extenuating circumstances.

Contact the Railroad Liaison in the HQ Design Office for more information.

930.11 Light Rail

Light Rail, also known as streetcars, is developing in some urban areas of the state. For the most part, criteria for light rail are very similar to those for freight and passenger rail with the exception of locations where light rail shares a street right of way with motor vehicles. The MUTCD now includes a chapter devoted exclusively to Light Rail. Consult this reference as the situation warrants http://mutcd.fhwa.dot.gov/HTM/2003/part10/part10-toc.htm.

930.12 Documentation

A list of the documents that are required to be preserved in the Design Documentation Package (DDP) and the Project File (PF) is on the following website:

http://www.wsdot.wa.gov/eesc/design/projectdev/

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	Access Point Decision 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.

(2) Interchange Patterns

Basic interchange patterns have been established that can be used under certain general conditions and modified or combined to apply to many more. Alternatives must be considered in the design of a specific facility, but the conditions in the area and on the highway involved must govern and rigid patterns must not be indiscriminately imposed.

Selection of the final design must be based on a study of projected traffic volumes, site conditions, geometric controls, criteria for intersecting legs and turning roadways, driver expectancy, consistent ramp patterns, continuity, and cost.

The patterns most frequently used for interchange design are those commonly described as directional, semidirectional, cloverleaf, partial cloverleaf, diamond, and single point (urban) interchange. (See Figure 940-4.)

(a) **Directional** A directional interchange is the most effective design for connection of intersecting freeways. The directional pattern has the advantage of reduced travel distance, increased speed of operation, and higher capacity. These designs eliminate weaving and have a further advantage over cloverleaf designs in avoiding the loss of sense of direction drivers experience in traveling a loop. This type of interchange is costly to construct, commonly using a four-level structure.

(b) **Semidirectional** A semidirectional interchange has ramps that loop around the intersection of the highways. This requires multiple single-level structures and more area than the directional interchange.

(c) **Cloverleaf** The full cloverleaf interchange has four loop ramps that eliminate all the left-turn conflicts. Outer ramps provide for the right turns. A full cloverleaf is the minimum type interchange that will suffice for a freeway-to-freeway interchange. Cloverleaf designs often incorporate a C-D road to minimize signing difficulties and to remove weaving conflicts from the main roadway.

The principal advantage of this design is the elimination of all left-turn conflicts with one single-level structure. Because all movements are merging movements, it is adaptable to any grade line arrangement.

The cloverleaf has some major disadvantages. The left-turn movement has a circuitous route on the loop ramp, the speeds are low on the loop ramp, and there are weaving conflicts between the loop ramps. The cloverleaf also requires a large area. The weaving and the radius of the loop ramps are a capacity constraint on the left-turn movements.

(d) **Partial Cloverleaf (PARCLO)** A partial cloverleaf has loop ramps in one, two, or three quadrants that are used to eliminate the major left-turn conflicts. These loops may also serve right turns for interchanges that have one or two quadrants that must remain undeveloped. Outer ramps are provided for the remaining turns. Design the grades to provide sight distance between vehicles approaching these ramps.

(e) **Diamond** A diamond interchange has four ramps that are essentially parallel to the major arterial. Each ramp provides for one right and one left-turn movement. Because left-turns are made at grade across conflicting traffic on the crossroad, intersection sight distance is a primary consideration.

The diamond design is the most generally applicable and serviceable interchange configuration and usually requires less space than any other type. Consider this design first when a semidirectional interchange is required unless another design is clearly dictated by traffic, topography, or special conditions.

(f) **Single Point (Urban)** A single point urban interchange is a modified diamond with all of its ramp terminals on the crossroad combined into one signalized at-grade intersection. This single intersection accommodates all interchange and through movements.

A single point urban interchange can improve the traffic operation on the crossroad with less right of way than a <u>typical</u> diamond interchange; however, a larger structure is required.

(3) Spacing

To avoid excessive interruption of main line traffic, consider each proposed facility in conjunction with adjacent interchanges, intersections, and other points of access along the route as a whole.

The minimum spacing between adjacent interchanges is 1 mi in urban areas and 2 mi in rural areas. In urban areas, spacing less than 1 mi may be used with C-D roads or grade separated (braided) ramps. Generally, the average interchange spacing is not less than 2 mi in urban areas and not less than 4 mi in suburban areas. Interchange spacing is measured along the freeway center line between the center lines of the crossroads.

The spacing between interchanges may also be dependent on the spacing between ramps. The minimum spacing between the noses of adjacent ramps is given on Figure 940-5.

Consider either frontage roads or C-D roads when it is necessary to facilitate the operation of near-capacity volumes between closely spaced interchanges or ramp terminals. C-D roads may be required where cloverleaf loop ramps are involved or where a series of interchange ramps requires overlapping of the speed change lanes. Base the distance between successive ramp terminals on capacity requirements and check the intervening sections by weaving analysis to determine whether adequate capacity and sight distance and effective signing can be ensured without the use of auxiliary lanes or C-D roads.

(4) Route Continuity

Route continuity refers to the providing of a directional path along the length of a route designated by state route number. Provide the driver of a through route a path on which lane changes are minimized and other traffic operations occur to the right.

In maintaining route continuity, interchange configuration may not always favor the heavy traffic movement, but rather the through route. In this case, design the heavy traffic movements with multilane ramps, flat curves, and reasonably direct alignment.

(5) Drainage

Avoid interchanges located in proximity to natural drainage courses. These locations often result in complex and unnecessarily costly hydraulic structures.

The open areas within an interchange can be used for storm water detention facilities when these facilities are required.

(6) Uniformity of Exit Pattern

While interchanges are of necessity custom designed to fit specific conditions, it is desirable that the pattern of exits along a freeway have some degree of uniformity. From the standpoint of driver expectancy, it is desirable that each interchange have only one point of exit, located in advance of the crossroad.

940.05 Ramps

(1) Ramp Design Speed

The design speed for a ramp is based on the design speed for the freeway main line.

It is desirable for the ramp design speed at the connection to the freeway be equal to the free-flow speed of the freeway. Meet or exceed the upper range values from Figure 940-1 for the design speed at the ramp connection to the freeway. Transition the ramp design speed to provide a smooth acceleration or deceleration between the speeds at the ends of the ramp. However, do not reduce the ramp design speed below the lower range speed of 25 mph. For loop ramps, use a design speed as high as practical, but not less than 25 mph.

These design speed guidelines do not apply to the ramp in the area of the ramp terminal at-grade intersection. In the area of the intersection, a design speed of 15 mph for turning traffic or 0 mph for a stop condition is adequate. Use the allowed skew at the ramp terminal at-grade intersection to minimize ramp curvature.

For freeway-to-freeway ramps and C-D roads, the design speed at the connections to both freeways is the upper range values from Figure 940-1; however, with justification, the midrange values from Figure 940-1 may be used for the remainder of the ramp. When the design speed for the two freeways is different, use the higher design speed.

Existing ramps meet design speed requirements if acceleration or deceleration requirements are met (figure 940-8 or 940-10) and superelevation meets or will be corrected to meet the requirements in Chapter 642.

Main Line Design Speed mph		50	55	60	65	70	80
Ramp Design Speed (mph)	Upper Range	45	50	50	55	60	70
	Midrange	35	40	45	45	50	60
	Lower Range	25	25	25	25	25	25

Ramp Design Speed
Figure 940-1

(2) Sight Distance

Design ramps in accordance with provisions in Chapter 650 for stopping sight distances.

(3) Grade

The maximum grade for ramps for various design speeds is given in Figure 940-2.

Ramp Design Speed (mph)	25-30	35-40	45 and above
Desirable Grade (%)	5	4	3
Maximum Grade (%)	7	6	5
On one-way ramps down grades may be 2% greater.			

Maximum Ramp Grade
Figure 940-2

(4) Cross Section

Provide the minimum ramp widths given in Figure 940-3. Ramp traveled ways may require additional width to these minimums as one-way turning roadways. See Chapters 640 and 641 for additional information and roadway sections.

Number of Lanes		1	2
Traveled Way(1)		15(2)	25(3)
Shoulders	Right	8	8
	Left	2	4
Medians(4)		6	8

(1) See Chapter 641 for turning roadway widths. See Chapter 1050 for additional width when an HOV lane is present.
(2) May be reduced to 12 ft on tangents.
(3) Add 12 ft for each additional lane.
(4) The minimum median width is not less than that required for traffic control devices and their respective clearances.

Ramp Widths (ft)
Figure 940-3

Cross slope and superelevation requirements for ramp traveled way and shoulders are as given in Chapters 640 and 642 for roadways.

Whenever feasible, make the ramp cross slope at the ramp beginning or ending station equal to the cross slope of the through lane pavement. Where space is limited and superelevation runoff is long or when parallel connections are used, the superelevation transition may be ended beyond (for on-ramps) or begun in advance of (for off-ramps) the ramp beginning or ending station, provided that the algebraic difference in cross slope at the edge of the through lane and the cross slope of the ramp does not exceed 4%. In such cases, ensure smooth transitions for the edge of traveled way.

(5) Ramp Lane Increases

When off-ramp traffic and left-turn movement volumes at the ramp terminal at-grade intersection cause congestion, it may be desirable to add lanes to the ramp to reduce the queue length caused by turning conflicts. Make provision for the addition of ramp lanes whenever ramp exit or entrance volumes, after the design year, are expected to result in poor service. See Chapter 620 for width transition design.

(6) Ramp Meters

Ramp meters are used to allow a measured or regulated amount of traffic to enter the freeway. When operating in the "measured" mode, they release traffic at a measured rate to keep downstream demand below capacity and improve system travel times. In the "regulated" mode, they break up platoons of vehicles that occur naturally or result from nearby traffic signals. Even when operating at near capacity, a freeway main line can accommodate merging vehicles one or two at a time, while groups of vehicles will cause main line flow to break down.

The location of the ramp meter is a balance between the storage and acceleration requirements. Locate the ramp meter to maximize the available storage and so that the acceleration lane length, from a stop to the freeway main line design speed, is available from the stop bar to the merging point. With justification, the average main line running speed during the hours of meter operation may be used for the highway design speed to determine the minimum acceleration lane length from the ramp meter. See 940.06(4) for information on the design of on-connection acceleration lanes. See Chapter 860 for additional information on the design of ramp meters.

Driver compliance with the signal is required for the ramp meter to have the desired results. Consider enforcement areas with ramp meters.

Consider HOV bypass lanes with ramp meters. See Chapter 1050 for design data for ramp meter bypass lanes.

940.06 Interchange Connections

Provide uniform geometric design and uniform signing for exits and entrances, to the extent possible, in the design of a continuous freeway. Do not design an exit ramp as an extension of a main line tangent at the beginning of a main line horizontal curve.

Provide spacing between interchange connections as given by Figure 940-5.

Avoid on-connections on the inside of a main line curve, particularly when the ramp approach angle is accentuated by the main line curve, the ramp approach requires a reverse curve to connect to the main line, or the elevation difference will cause the cross slope to be steep at the nose.

Keep the use of mountable curb at interchange connections to a minimum. Justification is required when it is used adjacent to traffic expected to exceed 40 mph.

(1) Lane Balance

Design interchanges to the following principles of lane balance:

(a) At entrances, make the number of lanes beyond the merging of two traffic streams not less than the sum of all the lanes on the merging roadways less one. (See Figure 940-6a.)

(b) At exits, make the number of approach lanes equal the number of highway lanes beyond the exit plus the number of exit lanes less one. (See Figure 940-6a.) Exceptions to this are at a cloverleaf or at closely spaced interchanges with a continuous auxiliary lane between the entrance and exit. In these cases the auxiliary lane may be dropped at a single-lane, one lane reduction, off-connection with the number of approach lanes being equal to the sum of the highway lanes beyond the exit and the number of exit lanes. Closely spaced interchanges have a distance of less than 2,100 ft between the end of the acceleration lane and the beginning of the deceleration lane.

Maintain the basic number of lanes, as described in Chapter 620, through interchanges. When a two-lane exit or entrance is used, maintain lane balance with an auxiliary lane. (See Figure 940-6b.) The only exception to this is when the basic number of lanes is changed at an interchange.

(2) Main Line Lane Reduction

The reduction of a basic lane or an auxiliary lane may be made at a two-lane exit or may be made between interchanges. When a two-lane exit is used, provide a recovery area with a normal acceleration taper. When a lane is dropped between interchanges, drop it 1,500 to 3,000 ft from the end of the acceleration taper of the previous interchange. This will allow for adequate signing but not be so far that the driver will become accustomed to the number of lanes and be surprised by the reduction. (See Figure 940-7.)

Reduce the traveled way width of the freeway by only one lane at a time.

(3) Sight Distance

Locate off-connections and on-connections on the main line to provide decision sight distance for a speed/path/direction change as described in Chapter 650.

(4) On-Connections

On-connections are the pavement at the end of on-ramps, connecting them to the main lane of a freeway. They have two parts, an acceleration lane and a taper. The acceleration lane allows entering traffic to accelerate to the freeway speed and evaluate gaps in the freeway traffic. The taper is for the entering vehicle to maneuver into the through lane.

On-connections are either taper type or parallel type. The tapered on-connection provides direct entry at a flat angle, reducing the steering control needed. The parallel on-connection adds a lane adjacent to the through lane for acceleration with a taper at the end. Vehicles merge with the through traffic with a reverse curve maneuver similar to a lane change. While the taper requires less steering control, the parallel is narrower at the end of the ramp and has a shorter taper at the end of the acceleration lane.

(a) Provide the minimum acceleration lane length, given on Figure 940-8, for each ramp design speed on all on-ramps. When the average grade of the acceleration lane is 3% or greater, multiply the distance from the Minimum Acceleration Lane Length table by the factor from the Adjustment Factor for Grades table.

For existing ramps that do not have significant accidents in the area of the connection with the freeway, the freeway posted speed may be used to calculate the acceleration lane length for preservation projects. If corrective action is indicated, use the freeway design speed to determine the length of the acceleration lane.

Document existing ramps to remain in place with an acceleration lane length less than to the design speed as a design exception. Also, include the following documentation in the project file: the ramp location, the acceleration length available, and the accident analysis that shows that there are not significant accidents in the area of the connection.

The acceleration lane is measured from the last point designed at each ramp design speed (usually the PT of the last curve for each design speed) to the last point with a ramp width of 12 ft. Curves designed at higher design speeds may be included as part of the acceleration lane length.

(b) For parallel type on-connections, provide the minimum gap acceptance length (L_g) to allow entering traffic to evaluate gaps in the freeway traffic and position the vehicle to use the gap. The length is measured beginning at the point that the left edge of traveled way for the ramp intersects the right edge of traveled way of the main line to the ending of the acceleration lane. (See Figures 940-9b and 9c.) The gap acceptance length and the acceleration length overlap with the ending point controlled by the longer of the two.

(c) Single-lane on-connections may be either taper type or parallel type. The taper type is preferred; however, the parallel may be used with justification. Design single-lane taper type on-connections as shown on Figure 940-9a and single lane parallel type on-connections as shown on Figure 940-9b.

(d) For two-lane on-connections, the parallel type is preferred. Design two-lane parallel on-connections as shown on Figure 940-9c. A capacity analysis will normally be the basis for determining whether a freeway lane or an auxiliary lane is to be provided.

When justification is documented, a two-lane tapered on-connection may be used. Design two-lane tapered on-connections in accordance with Figure 940-9d.

(5) Off-Connections

Off-connections are the pavement at the beginning of an off-ramp, connecting it to a main lane of a freeway. They have two parts, a taper for maneuvering out of the through traffic and a deceleration lane to slow to the speed of the first curve on the ramp. Deceleration is not assumed to take place in the taper.

Off-connections are either taper type or parallel type. The taper type is preferred because it fits the path preferred by most drivers. When a parallel type connection is used, drivers tend to drive directly for the ramp and not use the parallel lane. However, when a ramp is required on the outside of a curve, the parallel off-connection is preferred. An advantage of the parallel connection is that it is narrower at the beginning of the ramp.

(a) Provide the minimum deceleration lane length given on Figure 940-10 for each design speed for all off-ramps. Also, provide deceleration lane length to the end of the anticipated queue at the ramp terminal. When the average grade of the deceleration lane is 3% or greater, multiply the distance from the Minimum Deceleration Lane Length table by the factor from the Adjustment Factor for Grades table.

For existing ramps that do not have significant accidents in the area of the connection with the freeway, the freeway posted speed may be used to calculate the deceleration lane length for preservation projects. If corrective action is indicated, use the freeway design speed to determine the length of the deceleration lane.

Document existing ramps to remain in place with a deceleration lane length less than to the design speed as a design exception. Also, include the following documentation in the project file: the ramp location, the deceleration length available, and the accident analysis that shows that there are not significant accidents in the area of the connection.

The deceleration lane is measured from the point where the taper reaches a width of 12 ft to the first point designed at each ramp design speed (usually the PC of the first curve for each design speed). Curves designed at higher design speeds may be included as part of the deceleration lane length.

(b) Gores, Figures 940-11a and 11b, are decision points that must be clearly seen and understood by approaching drivers. In a series of interchanges along a freeway, it is desirable that the gores be uniform in size, shape, and appearance.

The paved area between the physical nose and the gore nose is the reserve area. It is reserved for the installation of an impact attenuator. The minimum length of the reserve area is controlled by the design speed of the main line. (See Figures 940-11a and 11b.)

In addition to striping, raised pavement marker rumble strips may be placed for additional warning and delineation at gores. See the Standard Plans for striping and rumble strip details.

The accident rate in the gore area is greater than at other locations. Keep the unpaved area beyond the gore nose as free of obstructions as possible to provide a clear recovery area. Grade this unpaved area as nearly level with the roadways as possible. Avoid placing obstructions such as heavy sign supports, luminaire poles, and structure supports in the gore area.

When an obstruction must be placed in a gore area, provide an impact attenuator (Chapter 720) and barrier (Chapter 710). Place the beginning of the attenuator as far back in the reserve area as possible, preferably after the gore nose.

(c) For single-lane off-connections, the taper type is preferred. Use the design shown on Figure 940-12a for tapered single-lane off-connections. When justification is documented, a parallel single-lane off-connection, as shown on Figure 940-12b, may be used.

(d) The single-lane off-connection with one lane reduction, Figure 940-12c, is only used when the conditions from lane balance for a single lane exit, one lane reduction, are met.

(e) The tapered two-lane off-connection design shown on Figure 940-12d is preferred where the number of freeway lanes is to be reduced, or where high volume traffic operations will be improved by the provision of a parallel auxiliary lane and the number of freeway lanes is to be unchanged.

The parallel two-lane off-connection, Figure 940-12e, allows less operational flexibility than the taper, requiring more lane changes. Use a parallel two-lane off-connection only with justification.

(6) Collector Distributor Roads

A C-D road can be within a single interchange, through two closely spaced interchanges, or continuous through several interchanges. Design C-D roads that connect three or more interchanges to be two lanes wide. All others may be one or two lanes in width, depending on capacity requirements. Consider intermediate connections to the main line for long C-D roads. See Figure 940-13a for designs of collector distributor outer separations. Use Design A, with concrete barrier, when adjacent traffic in either roadway is expected to exceed 40 mph. Design B, with mountable curb, may be used only when adjacent traffic will not exceed 40 mph.

(a) The details shown in Figure 940-13b apply to all single-lane C-D road off-connections. Where conditions require two-lane C-D road off-connections, a reduction in the number of freeway lanes, the use of an auxiliary lane, or a combination of these, design it as a normal off-connection per 940.06(5).

(b) Design C-D road on-connections as required by Figure 940-13c.

(7) Loop Ramp Connections

Loop ramp connections at cloverleaf interchanges are distinguished from other ramp connections by a low speed ramp on-connection followed closely by an off-connection for another low speed ramp. The loop ramp connection design is shown on Figure 940-14. The minimum distance between the ramp connections is dependent on a weaving analysis. When the connections are spaced far enough apart that weaving is not a consideration, design the on-connection per 940.06(4) and off-connection per 940.06(5).

(8) Weaving Sections

Weaving sections are highway segments where one-way traffic streams cross by merging and diverging. Weaving sections may occur within an interchange, between closely spaced interchanges, or on segments of overlapping routes. Figure 940-15 gives the length of the weaving section for preliminary design. The total weaving traffic is the sum of the traffic entering from the ramp to the main line and the traffic leaving the main line to the exit ramp in equivalent passenger cars. For trucks, a passenger car equivalent of two may be estimated. Use the *Highway Capacity Manual* for the final design of weaving sections.

Because weaving sections cause considerable turbulence, interchange designs that eliminate weaving or remove it from the main roadway are desirable. Use C-D roads for weaving between closely spaced ramps when adjacent to high speed highways. C-D roads are not required for weaving on low speed roads.

940.07 Ramp Terminal Intersections at Crossroads

Design ramp terminal intersections at grade with crossroads as intersections at grade. (See Chapter 910.) Whenever possible, design ramp terminals to discourage wrong way movements. Review the location of ramp intersections at grade with crossroads to ensure signal progression if the intersection becomes signalized in the future. Provide intersection sight distance as described in Chapter 910.

In urban and suburban areas, match design speed at the ramp terminal to the speed of the crossroad. Provide steeper intersection angles between the ramp terminal and crossroad to slow motor vehicle traffic speeds and reduce crossing distances for bicyclists and pedestrians.

The intersection configuration requirements for ramp terminals is normally the same as for other intersections. One exception to this is an angle point is allowed between an off ramp and an on ramp. This is because the through movement of traffic getting off the freeway, going through the intersection, and back on the freeway is minor.

Another exception is at ramp terminals where the through movement is eliminated (for example at a Single Point interchange). For ramp terminals that have two wye connections, one for right turns and the other for left turns and no through movement, the intersection angle has little meaning and does not need to be considered.

940.08 Interchanges on Two-Lane Highways

Occasionally, the first stage of a conventional interchange will be built with only one direction of the main roadway and operated as a two-lane two-way roadway until the ultimate roadway is constructed.

The design of interchanges on two-lane two-way highways may vary considerably from traditional concepts due to the following conditions:

- The potential for center-line-crossing related accidents due to merge conflicts or motorist confusion.
- The potential for wrong way or U-turn movements.
- Future construction considerations.
- Traffic type and volume.
- The proximity to multilane highway sections that might influence the driver's impression that these roads are also multilane.

The deceleration taper is required for all exit conditions. Design the entering connection with either the normal acceleration taper or a "button hook" type configuration with a stop condition before entering the main line. Consider the following items:

- Design the stop condition connection in accordance with the requirements for a Tee intersection in Chapter 910. Use this type of connection only when an acceleration lane is not possible. Provide decision sight distance as described in Chapter 650.
- Since each design will probably vary from project to project, analyze each project for most efficient signing placement such as one way, two way, no passing, do not enter, directional arrows, guide posts, and traffic buttons.
- Prohibit passing through the interchange area on two lane highways by means of signing, pavement marking, or a combination of both. A 4 ft median island highlighted with raised pavement markers and diagonal stripes is the preferred treatment. When using a 4 ft median system, extend the island 500 ft beyond any merging ramp traffic acceleration taper. The width for the median can be provided by reducing each shoulder 2 ft through the interchange. (See Figure 940-16.)
- Inform both the entering and through motorists of the two-lane two-way characteristic of the main line. Include signing and pavement markings.
- Use as much of the ultimate roadway as possible. Where this is not possible, leave the area for future lanes and roadway ungraded.
- Design and construct temporary ramps as if they were permanent unless second stage construction is planned to rapidly follow the first. In all cases, design the connection to meet the safety needs of the traffic. (See Figure 940-16.)

940.09 Interchange Plans

Figure 940-17 is a sample showing the general format and data required for interchange design plans.

Compass directions (W-S Ramp) or crossroad names (E-C Street) may be used for ramp designation to realize the most clarity for each particular interchange configuration and circumstance.

Include the following as applicable:

- Classes of highway and design speeds for main line and crossroads (Chapter 440).
- Curve data on main line, ramps, and crossroads.
- Numbers of lanes and widths of lanes and shoulders on main line, crossroads, and ramps.

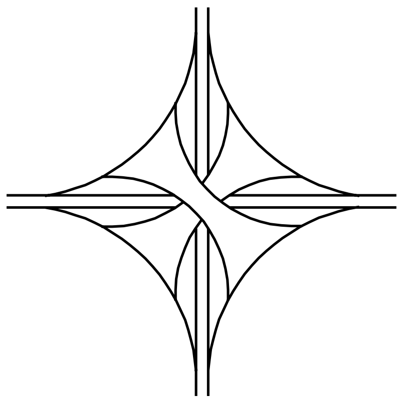
- Superelevation diagrams for the main line, the crossroad, and all ramps (may be submitted on separate sheets).
- Channelization (Chapter 910).
- Stationing of ramp connections and channelization.
- Proposed right of way and access control treatment (Chapters 1410, 1420, and 1430).
- Delineation of all crossroads, existing and realigned (Chapter 910).
- Traffic data necessary to justify the proposed design. Include all movements.
- For HOV direct access connections on the left, include the statement that the connection will be used solely by HOVs or will be closed.

Prepare a preliminary contour grading plan for each completed interchange. Show the desired contours of the completed interchange including details of basic land formation, slopes, graded areas, or other special features. Coordinate the contour grading with the drainage design and the roadside development plan.

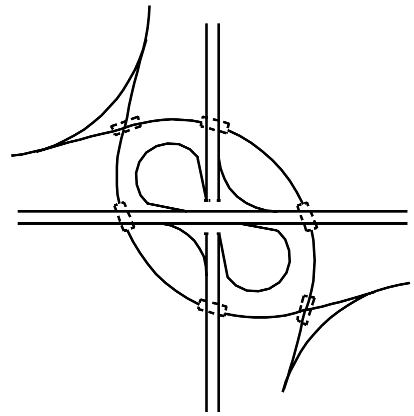
Alternative designs considered, studied, and rejected may be shown as reduced scale diagrams with a brief explanation of the advantages and disadvantages of the alternative designs, including the recommended design.

940.10 Documentation

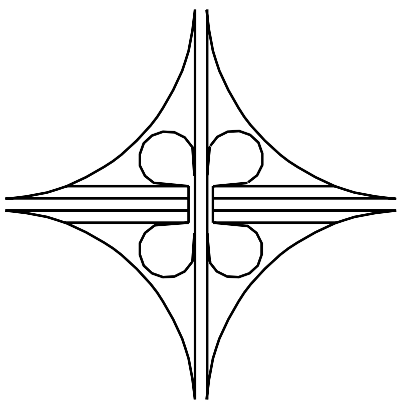
A list of documents that are to be presereved [in the Design Documentation Package (DDP) or the project File (PF) is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/



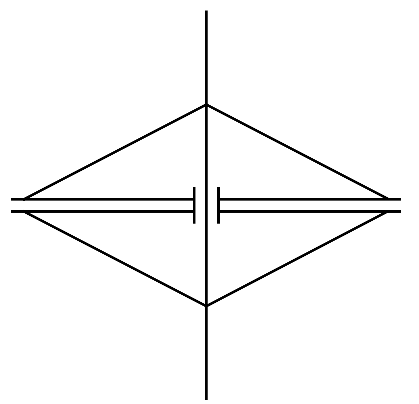
Directional



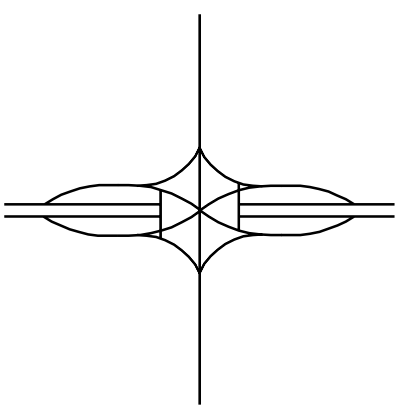
Semidirectional



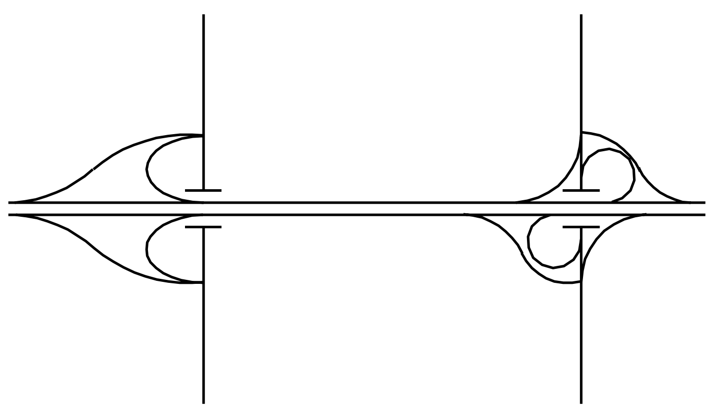
Cloverleaf with C-D Roads



Diamond

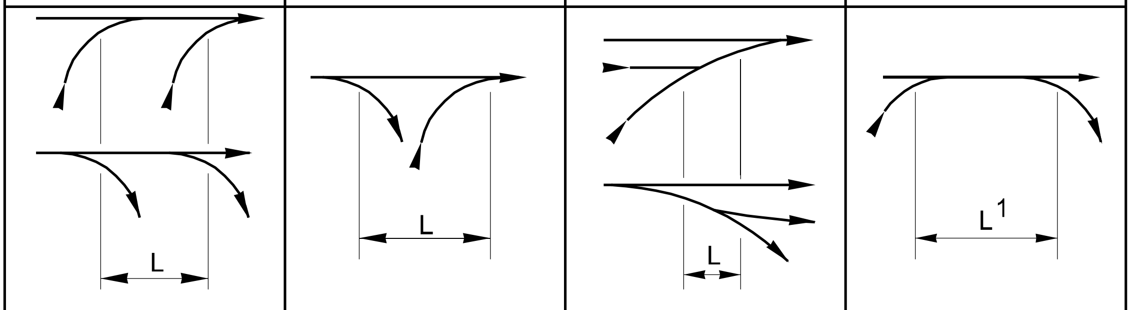


Single Point (Urban)



Partial Cloverleaf

Basic Interchange Patterns
Figure 940-4



On - On or Off - Off		Off - On		Turning Roadways		On - Off (weaving)			
Freeway	C-D Road	Freeway	C-D Road	System Interchange[2]	Service Interchange[3]	A	B	C	D
1000	800	500	400	800	600	2000	1600	1600	1000

L = Minimum distance in feet from nose to nose. The nose is the beginning of the unpaved area within the gore for an exit and the ending of the unpaved area for an entrance.

A Between two interchanges connected to a freeway, a system interchange[2] and a service interchange[3].

B Between two interchanges connected to a C-D road, a system interchange[2] and a service interchange[3].

C Between two interchanges connected to a freeway, both service interchanges[3].

D Between two interchanges connected to a C-D road, both service interchanges[3].

Notes:

These recommendations are based on operational experience, need for flexibility, and adequate signing. Check them in accordance with Figure 940-15 and the procedures outlined in the *Highway Capacity Manual* and use the larger value.

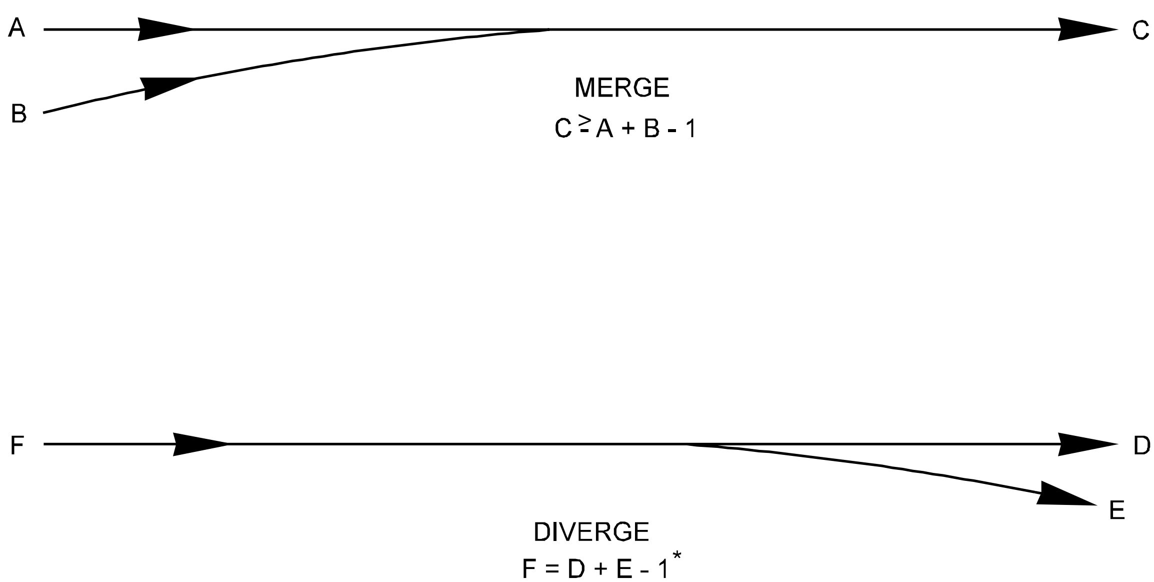
(1) With justification, these values may be reduced for cloverleaf ramps.

(2) A system interchange is a freeway to freeway interchange.

(3) A service interchange is a freeway to local road interchange.

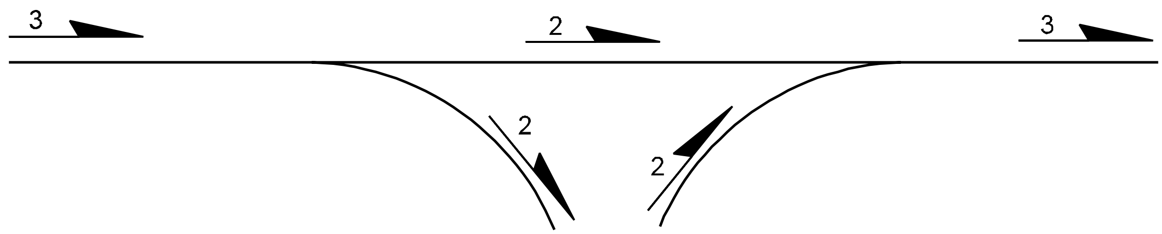
Minimum Ramp <u>Connection</u> Spacing

Figure 940-5

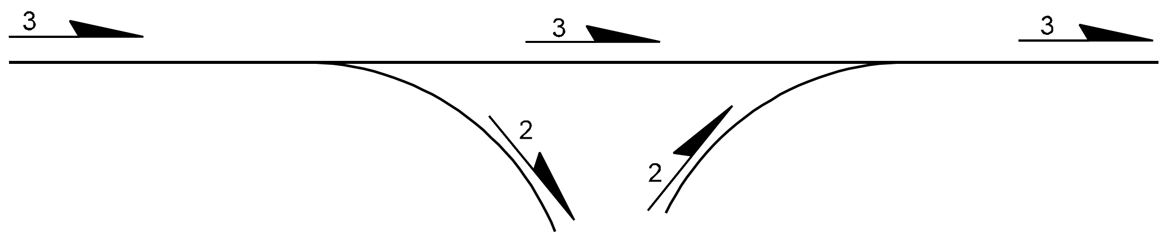


* Number of lanes, F, may be more by one lane only, provided the lane dropped is an auxiliary lane between closely spaced entrance and exit ramps.

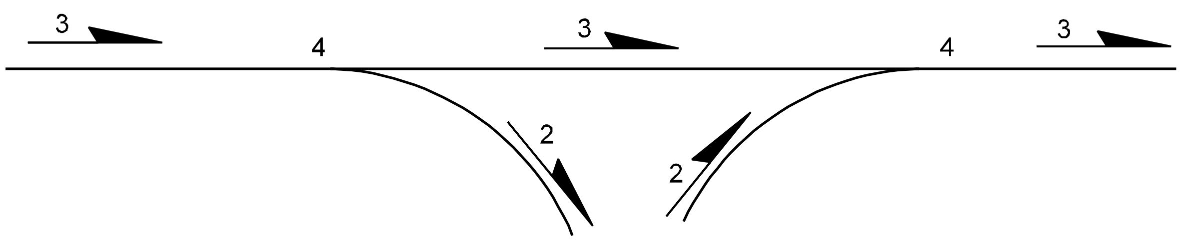
Lane Balance
Figure 940-6a



UNDESIRABLE Lane balance but no compliance with basic number of lanes.

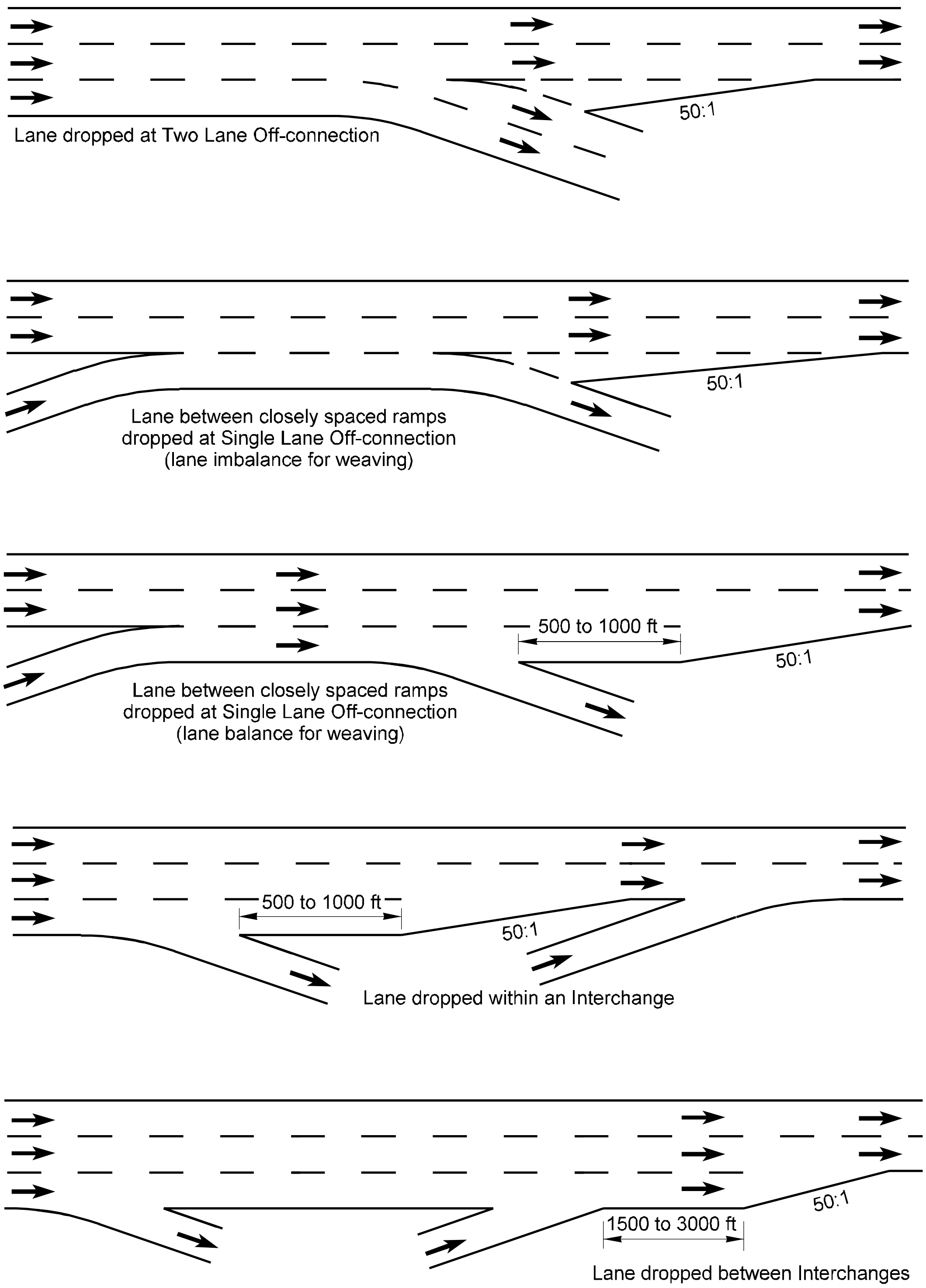


UNDESIRABLE No lane balance but compliance with basic number of lanes.

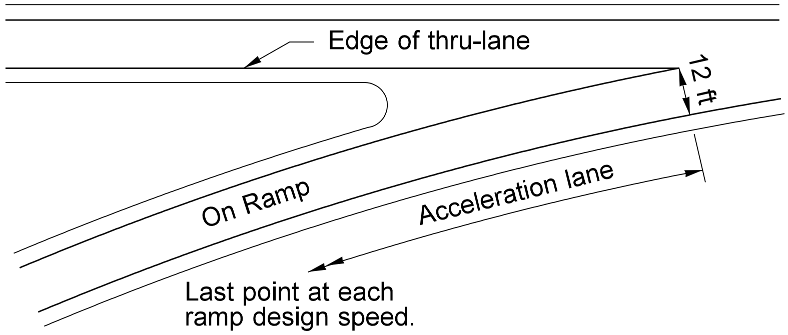


DESIRABLE Compliance with both lane balance and number of lanes.

Lane Balance
Figure 940-6b



Main Line Lane Reduction Alternatives
Figure 940-7



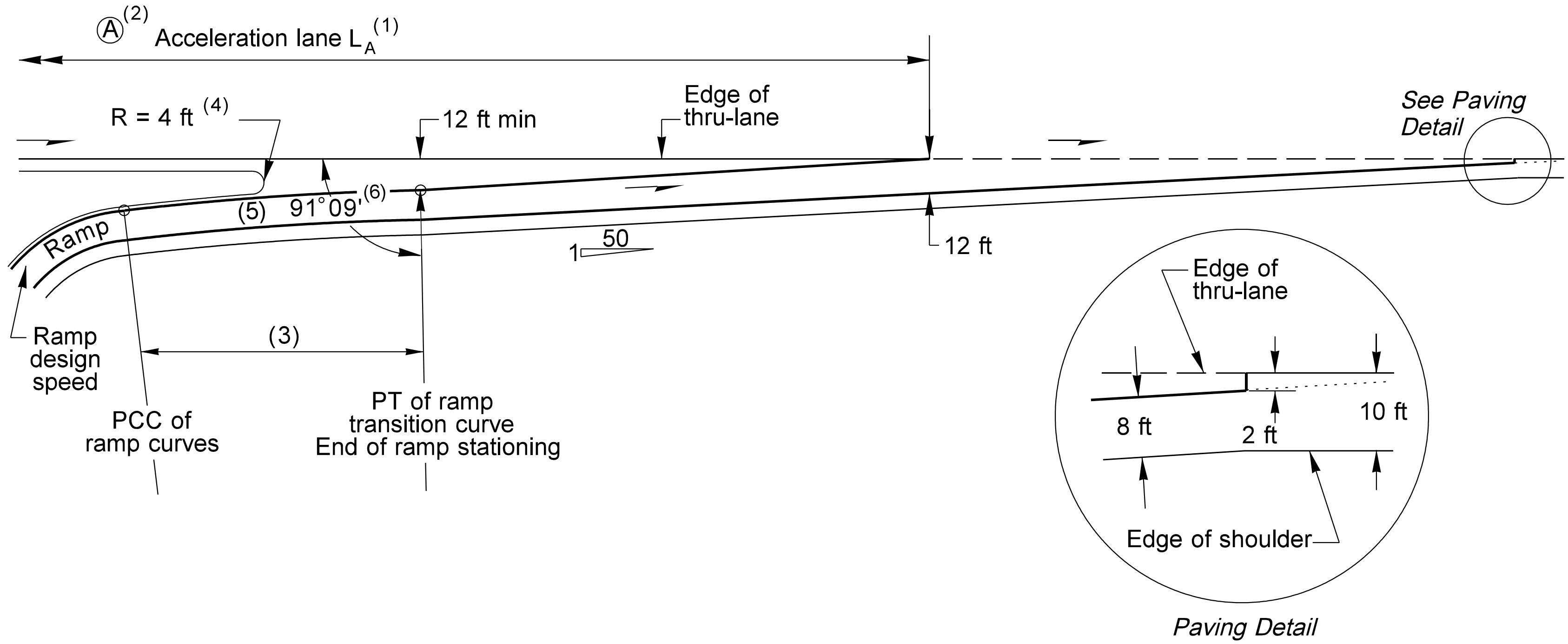
Highway Design Speed (mph)	Ramp Design Speed (mph)										
	0	15	20	25	30	35	40	45	50	60	70
30	180	140									
35	280	220	160								
40	360	300	270	210	120						
45	560	490	440	380	280	160					
50	720	660	610	550	450	350	130				
55	960	900	810	780	670	550	320	150			
60	1200	1140	1100	1020	910	800	550	420	180		
65	1410	1350	1310	1220	1120	1000	770	600	370		
70	1620	1560	1520	1420	1350	1230	1000	820	580	210	
80	2000	1950	1890	1830	1730	1610	1380	1200	970	590	210

Minimum Acceleration Lane Length (ft)

Highway Design Speed (mph)	Grade	Up Grade				Down Grade
		Ramp Design Speed				All Ramp Design Speeds
		20	30	40	50	
40	3% to less than 5%	1.3	1.3			0.70
45		1.3	1.35			0.675
50		1.3	1.4	1.4		0.65
55		1.35	1.45	1.45		0.625
60		1.4	1.5	1.5	1.6	0.60
70		1.5	1.6	1.7	1.8	0.60
40	5% or more	1.5	1.5			0.60
45		1.5	1.6			0.575
50		1.5	1.7	1.9		0.55
55		1.6	1.8	2.05		0.525
60		1.7	1.9	2.2	2.5	0.50
70		2.0	2.2	2.6	3.0	0.50

Adjustment Factors for Grades Greater than 3%

Acceleration Lane Length
Figure 940-8



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point A is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line.

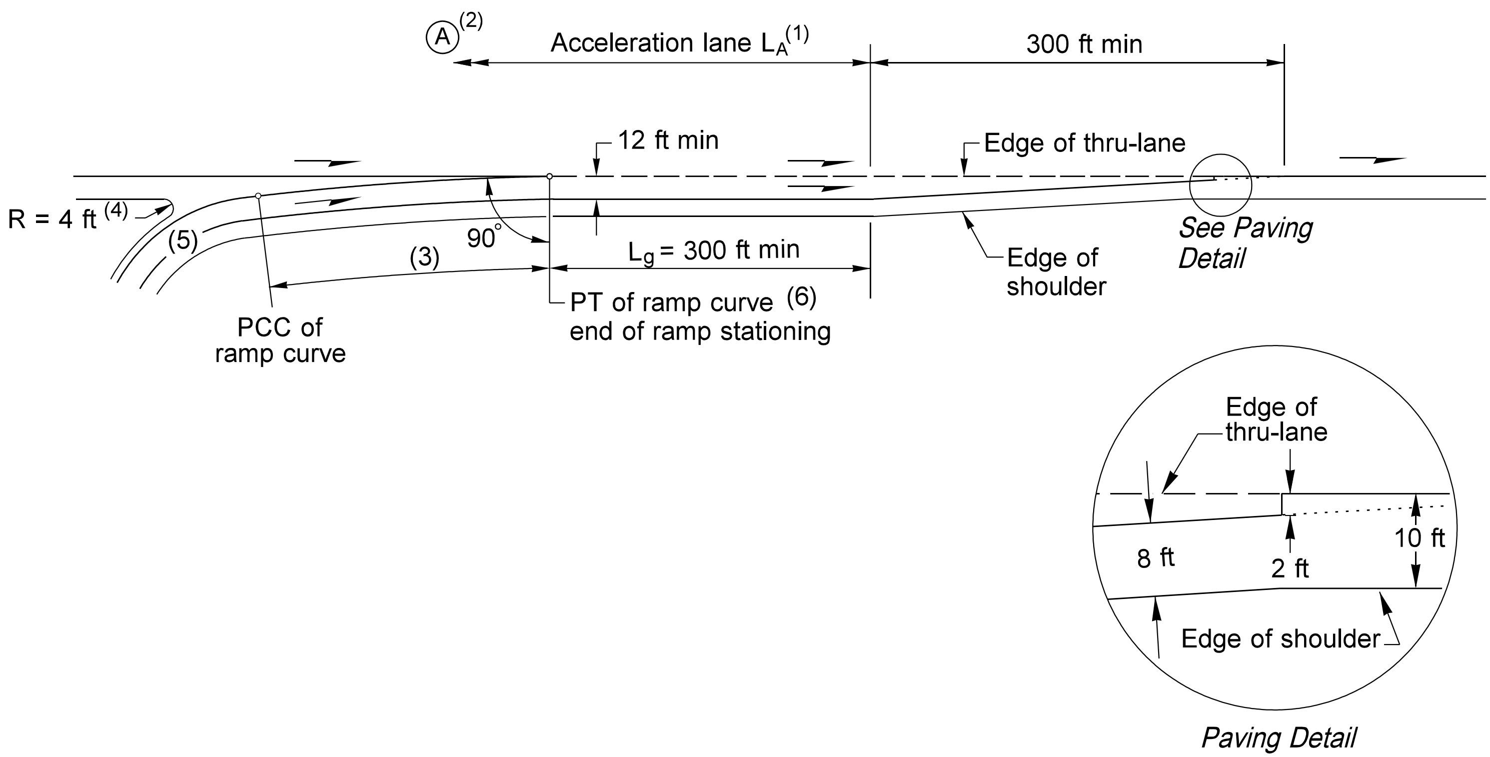
(4) Radius may be reduced when concrete barrier is placed between the ramp and main line.

(5) For ramp lane and shoulder widths, see Figure 940-3.

(6) Approximate angle to establish ramp alignment.

(7) For Striping, see the Standard Plans.

On-Connection (Single-Lane, Taper Type)
Figure 940-9a



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point Ⓐ is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line. <u>The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.</u>

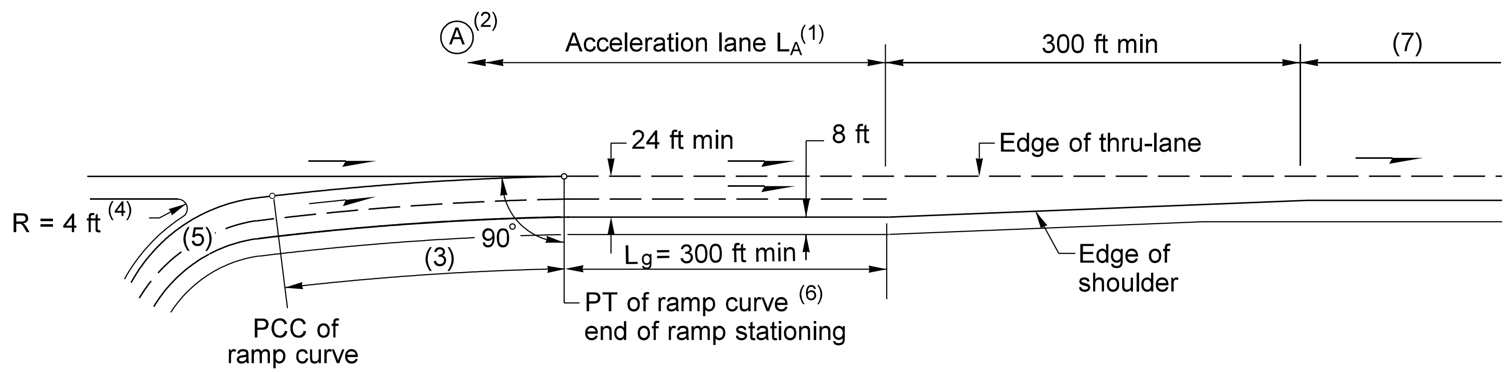
(4) <u>Radius may be reduced when concrete barrier is placed between the ramp and main line.</u>

(5) For ramp lane and shoulder widths, see Figure 940-3.

(6) <u>Ramp stationing may be extended to accommodate superelevation transition.</u>

(7) For striping, see the Standard Plans.

On-Connection (Single-Lane, Parallel Type)
Figure 940-9b



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point Ⓐ is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line. <u>The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.</u>

(4) <u>Radius may be reduced when concrete barrier is placed between the ramp and main line.</u>

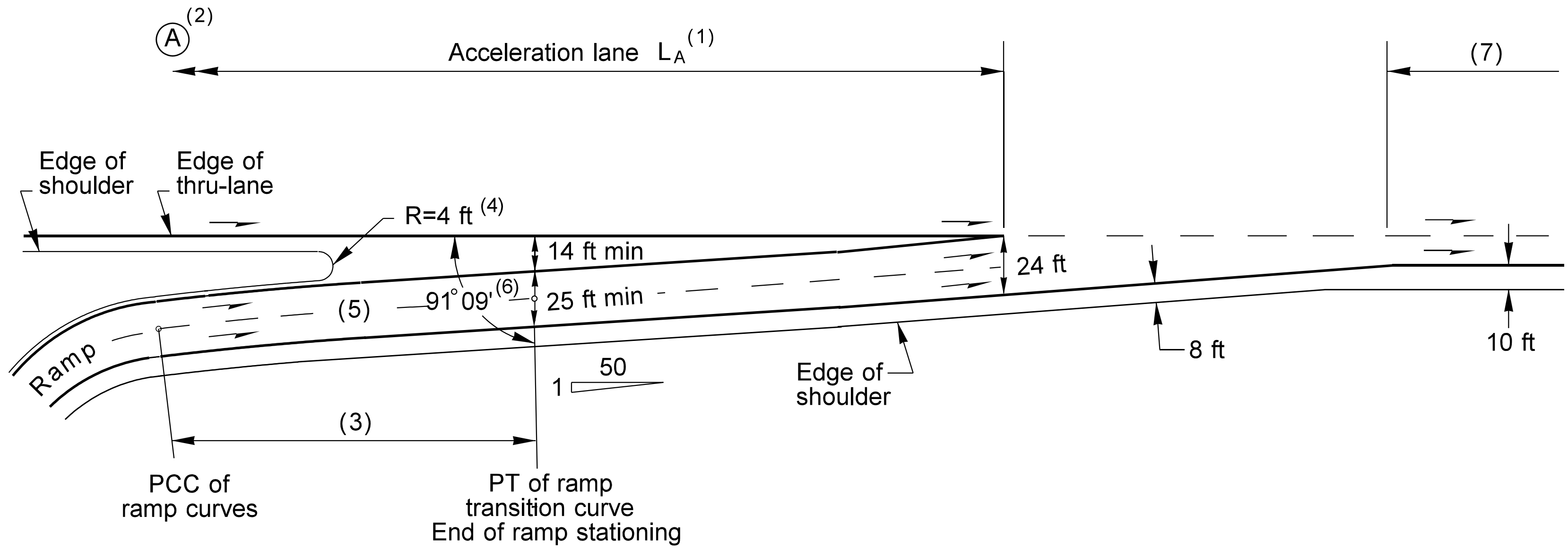
(5) For ramp lane and shoulder widths, see figure 940-3.

(6) <u>Ramp stationing may be extended to accommodate superelevation transition.</u>

(7) Added lane or 1,500 ft auxiliary lane plus 600 ft taper.

(8) For striping, see the Standard Plans.

On-Connection (Two-Lane, Parallel Type)
Figure 940-9c



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point Ⓐ is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line.

(4) <u>Radius may be reduced when concrete barrier is placed between the ramp and main line.</u>

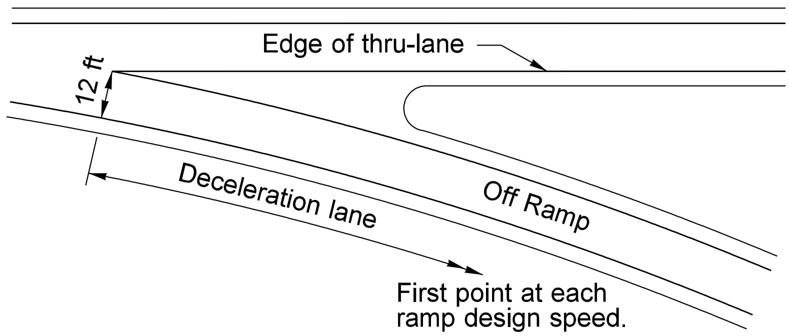
(5) For ramp lane and shoulder widths, see figure 940-3.

(6) Approximate angle to establish ramp alignment.

(7) Added lane or 1,500 ft auxiliary lane plus 600 ft taper.

(8) For striping, see the Standard Plans.

On-Connection (Two-Lane, Taper Type)
Figure 940-9d



Highway Design Speed (mph)	Ramp Design Speed (mph)										
	0	15	20	25	30	35	40	45	50	60	70
30	235	200	170	140							
35	280	250	210	185	150						
40	320	295	265	235	185	155					
45	385	350	325	295	250	220	155				
50	435	405	385	355	315	285	225	175			
55	480	455	440	410	380	350	285	235	180		
60	530	500	480	460	430	405	350	300	240		
65	570	540	520	500	470	440	390	340	280	185	
70	615	590	570	550	520	490	440	390	340	240	
80	735	710	690	670	640	610	555	510	465	360	265

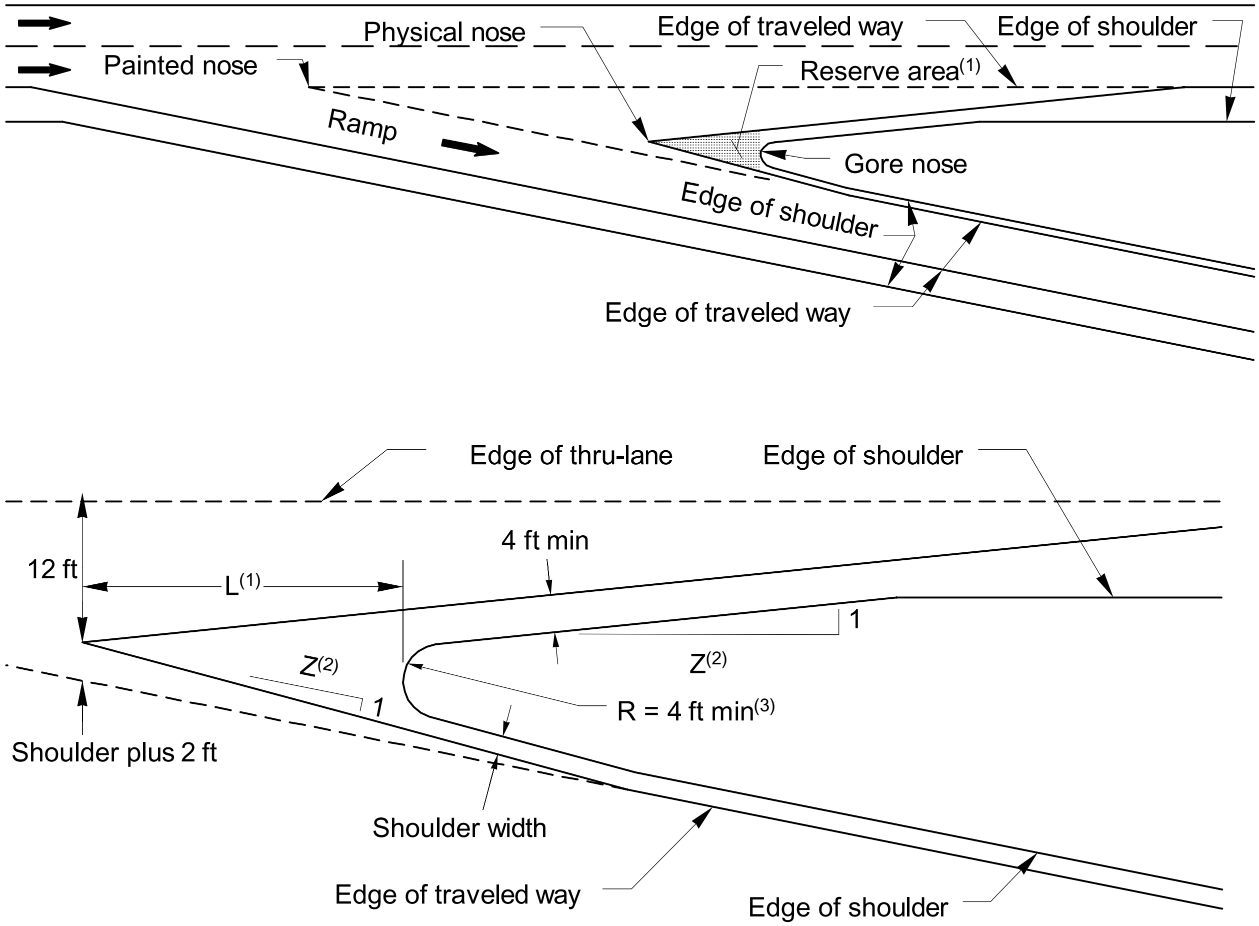
Minimum Deceleration Length (ft)

Grade	Up Grade	Down Grade
3% to less than 5%	0.9	1.2
5% or more	0.8	1.35

Adjustment Factors for Grades Greater than 3%

Deceleration Lane length

Figure 940-10



Notes:

(1) The reserve area length (L) is not less than:

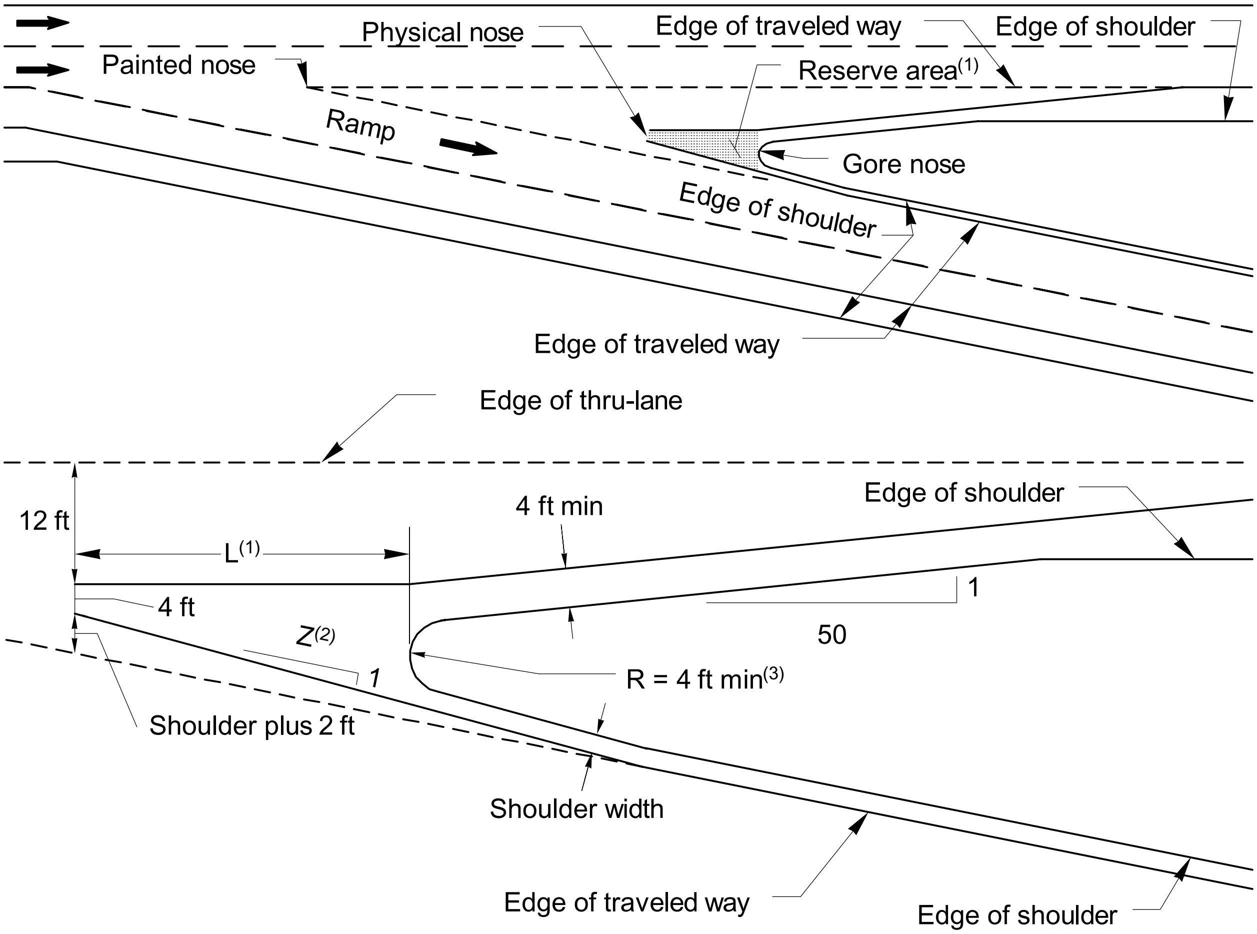
Main Line Design Speed (mph)	40	45	50	55	60	65	70	80
L (ft)	25	30	35	40	45	50	55	70

(2) $Z = \frac{\text{Design Speed}}{2}$, Design speed is for the main line.

(3) R may be reduced, when protected by an impact attenuator.

Gore Area Characteristics

Figure 940-11a



Notes:

(1) The reserve area length (L) is not less than:

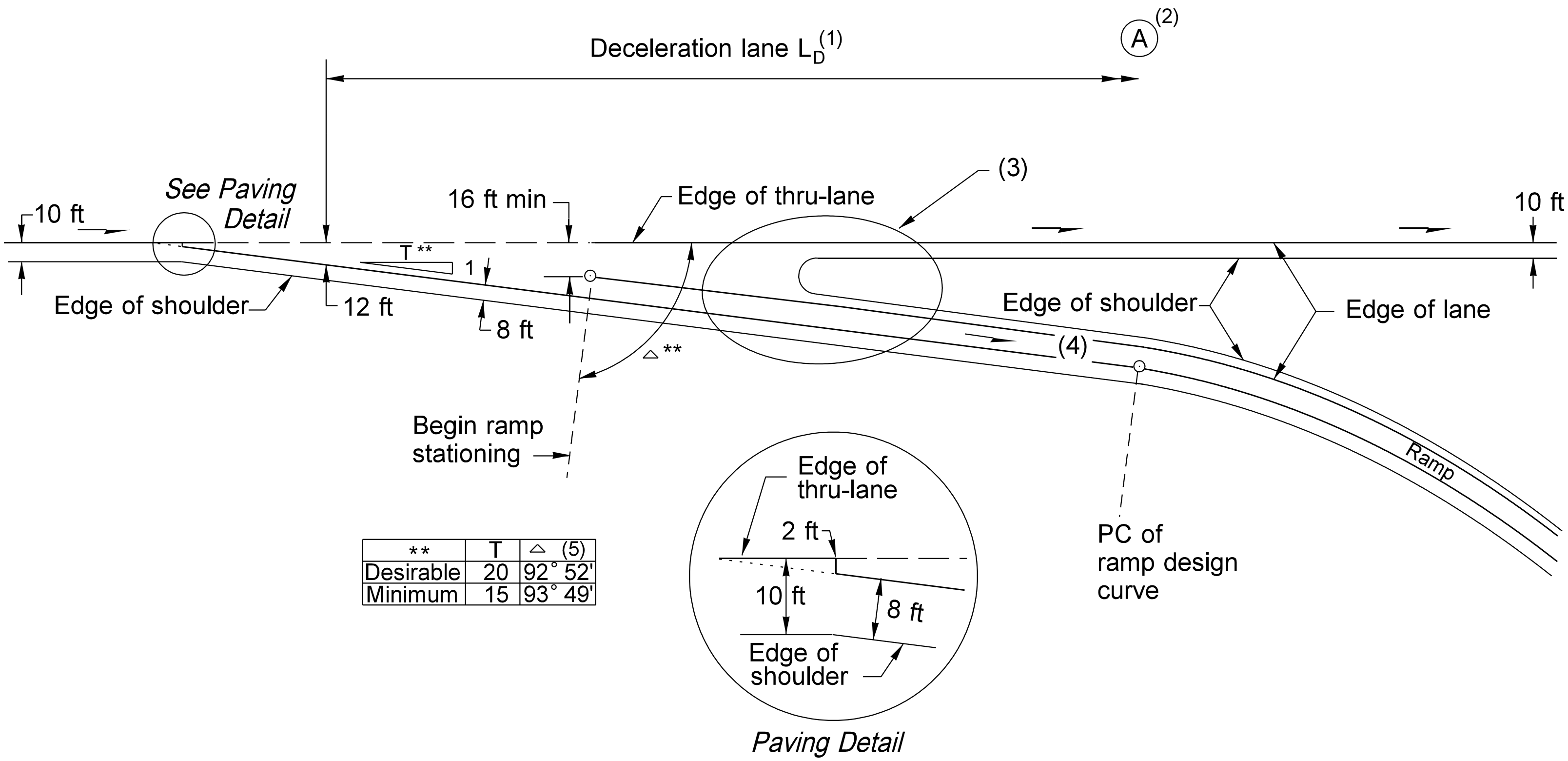
Main Line Design Speed (mph)	40	45	50	55	60	65	70	80
L (ft)	25	30	35	40	45	50	55	70

(2) $Z = \frac{\text{Design Speed}}{2}$, Design speed is for the main line.

(3) R may be reduced, when protected by an impact attenuator.

Gore Area Characteristics

Figure 940-11b



**	T	△ (5)
Desirable	20	92° 52'
Minimum	15	93° 49'

Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point (A) is the point controlling the ramp design speed.

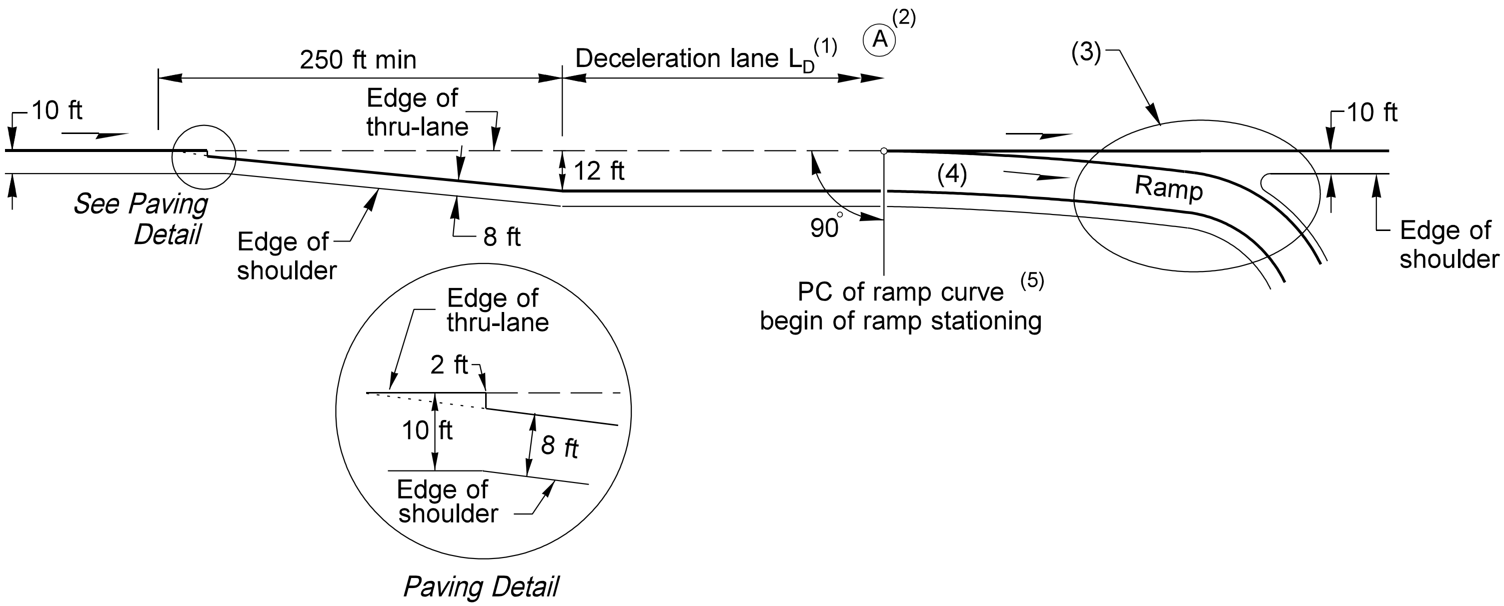
(3) <u>See Figure 940-11a for gore details.</u>

(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) Approximate angle to establish ramp alignment.

(6) For striping, see the Standard Plans.

Off-Connection (Single-Lane, Taper Type)
Figure 940-12a



Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point (A) is the point controlling the ramp design speed.

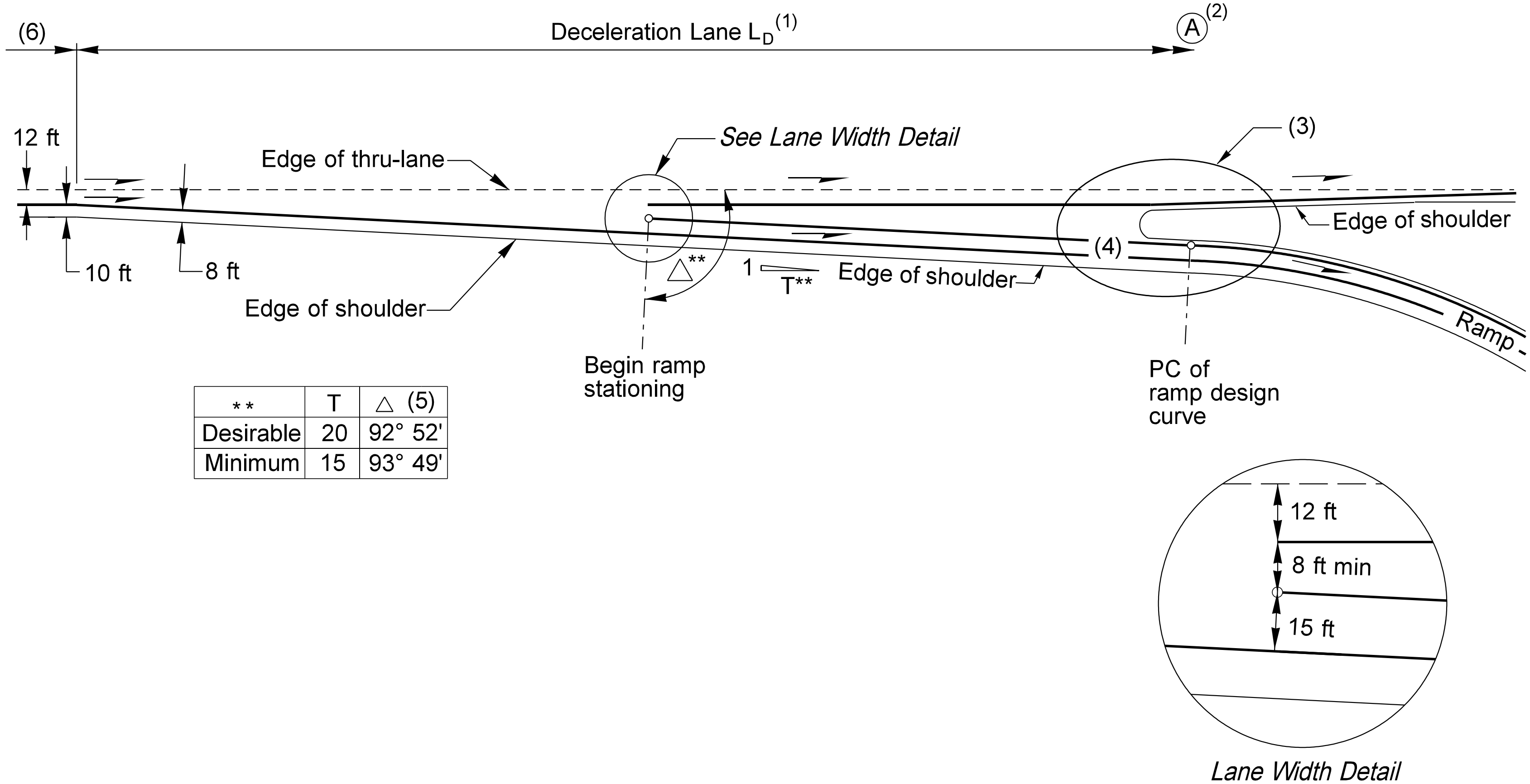
(3) <u>See Figure 940-11a for gore details.</u>

(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) <u>Ramp Stationing may be extended to accommodate superelevation transition.</u>

(6) For striping, see the Standard Plans.

Off-Connection (Single-Lane, Parallel Type)
Figure 940-12b



**	T	△ (5)
Desirable	20	92° 52'
Minimum	15	93° 49'

Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point Ⓐ is the point controlling the ramp design speed.

(3) See Figure 940-11b for gore details.

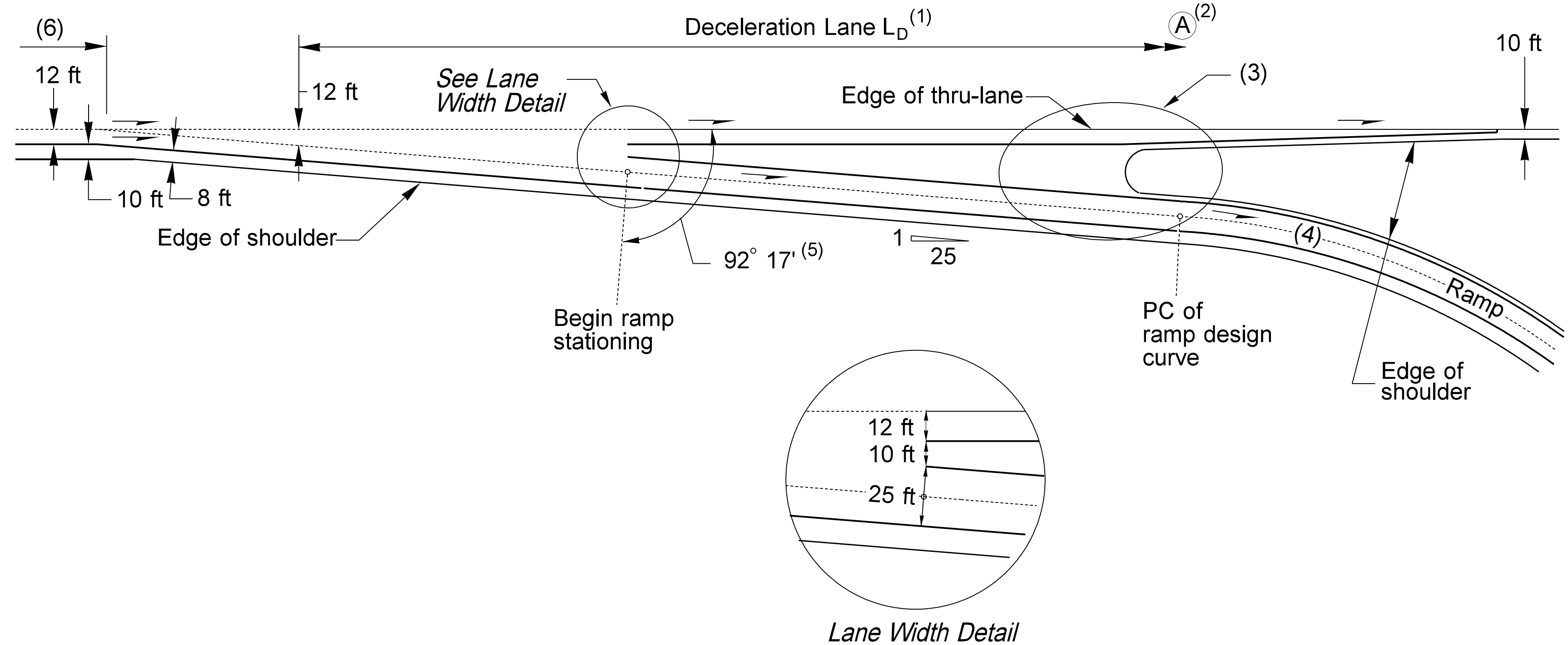
(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) Approximate angle to establish ramp alignment.

(6) Auxiliary lane between closely spaced interchanges to be dropped.

(7) For striping, see the Standard Plans.

Off-Connection (Single-Lane, One-Lane Reduction)
Figure 940-12c



Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point Ⓐ is the point controlling the ramp design speed.

(3) See Figure 940-11b for gore details.

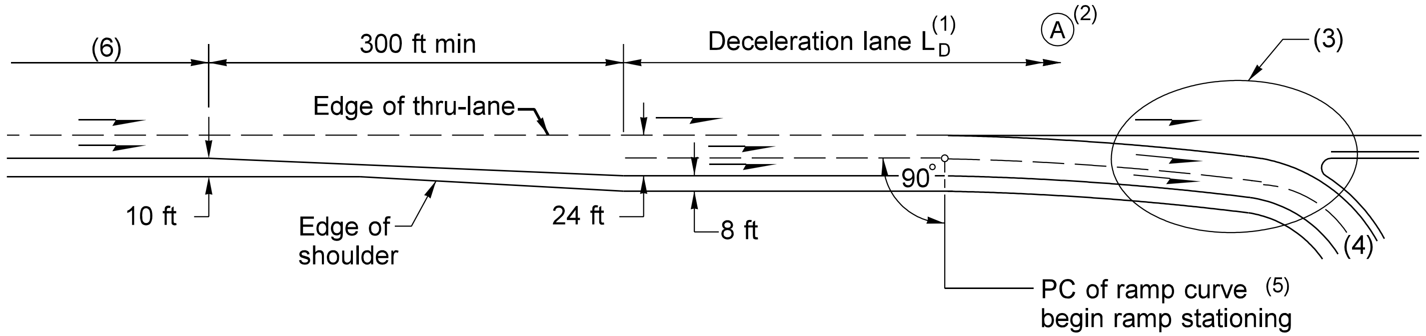
(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) Approximate angle to establish ramp alignment.

(6) Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300 ft taper.

(7) For striping, see the Standard Plans.

Off-Connection (Two-Lane, Taper Type)
Figure 940-12d



Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point A is the point controlling the ramp design speed.

(3) See Figure 940-11b for gore details.

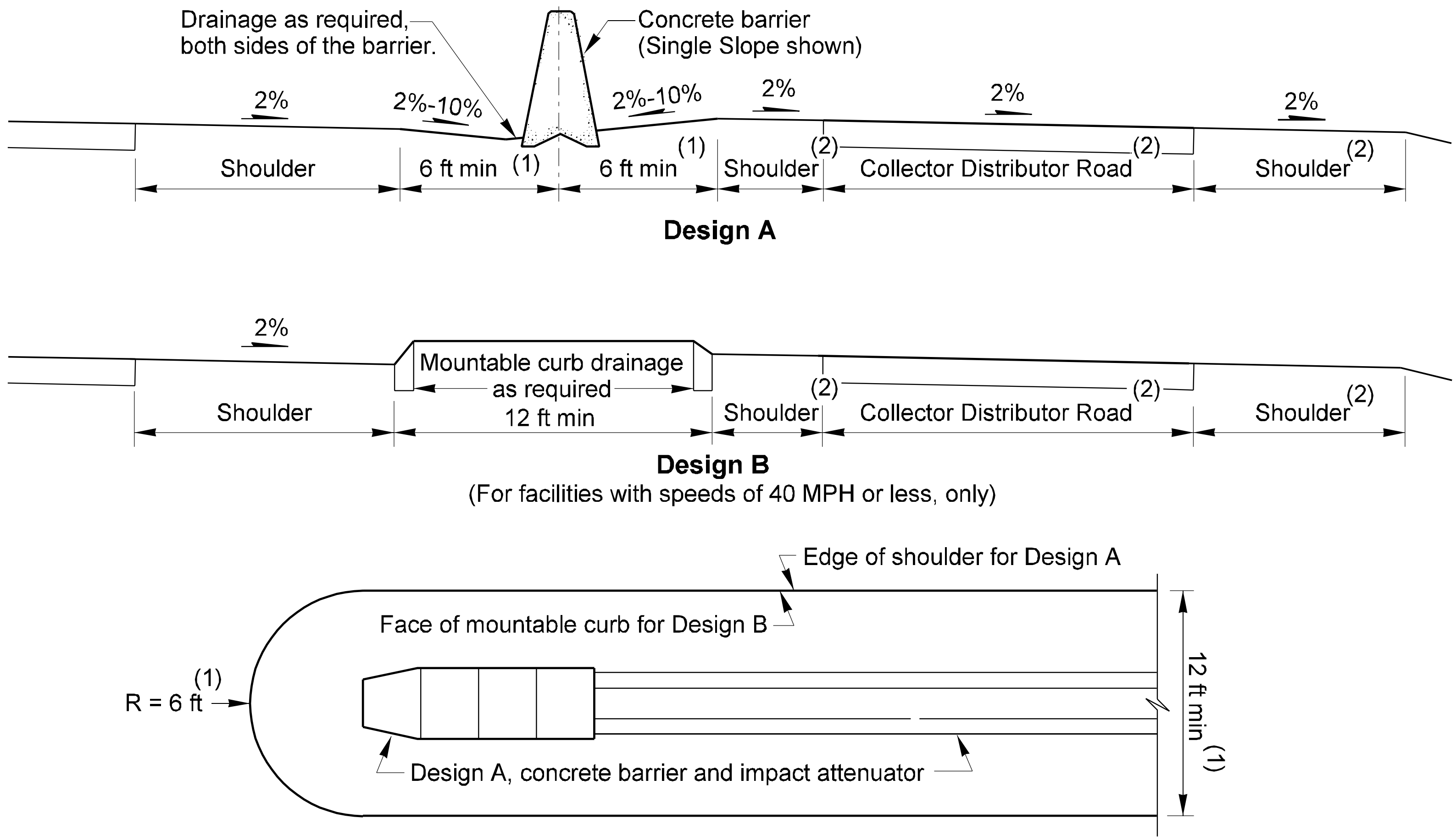
(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) Ramp stationing may be extended to accommodate superelevation transition.

(6) Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300 ft taper.

(7) For striping, see the Standard Plans.

Off-Connection (Two-Lane, Parallel Type)
Figure 940-12e

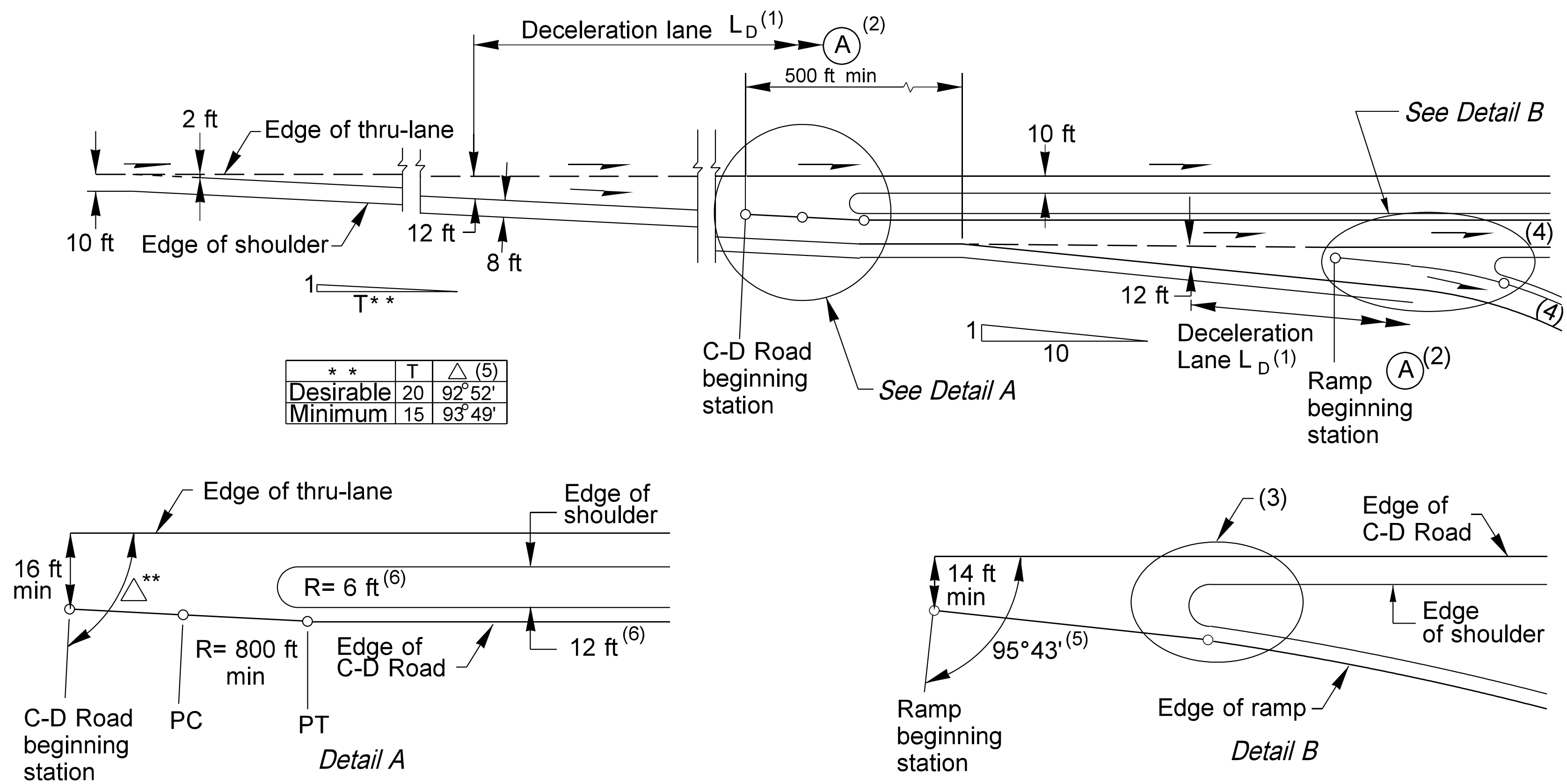


Notes:

(1) With justification, the concrete barrier may be placed with 2 ft <u>between</u> the edge of either shoulder <u>and</u> the face of barrier. The minimum width between the edge of through-shoulder and the edge of C-D road shoulder will be reduced to 6 ft, and the radius at the nose will be reduced to 3 ft.

(2) For collector distributor road lane and shoulder widths, see ramp lane and shoulder widths, Figure 940-3.

Collector Distributor (Outer Separations)
Figure 940-13a



* *	T	△ (5)
Desirable	20	92°52'
Minimum	15	93°49'

Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point (A) is the point controlling the C-D road or ramp design speed.

(3) See Figure 940-11a for gore details.

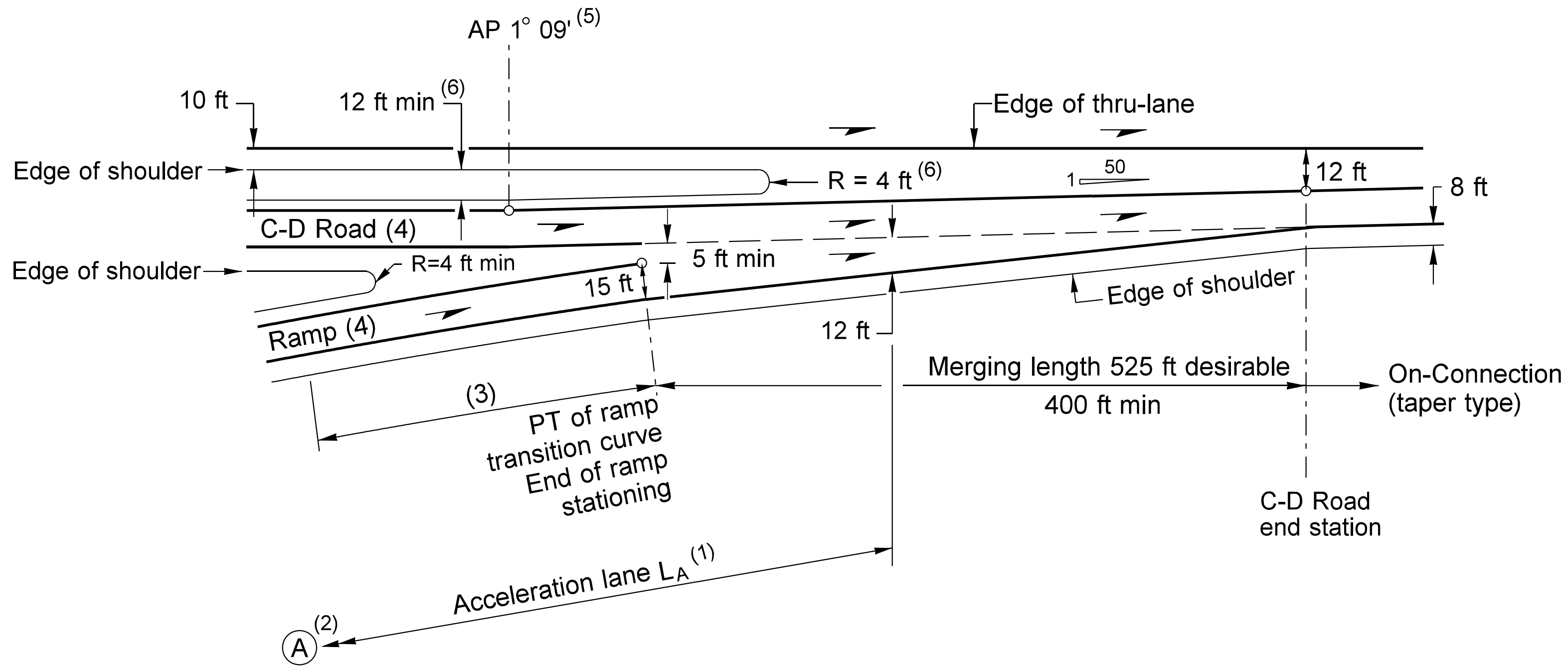
(4) For C-D road and ramp lane and shoulder widths, see Figure 940-3.

(5) Approximate angle to establish alignment.

(6) May be reduced with justification. (See Figure 940-13a.)

(7) For striping, see the Standard Plans.

Collector Distributor (Off-Connections)
Figure 940-13b



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point Ⓐ is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the C-D road is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the C-D road.

(4) For C-D road and ramp lane and shoulder widths, see Figure 940-3.

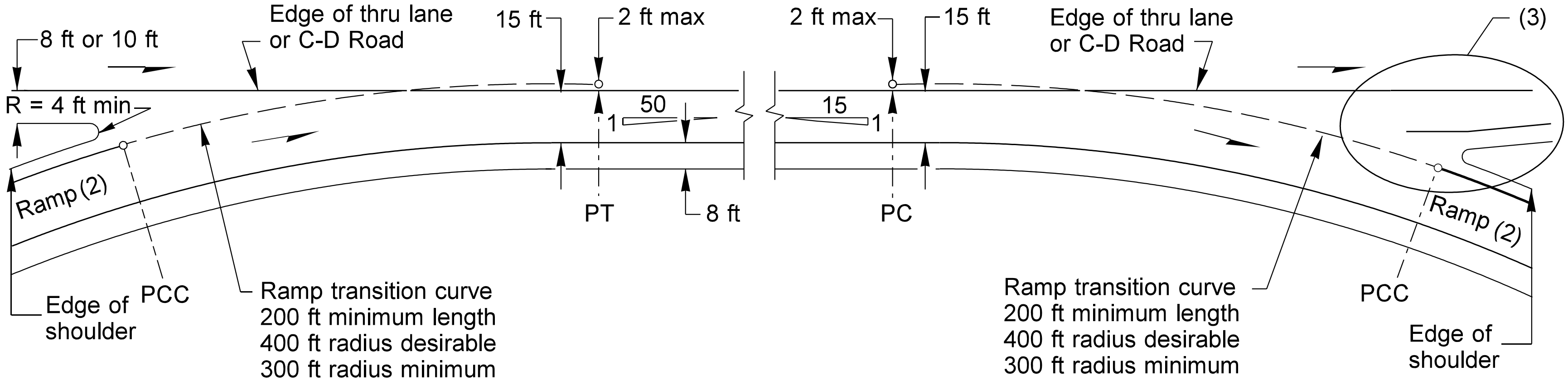
(5) Approximate angle to establish alignment.

(6) May be reduced with justification. (See Figure 940-13a.)

(7) For striping, see the Standard Plans.

Collector Distributor (On-Connections)

Figure 940-13c



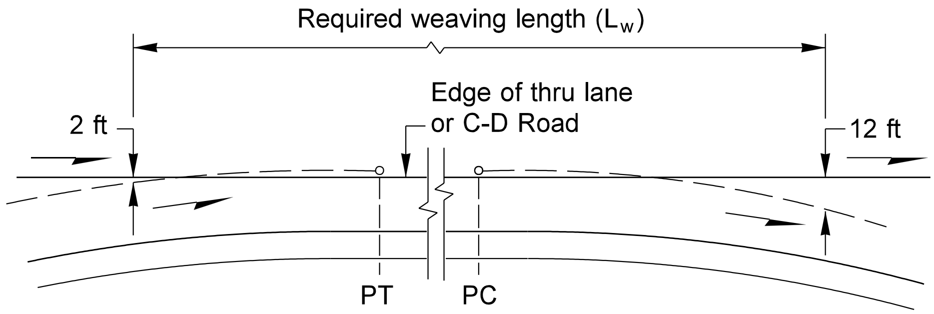
Notes:

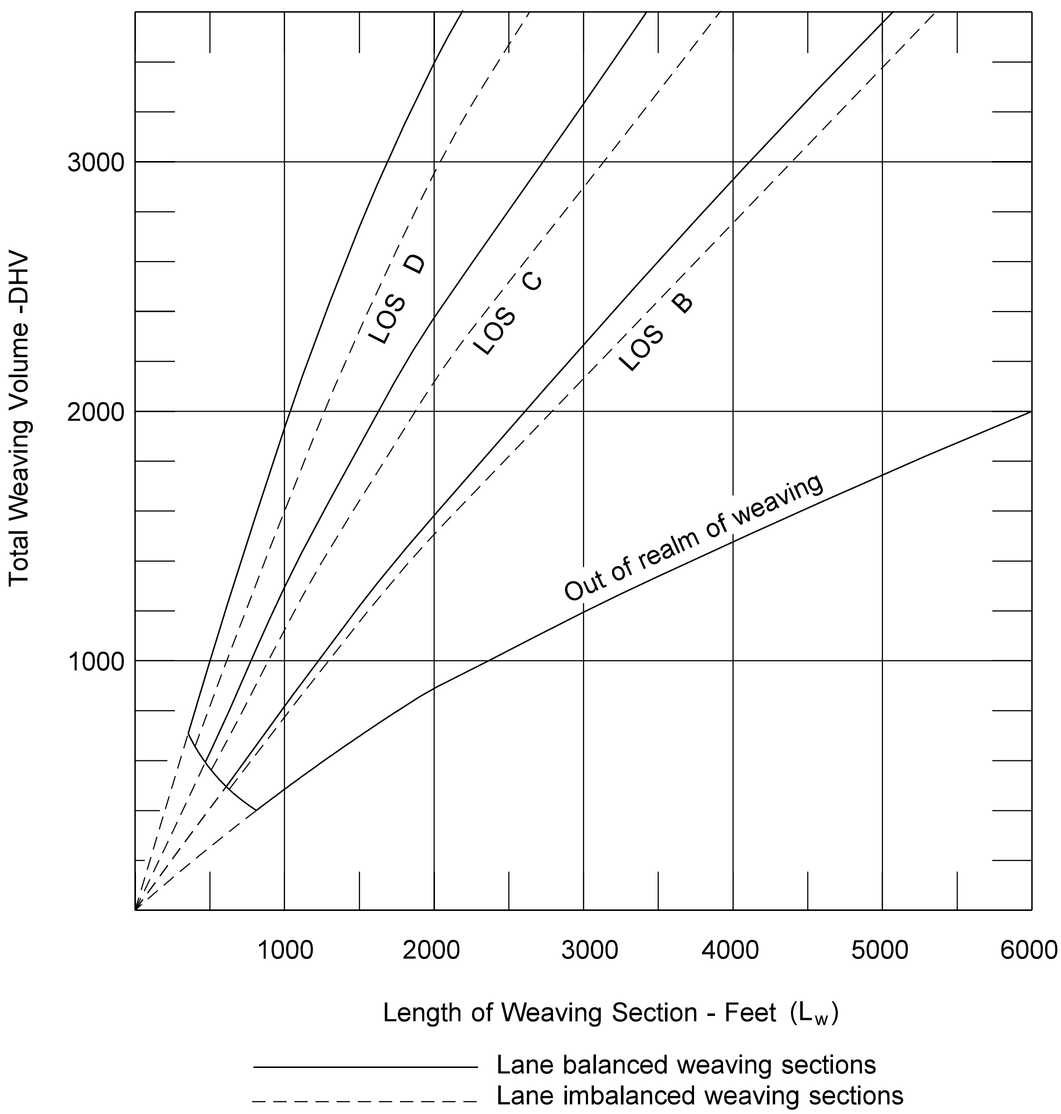
(1) See Figure 940-15 for required minimum weaving length.

(2) For minimum ramp lane and shoulder widths, see Figure 940-3.

(3) <u>See Figure 940-11b for gore details.</u>

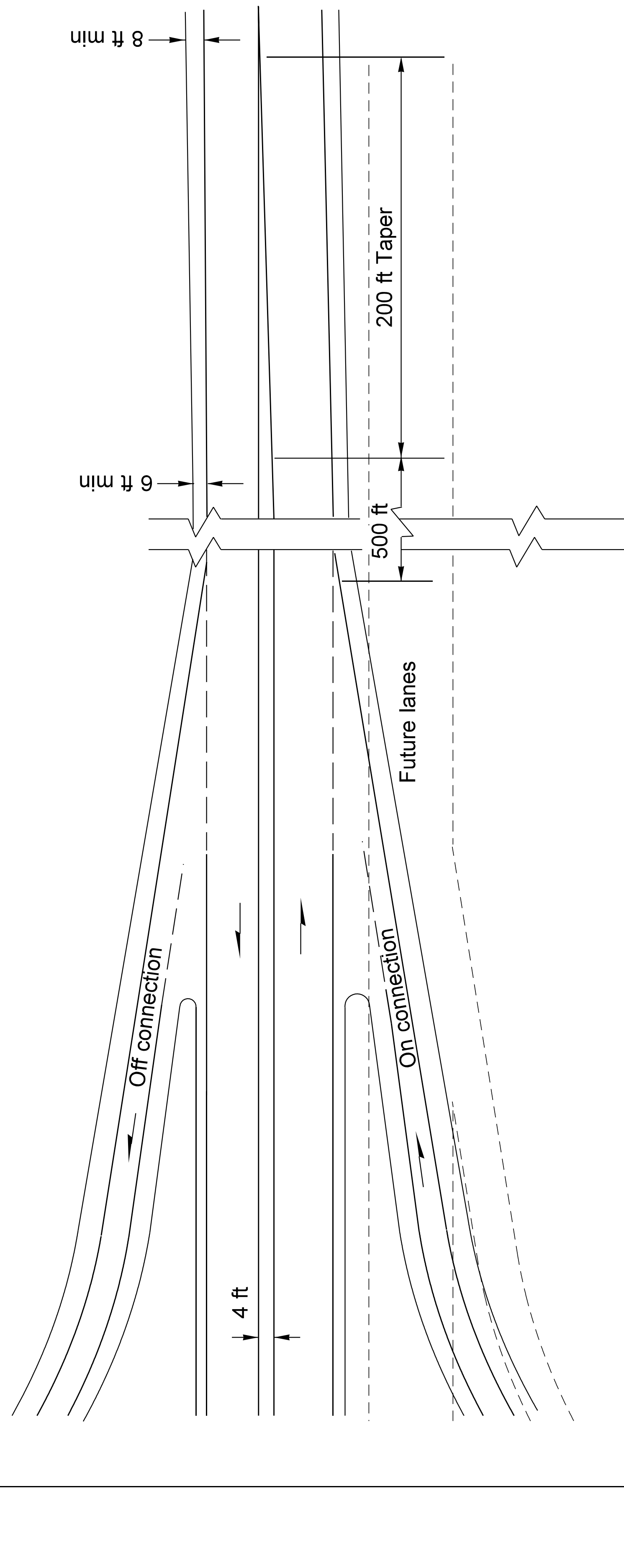
Loop Ramps Connections
Figure 940-14



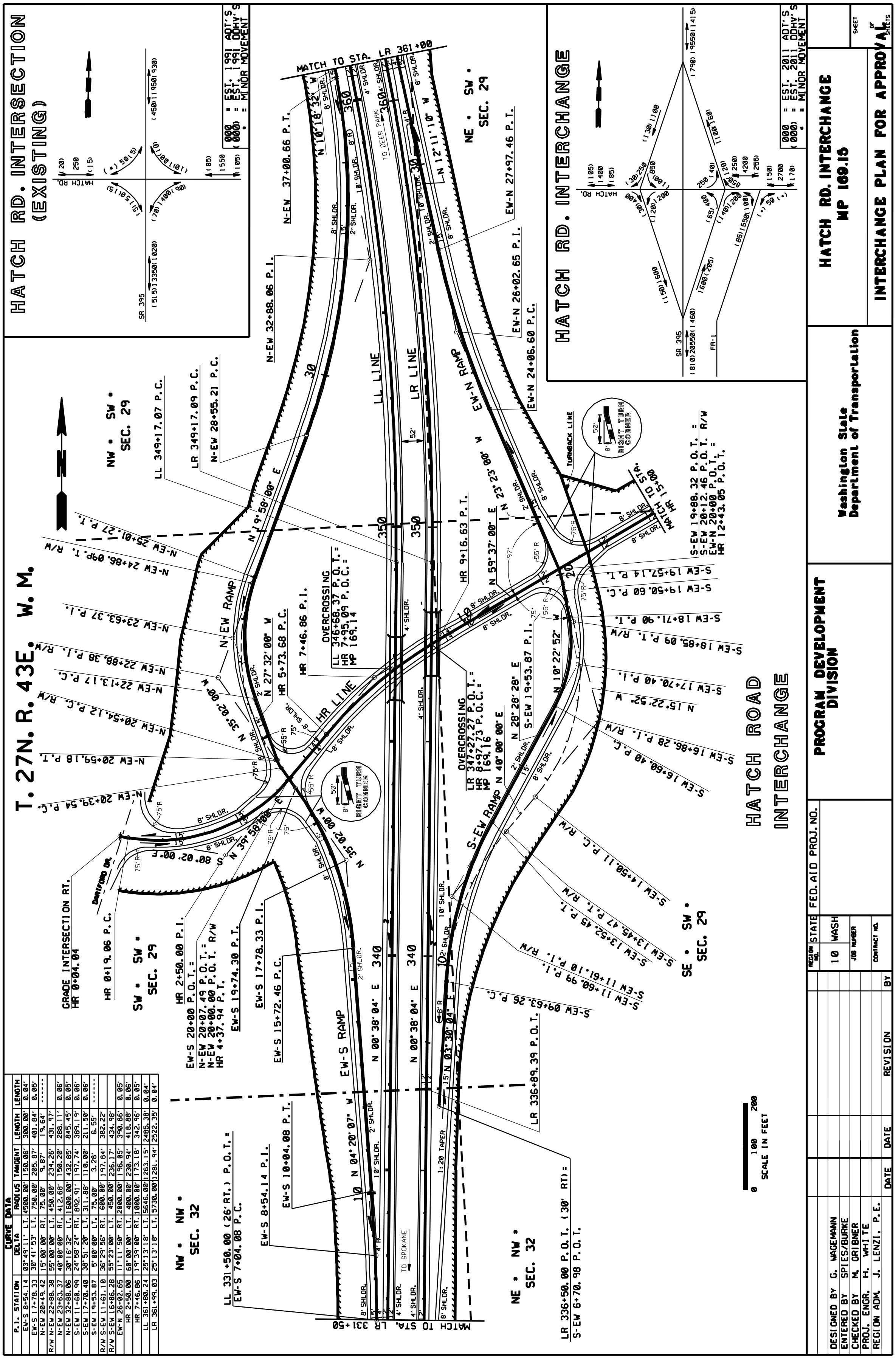


See Figure 940-7 to determine
whether or not lane balance exists

Length of Weaving Sections
Figure 940-15



Temporary Ramps
Figure 940-16



Interchange Plan
Figure 940-17

Chapter 960 Median Crossovers

960.01 General

Median crossovers are provided at selected locations on divided highways for crossing by maintenance, traffic service, emergency, and law enforcement vehicles. Crossovers may be provided:

- Where they appear on the master plan of crossovers for the corridor
- Where analysis demonstrates that access through interchanges or intersections is not practical
- As part of a law-enforcement plan

This chapter provides guidance for locating and designing median openings not located at an intersection and for which use is restricted to maintenance, traffic service, emergency, and law enforcement vehicles. For median openings to provide unrestricted U-turns to allow public access to both sides of the roadway, see Chapter 910, Intersections At Grade.

960.02 Analysis

A list of existing and preapproved median crossovers is available from the HQ Transportation Data Office of Strategic Planning and Programming.

Two general categories of vehicles are recognized as legitimate users of median crossovers. One category is law enforcement vehicles and the other is governmental services vehicles (emergency, traffic service, and maintenance vehicles).

In an urban area with a high occupancy vehicle lane adjacent to the median, crossovers may be used in conjunction with law enforcement observation points, and downstream enforcement (widened shoulder) areas, as part of the law enforcement plan.

In other urban areas and in rural areas, crossovers may be necessary to a law enforcement plan.

A crossover that is primarily for governmental service vehicles may be justified on the basis that access through interchanges or intersections is not practical. In urban areas where there are 3 or more miles between access points, providing an unobtrusive crossover may improve emergency service or improve efficiency for traffic service and maintenance forces.

Locate rural crossovers 3 or more miles from an interchange.

Where crossovers are justified and used for winter maintenance operations such as snow and ice removal, the interchange or intersection spacing rule does not apply and the distance from the ramp merge or diverge points may be decreased to a 500-ft minimum with 1,000 ft the desirable minimum.

Minimize visibility of the crossover to the traveling public.

960.03 Design

Consider the following design criteria for all median crossovers. However, taking into consideration the intended vehicle usage, some of the criteria may not apply to crossovers intended primarily for enforcement.

- Adequate median width at the crossover location is required to allow the design vehicle to complete a U-turn maneuver without encroaching within 8 ft of the traffic lanes, and without backing. The common design vehicles for this determination are a passenger car and a single unit truck depending upon the intended use of the crossover. Generally the minimum recommended median width is 40 ft.
- Use grades and radii that are suitable for all authorized user vehicles.

- Provide adequate inside shoulders to allow vehicle deceleration and acceleration to occur off the traffic lanes. Ten-foot inside shoulders are adequate for most cases. Provide full 10-foot shoulders for a distance of 450 ft upstream of the crossover area to accommodate deceleration, and extend downstream of the crossover area for a distance of 600 ft to allow acceleration prior to entering the traffic lane.
- Provide adequate stopping sight distance for vehicles approaching the crossover area. Because of the unexpected maneuvers associated with these inside access points and higher operating speeds commonly experienced in the inside traffic lanes, use conservative values for stopping sight distance. (See the Roadside Classification Plan.)
- Use side slopes of the crossing no steeper than 10H:1V. Grade for a relatively flat and gently contoured appearance that is inconspicuous to the public.
- Do not use curbs or pavement markings.
- Flexible guide posts may be provided for night reference. (See the Standard Plans.)
- Consider the terrain and locate the crossover to minimize visibility to the public.
- Vegetation may be used to minimize visibility. Low vegetation, with a 3-ft year-round maximum height is recommended for this purpose. (See Chapter 1300).
- In locations where vegetation cannot be used to minimize visibility and there is a high incidence of unauthorized use, appropriate signing (No U-Turns) may be used to discourage unauthorized use.

A stabilized all-weather surface is required. Urban crossovers for a high occupancy vehicle enforcement plan are usually paved. Other urban crossovers may be paved if unauthorized use is minimized. Rural crossovers are not usually paved in order to be inconspicuous.

960.04 Approval

All existing and planned crossover locations will be designated on a corridor or regional Master Plan for Median Crossovers. A committee consisting of the Assistant Regional Administrator for Operations or Project Development, the Washington State Patrol Assistant District Commander, the Headquarters (HQ) Access Engineer and the FHWA Safety and Operations Engineer or equivalents will be responsible for establishing and updating this plan yearly with proposed new crossings and removal of crossings that are no longer necessary.

Regional Administrators are responsible for the design and construction of median crossovers. Prior to construction of the opening, submit the documentation of crossover and the design data (together with a right of way print showing the opening in red) to the State Design Engineer for right of way or limited access plan approval. Construction should not proceed until approval is received.

After notification of approval, the Headquarters (HQ) Right of Way Plans Section sends the region a revised reproducible right of way or limited access plan which includes the approved crossover location.

960.05 Documentation

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

1010 Auxiliary Lanes

1010.01 General

Auxiliary lanes are used to comply with capacity requirements; to maintain lane balance; to accommodate speedx change, weaving, and maneuvering for entering and exiting traffic; or to encourage carpools, vanpools, and the use of transit.

See the Traffic Manual and the MUTCD for signing of auxiliary lanes.

Although slow vehicle turnouts, shoulder driving for slow vehicles, and chain-up areas are not auxiliary lanes they are covered in this chapter because they perform a similar function.

See the following chapters for additional information:

Chapter	**Subject**
910	Turn lanes
910	Speed change lanes at intersections
940	Speed change lanes at interchanges
940	Collector distributor roads
940	Weaving lanes
1050	High occupancy vehicle lanes

1010.02 References

Revised Code of Washington (RCW) 46.61, Rules of the Road.

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, M 24-01. WSDOT

Traffic Manual, M 51-02, WSDOT.

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 1994

Emergency Escape Ramps for Runaway Heavy Vehicles, FHWA-T5-79-201, March 1978

Highway Capacity Manual (Special Report 209), Transportation Research Board

NCHRP Synthesis 178, *Truck Escape Ramps*, Transportation Research Board

1010.03 Definitions

auxiliary lane The portion of the roadway adjoining the through lanes for parking, speed change, turning, storage for turning, weaving, truck climbing, passing, and other purposes supplementary to through-traffic movement.

climbing lane An auxiliary lane used for the diversion of slow traffic from the through lane.

emergency escape ramp A roadway leaving the main roadway designed for the purpose of slowing and stopping out-of-control vehicles away from the main traffic stream.

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

lateral clearance The distance from the edge of traveled way to a roadside object.

posted speed The maximum legal speed as posted on a section of highway using regulatory signs.

passing lane An auxiliary lane on a two-lane highway used to provide the desired frequency of safe passing zones.

roadway The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways.

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 and bicycles.

slow moving vehicle turnouts A widened shoulder area to provide room for a slow moving vehicle to pull safely out of the through traffic, allow vehicles following to pass, and return to the through lane.

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.

Warrant A minimum condition for which an action is authorized. Meeting a warrant does not attest to the existence of an unsafe or undesirable condition. Further justification is required.

1010.04 Climbing Lanes

(1) General

Normally, climbing lanes are associated with truck traffic, but they may also be considered in recreational or other areas that are subject to slow moving traffic. Climbing lanes are designed independently for each direction of travel.

Generally, climbing lanes are provided when the requirements of two warrants - speed reduction and level of service - are exceeded. The requirements of either warrant may be waived if, for example, slow moving traffic is demonstrably causing a high accident rate or congestion that could be corrected by the addition of a climbing lane. However, under most conditions climbing lanes are built when the requirements of both warrants are satisfied.

(2) Warrant No. 1 — Speed Reduction

Figure 1010-2a shows how the percent and length of grade affect vehicle speeds. The data is based on a typical heavy truck.

The maximum allowable entrance speed, as reflected on the graphs, is 55 mph. Note that this is the maximum value to be used regardless of the posted speed of the highway. When the posted speed is above 55 mph, use 55 mph in place of the posted speed. Examine the profile at least $^1/_4$ mi preceding the grade to obtain a reasonable approach speed.

If a vertical curve makes up part of the length of grade, approximate the equivalent uniform grade length.

Whenever the gradient causes a 15 mph speed reduction below the posted speed limit for typical heavy truck for either two-lane or multilane highways, the speed reduction warrant is satisfied (see Figure 1010-2b for an example).

(3) Warrant No. 2 — Level of Service (LOS)

The level of service warrant for two-lane highways is fulfilled when the up-grade traffic volume exceeds 200 VPH and the up-grade truck volume exceeds 20 VPH. On multilane highways, use Figure 1010-3.

(4) Design

When a climbing lane is justified, design it in accordance with Figure 1010-4. Provide signing and delineation to identify the presence of the auxiliary lane. Begin climbing lanes at the point where the speed reduction warrant is met and end them where the warrant ends for multilane and 300 ft beyond for 2-lane highways. Consider extending the auxiliary lane over the crest to improve vehicle acceleration and the sight distance.

Design climbing lane width equal to that of the adjoining through lane and at the same cross slope as the adjoining lanes. When ever possible, maintain the shoulders at standard width for the class of highway. However, on two-way two-lane highways, the shoulder may be reduced to 4 ft with justification.

1010.05 Passing Lanes

(1) General

Passing lanes are desirable where a sufficient number and length of safe passing zones do not exist and the speed reduction warrant for a climbing lane is not satisfied. Figure 1010-5 may be used to determine if a passing lane is recommended.

(2) Design

When a passing lane is justified, design it in accordance with Figure 1010-6. Make the lane long enough to permit several vehicles to pass. Passing lanes longer than 2 mi can cause the driver to lose the sense that the highway is basically a two-lane facility.

Passing lanes are preferably four-lane sections.

A three-lane section may be used, however. Alternate the direction of the passing lane at short intervals to ensure passing opportunities for both directions and to discourage illegal actions of frustrated drivers.

Make the passing lane width equal to the adjoining through lane and at the same cross slope. Full-width shoulders for the highway class are preferred; however, with justification, the shoulders may be reduced to 4 ft. Provide adequate signing and delineation to identify the presence of an auxiliary lane.

1010.06 Slow Moving Vehicle Turnouts

(1) General

On a two-lane highway where passing is unsafe, a slow moving vehicle is required, by RCW 46.61.427, to turn off the through lane wherever a safe turnout exists, in order to permit the following vehicles to proceed. A slow moving vehicle is one that is traveling at a speed less than the normal flow of traffic, behind which five or more vehicles are formed in a line.

A slow moving vehicle turnout is not an auxiliary lane. Its purpose is to provide sufficient room for a slow moving vehicle to safely pull out of through traffic and stop if necessary, allow vehicles following to pass, then return to the through lane. Generally, a slow moving vehicle turnout is provided on existing roadways where passing opportunities are limited, where slow moving vehicles such as trucks and recreational vehicles are predominant, and where the cost to provide a full auxiliary lane would be prohibitive.

(2) Design

Base the design of a slow moving vehicle turnout primarily on sound engineering judgment and Figure 1010-7. Design may vary from one location to another. A minimum length of 100 ft provides adequate storage, since additional storage is provided within the tapers and shoulders. The maximum length is 1/4 mi including tapers. Surface turnouts with a stable unyielding material such as BST or ACP with adequate structural strength to support the heavier traffic.

Locate slow vehicle turnouts where at least Design Stopping Sight Distance (Chapter 650) is available, decision sight distance is preferred, so that vehicles can safely reenter the through traffic. Sign slow moving vehicle turnouts to identify their presence.

When a slow moving vehicle turnout is to be built, document the location and why it was selected.

1010.07 Shoulder Driving for Slow Vehicles

(1) General

For projects where climbing or passing lanes are justified, but are not within the scope of the project, or where meeting the warrants for these lanes are borderline, the use of a shoulder driving section is an alternative.

Review the following when considering a shoulder driving section:

- Horizontal and vertical alignment
- Character of traffic
- Presence of bicycles
- Clear zone (Chapter 700)

(2) Design

When designing a shoulder for shoulder driving, use a minimum length of 600 ft. The minimum shoulder width is 8 ft with 10 ft preferred. When barrier is present, the minimum width is 10 ft with 12 ft preferred. Adequate structural strength for the anticipated traffic is necessary and may require reconstruction. Select locations where the side slope meets the requirements of Chapter 640 for new construction and Chapter 430 for existing roadways. When a transition is required at the end of a shoulder driving section, use a 50:1 taper.

Signing for shoulder driving is required. Install guideposts when shoulder driving is to be permitted at night.

Document the need for shoulder driving and why a lane is not being built.

1010.08 Emergency Escape Ramps

(1) General

Consider an emergency escape ramp whenever long steep down grades are encountered. In this situation the possibility exists of a truck losing its brakes and going out of control at a high speed. Consult local maintenance personnel and check traffic accident records to determine if an escape ramp is justified.

(2) Design

(a) **Type.** Escape ramps are one of the following types:

- Gravity escape ramps are ascending grade ramps paralleling the traveled way. They are commonly built on old roadways. Their long length and steep grade can present the driver with control problems, not only in stopping, but with rollback after stopping. Gravity escape ramps are the least desirable design.
- Sand pile escape ramps are piles of loose, dry sand dumped at the ramp site, usually not more than 400 ft in length. The deceleration is usually high and the sand can be affected by weather conditions; therefore, they are less desirable than arrester beds. However, where space is limited they may be suitable.
- Arrester beds are parallel ramps filled with a smooth, coarse, free-draining gravel. They stop the out-of-control vehicle by increasing the rolling resistance. Arrester beds are commonly built on an up grade to add the benefits of gravity to the rolling resistance. However, successful arrester beds have been built on a level or descending grade.

(b) **Location.** The location of an escape ramp will vary depending on terrain, length of grade, and roadway geometrics. The best locations include in advance of a critical curve, near the bottom of grade, or before a stop. It is desirable that the ramp leave the roadway on a tangent at least 3 mi from the beginning of the down-grade.

(c) **Length.** Lengths will vary depending on speed, grade, and type of design used. The minimum length is 200 ft. Calculate the stopping length using the following equation:

$$L = \frac{V^2}{0.3(R \pm G)}$$

Where:

- L = stopping distance (ft)
- V = entering speed (mph)
- R = rolling resistance (see Figure 1010-1)
- G = grade of the escape ramp (%)

Speeds of out-of control trucks rarely exceed 90 mph; therefore, an entering speed of 90 mph is preferred. Other entry speeds may be used when justification and the method used to determine the speed is documented.

Material	R
Roadway	1
Loose crushed aggregate	5
Loose noncrushed gravel	10
Sand	15
Pea gravel	25

Rolling Resistance (R)
Figure 1010-1

(d) **Width.** The width of each escape ramp will vary depending on the needs of the individual situation. It is desirable for the ramp to be wide enough to accommodate more than one vehicle. The desirable width of an escape ramp to accommodate two out-of-control vehicles is 40 ft and the minimum width is 26 ft.

(e) The following items are additional considerations in the design of emergency escape ramps:

- If possible, at or near the summit, provide a pull-off brake-check area. Also, include informative signing about the upcoming escape ramp in this area.
- A free draining, smooth, noncrushed gravel is preferred for an arrester bed. To assist in smooth deceleration of the vehicle, taper the depth of the bed from 3 in at the entry to a full depth of 18 to 30 in in not less than 100 ft.
- Mark and sign in advance of the ramp. Discourage normal traffic from using or parking in the ramp. Sign escape ramps in accordance with the guidance contained in the MUTCD for runaway truck ramps.

- Provide drainage adequate to prevent the bed from freezing or compacting.
- Consider including an impact attenuator at the end of the ramp if space is limited.
- A surfaced service road adjacent to the arrester bed is needed for wreckers and maintenance vehicles to remove vehicles and make repairs to the arrester bed. Anchors are desirable at 300 ft intervals to secure the wrecker when removing vehicles from the bed.

A typical example of an arrester bed is shown in Figure 1010-8.

Include justification, all calculations, and any other design considerations in the documentation of an emergency escape ramp documentation.

1010.09 Chain-Up Area

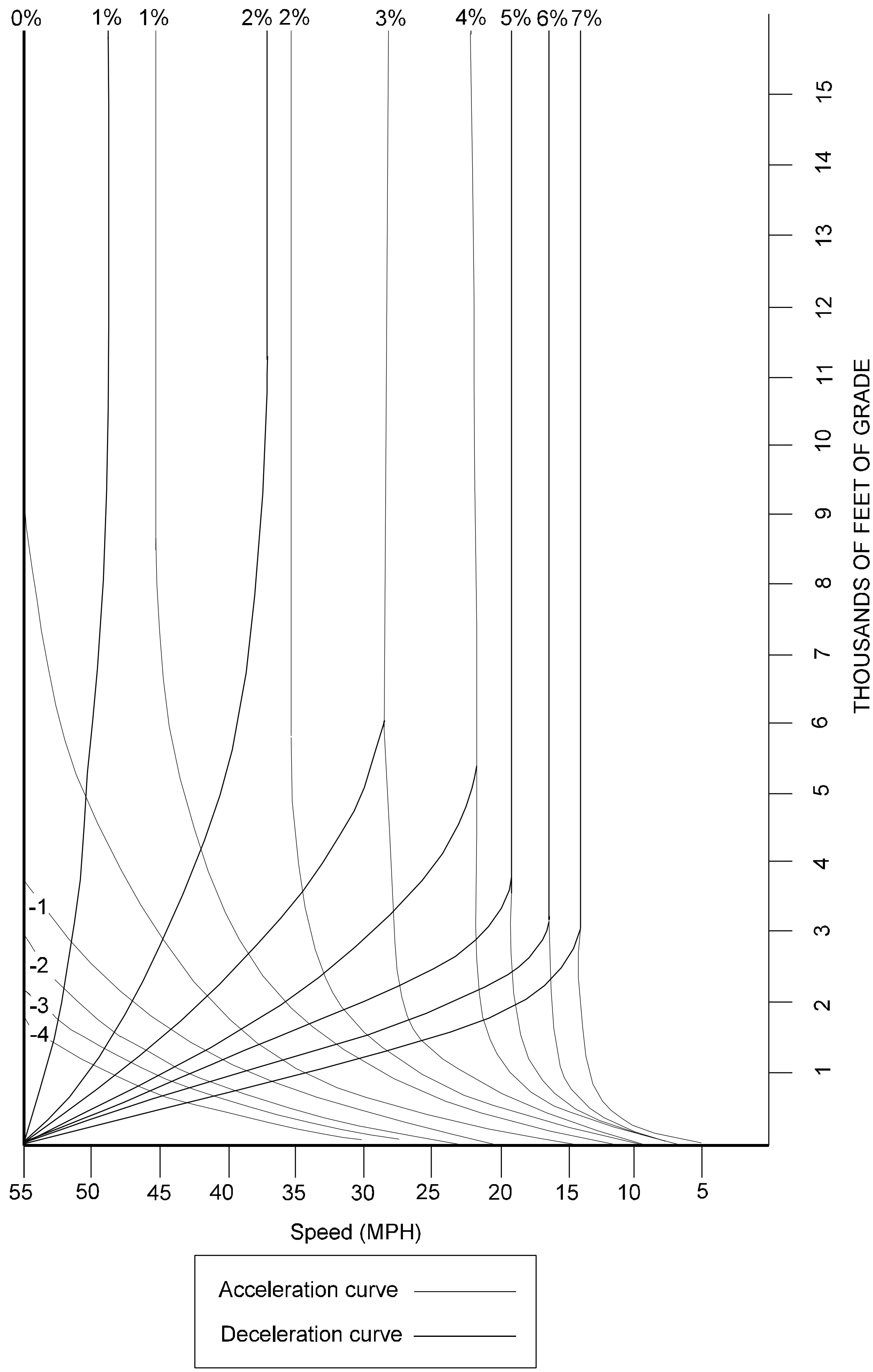
Provide chain-up areas to allow chains to be put on vehicles out of the through lanes at locations where traffic enters chain enforcement areas. Provide chain-off areas to remove chains out of the through lanes for traffic leaving chain enforcement areas.

Chain-up or chain-off areas are widened shoulders, designed as shown in Figure 1010-9. Locate chain-up and chain-off areas where the grade is 6% or less and preferably on a tangent section.

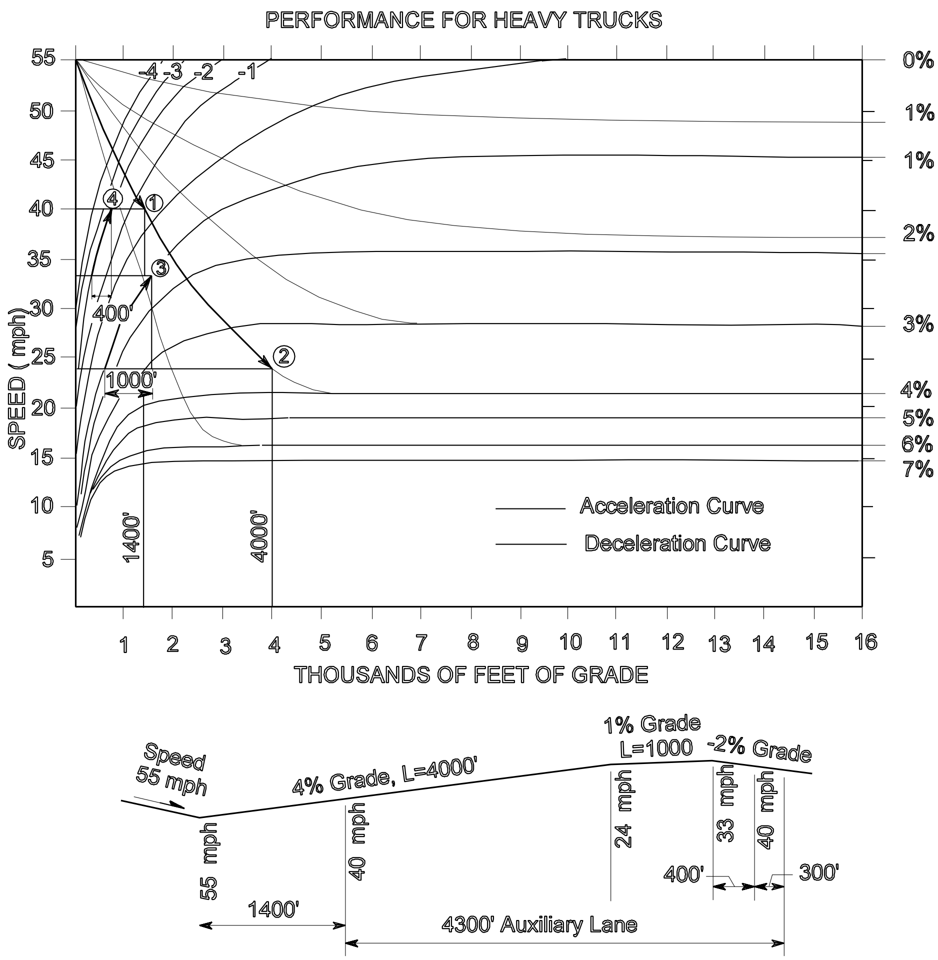
Consider illumination for chain-up and chain-off areas on multilane highways. When deciding whether or not to install illumination, consider traffic volumes during the hours of darkness and the availability of power.

1010.10 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/



Performance For Heavy Trucks
Figure 1010-2a



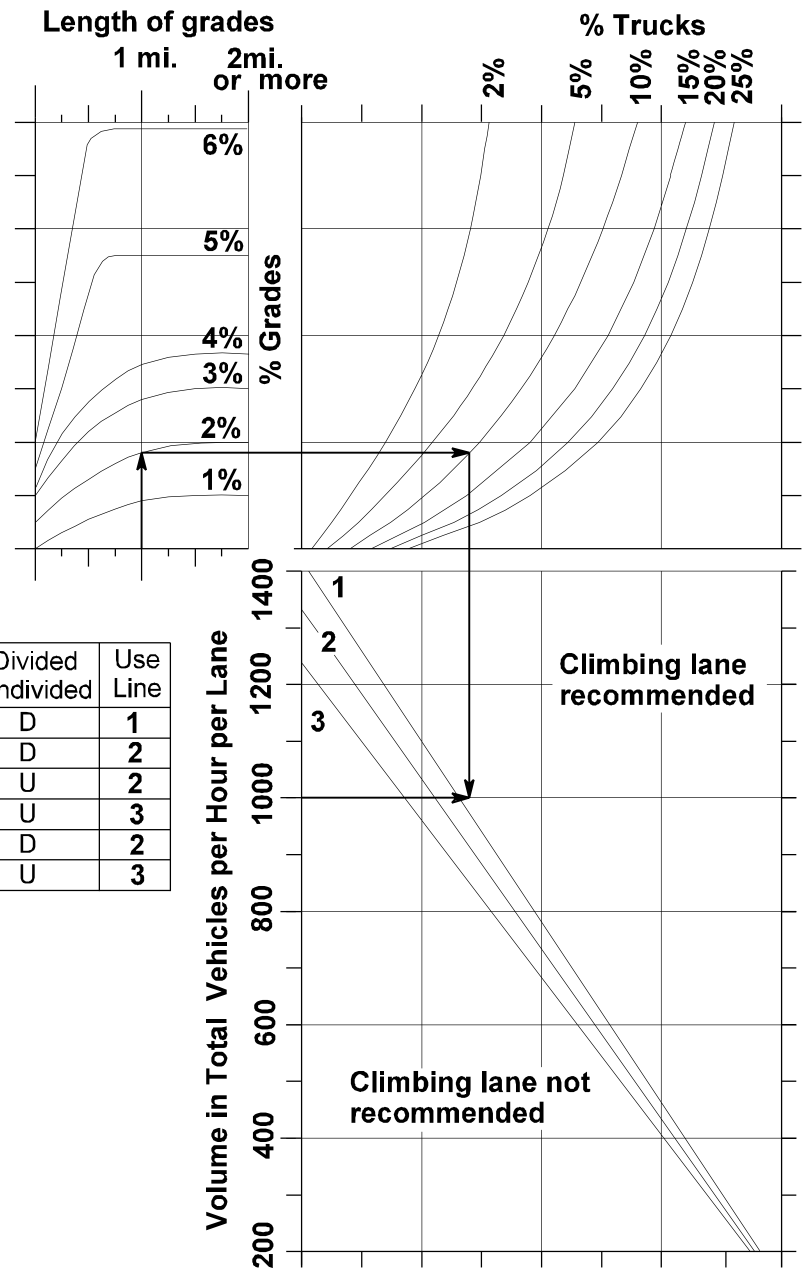
Given: A 2-lane highway meeting the level of service warrant, with the above profile, and a 55 mph posted speed.

Determine: Is the climbing lane warranted and, if so, how long?

Solution:

1. Follow the 4% grade deceleration curve from a speed of 55 mph to a speed of 40 mph at 1,400 ft. The speed reduction warrant is met and a climbing lane is needed.
2. Continue on the 4% grade deceleration curve to 4,000 ft. Note that the speed at the end of the 4% grade is 25 mph.
3. Follow the 1% grade acceleration curve from a speed of 25 mph for 1,000 ft. Note that the speed at the end of the 1% grade is 34 mph.
4. Follow the -2% grade acceleration curve from a speed of 34 mph to a speed of 40 mph, ending the speed reduction warrant. Note the distance required is 400 ft.
5. The total auxiliary lane length is (4,000-1,400)+1,00+400+300=4,300 ft. 300 ft is added to the speed reduction warrant for a 2-lane highway, see the text and Figure 1010-4.

Speed Reduction Example
Figure 1010-2b

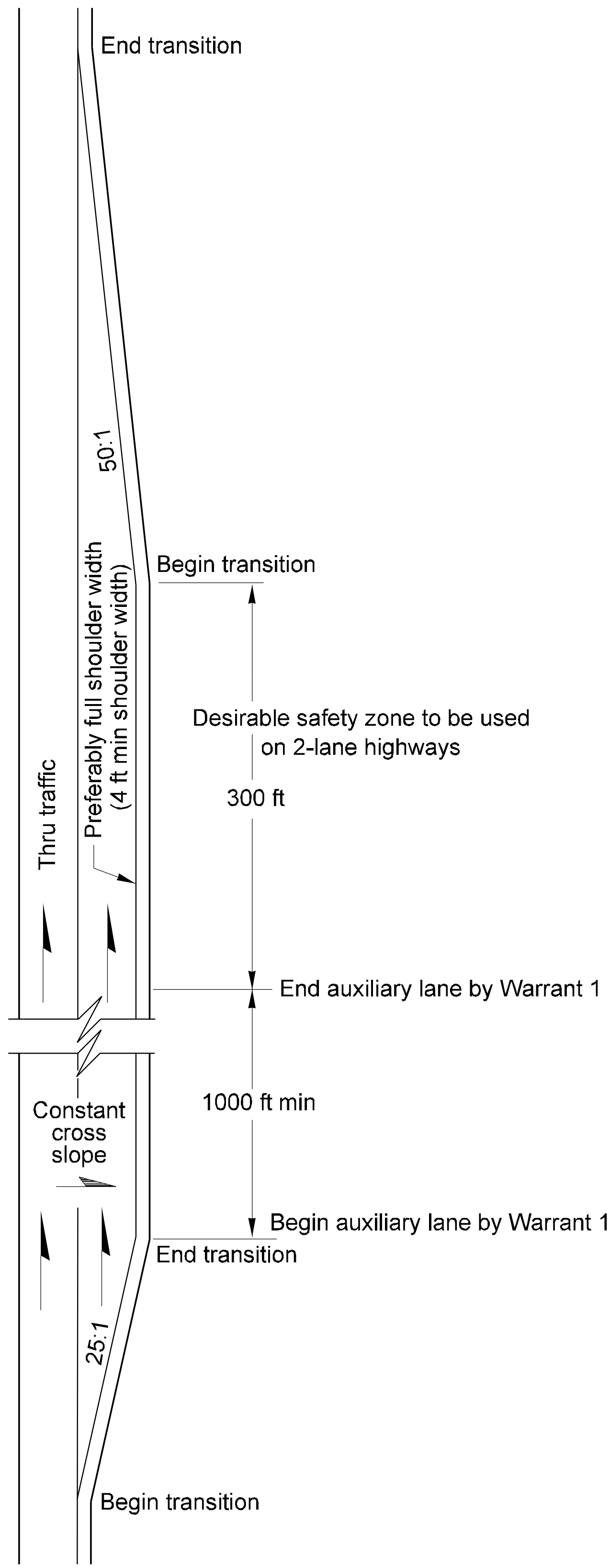


Lane Width	Lateral Clearance	Divided Undivided	Use Line
12	≥ 6	D	**1**
12	≤ 6	D	**2**
12	≤ 6	U	**2**
12	< 6	U	**3**
11	All	D	**2**
11	All	U	**3**

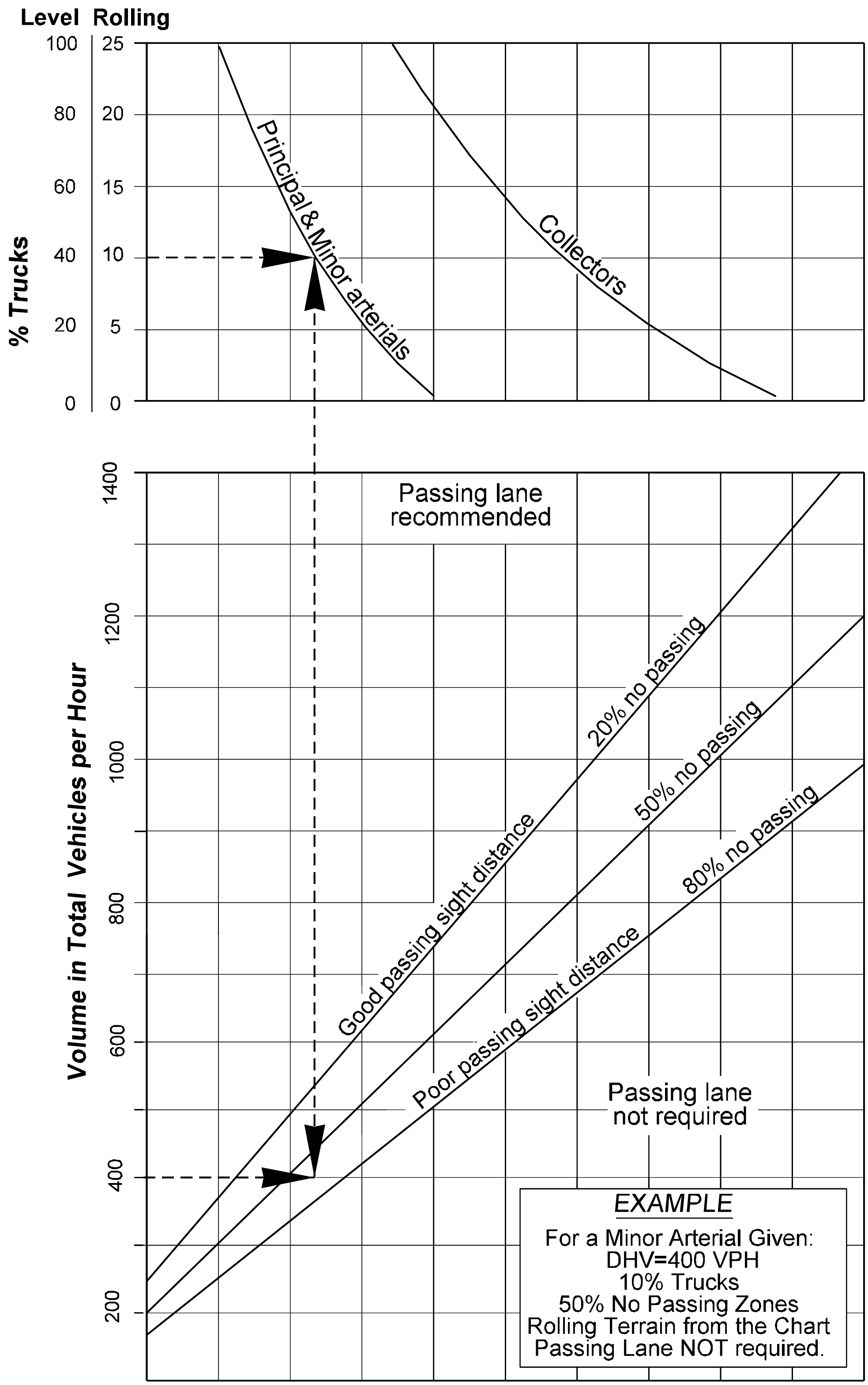
Example

2% grade for 1 Mile
10% Trucks
12' Lanes
Lateral Clearance
≥ 6'
4 Lane, Divided
DDHV = 2000
From the chart,
climbing lane
is recommended

Level of Service — Multilane
Figure 1010-3

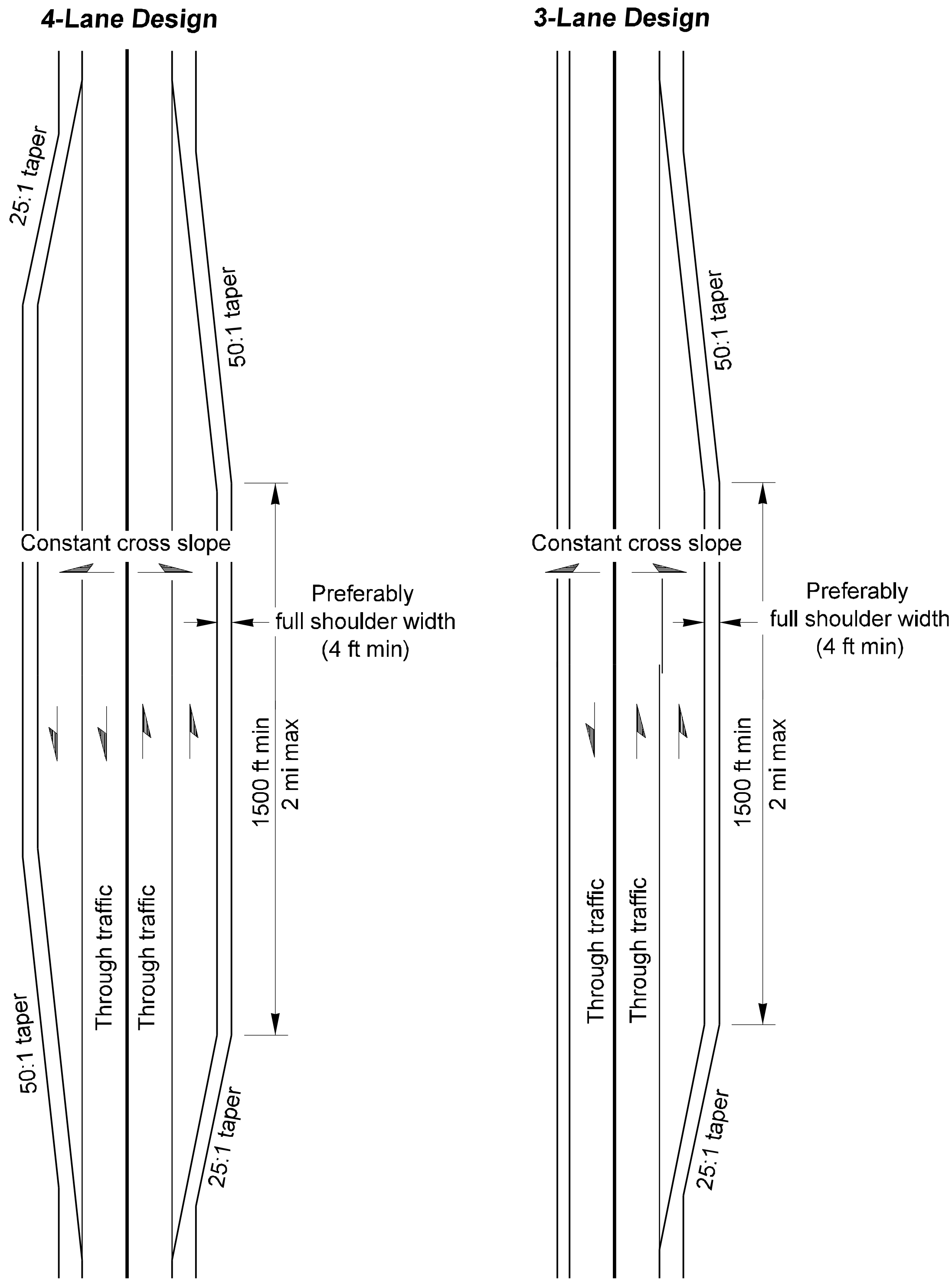


Auxiliary Climbing Lane
Figure 1010-4



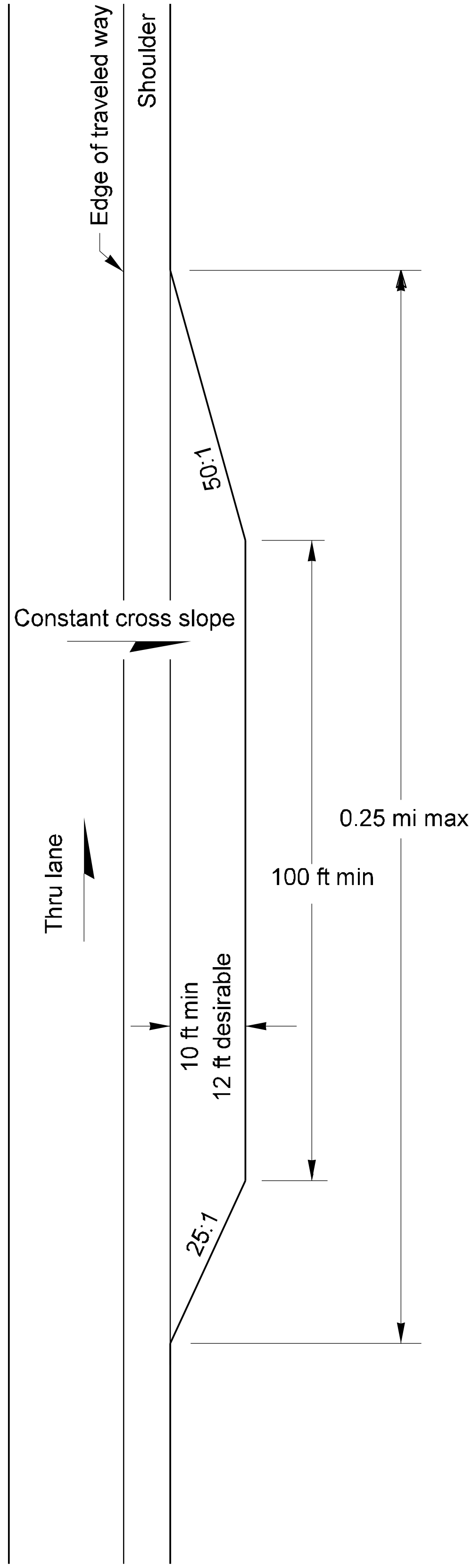
Warrant For Passing Lanes

Figure 1010-5

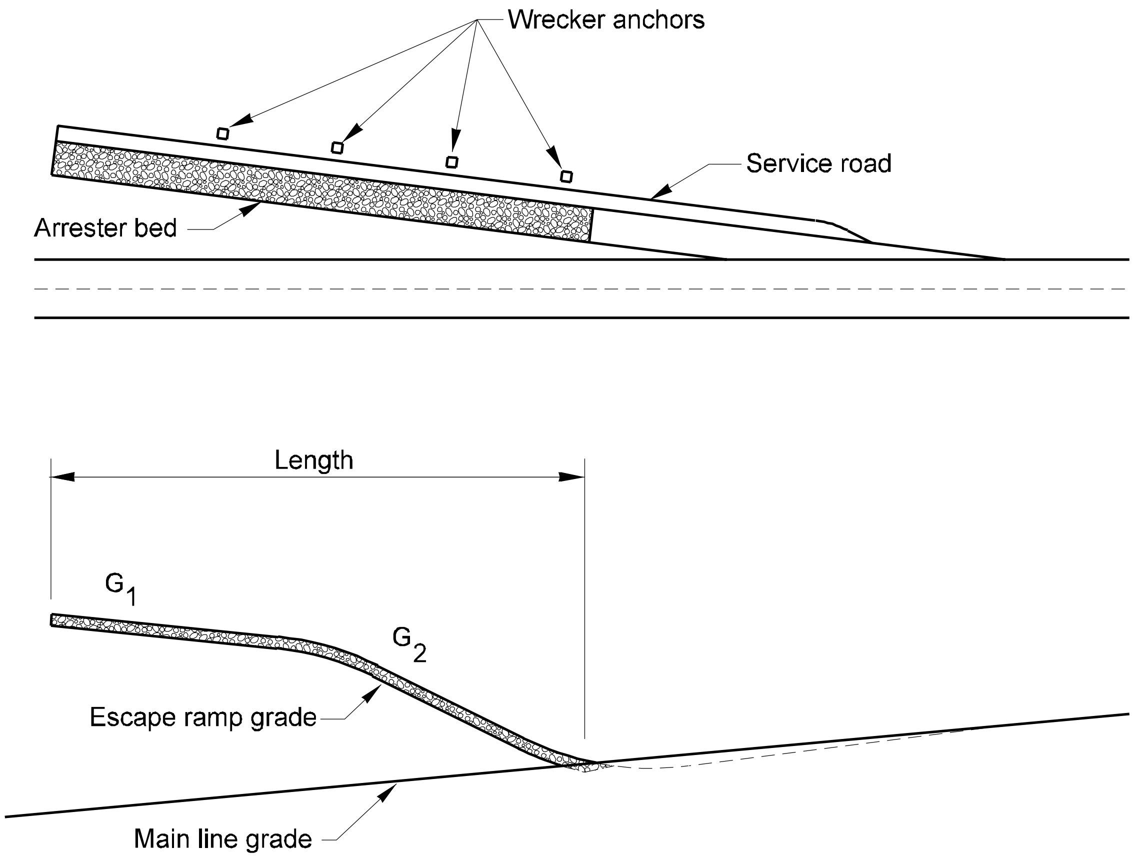


Auxiliary Passing Lane

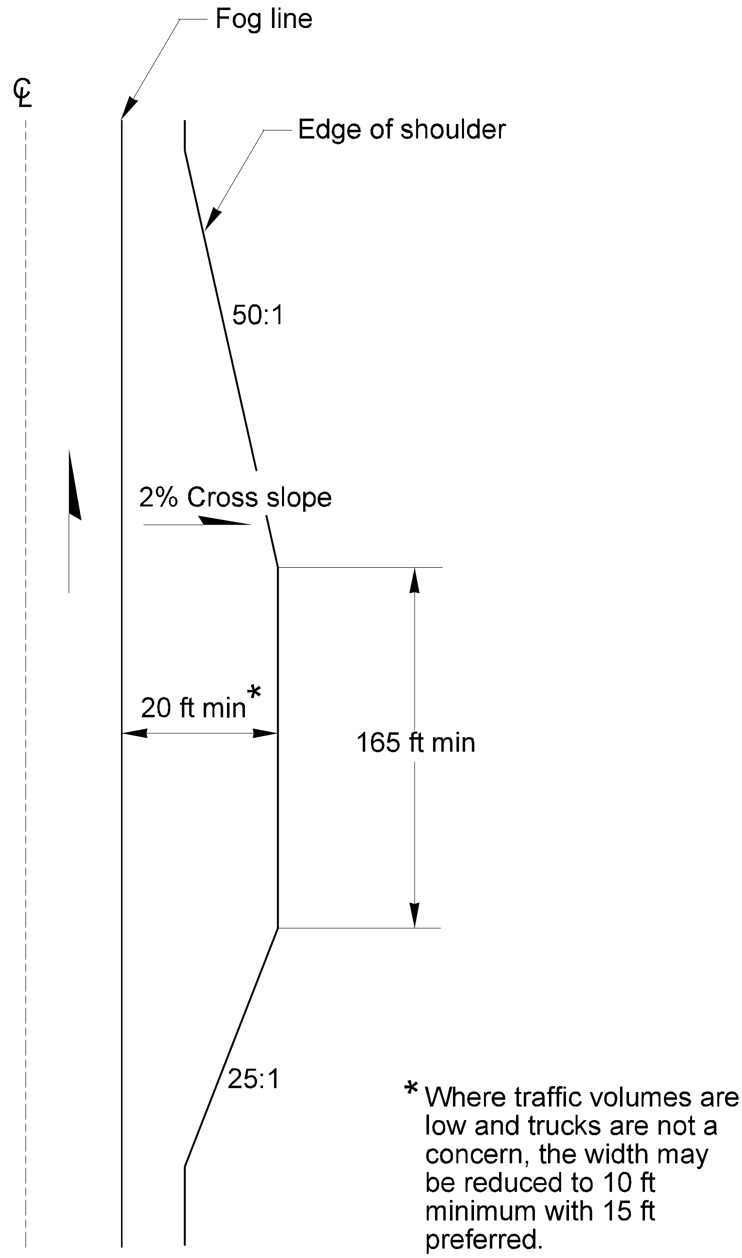
Figure 1010-6



Slow Moving Vehicle Turnout
Figure 1010-7



Typical Emergency Escape Ramp
Figure 1010-8



Chain-Up/Chain-Off Area
Figure 1010-9

1020.01 General

The Washington State Department of Transportation (WSDOT) encourages multimodal use of its transportation facilities. Bicycle facilities or improvements for bicycle transportation are included in the project development and highway programming processes where bicycle use is likely and can be accommodated safely.

This chapter is to serve as a guide for selecting and designing the most useful and cost-effective bicycle facility possible and for how to include the region's Bicycle Coordinator in the design process. 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.

State law (46.61.710 RCW) prohibits the operation of mopeds on facilities specifically designed for bicyclists, pedestrians, and equestrians. Mopeds 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 a bridle trail that is separate from the shared use path in common equestrian corridors.

1020.02 References

Guide for the Development of Bicycle Facilities, 1999, AASHTO

*A Policy on Geometric Design of Highways and Streets (*Green Book), 1994, AASHTO

Manual on Uniform Traffic Control Devices (MUTCD), Federal Highway Administration (FHWA), National Advisory Committee on Uniform Traffic Control Devices including the *Washington State Modifications to the MUTCD,* M 24-01, WSDOT

Washington Administrative Code (WAC) 468-95-035, Pavement Edge and Raised Pavement Markers Supplementing Other Markings

Revised Code of Washington (RCW) 46.61, Rules of the Road

RCW 46.61.710, Mopeds, electric-assisted bicycles—General requirements and operation

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

State Highway System Plan, WSDOT

1020.03 Definitions

bicycle route A system of bikeways, designated by the jurisdiction(s) having the authority, featuring appropriate directional and informational route markers. A series of bikeways 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/or pavement markings reserved for bicycle use.

bikeway Any trail, path, part of a highway or shoulder, or any other traveled way specifically signed and/or marked for bicycle travel.

Category A bicyclist Advanced or experienced riders who are generally using their bicycles as they would a motor vehicle. They want direct access to destinations with a minimum of delay and are comfortable riding with motor vehicle traffic. When touring, their vehicles are commonly heavily loaded with a tandem rider(s), children, or camping gear. They need sufficient operating space on the traveled way or shoulder to eliminate the need for them or passing vehicles to shift position.

Category B bicyclist Basic or less confident adult bicyclists who might be using their bicycles for transportation purposes. They prefer to avoid roads with fast and busy motor vehicle traffic unless there is ample roadway width. Basic bicyclists are comfortable riding on neighborhood streets and shared use paths; however, on busier streets, they prefer designated facilities such as bike lanes or wide shoulder lanes.

Category C bicyclist Children, riding alone or with their parents, who need access to key destinations in the community such as schools, friends, recreational facilities, and convenience stores. Residential streets with low motor vehicle speeds (linked with shared use paths and busier streets with well-defined pavement marking between bicycles and motor vehicles) can accommodate children without encouraging them to ride in the traveled lane of major arterials.

rural bicycle touring routes State highways or sections of state highways that are used or have a high potential for use by Category A bicyclists riding long distance on single or multiday trips.

shared roadway A roadway that is open to both bicycle and motor vehicle travel. Shared roadways do not have dedicated facilities for bicycle travel.

signed shared roadway (designated as a bike route) A shared roadway that has been designated by signing as a preferred route for bicycle use. Appropriate bike route signs are installed to assure bicyclists that improvements such as widening shoulders have been made to improve safety.

shared use path A facility on exclusive right of way with minimal cross flow 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), and others.

1020.04 Planning

(1) General

Bikeway planning includes provisions and facilities for safe and efficient bicycle travel. An effective multimodal transportation program addresses the issue of upgrading highways to accommodate shared use by bicyclists and motorists.

Bicyclists of all skill levels will use well-designed facilities. Bicyclists will avoid a poorly designed facility.

To enhance bicycle travel, consider upgrading existing roads that are used regularly by Category A or B bicyclists. The upgrading includes improving the width and quality of the surface and maintaining the right-hand portion in a condition suitable for bicycle riding.

Consider bicycle facilities when designing construction projects and normal safety and operational improvements. Shoulder widening projects along existing highways, might be an opportunity to encourage bicycle traffic and enhance bicycle safety. Correcting short areas of restricted width (such as bridges, cuts, or fills) to provide bikeways might not be cost effective. However, the presence of these short, restricted areas does not diminish the importance of widening the adjoining shoulder sections.

Bikeway planning is an integral part of the facility planning for other transportation modes and land use development. Use the location criteria that follow for long-term planning and project development as applicable.

(2) Programming

The *State Highway System Plan* identifies two elements of bicycle project funding:

- Urban Bicycle Projects: Complete local bicycle networks by building short sections of appropriate bicycle facilities along or across state highways.
- Rural Bicycle Touring Routes: Shoulder improvements along sections of designated state routes.

Urban Bicycle Projects have been prioritized by the region's Planning Offices, the OSC Bicycle Program, and the department's Bicycle Advisory Committee and are listed in the *State Highway System Plan*. Urban Bicycle Projects are selected in each region, prioritized, and will compete for funding.

Rural Bicycle Touring Routes (RBTR) programming priority areas are listed in the *State Highway System Plan*. Each region's Planning Office has a map with the priority areas marked. The purpose of the RBTR program is to add funding to a project in an RBTR shoulder deficiency area. Designers are to consult the region's Planning Office to determine if their project is within an RBTR shoulder deficiency area. If the project is within an RBTR shoulder deficiency area, the designer requests the region's Program Management to determine RBTR funding availability.

Consider spot bikeway improvements in other types of projects such as P1 paving and I2 safety improvement projects. Identify small improvements in the project definition phase. Consult the region's Bicycle Coordinator for recommendations and the limits of the work. Funding from other sources such as the Urban Bicycle and Rural Bicycle programs might be available.

(3) Selection of the Type of Facility

In selecting an appropriate facility, ensure that the proposed facility will not encourage or require bicyclists or motorists to operate in a manner that is inconsistent with the Rules of the Road (RCW 46.61).

An important consideration is route continuity. Alternating bikeways from side to side along a route is generally unacceptable. Designing a route that requires bicyclists to cross the roadway could result in inappropriate maneuvers and/or encourage Rules of the Road violations. In addition, wrong-way bicycle travel might occur beyond the ends of shared use paths because of the inconvenience of having to cross the street.

Many factors are involved in determining which type of facility will benefit the greatest number of bicyclists. Outlined below are the most common applications for each type.

Shared Use Path
Figure 1020-1

(a) **Shared Use Path.** The most common applications for shared use paths (See Figure 1020-1) are along rivers and streams, ocean beachfronts, canals, utility rights of way, and abandoned railroad rights of way; within college campuses; and within and between parks. There might also be situations where such facilities can be provided as part of planned developments. Another common application of shared use paths is to close gaps in bicycle travel caused by construction of freeways, or the existence of natural barriers (rivers, mountains, and other large geographic features).

Generally, shared use paths are used to serve corridors not served by streets and highways or where wide rights of way exist permitting such facilities to be constructed away from the influence of parallel roadways. Shared use paths offer opportunities not provided by the road system. They can either provide a recreational opportunity or serve to minimize motor vehicle interference by providing direct high-speed bicycle commute routes.

Bike Lane
Figure 1020-2

Shared Roadway
Figure 1020-3

(b) **Bike Lane.** Bike lanes are established along streets in corridors where there is or, in the future, might be significant bicycle demand. (See Figure 1020-2.) Bike lanes delineate the rights of way assigned to bicyclists and motorists and provide for movements that are more predictable by each. An important reason for establishing bike lanes is to better accommodate bicyclists through corridors where insufficient room exists for safe bicycling on existing streets. This can be accomplished by reducing the number of lanes or prohibiting parking in order to delineate bike lanes.

Where street improvements are not possible, improve the bicyclist's environment by providing shoulder sweeping programs and special signal facilities.

When considering the selection of appropriate streets for bike lanes, refer to the location criteria discussed in 1020.04(4).

Do not designate sidewalks as bike lanes.

(c) **Shared Roadway.** Most bicycle travel in Washington occurs on highways and streets without bikeway designations. (See Figure 1020-3.) In most instances, entire street systems are fully adequate for safe and efficient bicycle travel and signing and pavement markings for bicycle use are unnecessary.

The region's Traffic are responsible for determining sections of state highways where bicycle traffic is inappropriate. The State Traffic Engineer, after consultation with the Bicycle Advisory Committee, prohibits bicycling on sections of state highways through the traffic regulation process. Also, see Chapter 1420 "Access Control Design Policy".

Bicyclists traveling between cities, or on recreational trips, may use many rural highways. In most cases, rural highways are not designated as bike routes because of the limited use and the lack of continuity with other bike routes. However, the development and maintenance of paved shoulders, with or without a standard edge stripe, can significantly improve safety and convenience for bicyclists and motorists along such routes.

Signed Shared Roadway (Designated Bike Route)
Figure 1020-4

(d) **Signed Shared Roadway.** Designate signed shared roadways as bike routes by posting bike route signs. (See Figure 1020-4.) These routes provide continuity to other bicycle facilities and designate preferred routes through high bicycle-demand corridors. As with bike lanes, designating shared roadways as bike routes is an indication to bicyclists that there are particular advantages to using these bike routes as compared with alternative routes. This means that the responsible agencies have taken action to ensure that these routes are suitable as bike routes and are maintained in a manner consistent with the needs of bicyclists. Signing also alerts motor vehicle operators that bicycles are present.

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.
- It provides for through and direct travel in bicycle-demand corridors.
- It connects discontinuous segments of bikeways.
- Traffic control devices have been adjusted to accommodate bicyclists.
- Street parking is restricted for improved safety where lane width is critical.
- Surface hazards to bicyclists have been corrected.
- Maintenance of the route is to a higher standard than comparable streets, such as more frequent street sweeping and repair.

In general, do not designate sidewalks as bikeways for the following reasons:

- Sidewalks tend to be used in both directions, despite any signing to the contrary.
- At approaches to intersections, parked cars might impede sight distance of motorists and bicyclists. At driveways, property fences, shrubs, and other obstructions often impair sight distances.
- At intersections, motorists are not looking for bicyclists entering the crosswalk area, particularly when motorists are making a turn.
- Sidewalks are typically designed for pedestrian speeds, and might not be safe for higher-speed use. Conflicts between bicyclists and pedestrians are common, as are conflicts with fixed objects such as parking meters, utility poles, signposts, bus shelters, benches, trees, hydrants, and mailboxes. In addition, bicyclists riding on the curb side of sidewalks might accidentally drop off the sidewalk into the path of motor vehicle traffic.

Only consider a sidewalk as a bike route under special circumstances, such as on long, narrow bridges. Even then, the preferred solution is to widen the roadway to provide space for bicyclists. In residential areas, sidewalk riding is commonly done by Category B and C bicyclists who are not comfortable riding in the street. However, it is inappropriate to sign these facilities as bike routes.

(4) Location Criteria

Factors to consider in determining the location of a bikeway are:

(a) **Potential Use.** Locate bikeways along corridors or a convenient road parallel to the corridor to maximize use. However, to attract commuting bicyclists, the roadway must offer through route conditions.

(b) **Directness.** Locate facilities along a direct line and in such a way that they connect bicycle traffic generators for the convenience of the users. Bicyclists are interested in the same destinations as motorists.

(c) **Access.** When locating a shared use path, provide adequate access points. The more access points, the more the facility will be used. Adequate access for emergency and service vehicles is also necessary.

(d) **Shared Use Path Widths.** Figure 1020-13 shows the widths and minimum horizontal clearances needed when a shared use path is on an alignment separate from a highway right of way.

Figure 1020-14 shows shared use path width when adjacent to a roadway and within its right of way. See 1020.05(2)(e) to find if a barrier will be needed.

(e) **Available Roadway Width.** For a bike lane or shared roadway (with or without signing), the overall roadway width must meet or exceed the highway minimum design criteria. See Chapter 430 “Modified Design Level” and 440 “Full Design Level” and Figures 1020-14 and 1020-15 for further width information.

(f) **On-Street Motor Vehicle Parking.** Consider the density of on-street parking and the safety implications, such as opening car doors. If possible, select a route where on-street parking is light or where it can be prohibited.

(g) **Delays.** Bicyclists have a strong desire to maintain momentum. If bicyclists are required to make frequent stops, they might avoid the route.

(h) **Traffic Volumes and Speeds.** For an on-street bikeway, the volume and speed of auto traffic, along with the available width, are factors in determining the best location. Commuting bicyclists generally ride on arterial streets to minimize delay and because they are normally the only streets offering continuity for trips of several miles. The FHWA has developed a spreadsheet to evaluate roadways for bicycle compatibility. The Bicycle Compatibility Index (BCI) measures roadways based on traffic volume, speed, lane width, and other factors. A copy of the BCI and supporting information is found at http://www.hsrc.unc.edu/research/pedbike/bci/index.html

(i) **Truck and Bus Traffic.** High-speed truck, bus, and recreational vehicle traffic can cause problems along a bikeway because of aerodynamic effects and vehicle widths. Evaluate the need to widen shoulders or change the location of the bicycle facility if it is on a roadway with this type of traffic.

(j) **Existing Physical Barriers.** In some areas there are physical barriers to bicycle travel caused by topographical features such as rivers, limited access highways, or other impediments. In such cases, developing a facility that allows a bikeway to cross an existing barrier can provide access opportunities for bicyclists.

(k) **Collision History.** Check the collision experiences along a prospective bicycle route to determine its relative safety compared to other candidate routes. This involves analysis of the collision types to determine which of them might be reduced. (See 1020.04(4)(p).) Consider both the impacts caused by adding bicycle traffic and the potential for introducing new accident problems. The region’s Traffic Office is a good resource when considering collision factors.

(l) **Grades.** Avoid steep grades on bikeways whenever possible. Refer to 1020.05(2)(k) for specific criteria.

(m) **Pavement Surface Quality.** Establish an on-street bikeway only where pavement can be brought to a reasonable condition for safe bicycle travel. Dense graded asphalt concrete surfaces are preferable to open-graded asphalt concrete, Portland cement concrete, and seal-coated surfaces.

(n) **Maintenance.** Ease of maintenance is an important consideration in locating and developing a bikeway. Consider the ease of access by maintenance vehicles. Bicyclists will often shun a poorly maintained bikeway in favor of a parallel roadway. Consult with area maintenance personnel during the planning stage.

(o) **Environmental Compatibility.** Consider scenic value, erosion and slope stability, and compatibility with the surrounding terrain when developing a bikeway. Provide landscaping to minimize adverse environmental effects.

(p) **Use Conflicts.** Different types of facilities produce different types of conflicts. On-street bikeways involve conflicts with motor vehicles. Shared use paths usually involve conflicts with other bicyclists, pedestrians, skaters, and runners on the path, and with motor vehicles at street intersections. Conflicts between bicyclists and motorists can also occur at highway and driveway intersections, tight corners, and narrow facilities like bridges and tunnels.

(q) **Security.** The potential for criminal acts against bicyclists and other users of bikeways exists anywhere, especially along remote stretches. There also is the possibility of theft or vandalism at parking locations. Consult local law enforcement agencies for guidance in making these areas safer. Also consider installation of telephones in high risk areas.

(r) **Cost/Funding.** Location selection will normally involve a cost comparison analysis of alternatives. Funding availability will often eliminate some alternatives; however, it is more desirable to delay constructing a bicycle facility than to construct an inadequate facility.

(s) **Structures.** Continuity can be provided to shared use path by using an overpass, underpass, tunnel, bridge, or by placing the facility on a highway bridge to cross obstacles. See 1020.05(2)(m) for design information.

Retrofitting bicycle facilities on existing bridges involves a large number of variables; compromises in desirable design criteria are often inevitable. The planner, with the assistance of the region's Bicycle Coordinator and the Bridge and Structures Office, on a case-by-case basis, will determine the desirable design criteria.

Consider the following alternatives when placing a shared use path on an existing highway bridge:

- On one side of a bridge. Do this where: the bridge facility connects at both ends to the path; there is sufficient width on that side of the bridge or additional width can be gained by remarking the pavement; and provisions have been made to physically separate the motor vehicle traffic from the bicycle traffic. See Figure 1020-16.
- Provide bicycle lanes, shoulders, or wide curb lanes over a bridge. This is advisable where: bike lanes and shoulders connect on either end of the structure, and when sufficient width exists or can be obtained by widening or remarking the pavement. Use this option only if the bike lane or wide outside lane can be accessed without increasing the potential for wrong-way riding or inappropriate crossing movements.

(v) **Lighting.** Illumination of bicycle facilities might be necessary to achieve minimum levels of safety, security, and visibility.

(w) **Support Facilities.** Where bicycles are used extensively for utility trips or commuting, consider placing adequate bicycle parking and/or storage facilities at common destinations (such as park and ride lots, transit terminals, schools, and shopping centers). Contact the region's Bicycle Coordinator for additional information.

1020.05 Design

(1) Project Requirements

For urban bicycle mobility improvement projects (Bike/Ped connectivity projects in the matrices, Chapter 325), apply the guidance in this chapter to the bikeway.

For highway design elements affected by the project, apply the appropriate design level (Chapter 325) and as found in the applicable *Design Manual* chapters.

For highway design elements not affected by the project, no action is required.

(2) Design Criteria for Shared Use Path

Shared use paths are facilities for the primary use of bicyclists but are also used by pedestrians, joggers, skaters, and others.

(a) **Widths.** The geometric guidelines for shared use paths are shown in Figures 1020-13 and 1020-14.

A path width of 8 ft may be used when all the following conditions apply:

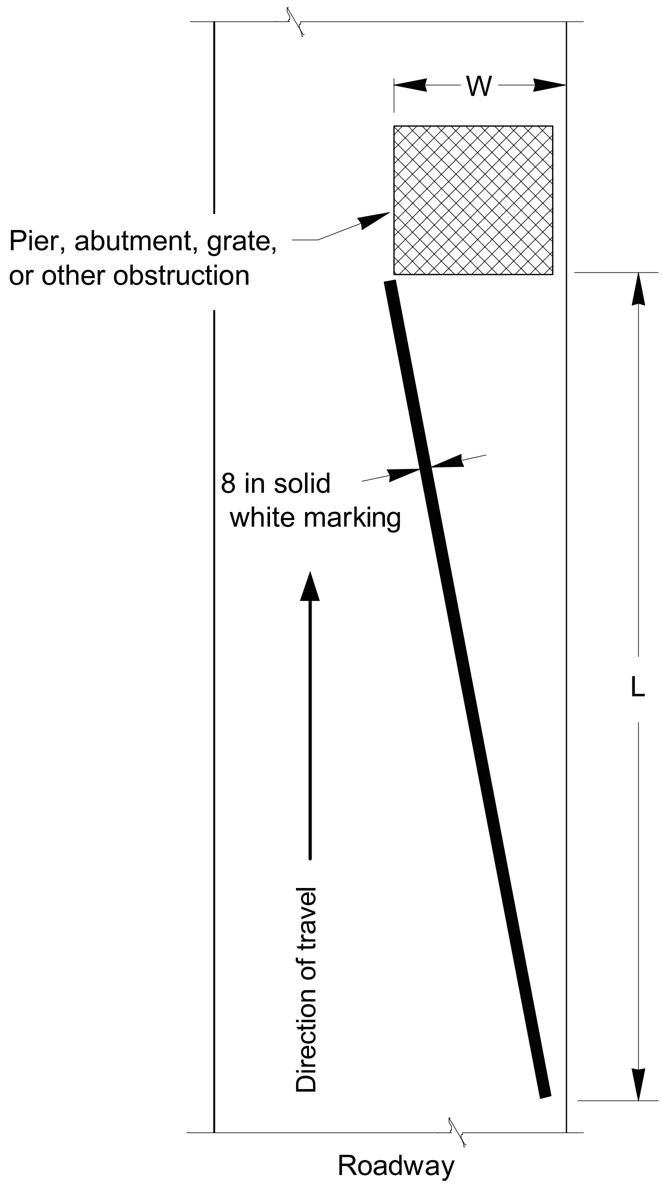
- Bicycle traffic is expected to be low (less than 60 bicycles per day [bpd]).
- Pedestrian use is not expected to be more than occasional.
- The horizontal and vertical alignment adequately provide safe and frequent passing opportunities.
- Normal maintenance activities can be performed without damaging the pavement edge.

The minimum paved width for a one-way shared use path is 6 ft. Use this minimum width only after ensuring that one-way operation will be enforced and maintenance can be performed.

Where the shared use path is adjacent to canals, ditches, or fill slopes steeper than 3H:1V, consider a wider separation. A minimum 5 ft separation from edge of the pavement to the top of slope is desirable. A physical barrier, such as dense shrubbery, railing, or chain link fence is needed at the top of a high embankment and where hazards exist at the bottom of an embankment.

(b) **Clearance to Obstructions**. The desirable horizontal clearance from the edge of pavement to an obstruction (such as a bridge pier) is at least 2 ft. Where this cannot be obtained; install signs and pavement markings to warn bicyclists of the condition. See Figure 1020-5 for pavement marking details.

The required minimum vertical clearance from bikeway pavement to overhead obstructions is 8 ft. However, a higher vertical clearance might be needed for passage of maintenance and emergency vehicles.



L = WV, where V is bicycle approach speed (mph)

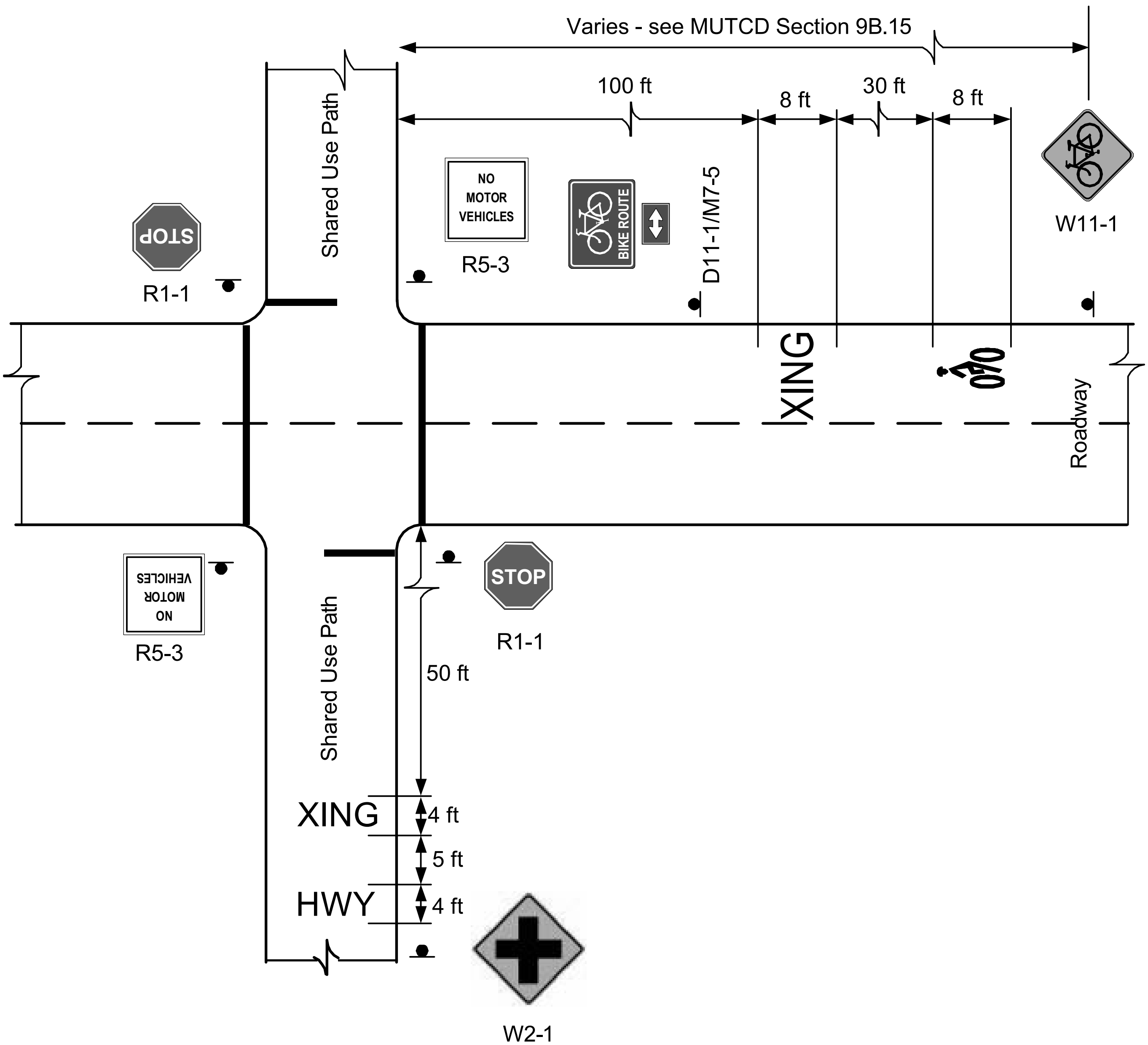
Obstruction Marking
Figure 1020-5

(c) **Intersections with Highways.** Collisions at intersections are the most common type of motor vehicle/bicycle collision. Shared use path and roadway intersections must clearly define who has the right of way and provide adequate sight distance for both users. There are three types of shared use path/roadway at-grade intersection crossings: midblock, adjacent path, and complex. Only at-grade midblock and adjacent crossings are addressed here. Complex intersections involve special designs which must be considered on a case-by-case basis.

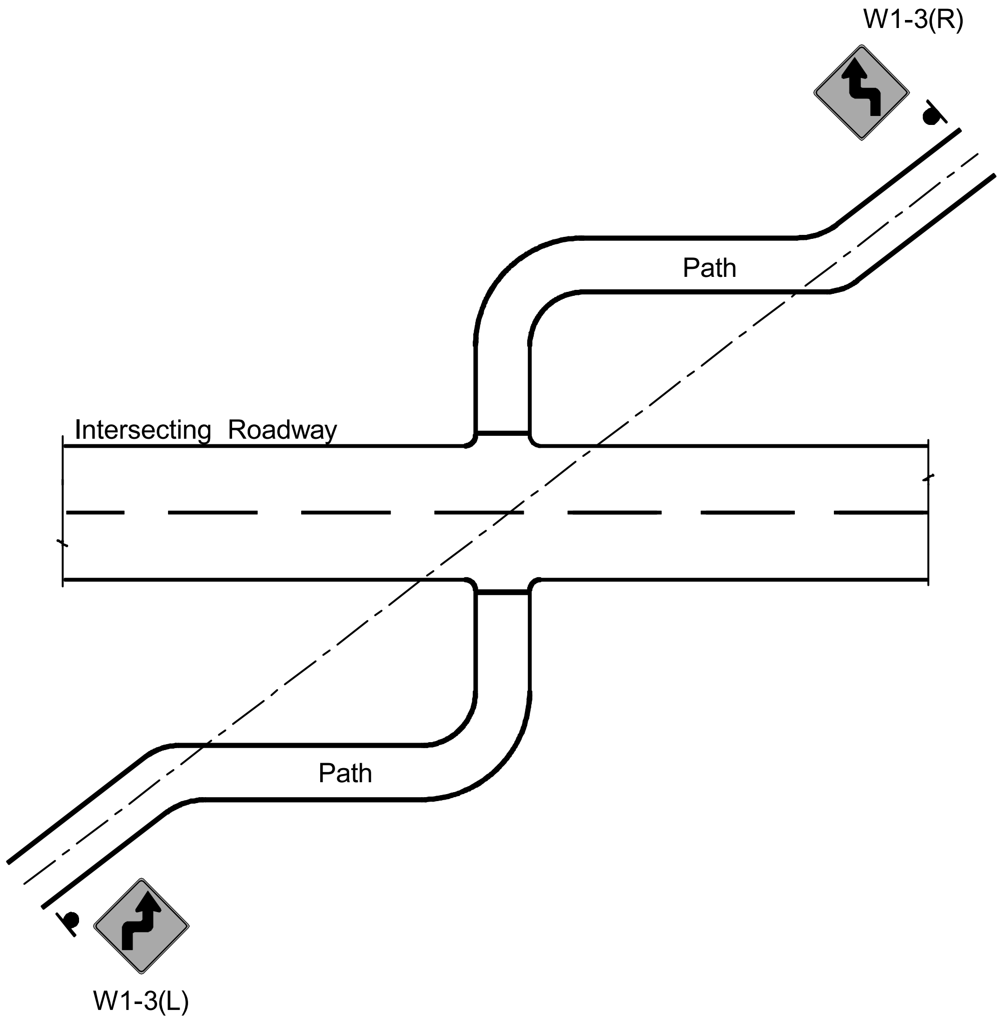
At-grade crossings at existing intersections are usually placed with existing pedestrian crossings where motorists can be expected to stop. If alternate intersection locations for a shared use path are available, select the one with the greatest sight distance.

When possible, place a crossing away from an intersection in order to eliminate conflicts.

Midblock crossings are the least complex of the other types of crossings. Locate midblock path crossings far enough away from intersections so that there is no conflict between the path crossing and the intersection motor vehicle traffic activities. A 90-degree intersection crossing is preferable (Figure 1020-6). A 75-degree angle is acceptable. A 45-degree angle is the minimum acceptable to minimize right of way requirements. A diagonal midblock crossing can be altered as shown in Figure 1020-7.



Midblock Type Shared Use Path Crossing
Figure 1020-6



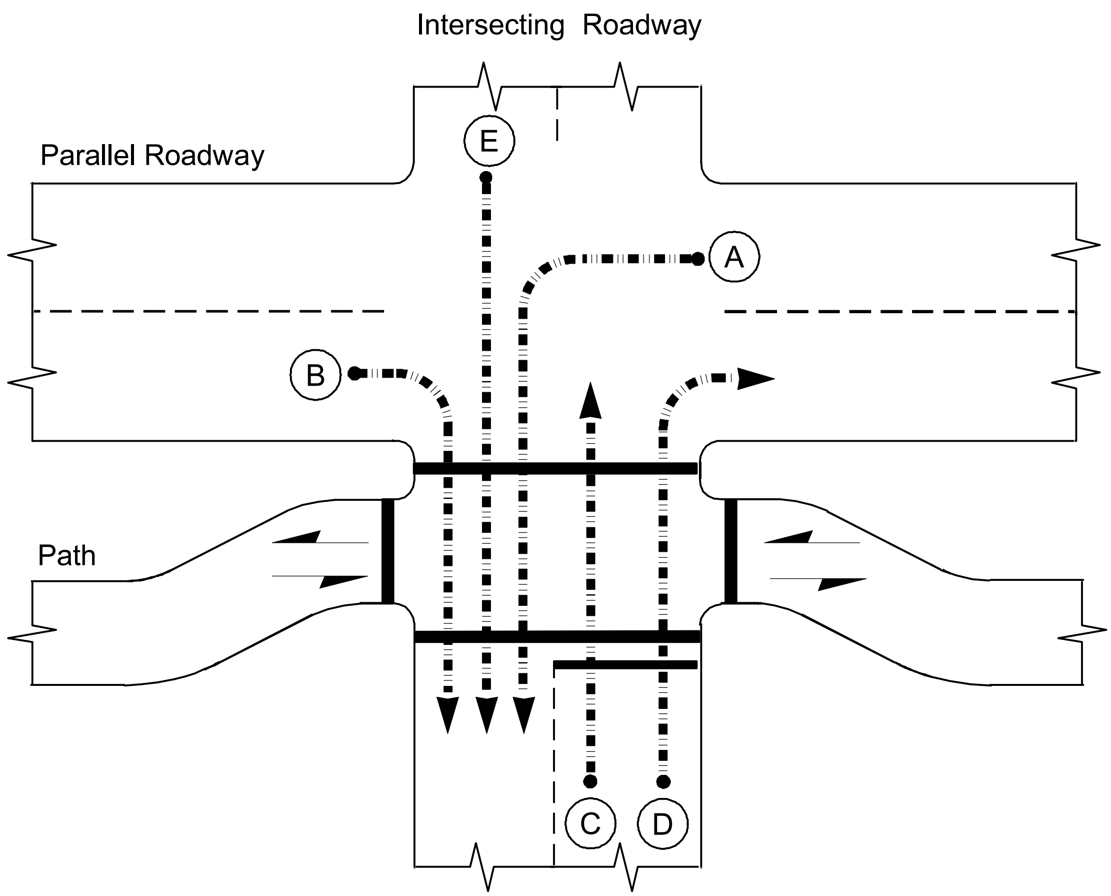
Note: The path and highway signing and markings are the same as in Figure 1020-6

Typical Redesign of a Diagonal Midblock Crossing
Figure 1020-7

There are other considerations when designing midblock crossings, including right of way assignment, 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 1020-8. It is preferable to integrate this type of crossing close to an intersection so that motorists and path users recognize each other 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, 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.



Note: Signing will be the same as shown in Figure 1020-6.

Adjacent Shared Use Path Intersection
Figure 1020-8

Improvements to complex crossings must be considered on a case-by-case basis. Suggested improvements include: move the crossing, install a signal, change signization timing, or provide a refuge island and make a two-step crossing for path users.

The major road might be either the parallel or the crossed roadway. Important elements that greatly affect the design of these crossings are: right of way assignment, traffic control devices, and separation distance between path and roadway.

Other roadway/path design considerations:

- **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.
- **Manually operated signal actuation mechanisms.** Locate the bicyclist's signal button where it is easily accessible to bicyclists and 4 ft above the ground and place a detector loop in the path pavement.
- **Signing**. Place path stop signs as close to the intended stopping point as possible. Four-way stops at shared use path and roadway intersections are not advisable due to confu-

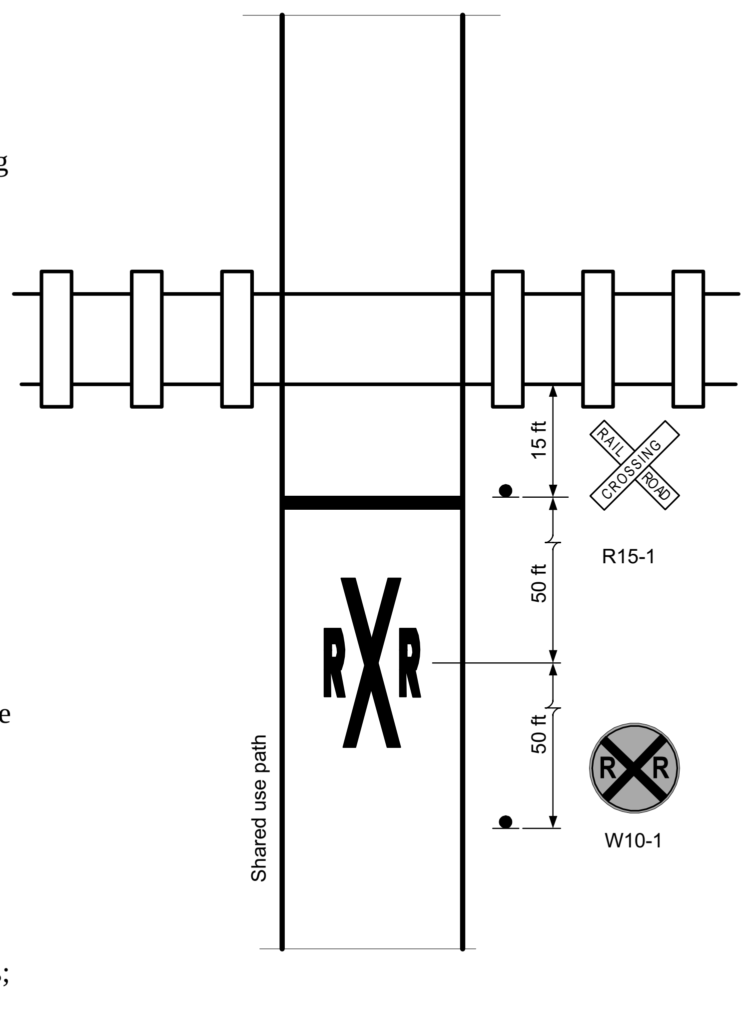
sion about or disregard for right of way laws. Yield signs for path traffic are acceptable at some locations, such as low-volume, low-speed neighborhood streets. Sign type, size, and location must be in accordance with the MUTCD. Do not place the shared use path signs where they will confuse motorists or place roadway signs where they will confuse bicyclists.

- **Approach treatments.** Design shared use path and roadway intersections with flat grades and adequate sight distances. Evaluate stopping sight distance at the intersection. Provide adequate advance warning signs and pavement makings (see MUTCD and Washington State Modifications to the MUTCD) that alert and direct bicyclists to stop before reaching the intersection, especially on downgrades. Provide unpaved shared use paths with paved aprons extending a minimum of 10 ft from the paved road surfaces. Speed bumps or other similar surface obstructions intended to cause bicyclists to slow down are not appropriate.
- **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 bicyclist and motorist at the transition areas.
- **Ramp widths.** Design ramps for curb cuts with the same width as the shared use path. Curb cuts and ramps are to provide a smooth transition between the shared use path and the roadway. Consider a 5 ft radius or flare to facilitate right turns for bicycles. This same consideration applies to intersections of two shared use paths.
- **Refuge islands**. Consider refuge islands when one or more of the following applies: high motor vehicle traffic volume and speeds; wide roadways; crossing will be used by elderly, children, disabled, or other slow moving users. See Figure 1020-17 for details.

(d) **At-Grade Railroad Crossings**. Whenever a bikeway crosses railroad tracks, continue the crossing at least as wide as the approach bikeway. Wherever possible, design the crossing at right angles to the rails. See Figure 1020-18.

For on-street bikeways, where a skew is unavoidable, widen the shoulder (or bike lane) to permit bicyclists to cross at right angles. If this is not possible, consider using special construction and materials to keep the flangeway depth and width to a minimum.

Seen Figure 1020-9 and the MUTCD for the signing and marking for a shared use path crossing a railroad track.



Railroad Crossing for Shared Use Path
Figure 1020-9

(e) **Separation, Barrier, and Fencing.** When possible, provide a wide separation between a shared use path and the traveled way where the path is located near the traveled way.

If the shared use path is inside the Design Clear Zone, provide a traffic barrier. (See Chapter 700, "Roadside Safety," for Design Clear Zone. See Chapter 710, "Traffic Barriers," for barrier location and deflection.) A concrete barrier presents less of a hazard to bicyclists than a W-beam guardrail and is preferred. However, if the edge of the path is farther than 10 ft from the barrier, a W-beam guardrail is also acceptable.

If the roadway shoulder is less than 6 ft wide and the edge of path is within 5 ft of a barrier, provide a taller barrier (minimum of 42") to reduce the potential for bicyclists falling over the barrier into the traveled way. If the roadway shoulder is more than 6 ft wide and the edge of path is more than 5 ft from a barrier, a standard height barrier may be used.

Where the path is to be located next to a limited access facility, there is also a need for an access barrier. Where space permits, fencing, as is described in Chapter 1460, can be provided in conjunction with a standard height barrier. Otherwise, provide a taller barrier (54" minimum height). Provide a taller barrier (54"minimum) on structures specifically designed for bicycle use as is shown on Figure 1020-16.

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.

Consider the impacts of barriers and fencing on the sight distances.

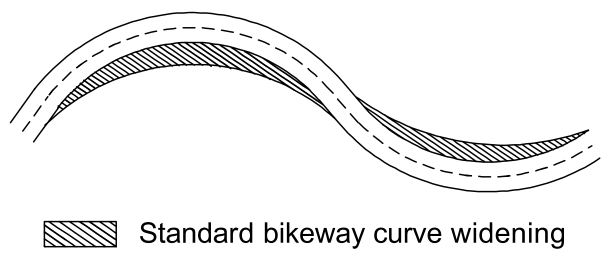
(f) **Design Speed.** The design speed for a shared use path is dependent on the expected conditions of use and on the terrain. See Figure 1020-10 for values.

Conditions	Design Speed MPH	Min. Curve Radius Ft
Open country (level or undulating); separate shared use path in urban areas	20	65
Long down grades (steeper than 4% and longer than 500 ft)	30	145

Bicycle Design Speeds
Figure 1020-10

(g) **Horizontal Alignment and Superelevation.** A straight 2% cross slope on tangent path sections is recommended. This is the maximum superelevation used. A greater superelevation can cause maneuvering difficulties for adult tricyclists and wheelchair users.

Increase pavement width up to 4 ft on the inside of a curve to compensate for bicyclist lean. (See Figure 1020-11.) In sharp curve conditions, consider center line pavement marking on two way facilities.



Radius	Additional Pavement Width
0 ft – 25 ft	4 ft
25 ft – 50 ft	3 ft
50 ft – 75 ft	2 ft
75 ft – 100 ft	1 ft
100 ft +	0 ft

Bikeway Curve Widening
Figure 1020-11

(h) **Stopping Sight Distance.** Figure 1020-19 indicates the minimum stopping sight distances for various design speeds and grades. The values are based on a 4.5 ft eye height for the bicyclist and 0 ft height for the object (roadway surface). On grades, the descending direction controls the design for two-way shared use paths. (Passing sight distance is not considered due to the relatively low speed of bicyclists. Intersection sight distance is not a consideration because of the presence of either signals or stop signs at roadway crossings.)

(i) **Sight Distance of Crest Vertical Curves.** Figure 1020-20, Sight Distance for Crest Vertical Curves, indicates the minimum lengths of crest vertical curves for varying design speeds.

(j) **Lateral Clearance on Horizontal Curves.** Figure 1020-21 indicates the minimum clearances to line-of-sight obstructions for horizontal curves. Obtain the lateral clearance by entering, on the chart, the stopping sight distance from Figure 1020-19 and the proposed horizontal curve radius. Where minimum clearances cannot be obtained, provide standard curve warning signs and use supplemental pavement markings in accordance with the MUTCD.

(k) **Grades.** Some bicyclists are unable to negotiate long, steep uphill grades. Long downgrades can also cause problems on shared use paths. The maximum grade recommended for a shared use path is 5%. It is desirable that sustained grades (800 ft or longer) be limited to 2% to accommodate a wide range of users.

The following grade length limits are suggested:

5-6% for up to 800 ft
7% for up to 400 ft
8% for up to 300 ft
9% for up to 200 ft
10% for up to 100 ft
11+% for up to 50 ft

Grades steeper than 3% might not be practicable 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 ft of width to permit slower speed maneuverability and to provide a place where bicyclists can dismount and walk.
- Use signing in accordance with MUTCD to alert bicyclists of the steep down grades and the need to control their speed.
- Provide adequate stopping sight distance.
- Increase horizontal path side clearances (4 to 6 ft is recommended), and provide adequate recovery area and/or bike rails.

(l) **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. Principle loads will normally be from maintenance and emergency vehicles.

Unless otherwise justified, use asphalt concrete pavement (ACP) in the construction of a shared use path. Asphalt concrete pavement is to be 0.20 ft thick.

Contact the 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 1020-12

(m) **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 Figure 1020-13 for path and graded areas.

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 who have stopped on the bridge.

Undercrossings and tunnels are to have a minimum vertical clearance of 10 ft from the bikeway pavement to the structure. This allows access by emergency, patrol, and maintenance vehicles on the shared use path.

See Figure 1020-16 for barrier and rail placement on bridges. Consult with Maintenance and the Bridge Preservation Office to verify that these widths are 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. The sidewalk may be used as a bikeway or place signs instructing the bicyclist to dismount and walk for the length of a bridge with this type of decking.

Use bicycle-safe expansion joints for all decks with bikeways.

(n) **Drainage.** Sloping the pavement surface to one side usually simplifies longitudinal drainage design and surface construction and is the preferred practice. (See 1020.05(2)(g) for maximum permitted slope.) Generally, surface drainage from the path will be adequately dissipated as it flows down the gently sloping shoulder. 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. Refer to 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. Manhole covers are installed level with the surface of the path.

Drainage inlet grates on bikeways must have openings narrow enough and short enough to ensure that bicycle tires will not drop into the grates. Where it is not immediately feasible to replace existing grates with standard grates designed for bicycles or where grate clogging is a problem, steel cross straps may be installed with a spacing of 6 to 8 inches on centers, to adequately reduce the size of the openings.

(o) **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. Installing reflectors or reflectorized tape are ways to provide visibility. See Standard Plan H-13 Type 1 Bollard.

A single bollard installed in the middle of the path reduces the users' confusion. Where more than one post is necessary, use 5 ft spacing to permit passage of bicycle-towed trailers, wheelchairs, and adult tricycles and to ensure adequate room for safe bicycle passage without dismounting. Design bollard installations so they are removable to permit entrance by emergency and service vehicles, and with breakaway features when in the Design Clear Zone. Ensure that the bollard sleeve is flush with pavement surface.

(p) **Signing and Pavement Markings.** Refer to the MUTCD for guidance and directions for signing and pavement markings for bikeways. Consider a 4 in yellow center line 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. A 4 in white line on each edge of the path helps to delineate the path if nighttime use is expected. Lateral and vertical clearance for signs is shown on Figure 1020-13.

(q) **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 Refer to Chapter 840 for additional guidance concerning illumination of bikeways. Bikeway/roadway intersection lighting is recommended.

(3) Design Criteria for Bike Lane

(a) **Widths**. Some typical bike lane configurations are illustrated in Figure 1020-15 and are described below:

Figure 1020-15, 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.

Do not place bike lanes between the parking area and the curb. Such facilities create hazards for bicyclists, such as opening 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 1020-15, Design B, depicts bike lanes on an urban-type curbed street, where parking is permitted. Establish bike lanes in conjunction with the parking areas. As indicated, 12 ft is the minimum width of the bike lane where parking is permitted. This type of lane is satisfactory where parking is not extensive and where turnover of parked cars is infrequent. However, an additional width of 1 to 2 ft is recommend if parking is substantial or turnover of parked cars is high.

Figure 1020-15, Design C, depicts bike lanes along the outer portions of an urban-type curbed street where parking is prohibited. This configuration eliminates potential conflicts with motor vehicle parking. Opening car doors is an example. Minimum widths are shown. Both minimum widths shown must be achieved. With a normal 2 ft gutter, the minimum bike lane width is 5 ft. Post NO PARKING signs when necessary.

Figure 1020-15, Design D, depicts bike lanes on a highway without curbs and gutters. Minimum widths are shown. Additional width is desirable, particularly where motor vehicle operating speeds exceed 40 mph.

High-speed truck, bus, and recreational vehicle traffic can cause problems along a bike lane because of aerodynamic effects and vehicle widths. Increase shoulder width to accommodate the large vehicles and bicycle traffic when 5% or more of the daily traffic is truck, bus, or recreational vehicle traffic.

Bike lanes are not advisable on long, steep downgrades where bicycle speeds greater than 30 mph can be expected. As grades increase, downhill bicycle speeds will increase, which increases the handling problems if riding near the edge of the roadway. In such situations, bicycle speeds can approach those of motor vehicles, and Category A bicyclists will generally move into the motor vehicle lanes to increase sight distance and maneuverability. However, Category B & C bicyclists might be placed in a hazardous position, thus signing in accordance with the MUTCD is needed to alert them 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 only when it produces fewer conflicting movements between bicycles and motor vehicles.

(b) **Intersection and Signal Design**. Most motor vehicle/bicycle collisions occur at intersections. For this reason, 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. *(RCW 46.61)*

Figure 1020-22 illustrates a typical intersection of multilane streets, with bike lanes on all approaches. Some common movements of motor vehicles and bicycles are shown. At intersections where there are bike lanes and traffic signals, consider the installation of loop detectors within the bike lane (in advance of the intersection). Select loop detectors sensitive enough to detect bicycles. Bicyclists generally prefer not to use push button actuators, as they must go out of the way to actuate the signal. For additional guidance on signal design at intersections involving bike lanes, refer to Chapter 850.

Figures 1020-23a and b illustrate two pavement marking pattern options where bike lanes cross freeway off and on-ramps. Option 1 provides a defined crossing point for bicyclists that want to stay on their original course. This option is desirable when bicyclists for various reasons 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 is intended for use on highways to warn motorists of the possibility of bicyclists crossing the roadway.

Dashed lines across the off-ramp are not permitted.

Figure 1020-24 illustrates the recommended pavement marking patterns 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 eliminate all delineations at the approach of the right turn lane (or off-ramp) or to extend a single, dashed bike lane line at a flat angle across the right turn lane. A pair of parallel lines (delineating a bike lane crossing) to channelize the bike merge is not recommended as this encourages bicyclists to cross at a predetermined location. In addition, some motorists might assume they have the right of way and neglect to yield to bicyclists continuing straight.

A dashed 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.

(c) **Traffic Signals**. At signalized intersections, consider bicycle traffic when timing the traffic signal cycle and when selecting the method of detecting the presence of the bicyclist. Contact the region's Bicycle Coordinators for assistance in determining the timing criteria.

(d) **Signing and Pavement Markings**. Use the general guidelines in the MUTCD, Part IX, and the Washington State Modifications to the MUTCD for acceptable signing and pavement marking criteria. Additional guidelines are shown on Figures 1020-15, 1020-25, and 1020-26. Lateral and vertical clearance for signs is shown on Figure 1020-13.

(f) **Drainage Grates and Manhole Covers**. Locate drainage inlet grates and manhole covers to avoid bike lanes. When drainage grates or manhole covers are located on a bike lane, minimize the effect on bicyclists. A minimum of 3 ft 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 more information see 1020.05(2)(n).

(4) Design Criteria for Shared Roadway

Any improvements for motor vehicle traffic on a shared roadway will also improve the traveling conditions for bicycles.

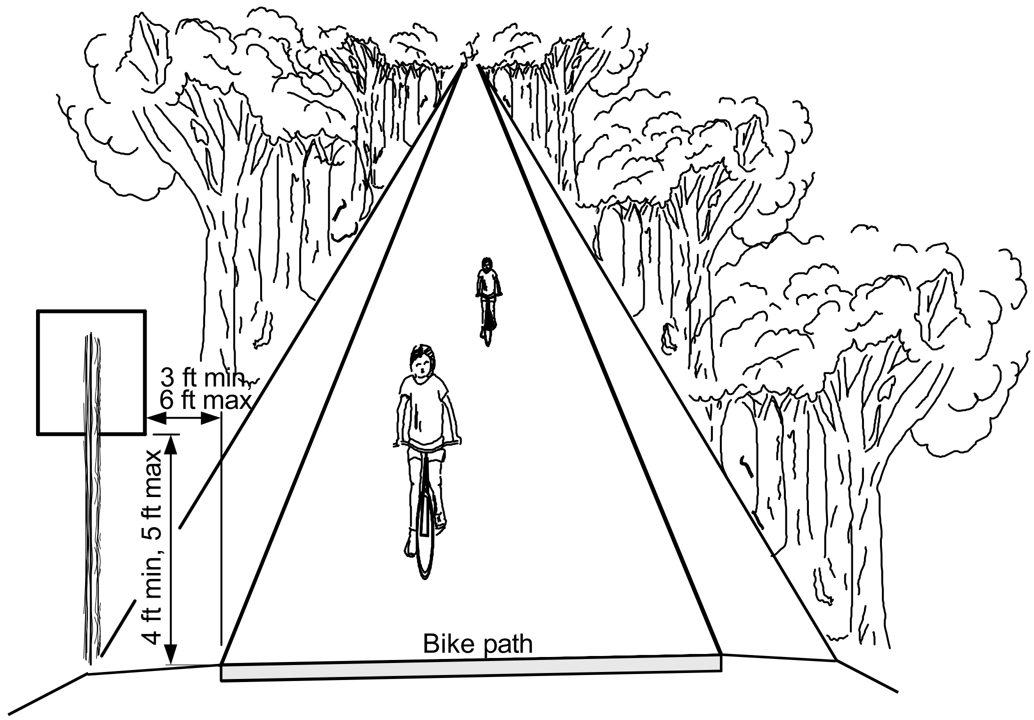
A shared roadway designated as a bike route offers a greater degree of service to bicyclists than other roadways. Establish a bike route by placing the MUTCD Bicycle Route signs or markers along the roadway. Improvements might have to be made for safer bicycle travel. Some improvements for facilitating better bicycle travel are widening the shoulders using the shoulder criteria in Chapter 430 "Modified Design Level" and 440 "Full Design Level", adding pavement markings, improving roadside maintenance, removing surface hazards such as drain grates not compatible with bicycle tires, and other facilities to provide better traveling for bicyclists.

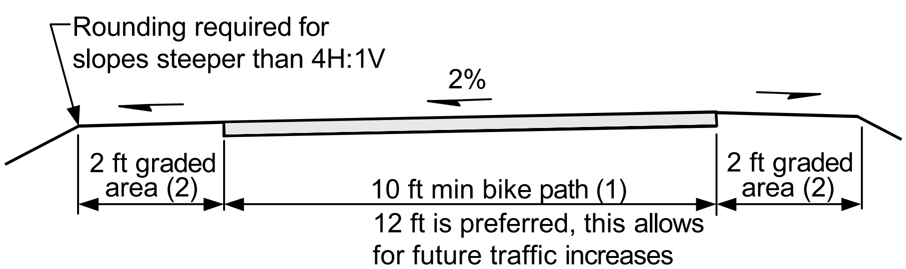
1020.06 Documentation

The following documents are to be preserved in the project file. See Chapter 330.

- ☐ Justification for reduction of roadway cross sections
- ☐ Justification for reduction of bikeway cross sections
- ☐ New or major improvement projects where bike lanes or bike paths are not accommodated (except where prohibited).

P65:DP/DM



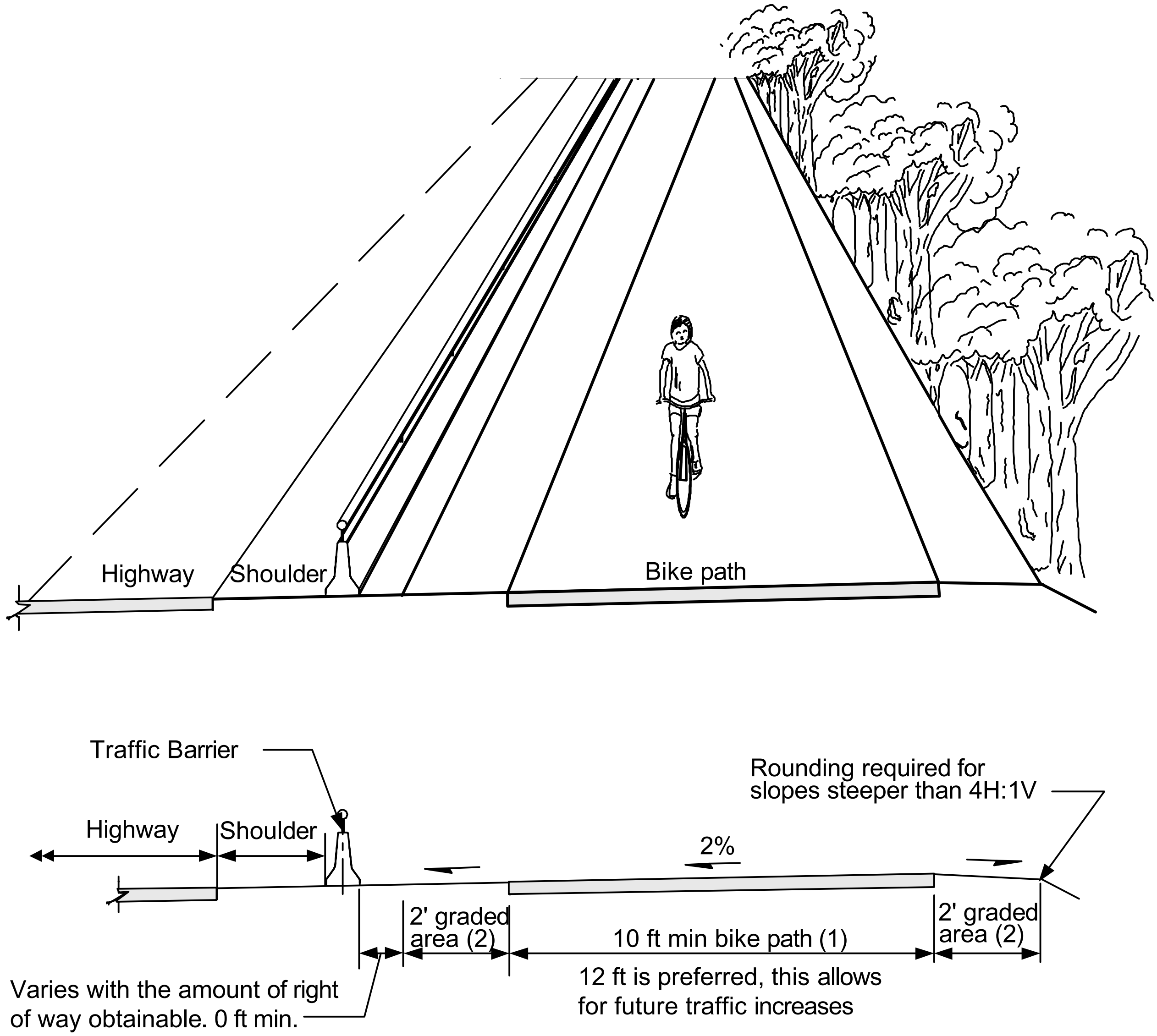


NOTE:

(1) Use 12 to 14 ft when maintenance vehicles use a shared use path as an access road for utilities. Use of 12 to 14 ft paths is recommended when there will be substantial use by bicycles (≥60 bicycles per day), or joggers, skaters, and pedestrians (20 per hour). Contact region's Bicycle Coordinator for bicycle use information. See 1020.05(2)(a) for more discussion on bicycle path widths.

(2) Where the paved width is wider than the minimum required, reduce the graded area accordingly.

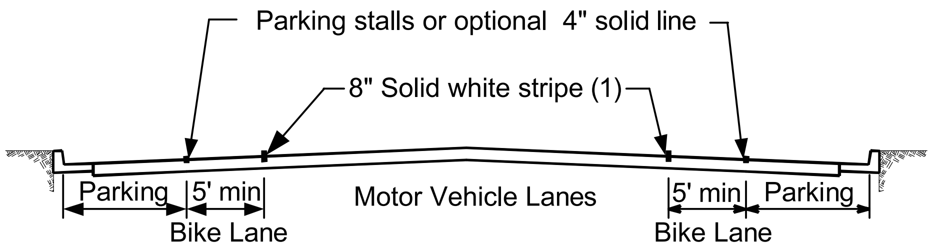
Two-Way Shared Use Path on Separate Right of Way
Figure 1020-13



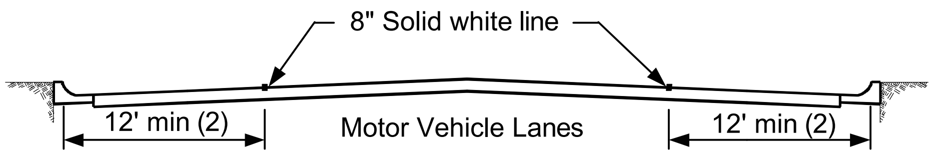
For Notes (1) and (2) see Figure 1020-13

See 1020.05(2)(e) for selecting barriers between bicycle path and shoulder and the need for fencing on limited access roadways.

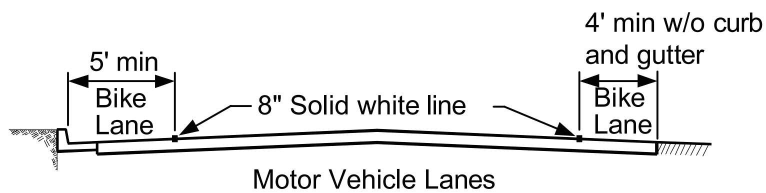
Two-Way Shared Use Path Adjacent to Roadway
Figure 1020-14



Design A marked parking

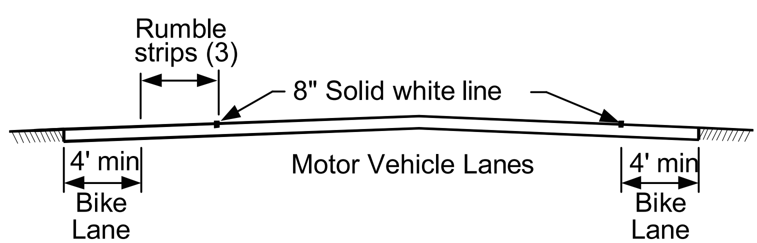


Design B parking permitted without parking line or stall



Design C parking prohibited

Post NO PARKING signs as required



Design D typical roadway

Note:

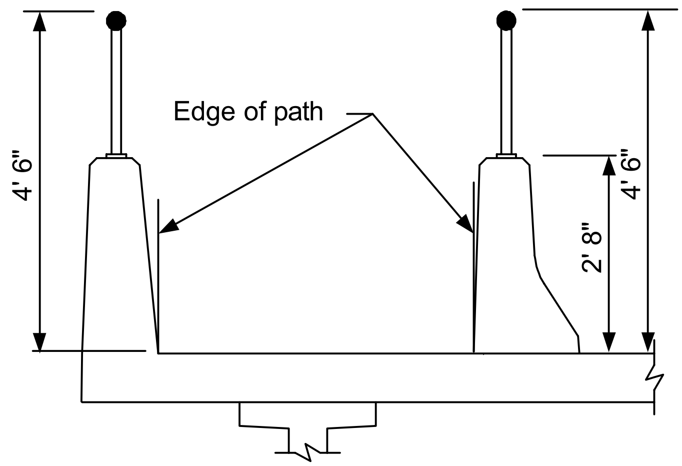
(1) The optional solid white line might be advisable where stalls are unnecessary (because parking is light) but there is concern that motorists might misconstrue the bike lane to be a traffic lane.

(2) 13 ft – 14 ft is recommended where there is substantial parking or turnover of parked cars is high.

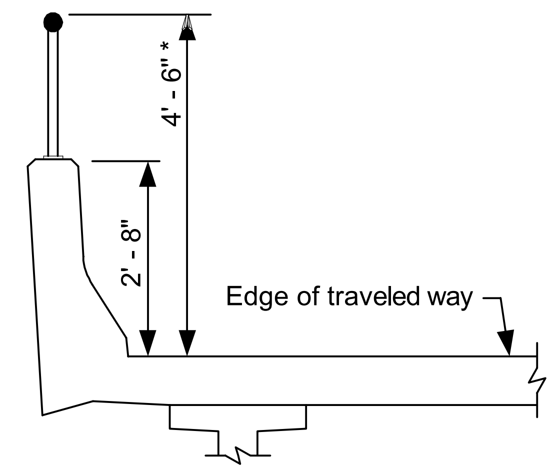
(3) If rumble strips exist, provide 4 ft minimum from the rumble strips to the outside edge of the shoulder.

Typical Bike Lane Cross Sections

Figure 1020-15



Separated (shared use paths only)



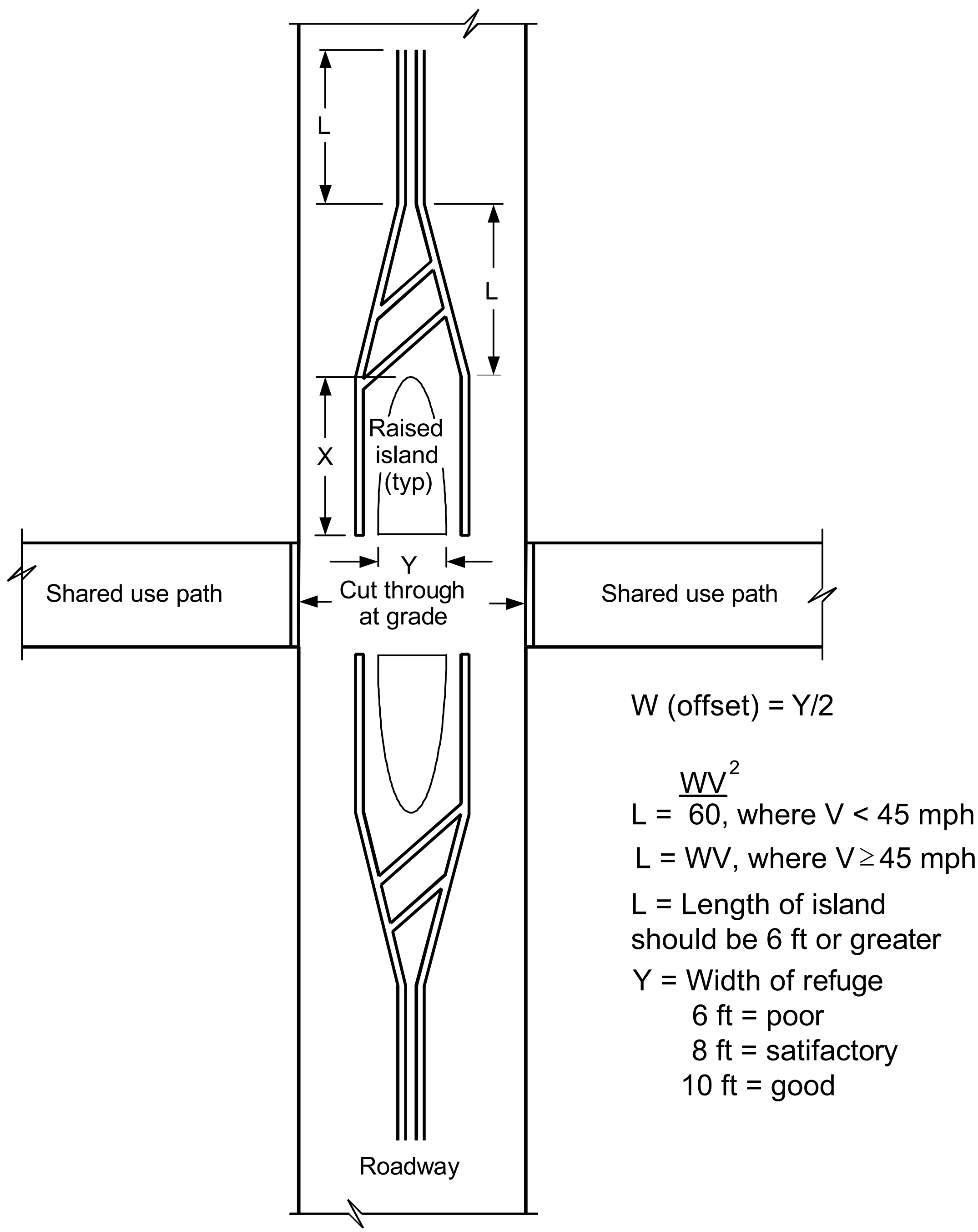
Unseparated (bike lanes and shared roadway)

Bicyclists use the shoulder between the edge of traveled way and the bridge rail.

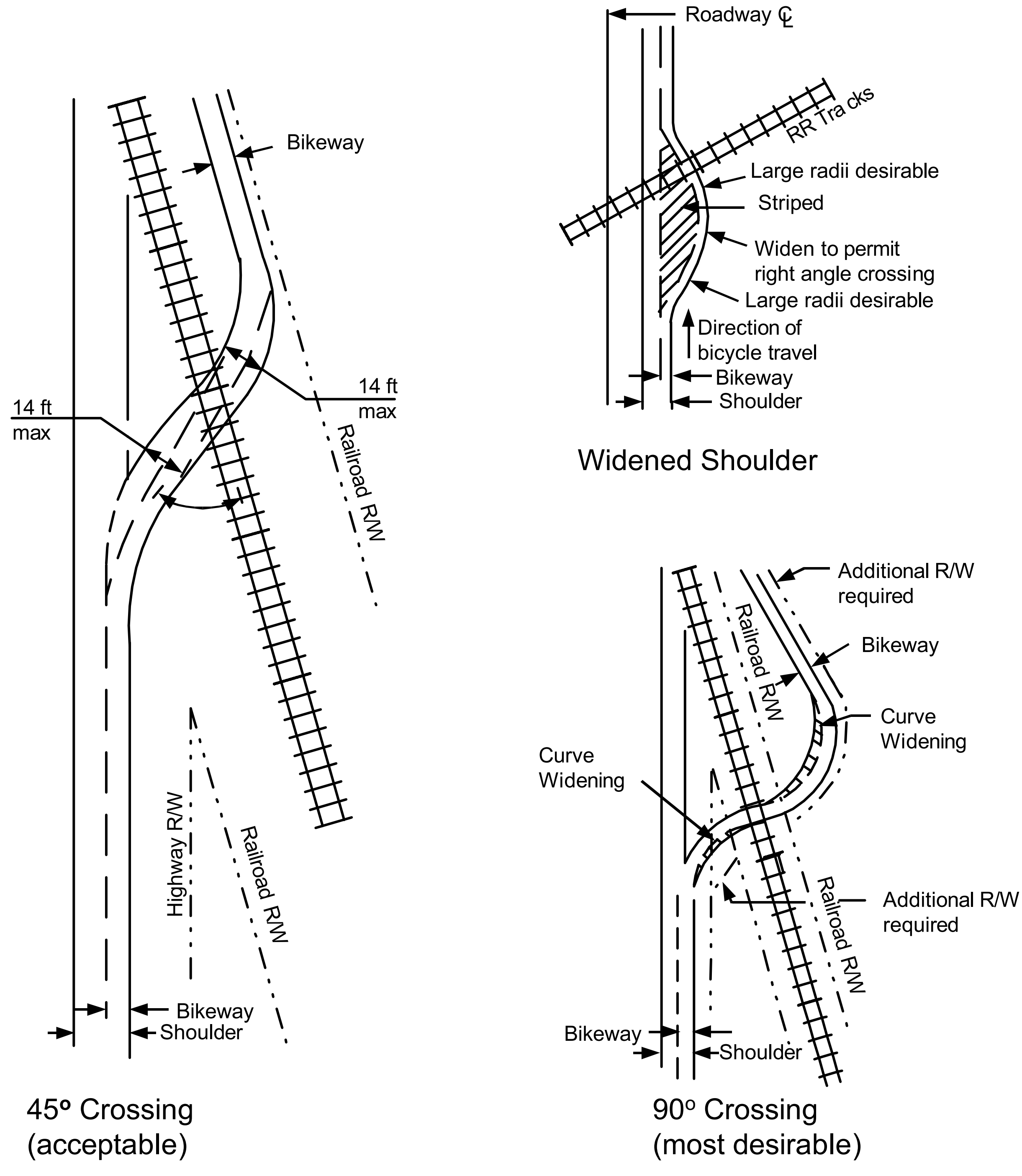
Note:

The above applies to bike lanes and shared use paths. The 2'-8" barrier is used for shared use roadways.

Bikeways on Highway Bridges
Figure 1020-16



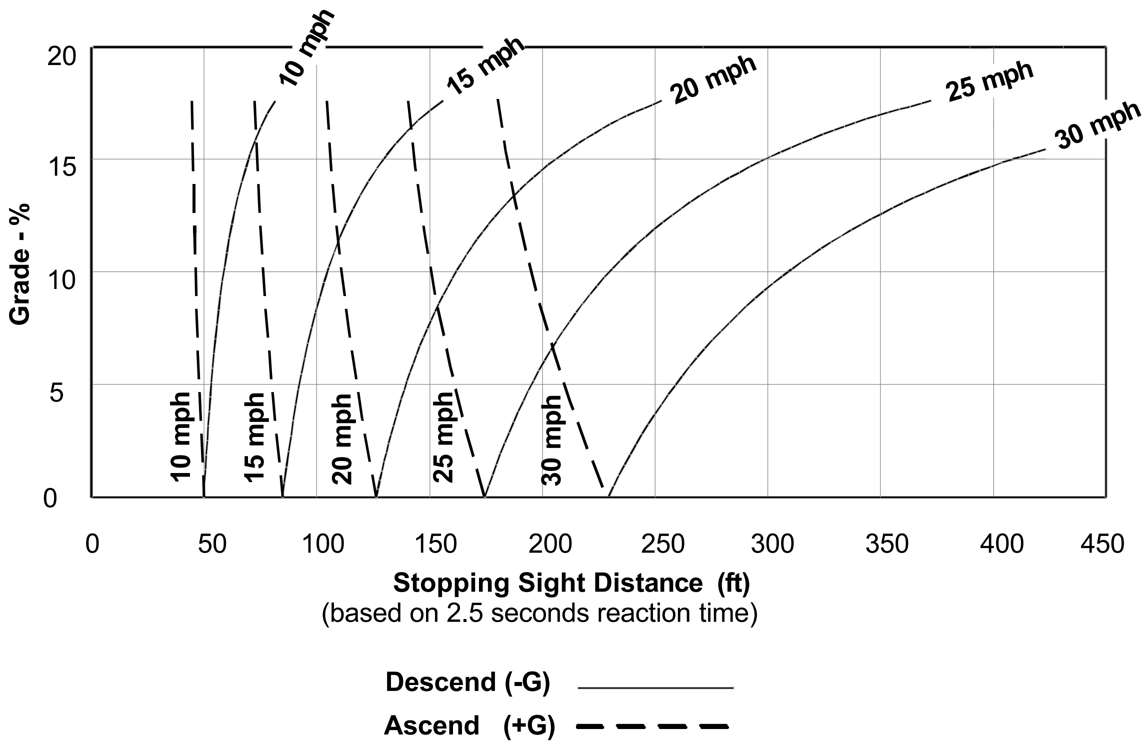
Refuge Area
Figure 1020-17



Note:

Provide additional width to 14 ft to be provided at railroad crossing to allow bicyclists to choose their own crossing routes.

At-Grade Railroad Crossings
Figure 1020-18



$$S = \frac{V^2}{30\,(f \pm G)} + 3.67\,V$$

Where:

S = Stopping Sight Distance, ft.
V = Velocity, mph
f = Coefficient of Friction (use 0.25)
G = Grade ft/ft (rise/run)

Stopping Sight Distance
Figure 1020-19

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)														

$$L = \frac{AS^2}{900} \quad \text{when } S < L$$

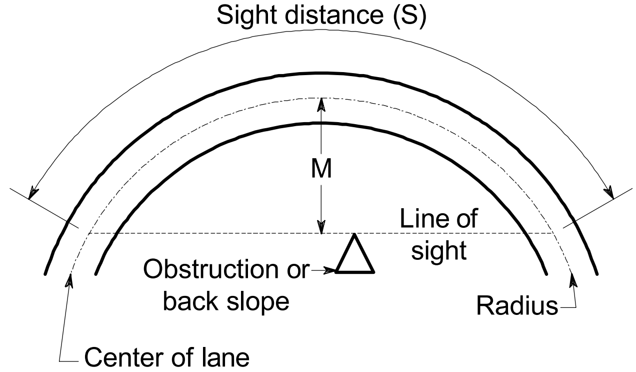
$$L = 2S - \frac{900}{A} \quad \text{when } S < L$$

Where:
S = Stopping sight distance.
A = Algebraic difference in grade.
L = Minimum vertical curve length

Based on an eye height of 4.5 ft and an object height of 0 ft.

Sight Distances for Crest Vertical Curves
Figure 1020-20

Height of eye: 4.50 ft
Height of object: 0.0 ft
Line of sight is normally 2.25 ft above center line of inside lane at point of obstruction provided no vertical curve is present in horizontal curve.



$$M = R\left(1 - \cos\frac{28.65\,S}{R}\right)$$

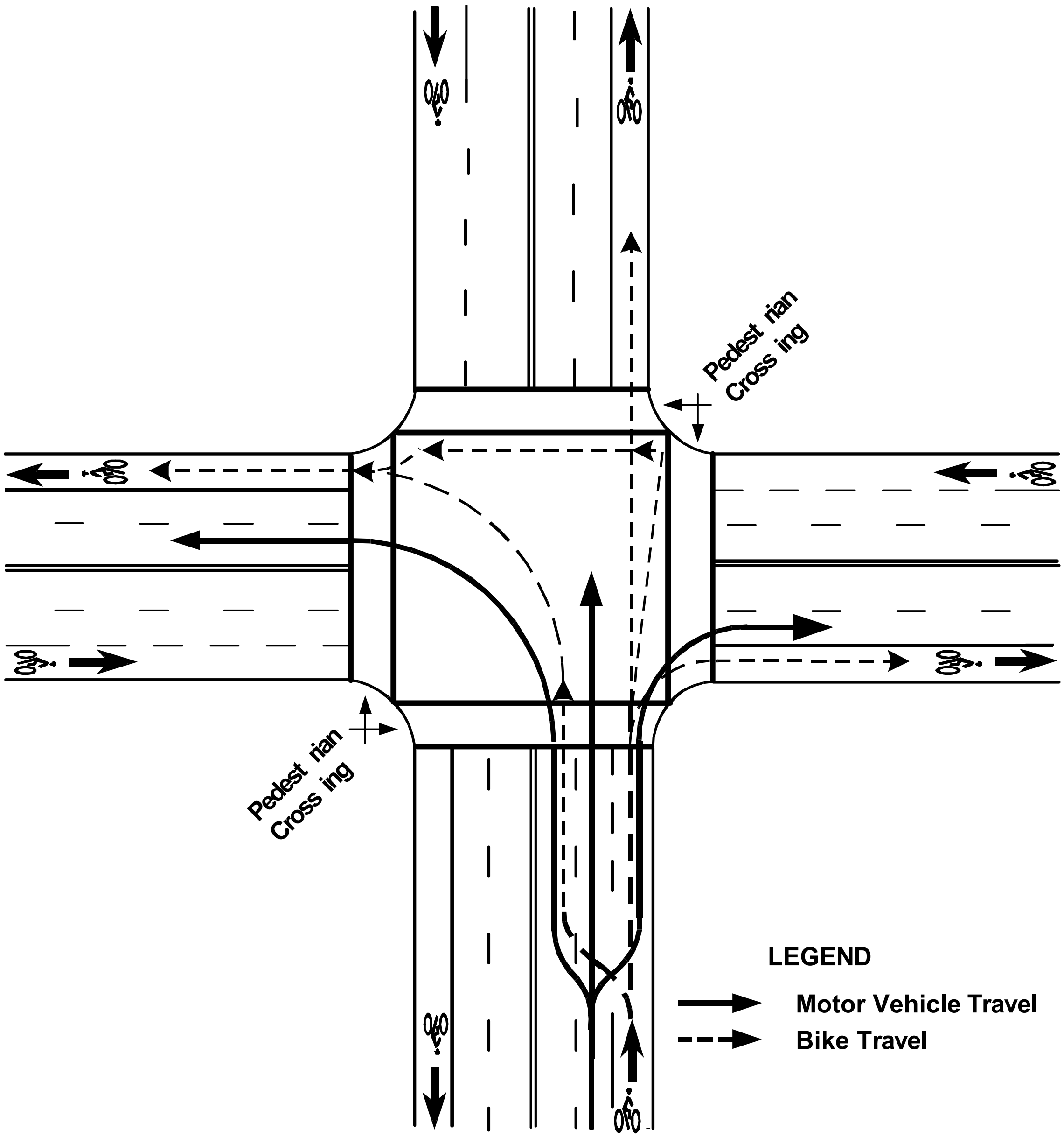
$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R-M}{R}\right)\right]$$

$S \leq$ Length of curve
Angle is expressed in degrees

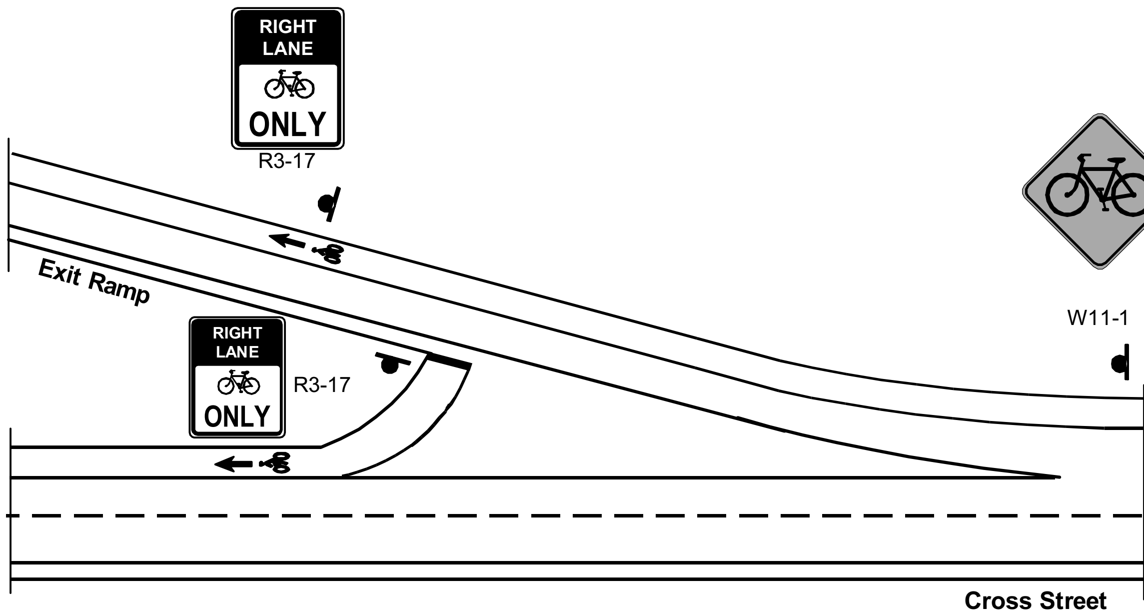
Where:
S = Sight distance in feet
R = Radius of center line inside lane in feet
M = Distance from center line inside lane in feet

R (ft)	Stopping Sight Distance, S (ft)													
	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)														

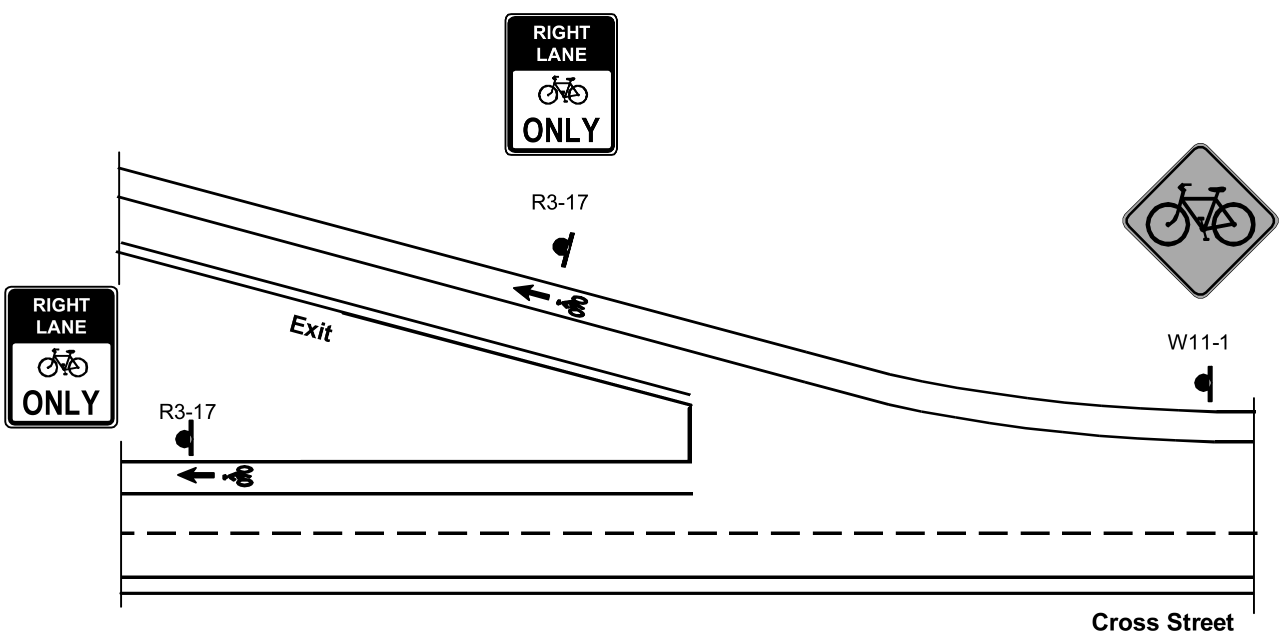
Lateral Clearance on Horizontal Curves
Figure 1020-21



Typical Bicycle/Auto Movements at Intersection of Multilane Streets
Figure 1020-22



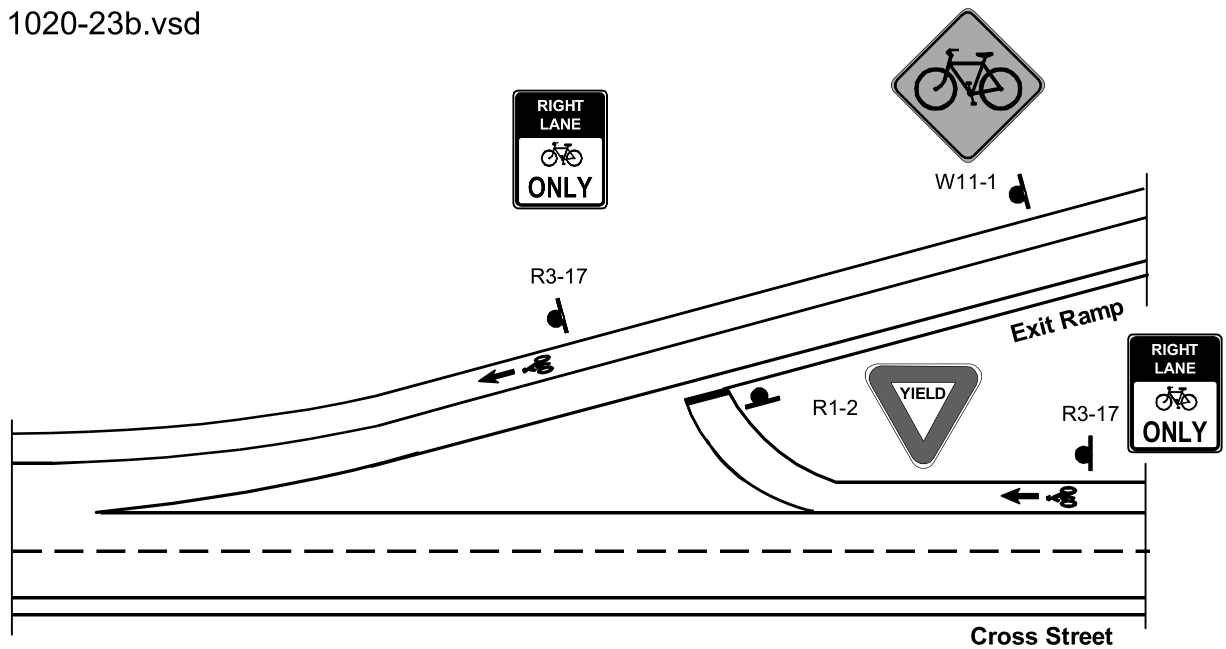
Option 1



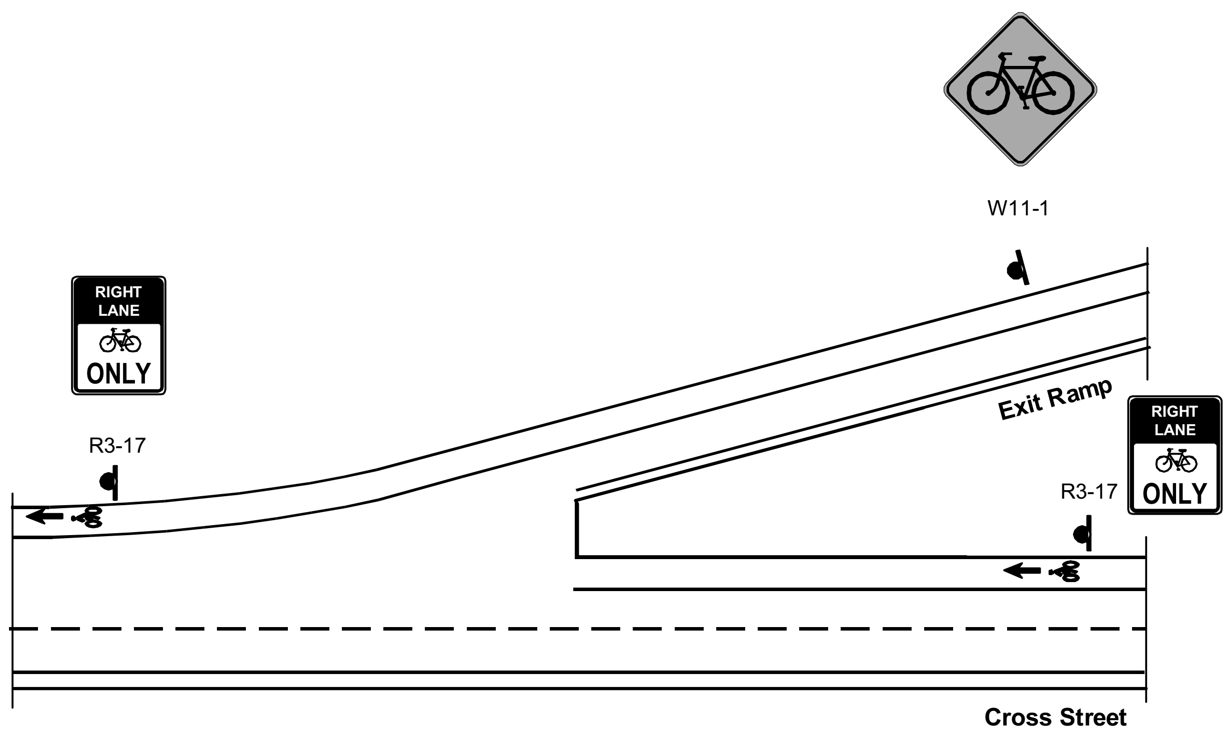
Option 2

Bicycle Crossing of Interchange Ramp
Figure 1020-23a

1020-23b.vsd

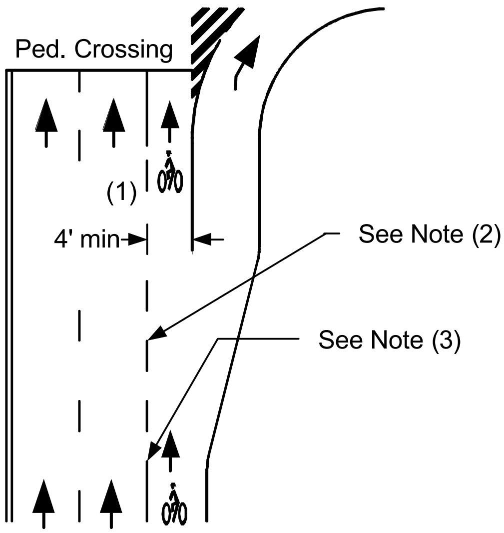


Option 1

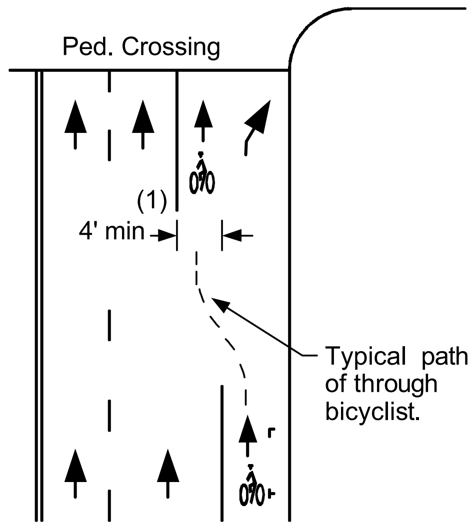


Option 2

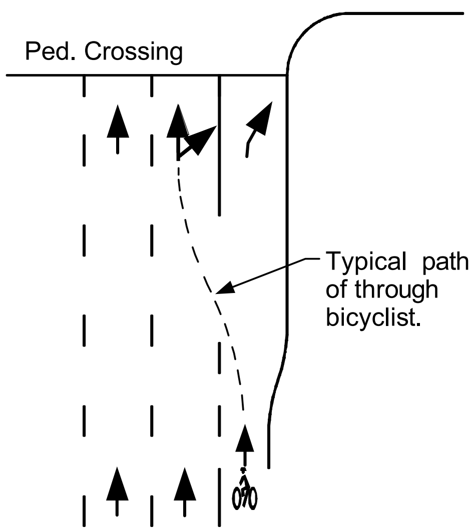
Bicycle Crossing of Interchange Ramp
Figure 1020-23b



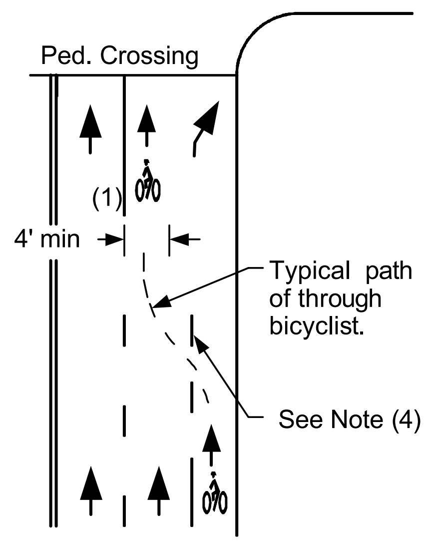
RIGHT-TURN-ONLY LANE



PARKING AREA BECOMES
RIGHT-TURN-ONLY LANE



OPTIONAL DOUBLE
RIGHT-TURN-ONLY LANE



RIGHT LANE BECOMES
RIGHT-TURN-ONLY LANE

Note:

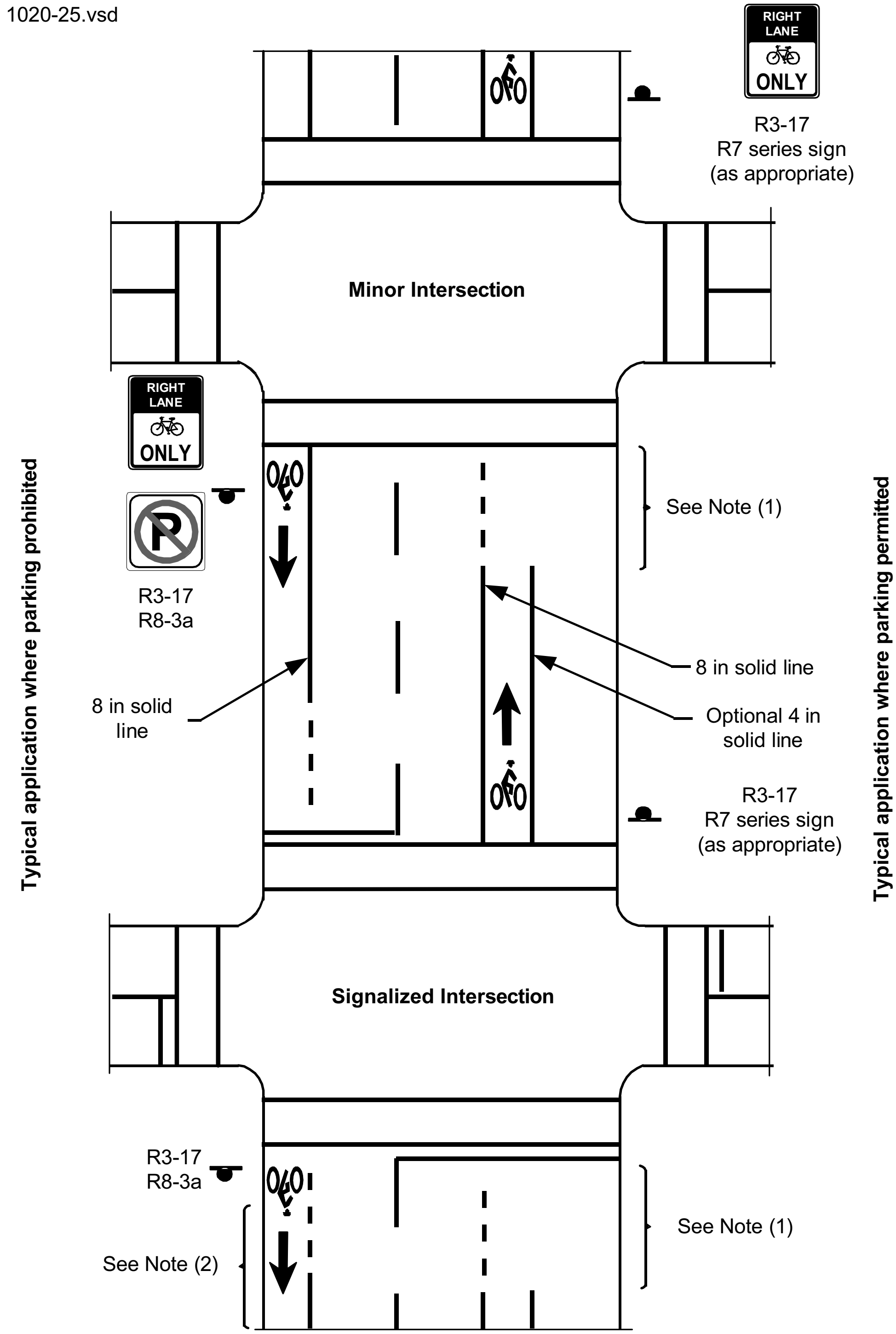
(1) If space is available.

(2) Optional dashed line. Not recommended where a long right-turn-only lane or double turn lanes exist.

(3) Otherwise, drop all delineation at this point.

(4) Drop bike lane line where right-turn-only designated.

Bike Lanes Approaching Motorists' Right-Turn-Only Lanes
Figure 1020-24

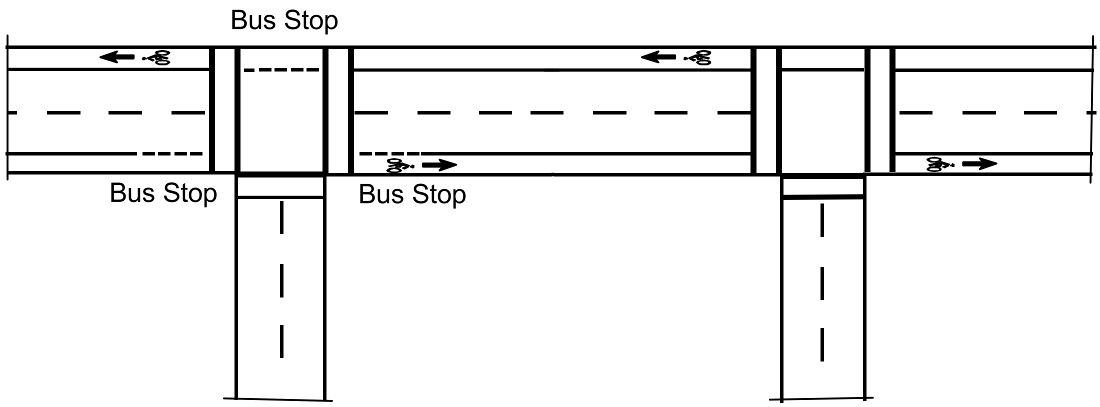


Note:

(1) 50 to 200 ft dotted line if bus stop or heavy right-turn volume, otherwise solid line.

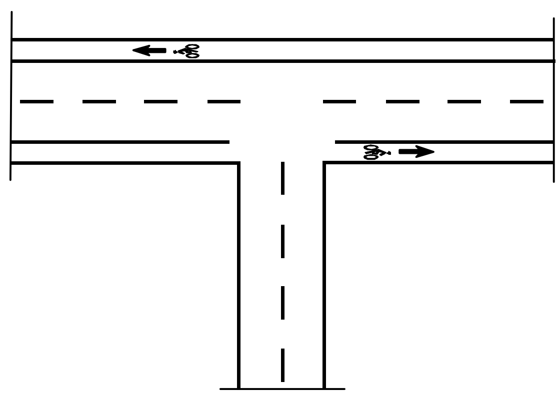
(2) Dotted line for bus stops immediately beyond the intersection is optional; otherwise use 8 in solid line

Typical Pavement Marking for Bike Lane on Two-Way Street
Figure 1020-25



T-Intersection
with bus stops
and painted crosswalks

T-Intersection
with painted crosswalks
and no bus stops



T-Intersection
with no painted crosswalks

Typical Bike Lane Pavement Markings at T-Intersections
Figure 1020-26

1025.01 General

Pedestrians are present on most highways and transportation facilities, yet their travel mode differs vastly and sometimes is in conflict with the requirements for vehicular travel. The challenge is to provide safe and efficient facilities that address these two competing interests within a limited amount of right of way. Sidewalks and trails serve as critical links in the transportation network. Facilities that encourage pedestrian activities are a part of comprehensive transportation planning and development programs for urban and rural communities.

1025.02 References

Design Guidance, Accommodating Bicycle and Pedestrian Travel. A Recommended Approach, USDOT Policy Statement, 2001

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT, Washington DC, 1988, including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT, 1996

RCW 46.04.160, "Crosswalk"

RCW 46.61.240, "Crossing at other than crosswalks"

RCW 47.24.010, City streets as part of state highways, "Designation-construction, maintenance-return to city or town"

RCW 47.24.020, City streets as part of state highways, "Jurisdiction, control"

Roadside Manual, M 25-30, WSDOT

Sidewalk Details, WSDOT, 2000

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

Pedestrian Facilities Guidebook: Incorporating Pedestrians into Washington's Transportation System, OTAK, 1997

1025.03 Definitions

accessible route An unobstructed pedestrian route that meets the requirements of the Americans with Disabilities Act accessibility guidelines.

ADA An abbreviation for the Americans with Disabilities Act of 1990. The ADA is a civil rights law that identifies and prohibits discrimination based on disability. The ADA requires public entities to design new facilities or alter existing facilities, including sidewalks and trails that are accessible to people with disabilities. Preservation projects, usually, are not considered an alteration of existing facilities. Accessibility can be addressed in preservation projects as a spot safety improvement.

bulb out A curb and sidewalk bulge or extension out into the roadway used to decrease the length of a pedestrian crossing.

crosswalk That marked or unmarked portion of a roadway designated for a pedestrian crossing.

landing A level area at the top of a pedestrian ramp.

midblock pedestrian crossing A marked pedestrian crossing located between intersections.

pedestrian facilities Walkways such as sidewalks, highway shoulders, walking and hiking trails, shared use paths, pedestrian grade separations, crosswalks, and other improvements provided for the benefit of pedestrian travel.

pedestrian-friendly A term for an environment that is safe, pleasant, and inviting to pedestrians.

pedestrian refuge island A raised area between traffic lanes that provides a place for pedestrians to wait to cross the street.

raised median A raised island in the center of a road used to restrict vehicle left turns and side street access. Pedestrians often use this median as a place of refuge when crossing a roadway.

1025.04 Policy

(1) General

Pedestrian facilities are required along and across most sections of state routes and are an integral part of the transportation system. Walkways and other pedestrian facilities are considered in the project definition phase. The only factors that will preclude providing pedestrian facilities in a project are as follows:

- Pedestrians are prohibited by law from using the facility.
- The cost of the improvements is excessive and disproportionate to the original need or probable use (as a guide, more than 20% of the original estimate).
- Low population density or other factors indicate that there is no need.

(2) Funding Programs

The adequacy of appropriate pedestrian facilities is addressed in mobility, safety, bridge replacement, and economic initiative projects in both the Highway Capitol Improvement and Preservation Programs. Federal, state, and local funds are available for pedestrian facility projects.

(a) **Improvement Program**

Mobility Program (I-1). Pedestrian facilities are included in improvement projects in urban areas unless the facility is restricted to motor vehicle use. In urban areas, pedestrian facilities can include traffic control devices, grade separations, crosswalks, sidewalks, and illumination. Other technologies, design features, or strategies, such as creating a pedestrian-friendly atmosphere, are generally beyond the scope of usual highway construction projects. These design features, however, can be included in a highway project when a local agency desires to participate and can provide the necessary funding. Partnership agreements between the state and local agencies to provide pedestrian amenities are effective ways to address seemingly different goals.

In rural areas, paved roadway shoulders are usually sufficient as pedestrian facilities. In high pedestrian use areas adjacent to the highway (state parks, recreation areas, and public-owned parking lots) additional signing, marked crosswalks, and separate pedestrian paths and trails might be necessary. Separate pedestrian paths or trails are appropriate, in some circumstances, as connections between activity centers or as part of a comprehensive trails plan.

Safety Program (I-2). Pedestrian Accident Locations (PALs) are sections of state routes with four or more pedestrian collisions with vehicles in a six-year period. PALs usually have a high societal cost and compete favorably with High Accident Locations (HALs) for safety funding.

Pedestrian Risk Projects are sections of state highways that have a high risk of pedestrian collisions with vehicles based on adjacent land use, roadway geometric design, and traffic conditions. Each region has a funding allotment to address pedestrian risk locations. Short sections of sidewalks, illumination, raised medians, and other pedestrian facilities are eligible for safety funding where there are pedestrian collisions, such as part of PAL or a High Accident Corridor (HAC).

Economic Initiatives (I-3). Projects supporting tourism development, promoting the interpretation of heritage resources, and ensuring public access to rest room equipped facilities can include limited pedestrian facility improvements if the site generates pedestrian activity.

(b) **Preservation Program**

Roadway Program (P-1). Projects funded by the Highway Capitol Preservation Program usually do not include enhancement of existing pedestrian facilities except as minor pedestrian spot safety improvements. Other funding sources, including local agency participation through federal grants, can be used for sidewalks, walkways, or other pedestrian facilities in these projects.

Structures Program (P-2). Bridge replacement funding can be used to replace existing pedestrian facilities or to match shoulder width or sidewalks of adjacent roadways on bridges.

Other Facilities (P-3). This funding source can be used to refurbish pedestrian facilities and address ADA requirements within existing rest areas.

(3) Project Requirements

For urban mobility improvement projects (Pedestrian connectivity projects in the matrices, Chapter 325), apply the guidance in this chapter to the pedestrian facility.

For highway design elements affected by the project, apply the appropriate design level (Chapter 325) and design requirements in the applicable *Design Manual* chapters.

For highway design elements not affected by the project, no action is required.

1025.05 Pedestrian Human Factors

Understanding the human behavior of pedestrians aids in the design of effective facilities. Young children tend to dart out into traffic because they have no understanding of vehicle stopping distances or sight limitations. Older children and teenagers are more likely to cross midblock, or step out in front of oncoming traffic. Adults are more capable of perceiving and dealing with risk. Senior adults and persons with disabilities are most likely to obey crosswalk laws and make predictable movements. Senior pedestrians, as a group, also tend to have reduced vision, balance, speed, stamina, and have trouble distinguishing objects in low light and nighttime conditions.

Walking rates are an important consideration in intersection design. The average walking speed for pedestrians is 4 feet per second. Actual walking speeds, however, can vary from 2.4 to 6.0 feet per second depending on the age group. In addition, people with disabilities require more time to cross a roadway. In areas with a higher senior adult population, a walking rate of 3.0 feet per second is more realistic. This can be mitigated at locations with traffic signals by providing longer pedestrian signal timings, or pedestrian refuge areas, such as islands and medians.

Factors that contribute to deterring pedestrian travel include:

- High vehicle volumes and speeds
- Lack of separated pedestrian facilities
- Lack of a continuous walkway system (missing links)
- Poor nighttime lighting
- Lack of connections to pedestrian activity generators
- Inaccessible to people with disabilities
- Concerns for personal safety
- Barriers on walking route (rivers, railroads, bridges without sidewalks)
- Narrow walkway width
- Lack of transit shelter

To encourage multimodal transportation, livable communities, and pedestrian safety, many agencies provide pedestrian-friendly features along their streets, roads, and highways. The following are several pedestrian-friendly practices in current use:

- ADA accessible routes
- More direct alignment of walkways to reduce travel distances
- A complete network of pedestrian connections
- Ramps and handrails for persons with disabilities
- Medians and pedestrian refuge islands
- Buffers between the walkway and roadway
- Lower vehicular speeds
- Adequate pedestrian signs, signals, and markings
- Pedestrian furniture and vegetation
- Bulb outs or curb extensions
- Adequate illumination
- Audible warning signals

1025.06 Pedestrian Activity Generators

The types of land uses that indicate high pedestrian activity are residential developments with four or more housing units per acre interspersed with multifamily dwellings or hotels located within 1/2 mile of other attractions. These attractions might be retail stores, schools, recreation areas, or senior citizen centers. Certain types of businesses, such as “deli-mart” type stores, fast food restaurants, and skateboard parks, can cater to a specific pedestrian age group and generate high activity levels.

Information on land use, development, and estimated pedestrian densities is available from metropolitan planning organizations, region planning offices, and city and county planning department comprehensive plans.

School districts designate walking routes for every elementary school. In general, children within one mile of the school are required to walk unless there are hazardous walking conditions. Contact the school district’s safety manager to determine the walking routes, average student age, transit stops, and the distance from the school to attractions. Sports, school plays, and other special events occurring after normal school hours can also generate exceptionally high levels of pedestrian activity. Consider the impact of these events when providing pedestrian facilities.

1025.07 Pedestrian Facility Design

(1) Facilities

The type of pedestrian facility provided is based on local transportation plans, the roadside environment, pedestrian volumes, user age group, safety-economic analysis, and continuity of local walkways along or across the roadway. Sidewalks can be either immediately adjacent to streets and highways or separated from them by a buffer. Walking trails, hiking trails, and shared use paths are independently aligned and generally serve recreational activities.

The type of walkway also depends on the access control of the highway as follows:

Full Access Control. Walking and hiking trails and shared use paths within the right of way are separated from vehicular traffic with physical barriers that discourage pedestrians from entering the roadway. These trails can connect with other trails outside the right of way if the access permit is modified. Grade separations are provided when the trail crosses the highway.

Partial or Modified Access Control. Walking and hiking trails and shared use paths are located between the access points of interchanges or intersections. Pedestrian crossings are usually either at-grade with an intersecting cross road or a grade separation. Midblock pedestrian crossings can be considered at pedestrian generators when the roadway has predominately urban characteristics.

Managed Access Control. In rural areas, paved shoulders are usually used for pedestrian travel. When pedestrian activity is high, separate walkways are provided. Sidewalks are used in urban areas where there is an identified need for pedestrian facilities. Trails and paths, separated from the roadway alignment, are used to connect areas of community development. Pedestrian crossings are at-grade.

(2) Pedestrian Travel Along Streets and Highways

(a) **General.** On state highways within the corporate limits of cities, the city has the responsibility for maintenance of all appurtenances beyond the curb. See RCW 47.24.020. Proposed projects that will damage or remove existing sidewalks or other walkways within the city’s jurisdiction must include reconstruction of these facilities. Examples of various types of pedestrian walkways are shown in Figures 1025-2a and 1025-2b.

The minimum clear width required by a person in a wheelchair or a walker is 3 ft. Utility poles and other fixtures located in the sidewalk can be obstacles for pedestrians with disabilities. Utility company lines, poles, and other fixtures are accommodated within the right of way. When relocation of these fixtures is necessary in a project, determine the impact of their new location on any pedestrian walkways. Utility vaults and junction boxes with special lids are used for installations in sidewalks to reduce tripping hazards. Improvement projects might provide opportunities to eliminate existing poorly located utilities that are hazards to pedestrians.

Hanging or protruding objects within the walkway are also hazards for pedestrians with visual impairments. The minimum vertical clearance for objects overhanging a walkway, including signs, is 7 feet.

Where the walkway is located behind guardrail, protruding guardrail bolts are cut off or a rub rail is installed to prevent snagging on the bolts. These construction requirements are specified in the contract.

Provide a smooth finish to vertical concrete surfaces adjacent to a pedestrian facility to prevent snagging or abrasive injuries from accidental contact with the surface.

(b) **Shoulders.** Pedestrian activity is usually minimal along rural roadways when the adjacent land use is one or less dwelling units per acre. Determine if the roadway's shoulders are of sufficient width and condition to permit safe travel for pedestrians. Paved shoulders are preferable for an all-weather walking surface. A 4 ft wide shoulder is acceptable where pedestrian activity is minor. Wider shoulders, up to 8 or 10 feet are desirable along high-speed highways, particularly when truck volumes are high or pedestrian activity is significant.

(c) **Shared Use Paths.** Shared use paths are used by pedestrians and bicyclists. Pedestrian facilities differ from bicycle facilities in their design requirements and goals and they are not always compatible. A busy sidewalk might not be safe for bicycle travel and a well-used bike path might be unsuitable as a pedestrian walkway. When a shared use path is determined to be in the best interests of both groups, see Chapter 1020, "Bicycle Facilities," regarding shared use paths.

(d) **Walking and Hiking Trails.** Walking and hiking trails are supplemental features and are considered on a project-by-project basis. These trails are less developed than other walkways and shared use paths and are usually unpaved. Because of their primitive nature, ADA requirements for accessibility are far less restrictive. See Figure 1025-1 for trail widths and grades. The clear area is the cross-sectional area of the trail that is cleared of limbs, exposed roots, brush, and other obstacles that might be a hazard to the hiker.

	Clear Area	Trail Width	Maximum Grade
Walking trail	8' high & 10' wide	4'	10% *
Hiking trail	8' high & 10' wide	3'	10% sustained, 20% (500' or less)

Trail Width and Grades
Figure 1025-1

* Note: When grades of 5% or more are used, provide 4 ft square resting areas adjacent to the trail every 500 ft.

(e) **Sidewalks.** Details for raised sidewalks are shown in the Standard Plans. Roadway classification and land use are important factors when considering sidewalks. Figure 1025-3 provides a generalized method of assessing the need for and adequacy of sidewalks and does not establish minimum requirements for their installation. When sidewalks are recommended for a particular roadway in this figure, conduct a more extensive study to determine if they can be justified. The most desirable installation for the pedestrian is a sidewalk separated from the traveled way by a planted buffer strip. The minimum width for the sidewalk is 5 ft and the buffer is not less than 3 ft. Where a sidewalk is separated from the traveled way with only a curb, the minimum sidewalk width is 6 feet. Wider sidewalks are used in areas of high pedestrian traffic. Sidewalks 8 ft or wider are more appropriate at these locations. In areas with heavy snowfall, snowplows might need to use the sidewalk for snow storage if there is no adjacent shoulder. Consider wider sidewalks or a sidewalk with a buffer to minimize the disruption to pedestrian travel.

A grade of 8.33% or less is required when the sidewalk is on an independent alignment and does not follow an adjacent roadway grade. Sidewalks located adjacent to a street or highway follow that facility's grade and can exceed 8.33%. On roadways with prolonged severe grades, consider providing level landings adjacent to the sidewalk at approximately 500 ft intervals as resting areas for people with physical disabilities. The cross slope of a sidewalk cannot exceed 2%. More extreme cross slopes are difficult for people in wheelchairs to negotiate.

The side slope adjacent to the sidewalk is a critical design element. See Figures 1025-2a and 2b. On embankment slopes of 4H:1V or flatter, provide a 1 ft widening at the edge of the sidewalk. On steeper embankment slopes provide a 4 ft embankment widening or use a sidewalk design with a 2 ft widening and a raised 6" high lip at the back edge of the sidewalk. When the adjacent roadway has a posted speed of 35 mph or less and there is a vertical drop-off of 2 ft 6 in or more behind the sidewalk, provide a pedestrian railing when embankment widening is not possible. Pedestrian railings are not designed to withstand vehicular impacts and cannot redirect errant vehicles. When a vertical drop off is present on a higher speed roadway, the Design Clear Zone is the primary consideration and a crash-worthy traffic barrier is required. See Chapter 700. In some cases, where the walkway is adjacent to a vertical drop off and is separated from the roadway, consider installing the traffic barrier between the travel way and the walkway. The pedestrian railing is then installed between the walkway and the vertical drop off.

Provide either raised sidewalks or ramps on the approaches to bridges when there are raised sidewalks on the bridge. The ramp is constructed of either asphalt or cement concrete and the slope of 20H:1V or flatter. These ramps can also be used as a transition from a raised sidewalk down to a paved shoulder. The ramp provides pedestrian access and mitigates the raised, blunt end of the concrete sidewalk.

(3) Pedestrian Crossings At-Grade

Wide, multilane streets are difficult for pedestrians to cross, particularly when there are insufficient gaps in vehicular traffic because of heavy volumes. The chart in Figure 1025-4 provides guidance in determining feasible pedestrian crossings based on vehicular traffic volume and speed. Appropriate additional safety features necessary for the crossing are also recommended in this chart.

Pedestrian crossings are permitted along the length of most highways. Pedestrian crossing of all legs of an intersection is also permitted. An illegal pedestrian crossing only occurs when signs prohibit a particular crossing at an intersection or the crossing occurs between two signalized intersections. See RCW 46.61.240. Pedestrian crossings of the roadway are inevitable. Simply prohibiting a crossing without providing a reasonable option is not an effective solution and fails to address the pedestrian's needs.

Crosswalks, whether marked or not, exist at all intersections. An unmarked crosswalk is the ten-foot wide area across the intersection behind a prolongation on the curb or edge of the through traffic lane. See RCW 46.04.160. A marked crosswalk is required when the intended pedestrian route is different than that cited in the RCW. See Figure 1025-5. At roundabouts and intersections with triangular refuge islands or offset legs, the desired pedestrian crossings might not be consistent with the definition of an unmarked crosswalk and markings become necessary. Marked crosswalks also clearly define the pedestrian route and permit enforcement of pedestrian crossing laws.

The standard crosswalk marking consists of a series of wide white lines aligned with the longitudinal axis of the roadway. The lines are positioned at the edges and centers of the traffic lanes to place them out of the normal wheel path of vehicles. This type of crosswalk is a Ladder Bar and is shown in the Standard Plans.

Specially textured crosswalks (consisting of colored pavement, bricks, or other materials) are sometimes used by local agencies in community enhancement projects. These crosswalks do not fall within the legal definition of a marked crosswalk and parallel white crosswalk lines are required to define the crosswalk.

When locating crosswalks at intersections, consider the visibility of the pedestrian from the motorist's point of view. Shrubbery, signs, parked cars, and other roadside appurtenances can block the motorist's view of the pedestrian. Figures 1025-6a and 6b illustrate these sight distance problems.

In urban areas where vehicle speeds are in the range of 25 to 35 mph, a sidewalk bulb out is sometimes used to place the pedestrian at a more visible location. The bulb out also shortens the length of the pedestrian crossing and reduces the pedestrian's exposure time. At intersections with traffic signals, the bulb out can be used to reduce both pedestrian signal timing and the mast arm lengths of the signal supports. Examples of sidewalk bulb outs are shown in the Figure 1025-7. The right turn path of the design vehicle or the vehicle most likely to make this turn is a critical element in determining the size and shape of the bulb out. Sidewalk bulb outs tend to restrict the width of the roadway and can make right turns difficult for extremely long trucks. Any proposal to install bulb outs on state highways is a deviation that requires approval and documentation.

On roadways with two-way left-turn lanes with pedestrian crossing traffic caused by nearby pedestrian generators, consider removing a portion of the turn lane and installing a raised median refuge and a midblock pedestrian crossing. The installation of a midblock pedestrian crossing on a state highway, however, is a design deviation that requires approval and documentation. An example of a midblock crossing is shown in Figure 1025-8.

An engineering study is required when considering a midblock pedestrian crossing on a state highway. Conditions that might favor a midblock crossing are:

- Significant pedestrian crossings and substantial pedestrian and vehicle conflicts occur.
- The proposed crossing can concentrate or channel multiple pedestrian crossings to a single location.
- The crossing is at an approved school crossing on a school walk route.
- The adjacent land use creates high concentrations of pedestrians needing to cross the highway.
- The pedestrians fail to recognize the best or safest place to cross along a highway and there is a need to delineate the optimal location.
- There is adequate sight distance for motorists and pedestrians.

Midblock pedestrian crossings on state highways are not desirable at the following locations:

- Immediately downstream (less than 300 ft) from a traffic signal or bus stop where motorists do not expect a pedestrian to cross.
- Within 600 ft of another pedestrian crossing.
- On high speed roadways as noted in Figure 1025-4.
- Where pedestrians must cross three or more lanes of traffic in the same direction.

The minimum width of a raised median refuge area is 6 ft to accommodate people in wheelchairs. Raised medians are usually too narrow to allow the installation of ramps and a level landing. When the median is 16 ft or less in width, provide a passageway through the median. This passageway connects with the two separate roadways and cannot exceed a grade of 5%.

(4) Sidewalk Ramps

Sidewalk ramps are required at all legal crossing. These ramps provide an easily accessible connection from a raised sidewalk down to the roadway surface. To comply with ADA requirements, these ramps are at least three feet wide and have slopes 12H:1V or flatter. Examples of sidewalk ramps are shown in the Standard Plans and the *Sidewalk Details* guide.

The lower terminus of the sidewalk ramp is always located at the beginning of a marked or unmarked crosswalk when separate ramps are used for each direction. Diagonal ramps are used at the junction of two crosswalks. A separate sidewalk ramp is preferred for each crossing because the crossing distance is shorter and people with vision impairments have fewer difficulties with this arrangement. Diagonal ramps are sometimes necessary when altering an existing roadway because of right of way constraints.

Surface water runoff from the roadway can flood the lower end of a sidewalk ramp. Determine the grades along the curb line and provide catch basins or inlets to prevent the flooding of the ramps. Figure 1025-9 shows examples of how drainage structures are located. Verify that the drainage structure will not be in the path of a wheelchair user.

A level landing is necessary at the top of a sidewalk ramp. This landing is provided to allow a person in a wheelchair room to maneuver into a position to use the ramp or to bypass it. In alterations of existing roadways, the landings must be at least three feet square. In new construction, a four-foot square landing is required. When right of way constraints are not an issue, provide a larger five-foot square landing. If the landing is next to a vertical wall, a five-foot wide clear area is desirable to allow a person in a wheelchair more room to maneuver. Examples of these wheelchair maneuvers are shown in the *Sidewalk Details* guide. When the upper area of a sidewalk ramp is adjacent to a vertical wall, a 5 ft clearance from the edge of the ramp to the wall is desirable.

At signalized intersections, the pedestrian push buttons are located near the sidewalk ramps for ADA accessibility. See Chapter 850, "Traffic Control Signals," for information on pedestrian requirements at traffic signal locations.

(5) Pedestrian Grade Separations

In areas where heavy pedestrian traffic is present and opportunities to cross the roadway are infrequent, consider providing a pedestrian grade separation. When considering a pedestrian structure, determine if the conditions that require the crossing are permanent. If there is a likelihood that the pedestrian activity generator might not exist in the near future, consider less costly solutions. Locate the grade separated crossing where pedestrians are most likely to cross the roadway. A crossing might not be used if the pedestrian is required to deviate significantly from a more direct route. A structure might be under-utilized if the additional average walking distance for 85 percent of the pedestrians exceeds 1/4 mile. It is sometimes necessary to install fencing or other physical barriers to channel the pedestrians to the structure and reduce the possibility of undesired at-grade crossings. Pedestrian grade separations are more effective when the roadway is below the natural ground line as in a "cut" section. Elevated grade separations, where the pedestrian is required to climb stairs or use long approach ramps, tend to be under-utilized.

Grade separated structures are proposed during the planning stage of a project because of the high costs associated with their design and construction. Consider grade-separated crossings under the following conditions:

- Where there is moderate to high pedestrian demand to cross a freeway or expressway
- Where there is a large number of young children, particularly on schools routes, who regularly cross a high speed or high volume roadway
- On streets with high vehicular volumes and high pedestrian crossing volumes, and crossings are extremely hazardous for pedestrians

The Headquarters (HQ) Bridge and Structures Office designs pedestrian grade separation bridges and tunnels on a project-by-project basis. Railings 3 ft 6 in high are provided on pedestrian bridges. The bridge rail is designed so that a 6-inch sphere cannot pass through any part of the railing. In addition, a 2 ft 6 in to 2 ft 10 in high handrail is provided for grades greater than 5%. The minimum width between the railings of an overhead structure or the vertical walls of a tunnel is 8 ft. The minimum overhead clearance for a tunnel is 10 ft. Protective screening to prevent objects from being thrown from an overhead pedestrian structure is sometimes necessary. See Chapter 1120, "Bridges."

The minimum vertical clearance from the bottom of the pedestrian structure to the roadway beneath is 17 ft 6 in. This minimum height requirement can affect the length of the pedestrian ramps to the structure. To comply with ADA requirements, a ramp cannot have a grade exceeding 8.33% and the maximum rise of the ramp cannot exceed 2 ft 6 in without landings. Landings are a minimum of 5 ft wide and 5 ft long except the landing at the bottom of the ramp, which is 6 ft in length. When ramps are not feasible, provide both elevators and stairways. Stairways are designed in accordance with the Standard Plans.

Pedestrian tunnels are an effective method for providing crossings for roadways located in embankment sections. When possible, design the tunnel with a nearly level profile to provide complete vision from portal to portal. Pedestrians are reluctant to enter a tunnel with a depressed profile because they are unable to see if the tunnel is occupied. Police officers also have difficulty patrolling depressed profile tunnels. Provide day and nighttime illumination within the pedestrian tunnel. Installing gloss-finished tile walls and ceilings can also enhance light levels within the tunnel.

(6) Transit and School Bus Stops

The location of transit stops is an important consideration in providing appropriate pedestrian facilities. See Chapter 1060, "Transit Benefit Facilities." A transit stop on one side of a street usually has a counterpart on the opposite side because transit routes normally function in both directions on the same roadway. When passengers use this type of route, they will either cross the street at the beginning of a trip or the end of the return trip. Pedestrian collisions are more frequent at these locations. When analyzing high pedestrian accident locations, consider the presence of nearby transit stops and the opportunities for a pedestrian to safely cross the street. At-grade midblock pedestrian crossings are effective at transit stop locations on roadways with lower vehicular volumes. Pedestrian grade separations are appropriate at midblock locations when vehicular traffic volumes prohibit pedestrian crossings at grade.

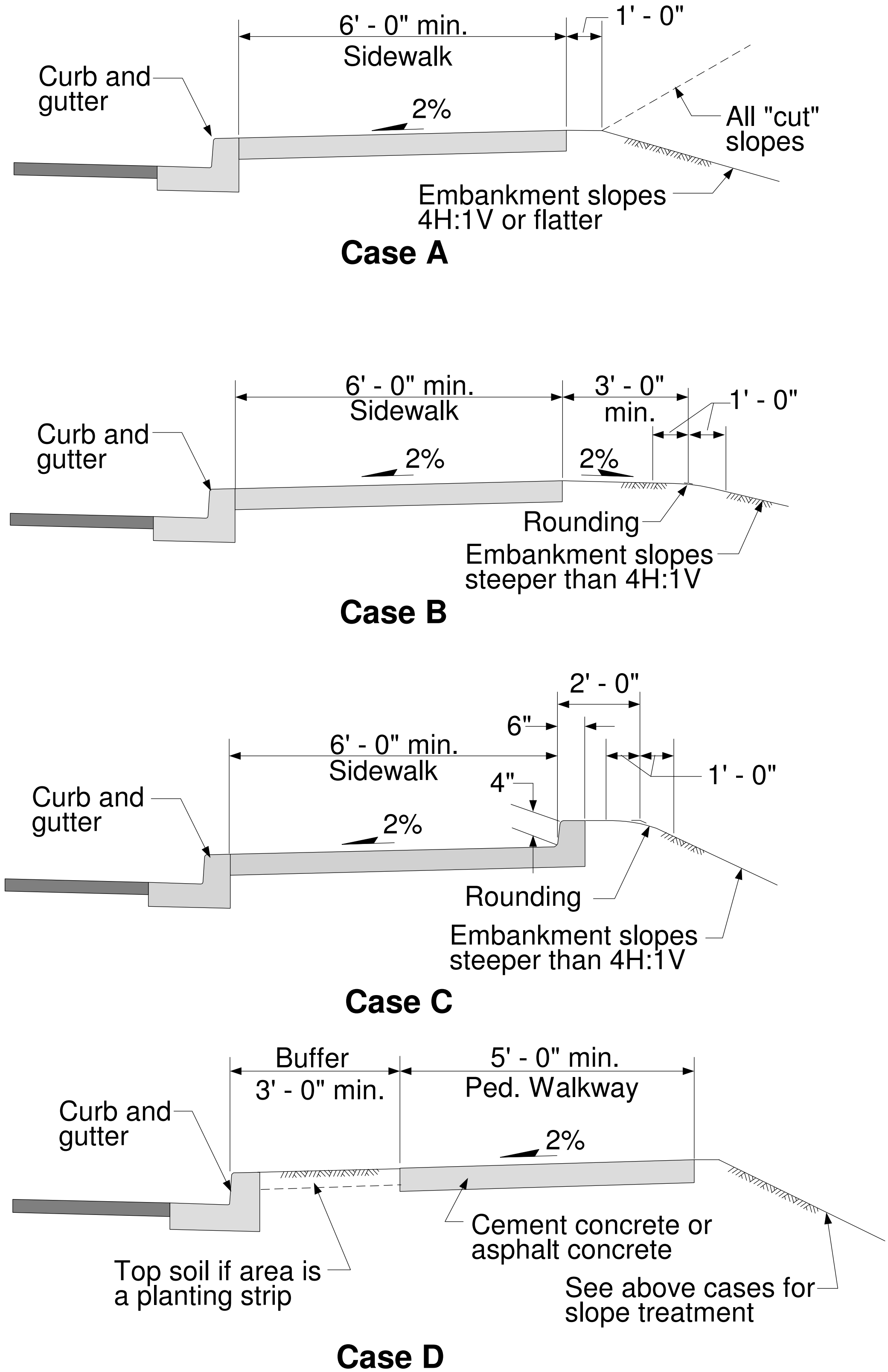
School bus stops are typically adjacent to sidewalks in urban areas and along shoulders in rural areas. Determine the number of children using the stop and provide an appropriate waiting area. Children, because of their smaller size, might be difficult for motorists to see at crossings or stops. Determine if utility poles, vegetation, and other roadside features interfere with the motorist's ability to see the children. When necessary, relocate the obstructions or move the bus stop. Parked vehicles can also block visibility and parking prohibitions might be necessary near the bus stop.

(7) Illumination and Signing

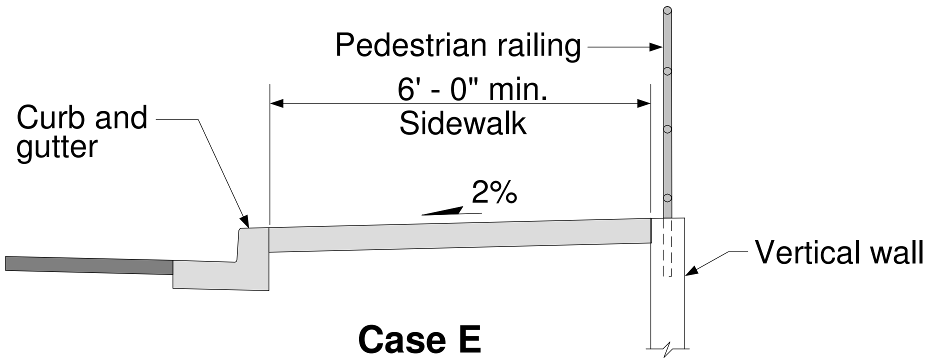
In Washington State, the highest number of collisions between vehicles and pedestrians occur in the months November through February when there is poor visibility and fewer daylight hours. At high pedestrian accident locations, illumination of pedestrian crossings and other walkways is an important design consideration. Illumination provided solely for vehicular traffic is not always effective in lighting parallel walkways for pedestrians. Consider additional lighting, mounted at a lower level, for walkways with considerable nighttime pedestrian activity. Design guidance for illumination is in Chapter 840. See Chapter 820 and the MUTCD for pedestrian related signing.

1025.08 Documentation

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

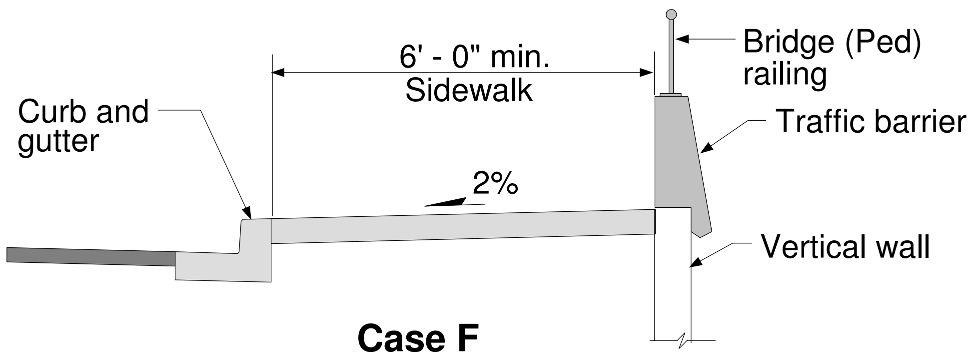


Pedestrian Walkways
Figure 1025-2a



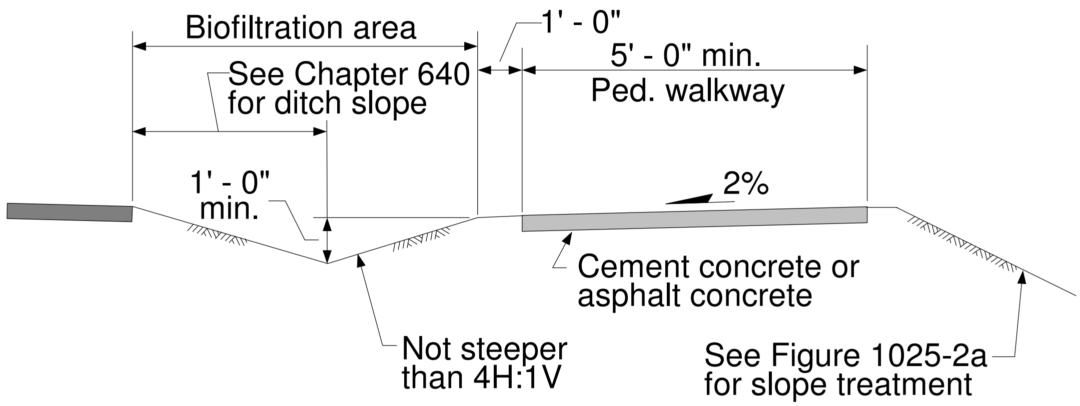
Case E

When the wall is outside of the Design Clear Zone

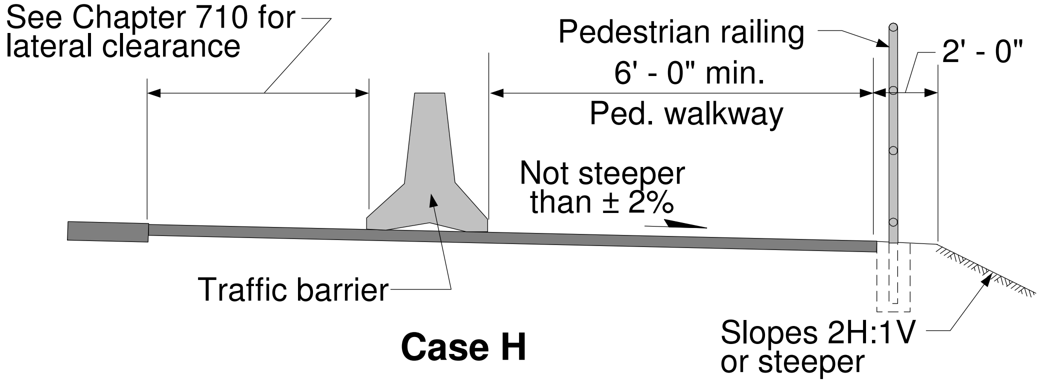


Case F

When the wall is within the Design Clear Zone



Case G



Case H

Pedestrian Walkways

Figure 1025-2b

Roadway classification & land use	Sidewalk recommendations
Rural highways (less than one dwelling unit per acre)	No sidewalk recommended. Shoulder (four feet minimum width) adequate.
Suburban highways (one or less dwelling units per acre)	Sidewalk on one side desirable. Four feet wide shoulders adequate.
Suburban highway (2 to 4 dwelling units per acre)	Sidewalks on both sides of roadway desirable. Sidewalk on one side recommended.
Major arterial in residential area	Sidewalks on both sides of roadway recommended.
Collector or minor arterial in residential area	Sidewalks on both sides of roadway recommended.
Local street in residential area with less than 1 dwelling unit per acre	Sidewalk on one side desirable. Four feet wide shoulders adequate.
Local street in residential area with 1 to 4 dwelling units per acre	Sidewalks on both sides of roadway desirable. Sidewalk on one side recommended.
Local street in residential area with more than 4 dwelling units per acre	Sidewalks on both sides of roadway recommended.
Streets in commercial area	Sidewalks on both sides of roadway recommended
Streets in industrial area	Sidewalks on both sides of roadway desirable. Sidewalk on one side recommended.

Sidewalk Recommendations
Figure 1025-3

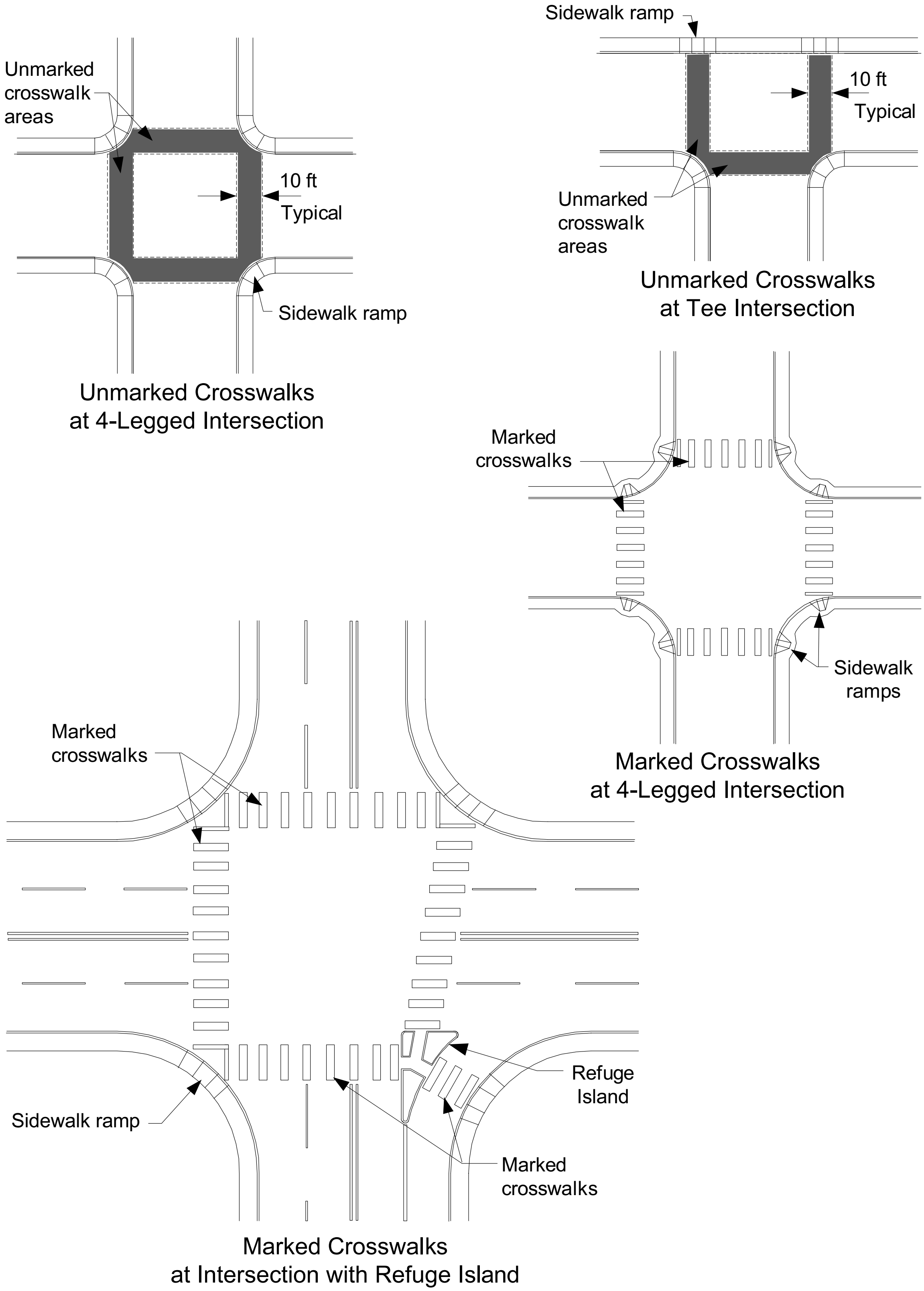
Traffic Volume ADT	Speed	Roadway Type			
		Two Lane	Three Lane	Multilane (4 or more lanes) with raised median	Multilane (4 or more lanes) without raised median
Less Than 9,000	30 mph or less	marked crosswalk	marked crosswalk	marked crosswalk	marked crosswalk
	35 mph	marked crosswalk	marked crosswalk	marked crosswalk	marked crosswalk
	40 mph or higher	marked crosswalk	marked crosswalk	marked crosswalk	marked crosswalk
9,000 to 11,999	30 mph or less	marked crosswalk	marked crosswalk	marked crosswalk	marked crosswalk
	35 mph	marked crosswalk	marked crosswalk	marked crosswalk	additional enhancement
	40 mph or higher	marked crosswalk	marked crosswalk	marked crosswalk	additional enhancement
12,000 to 14,999	30 mph or less	marked crosswalk	marked crosswalk	additional enhancement	additional enhancement
	35 mph	marked crosswalk	additional enhancement	additional enhancement	not recommended
	40 mph or higher	additional enhancement	not recommended	not recommended	not recommended
More than 15,000	30 mph or less	marked crosswalk	additional enhancement	additional enhancement	not recommended
	35 mph	additional enhancement	not recommended	not recommended	not recommended
	40 mph or higher	additional enhancement	not recommended	not recommended	not recommended

Notes:
These guidelines include intersection and midblock location with no traffic control signals or stop signs on the approach to the crossing. They do not apply to school crossings. A two-way left-turn lane is not considered a median. This chart is used in conjunction with an engineering study of pedestrian volumes, model vehicle operating speeds, sight distance, vehicle mix, and comparison to similar sites.

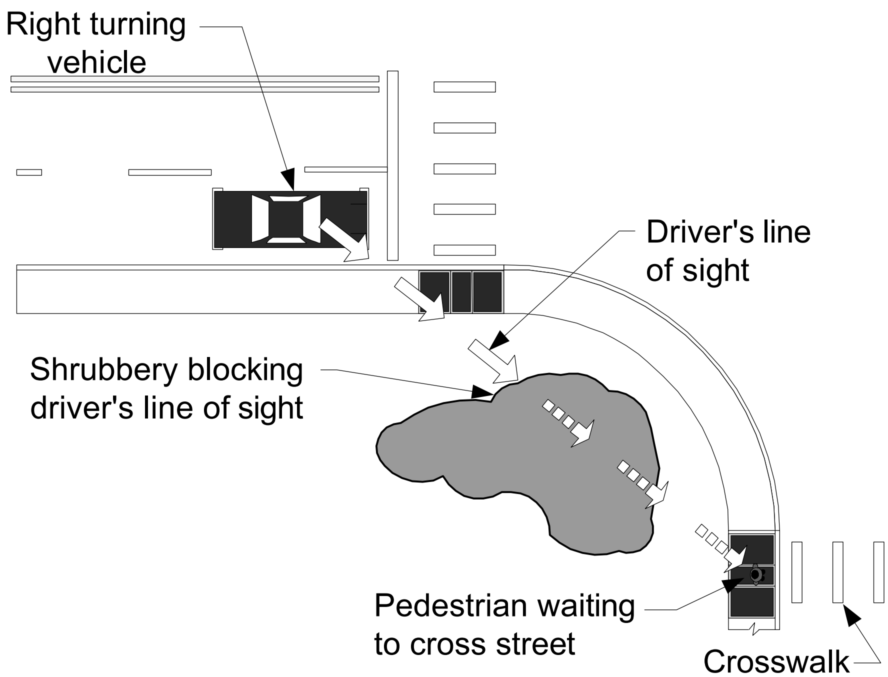
Meaning of terms in chart:

Marked crosswalk: Marked crosswalk can be installed at these locations.
Additional enhancements: Marked crosswalks can be used with additional safety items such as overhead illumination, curb bulb outs, flashing beacons, illuminated signing, or an in-roadway flashing light system.
Not recommended: A marked crosswalk is not recommended under these conditions without positive vehicular traffic control such as stop signs or traffic control signals.

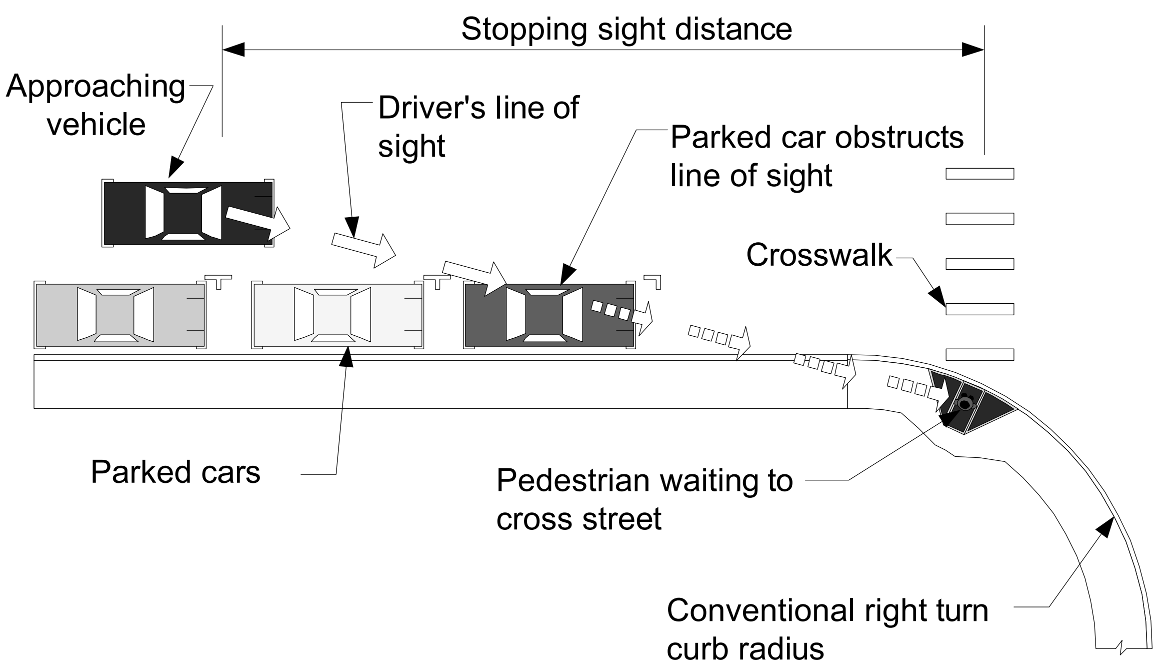
Marked Crosswalk Recommendations at Unsignalized Pedestrian Crossings
Figure 1025-4



Crosswalk Locations
Figure 1025-5

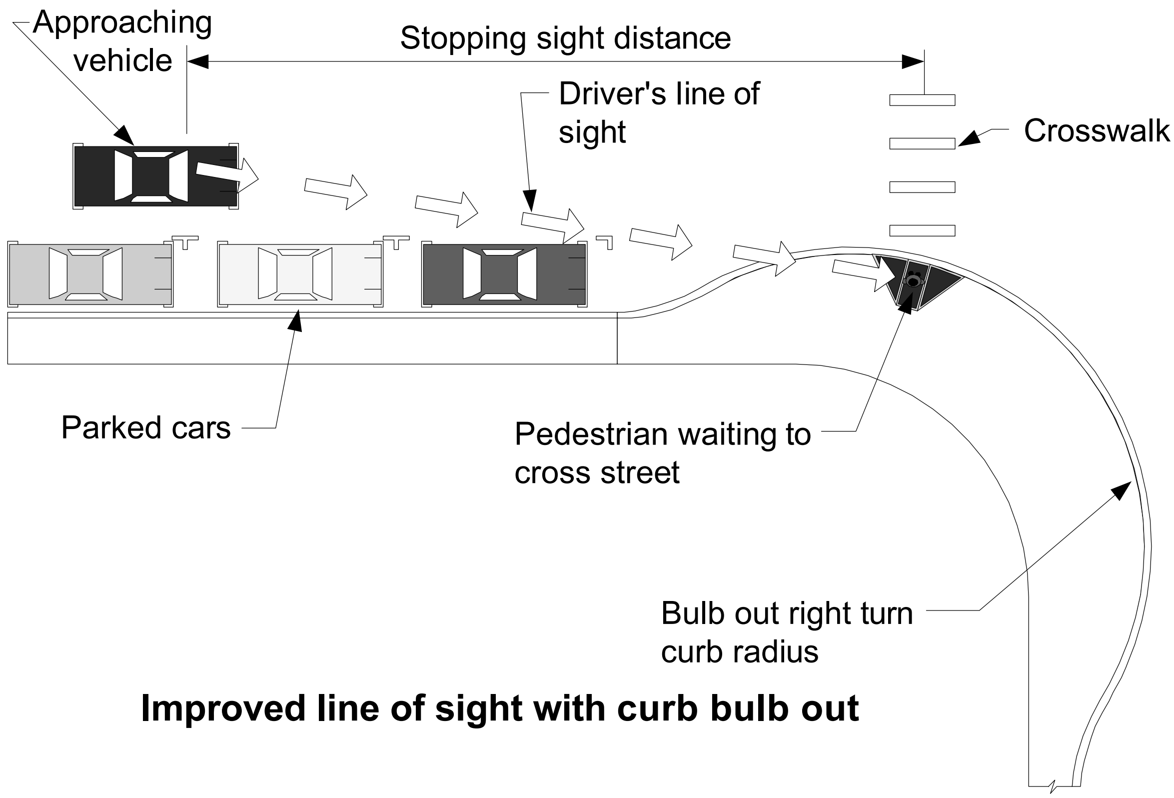


Shrubbery blocking line of sight

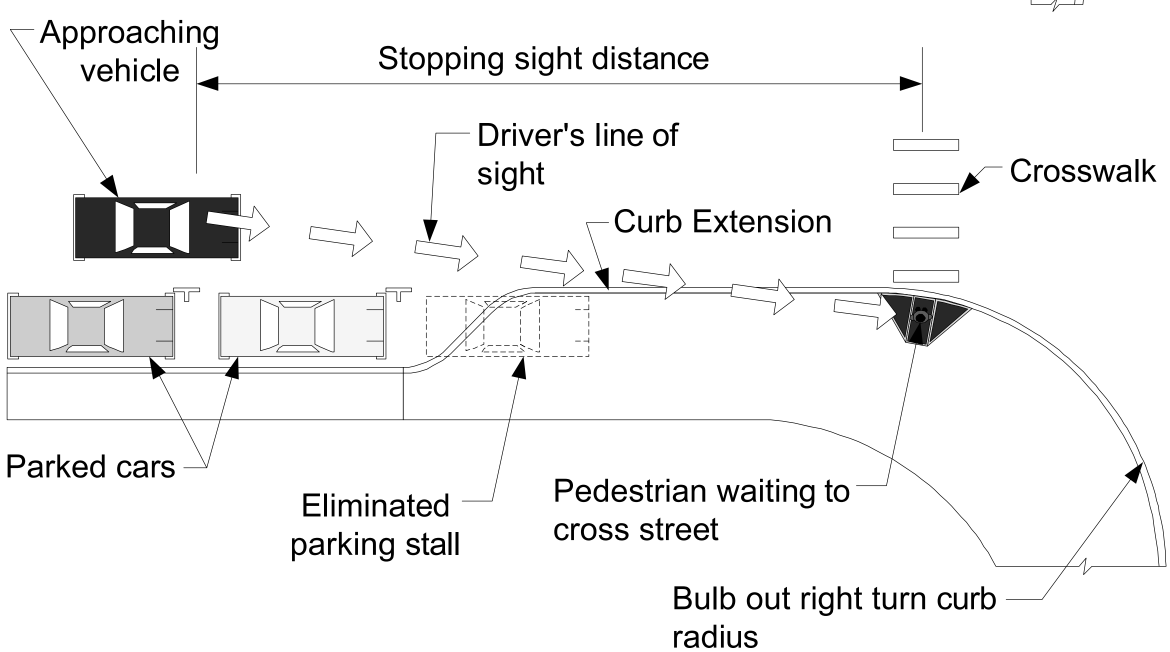


Parked car blocking line of sight

Sight Distance at Intersections
Figure 1025-6a



Improved line of sight with curb bulb out

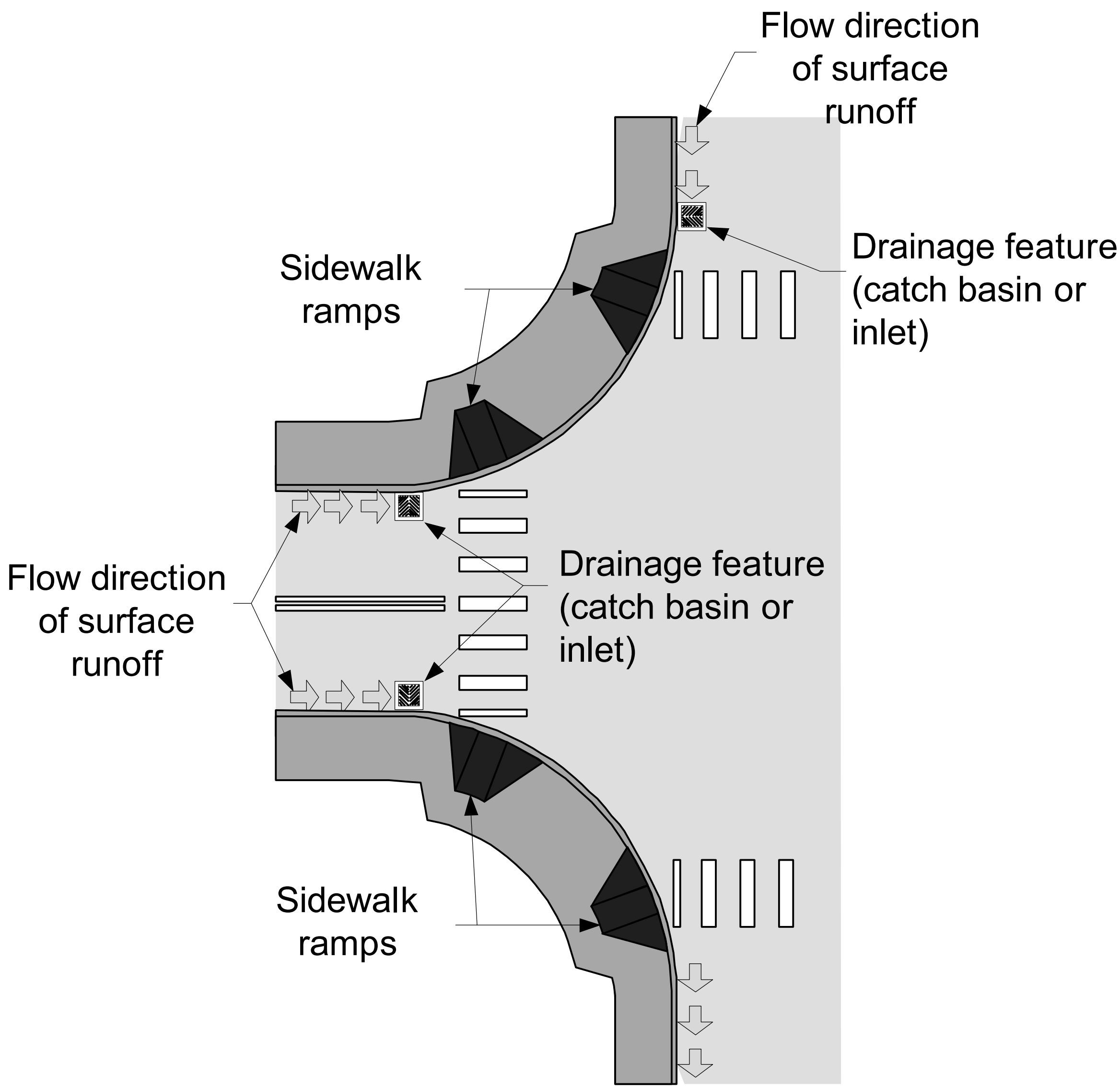


Improved line of sight with curb extension

Sight Distance at Intersections
Figure 1025-6b

Sidewalk Bulb Outs
Figure 1025-7

Midblock Pedestrian Crossing
Figure 1025-8



Sidwalk Ramp Drainage
Figure 1025-9

Chapter 1030 Safety Rest Areas and Traveler Services

1030.01 General

The Washington State Department of Transportation (WSDOT) has developed a statewide system of traveler services on Interstate highways and state routes. This system includes safety rest areas, roadside parks, points of interest, and traveler information centers. These traveler services provide the opportunity for rest and orientation. Benefits include improved safety, reduced driver fatigue, refuge from adverse driving conditions, and increased tourism.

Traveler services are planned and designed by a multidisciplinary team lead through the Safety Rest Area Program Planner in HQ Maintenance and Operations.

Safety rest areas and roadside parks are spaced approximately every 60 miles on the National Highway System and on Scenic and Recreational Highways. Use the *Safety Rest Area and Roadside Park Master Plan* as a guide when selecting a site location.

See the *Roadside Manual*, Division 6, for detailed information on planning, design, construction, and maintenance of safety rest areas and other traveler services.

1030.02 References

42 United States Code (USC) Section 12101et seq. Americans with Disabilities Act of 1990

23 Code of Federal Regulations (CFR) 1.23 Rights-of-Way

23 CFR 752 Landscape and roadside development

Revised Code of Washington (RCW) 46.16.063 Additional fee for recreational vehicles

RCW 46.68.170 RV account — Use for sanitary disposal systems

RCW 47.06.040 State-wide multimodal transportation plan

RCW 47.28.030 Contracts — State Forces

RCW 47.38 Roadside Areas — Safety Rest Areas

RCW 47.39 Scenic and Recreational Highway Act of 1967

Washington Administrative Code (WAC) 51-40 Uniform Building Code Requirements for Barrier-Free Accessibility

Roadside Manual, M 25-30, WSDOT

Highway Runoff Manual, M 31-16, WSDOT

Highway System Plan, WSDOT

Hydraulics Manual, M 23-03, WSDOT

Maintenance Manual, M 51-01, WSDOT

Right of Way Manual, M 26-01, WSDOT

Roadside Classification Plan, M 25-31, WSDOT

Traffic Manual, M 51-02, WSDOT

Safety Rest Area and Roadside Park Master Plan

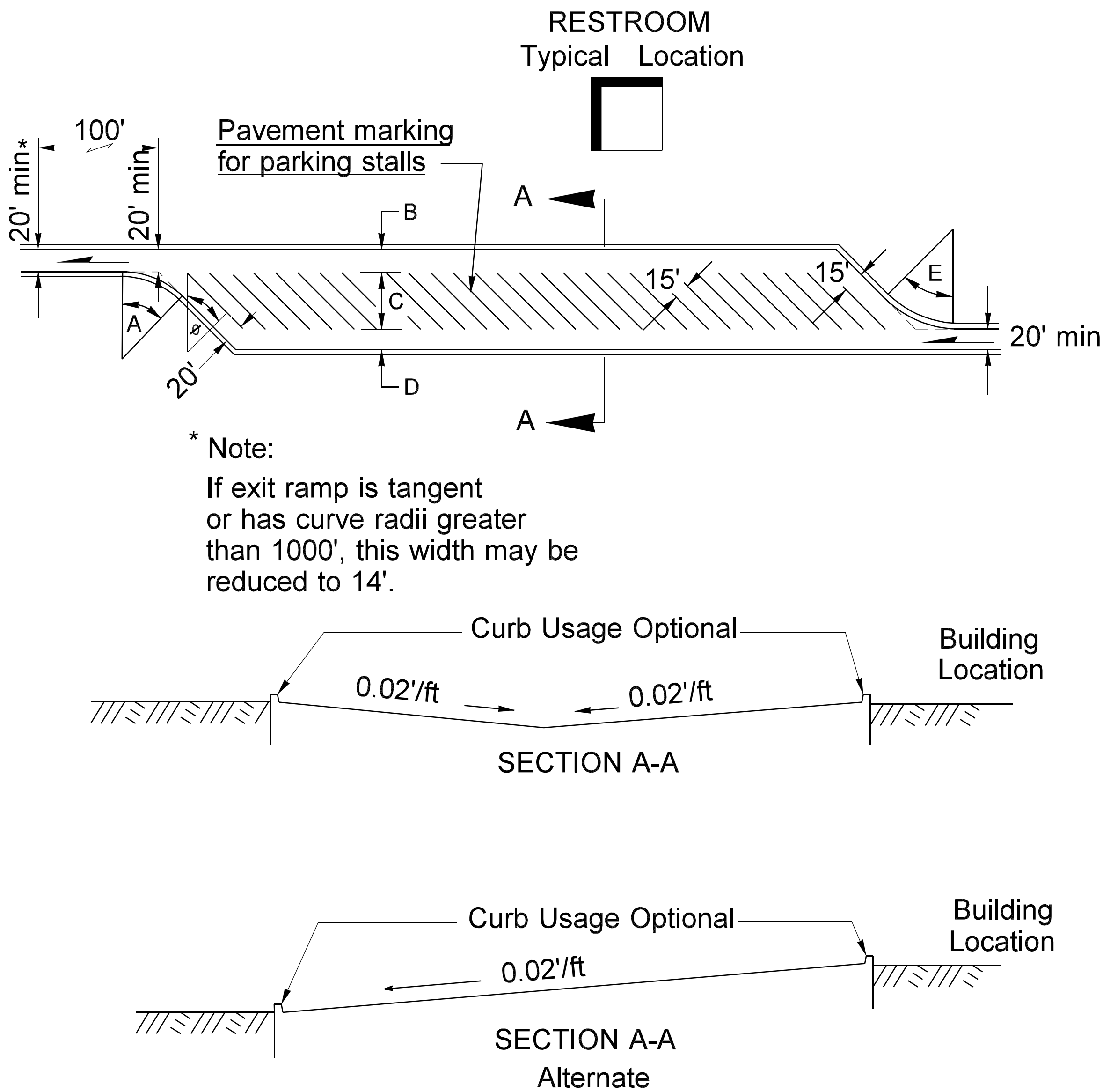
Manual on Uniform Traffic Control Devices USDOT, Washington DC, including the *Washington State Modifications to the MUTCD,* WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

"Safety Rest Areas: Planning, Location and Design," USDOT, FHWA, 1981

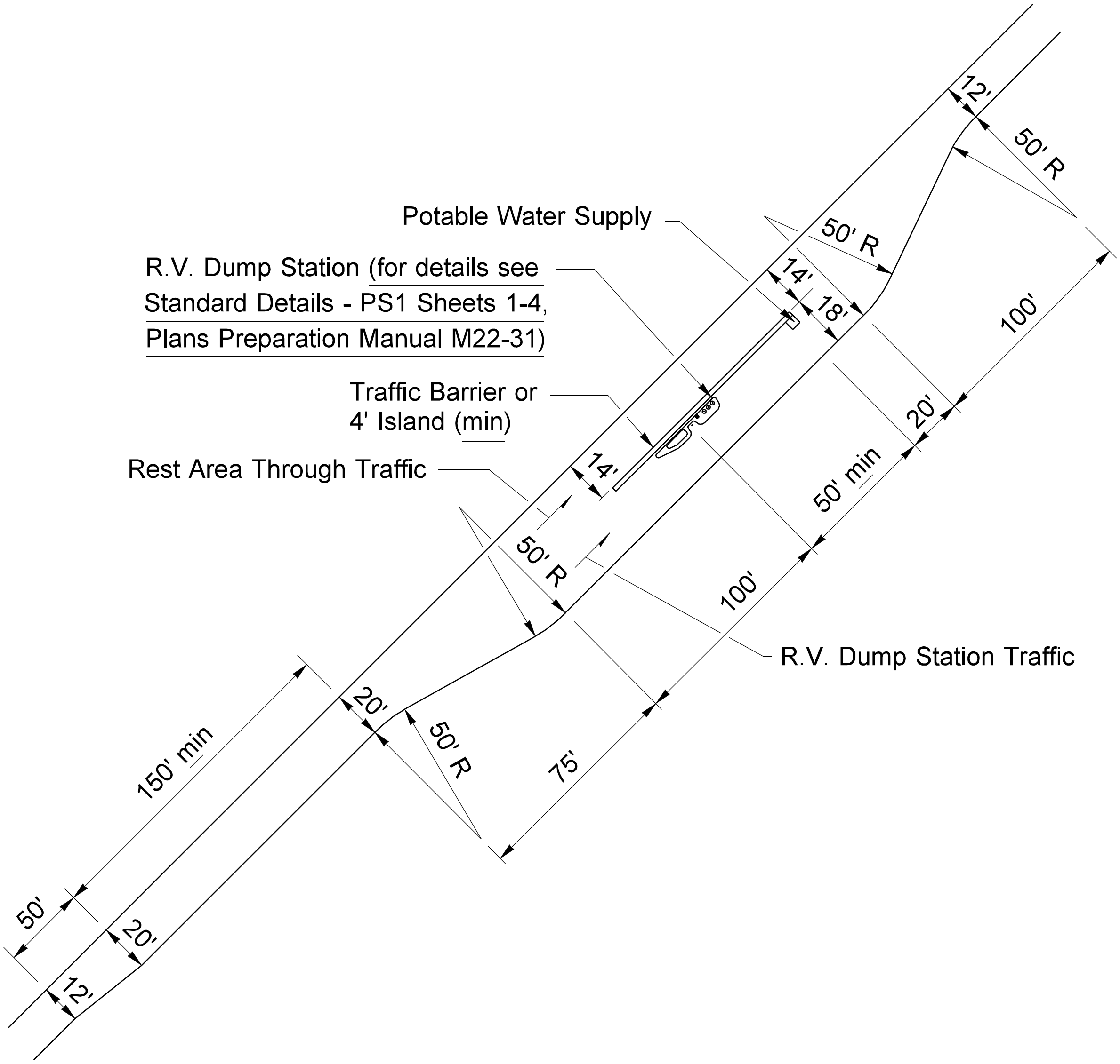
1030.03 Documentation

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

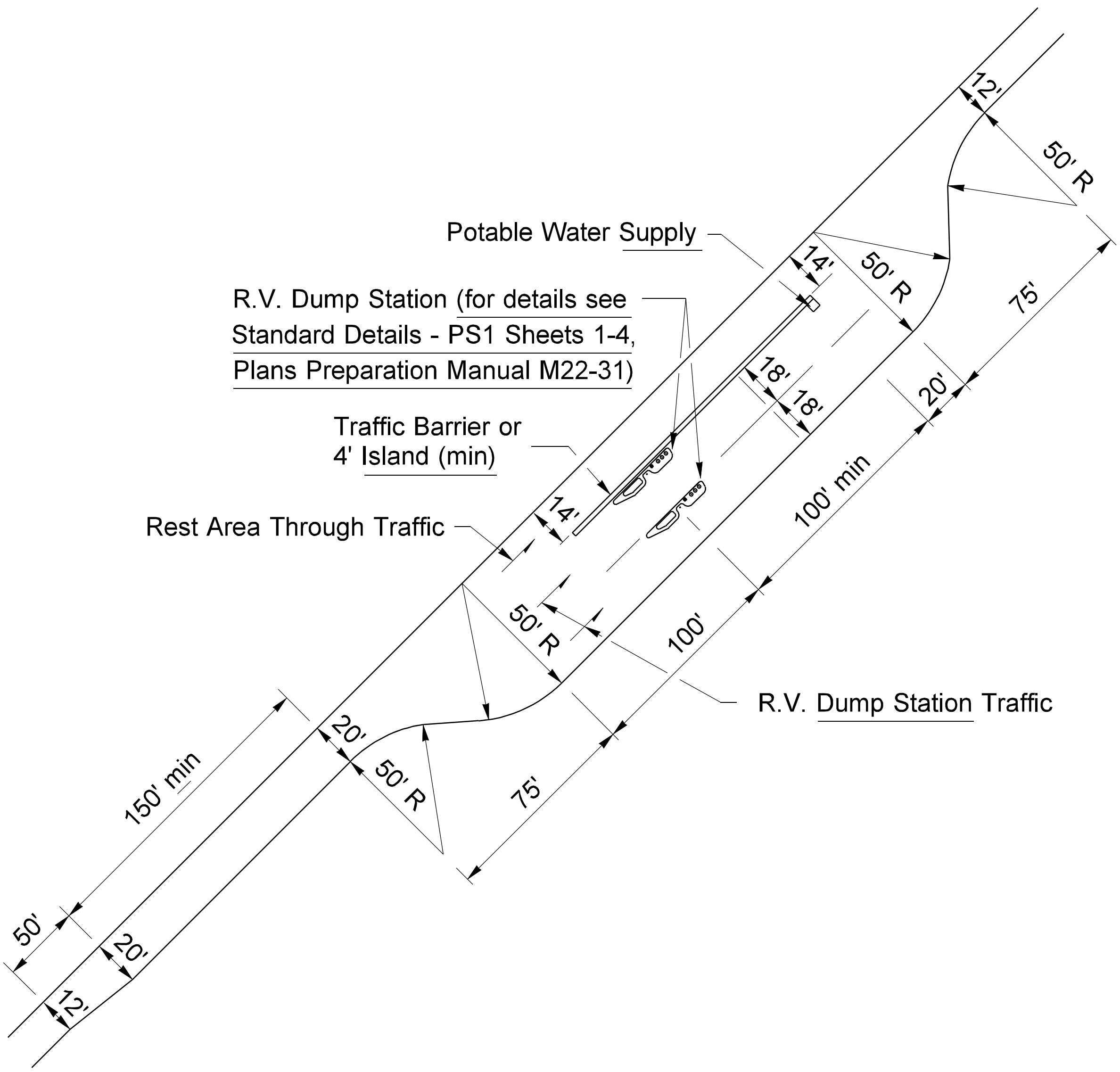
	Variables (feet)				
Ø	A	B	C	D	E
30°	85	30	50	30	100
35°	90	35	55	35	105
40°	95	35	60	35	110
45°	100	45	65	45	115



Typical Truck Storage
Figure 1030-1



Typical Single RV Dump Station Layout
Figure 1030-2



Typical Two RV Dump Station Layout
Figure 1030-3

1040.01 General

Truck weighing facilities are needed to protect state highways from overweight vehicles, to provide for vehicle safety inspection, and to provide a source of data for planning and research. The development, construction, and maintenance of these facilities is a cooperative effort between the Washington State Department of Transportation (WSDOT) and the Washington State Patrol (WSP).

1040.02 Definitions

Commercial Vehicle Information Systems and Networks (CVISN) A network that links intelligent transportation systems (ITS) to share information on commercial vehicles. When in operation at a weigh site it can enable commercial vehicles to clear the facility without stopping.

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, and select and complete an appropriate maneuver safely and efficiently.

functional classification The grouping of streets and highways according to the character of the service they are intended to provide. (See Chapter 440.)

frontage road An auxiliary road that is a local road or street located beside a highway for service to abutting property and adjacent areas and for control of access.

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.

roadway The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways.

sight distance The length of roadway 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 use by pedestrians and bicycles.

static scale A scale that requires a vehicle to stop for weighing.

stopping sight distance The sight distance required to safely stop a vehicle traveling at design speed.

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.

usable shoulder The width of the shoulder that can be used by a vehicle for stopping.

weigh in motion (WIM) A scale facility capable of weighing a vehicle without the vehicle stopping.

1040.03 Planning, Development, and Responsibilities

The WSP works with the WSDOT's Planning and Programming Service Center to develop a prioritized list of weigh facility needs for each biennium. The list includes:

- New permanent facilities
- New portable facilities
- New shoulder sites

- WIM equipment
- Vehicle inspection facilities
- Scale approach slab reconstruction

The WSP provides Program Management a project definition, that includes:

- A statement of need, the purpose of the project, and the type of work
- The general location of the project

Program Management sends this information to the region for preparation of a Project Summary. The region works with the WSP to identify the specific location of the facility, prepares a design decision estimate, and submits it to Program Management.

The region negotiates and the Regional Administrator executes any formal agreements with the WSP required for the design, construction, or maintenance of vehicle weighing and inspection facilities.

The Memorandum of Understanding Related to Vehicle weighing and Equipment Inspection Facilities on State Highways, Figure 1040-8, contains details about the various responsibilities of the WSDOT and the WSP.

1040.04 Permanent Facilities

Permanent truck weighing facilities have permanent scales and may have buildings. When these facilities are in operation, trucks are required stop. However, when Weigh In Motion (WIM) and Commercial Vehicle Information Systems and Networks (CVISN) capabilities have been installed, the driver may be notified to continue without stopping. The notification to continue may be through the use of signs or transponders.

(1) Site Locations

The exact location of a truck weighing facility is generally controlled by topography, highway alignment, and geometrics. It is also desirable to select a site where adequate right of way is already available. Select the most economical site to minimize site preparation, expense, or impact on the environment. Water, electricity availability, and sewage treatment and disposal are other considerations for site selection.

Locate the facility so that its operation will not hinder the operation of the highway or other related features such as intersections and interchanges.

To the extent possible, locate the facility to prevent truck traffic avoiding the facility on other roadways and the type and volume of truck traffic using the highway.

An Access Point Decision Report is required for weigh sites on multilane divided highways with access control. (See Chapter 1425.)

(2) Design Features

On multilane highways, provide standard off- and on-connections, as shown in Chapter 940. Figure 1040-1 is the minimal design of a weigh site on multilane highways.

Design weigh facilities on two-lane highways to best fit the existing conditions, with particular consideration given to the matter of access to and from the site. Standard off- and on-connections, as shown in Chapter 940, are preferred; however, with justification on-connections may be designed as intersections. (See Chapter 910.) Figure 1040-2 is a guide for the design of weigh sites on two-lane highways.

The following special design features apply:

- Level cement concrete approach slabs are required at both ends of the scales.

  Asphalt concrete pavement approach slabs will be allowed only when adequate soil conditions exist, projected truck volume is light, and benefit/cost analysis justifies the use of asphalt concrete pavement based on the small percentage of time the scales will be in operation.

  The approach slabs must be level and in the same plane as the scale.

- Provide adequate parking and storage to ensure that trucks do not impede the mainline through traffic. The WSDOT Regional Administrator and the WSP agree on the area to be provided.

- On multilane divided highways, install illuminated electronically controlled “open” and “closed” message signs that can be operated from the scale house or the control cabinet. Provide permanent signing for the facility, as requested by the WSP.
- The need for a vehicle safety inspection facility at any site is identified by the WSP. Figure 1040-3 is a guide for a site plan for a single bay vehicle inspection facility. Additional bays and site adaptation will be on a site by site basis. The WSDOT Regional Administrator and the WSP agree on the area to be provided.
- The need for some form of approach protective treatment for the scale house or a protective fence between the scale and roadway is identified by the WSP and agreed upon by the WSDOT Regional Administrator and the WSP. The need for the device is to protect the scale house from errant vehicles. See Chapter 700 for additional clear zone considerations.
- The need for WIM or CVISN capabilities is identified by the WSP. Design the in-place facilities to provide the ability to notify drivers whether to continue on or to stop for further investigation before they reach the exit for the static scale. The design is agreed upon by the WSDOT Regional Administrator and the WSP.
- Where WIM and CVISN are not included in the project, provide conduit for their future installation.
- With justification, at locations where space is limited, the depressed outer separation between the weigh facility and the through lanes may be replaced with concrete traffic barrier. (See Collector Distributor Outer Separations, Chapter 940.)
- Provide a clear view of the entire weigh site for the facility’s operator and the driver of an approaching vehicle.
- Asphalt concrete pavement is acceptable for use on the ramp and storage areas. Design the depth in accordance with the surfacing report.
- To optimize scale efficiency, make the storage area flat; however, to facilitate drainage, the slope may be up to 2%.
- Provide illumination when requested by the WSP. Illumination is required if the facility is to be operated during the hours of darkness and may be desirable at other locations to deter unauthorized use of the facility. See Chapter 840 for additional information on illumination.

1040.05 Portable Facilities

Portable truck weighing facilities have no permanent scales or buildings. When these facilities are in operation, they operate in the same manner as permanent facilities.

(1) Site Locations

Design portable truck weighing facilities located on two-lane and multilane roadways to best fit the existing conditions. Minor portable scale sites, as shown on Figure 1040-4, are used with two-way traffic and on multilane highways with low traffic volumes. Major portable scale sites, Figure 1040-5, are for use on expressways, freeways, and where traffic volumes are high.

Locate the weighing facility so that its operation will not hinder the operation of the highway or other related features such as an intersection.

An Access Point Decision Report is required for weigh sites on multilane divided highways with access control. (See Chapter 1425.)

(2) Design Features

The following special design features apply:

- Off- and on-connections, as shown in Figures 1040-4 and 5, are preferred; however, with justification on highways with no access control, on-connections may be designed as intersections. (See Chapter 910.)
- With justification, at locations where space is limited, the depressed outer separation between the weigh facility and the through lanes may be replaced with concrete traffic barrier. See the collector distributor outer separation figure in Chapter 940.

- Provide adequate parking and storage to ensure that trucks do not impede the main-line through traffic. The WSDOT Regional Administrator and the WSP agree on the area to be provided.
- Asphalt concrete pavement is acceptable for use on the ramp and storage areas. Design the depth in accordance with the surfacing report.
- To optimize portable scale efficiency, make the storage area flat; however, to facilitate drainage, the slope may be up to 2%.
- Provide permanent signing for the facility, as requested by the WSP.
- Provide illumination when requested by the WSP. Illumination is required if the facility is to be operated during the hours of darkness and may be desirable at other locations to deter unauthorized use of the facility. See Chapter 840 for additional information on illumination.

1040.06 Shoulder Sites

Shoulder sites are used by the WSP to pull a truck over for inspection and weighing with portable scales.

(1) Site Locations

Design shoulder sites to best fit the existing conditions. Small shoulder sites (Figure 1040-6) are for use on lower volume roadways (ADT 5,000 or less) with two-way traffic. Large shoulder sites (Figure 1040-7) are to be used with higher volume two-way roadways and multilane highways.

Locate the weighing facility so that its operation will not hinder the operation of the highway or other related features such as an intersection.

(2) Design Features

Shoulder sites are designed in coordination with the WSP. Input from the local WSP Commercial Vehicle Enforcement personnel will ensure that the proposed site will meet their needs without over-building the facility. Obtain written concurrence from the WSP for the length, width, and taper rates before the design is finalized.

When the ADT is 1,500 or less and with the written approval of the WSP, the tapers at small shoulder sites may be eliminated. The shoulders on either side of the site may be used as acceleration and deceleration lanes, whether or not they were designed for this use. Therefore, provide adequate strength to support truck traffic.

Asphalt concrete pavement is acceptable for use on all shoulder sites. Design the depth in accordance with the surfacing report. Design the shoulder pavement at this depth for a length not less than the deceleration lane length before, and the acceleration lane length after, the site (Chapter 940).

When the shoulders are designed to be used for deceleration and acceleration lanes, the minimum width is 12 ft with full pavement depth for the deceleration/acceleration lane lengths (Chapter 940).

Use a maximum of 2% slope in order to optimize portable scale efficiency and to facilitate drainage.

1040.07 Federal Participation

Federal funds appropriate to the system being improved may be used for the acquisition of right of way and the construction of truck weighing facilities and vehicle inspection facilities. This includes, but is not limited to on and off ramps, deceleration and acceleration lanes, passing lanes, driveways, parking areas, scale approach slabs, vehicle inspection facilities, roadway illumination, and signing.

1040.08 Procedures

Prepare site plans for all truck weigh facilities that include:

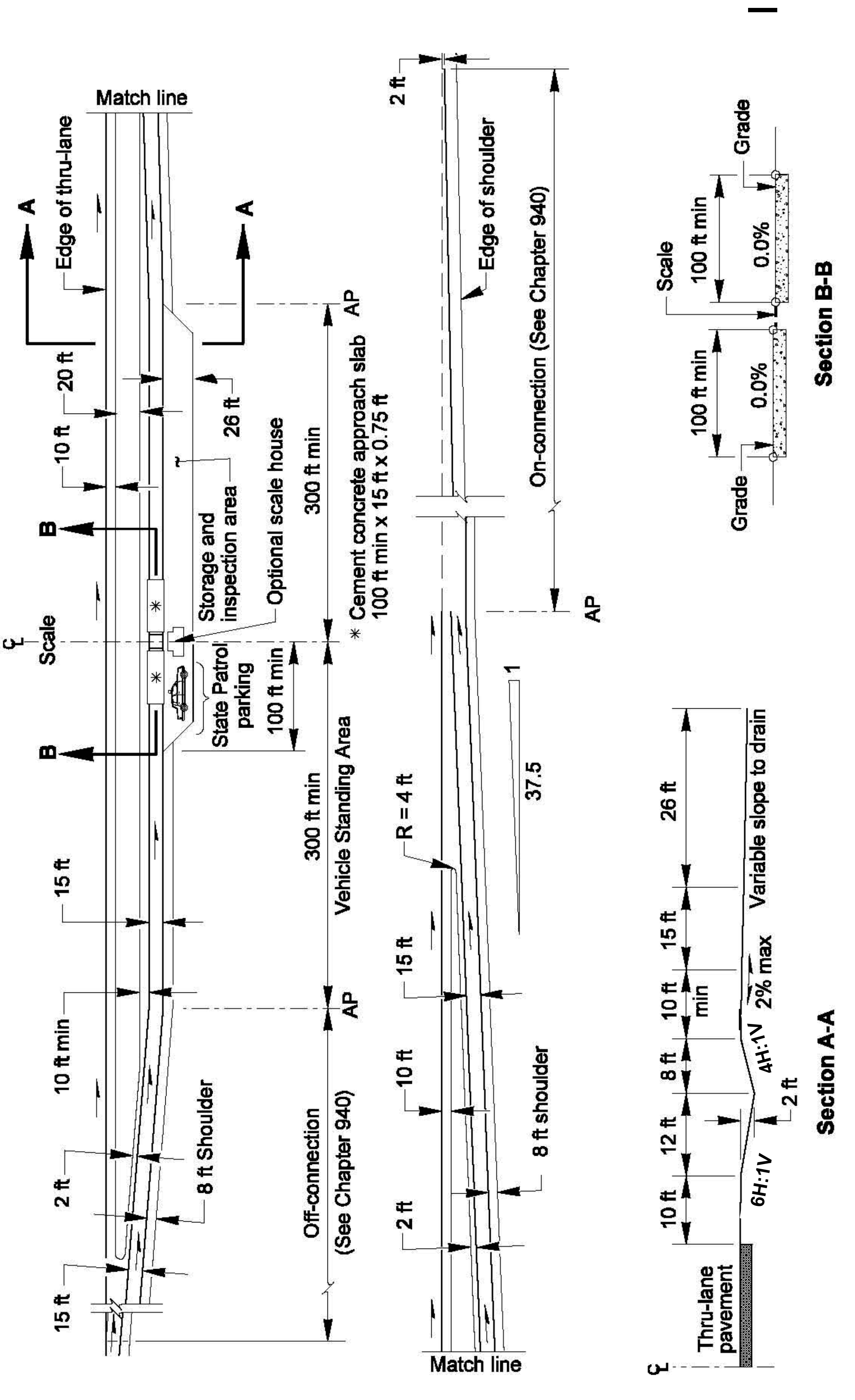
- Class of highway and design speed for main line (Chapter 440).
- Curve data on main line and weigh site.
- Numbers of lanes and widths of lanes and shoulders on main line and weigh site.
- Superelevation diagrams for the main line and weigh site.
- Stationing of ramp connections and channelization.

- Illumination.
- Signing.
- Water supply and sewage treatment.
- Roadside development.

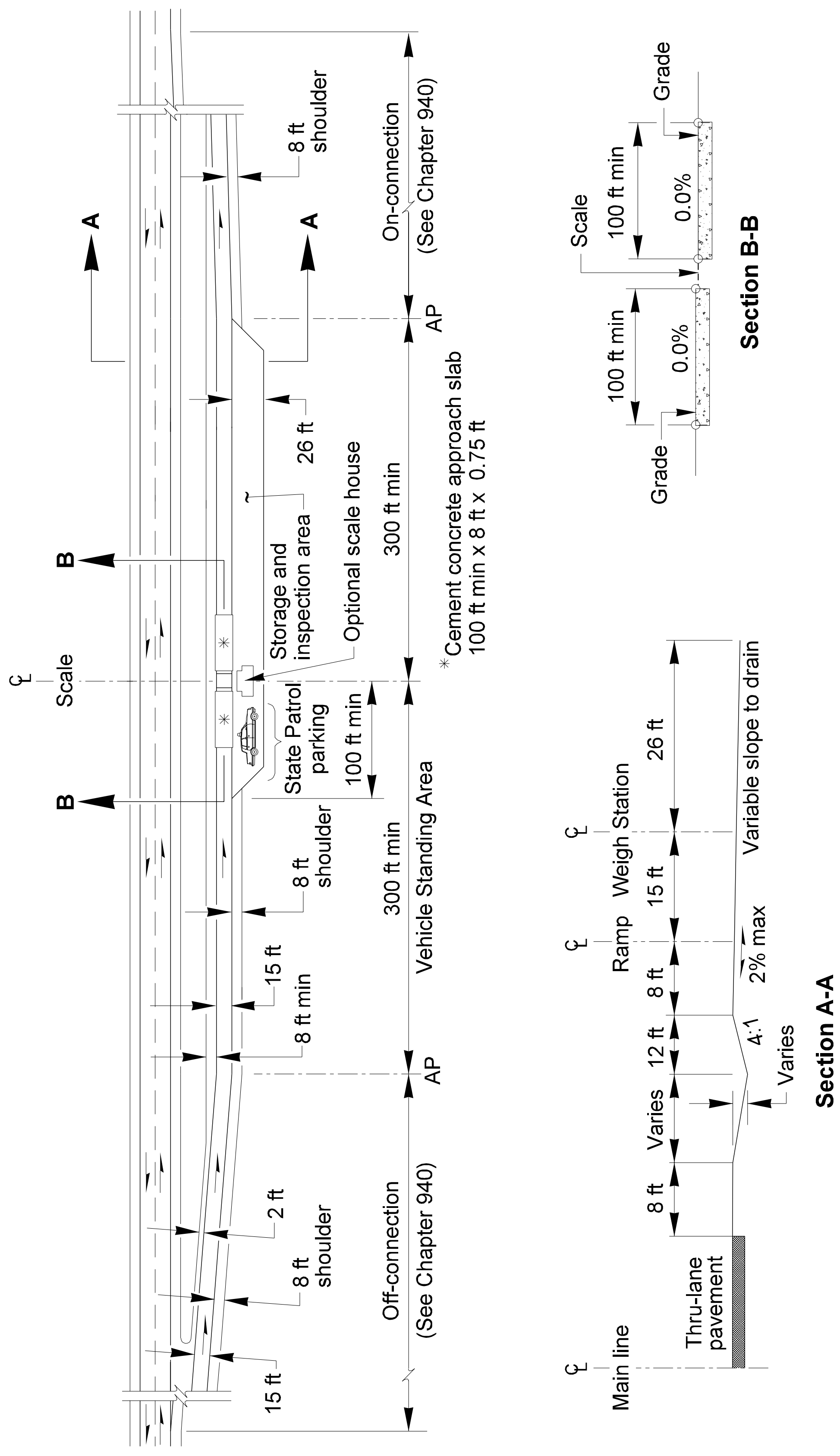
Get WSP approval of the site plans before the final plan approval.

1040.09 Documentation

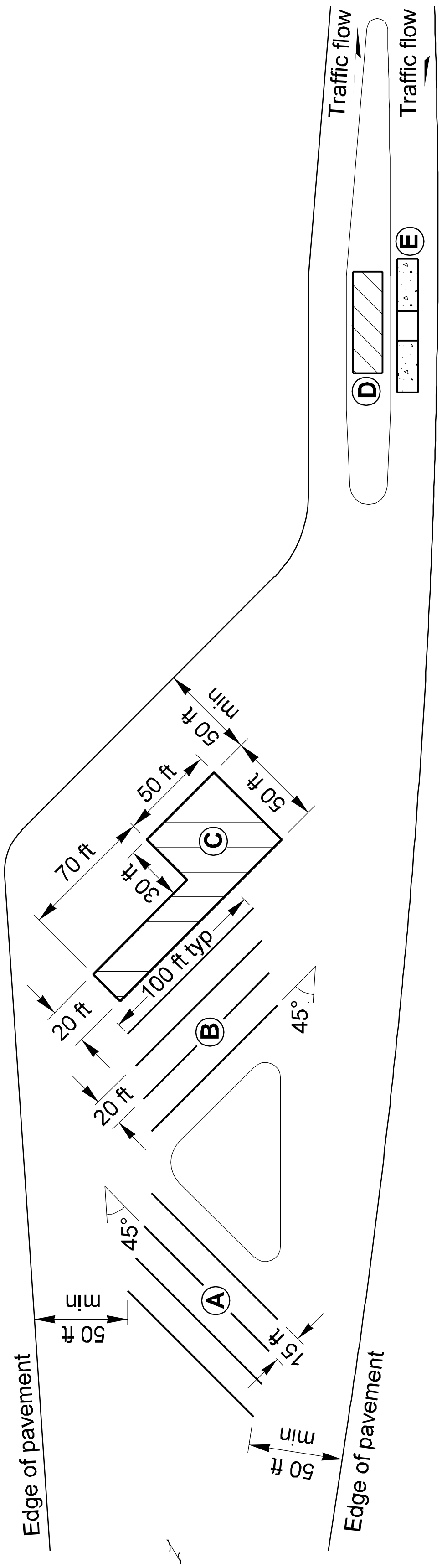
A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/



Truck Weigh Site (Multilane Highways)
Figure 1040-1

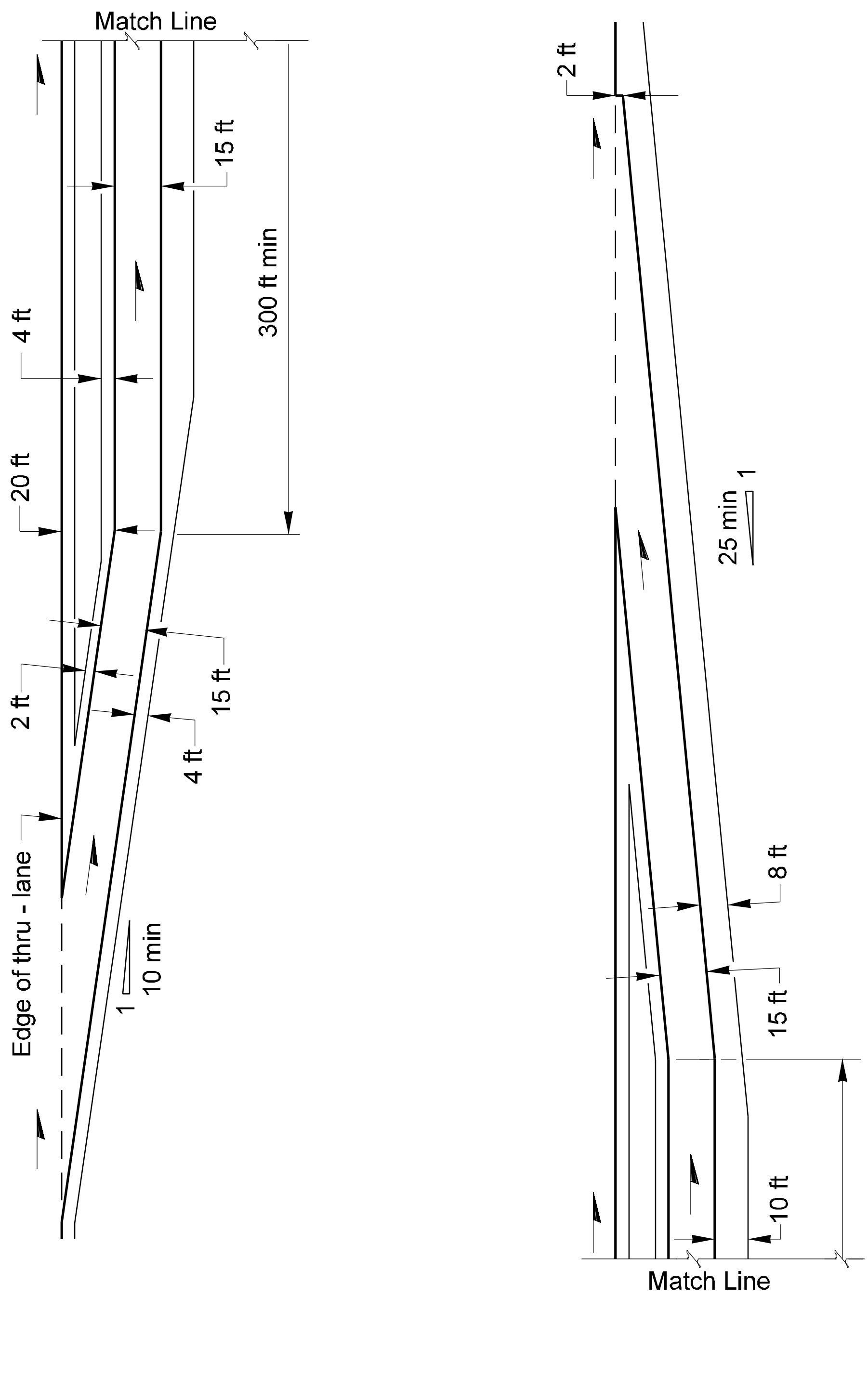


Truck Weigh Site (Two Lane Highways)
Figure 1040-2

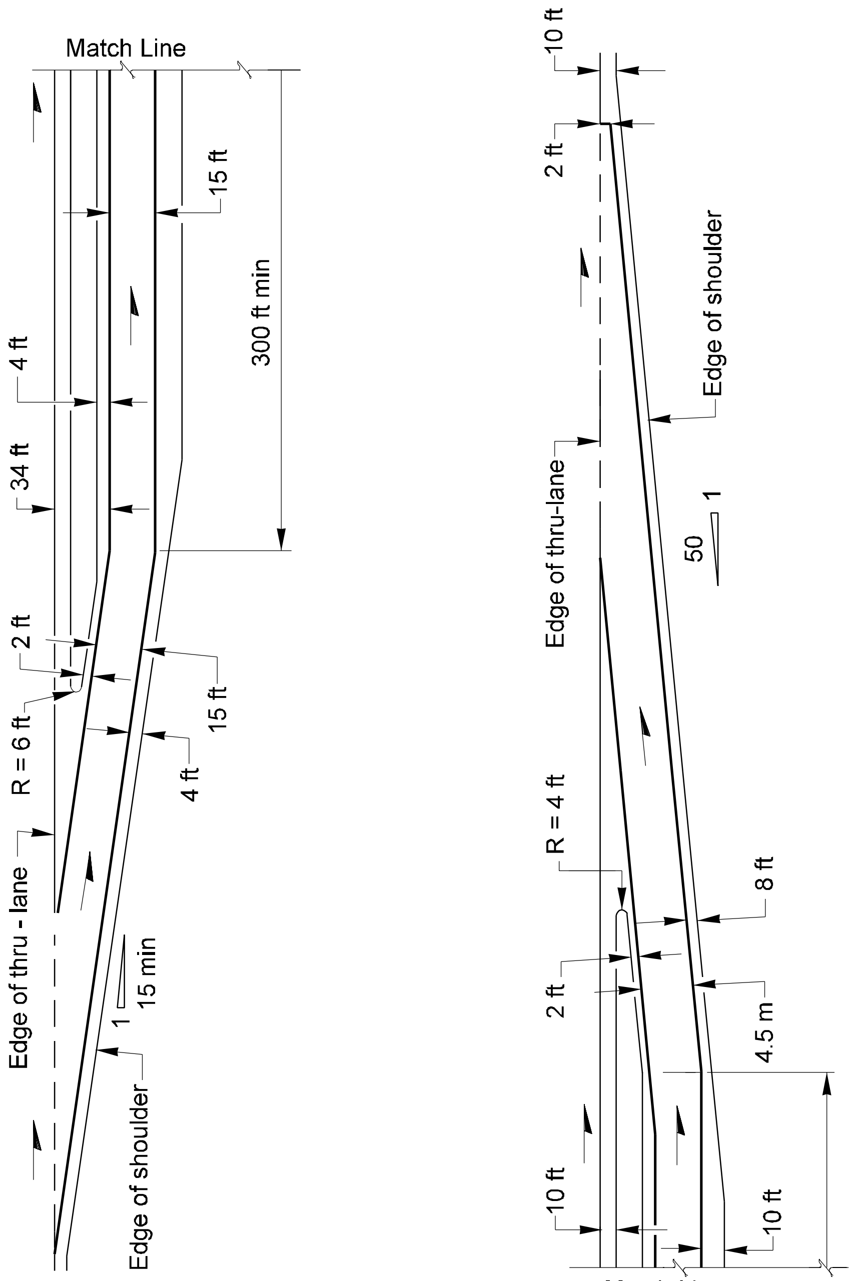


Ⓐ Truck storage and parking
Ⓑ Outside truck inspection and parking
Ⓒ Truck inspection building
Ⓓ Scalehouse
Ⓔ Scale

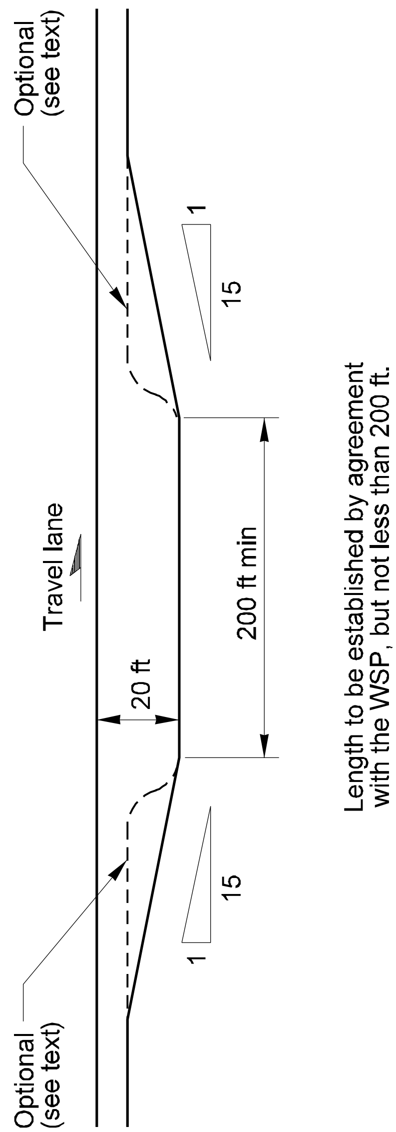
Vehicle Inspection Installation
Figure 1040-3



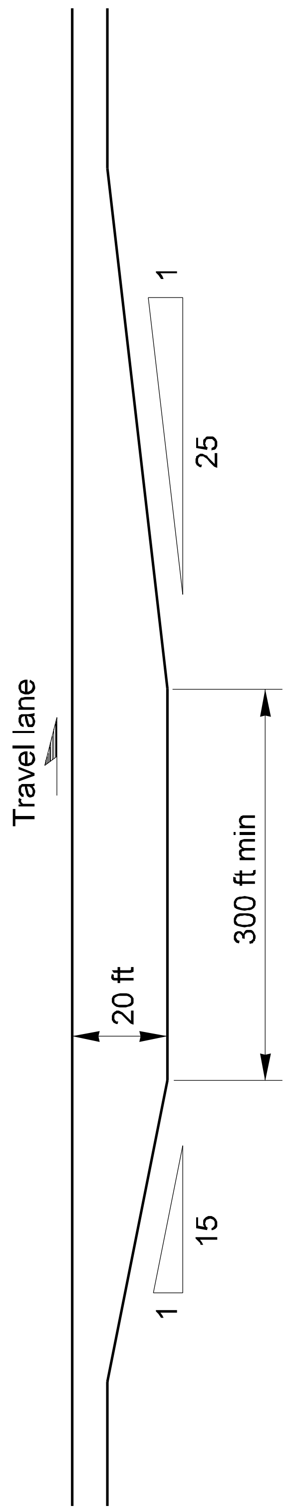
Minor Portable Scale Site
Figure 1040-4



Major Portable Scale Site
Figure 1040-5



Small Shoulder Site
Figure 1040-6



Large Shoulder Site
Figure 1040-7

C99047 / GSC

Memorandum of Understanding

Related to Vehicle Weighing and
Equipment Inspection Facilities on State Highways

This Memorandum of Understanding by and between the Washington State Department of Transportation hereinafter called the "Department of Transportation," and the Washington State Patrol, hereinafter called the "State Patrol," establishes procedures for coordinating and delineating the responsibilities for the location, design, construction, maintenance, signing, and other matters related to vehicle weighing and equipment inspection facilities and the state highway improvements needed as a result of these facilities.

It is mutually recognized that:

The Department of Transportation is responsible for planning, designing, constructing, and perpetuating public highways of the State Highway system for the safety and benefit of the traveling public;

The State Patrol is responsible for enforcement of the laws of the state of Washington regarding vehicle weight enforcement programs and vehicle safety inspection programs;

Nothing in this agreement is to be construed as conflicting with existing laws, regulations, and prescribed responsibilities, and

In recognition of the responsibilities, interest, and limitations set forth above and of the mutual benefits of established procedures to facilitate agreement on specific matters, the Department of Transportation and the State Patrol mutually agree as follows:

I. Planning

A. The State Patrol will work with the Department of Transportation's Planning and Programming Service Center to develop a prioritized list of weigh station needs at each biennium. The list will include:

- New permanent facilities
- New portable facilities
- Weigh-in-Motion (WIM) equipment
- Vehicle inspection facilities
- Scale approach slab construction

B. The State Patrol will provide the Planning and Programming Service Center with a project definition for each project, which will include statement of need, purpose of project, type of work, and general location of the project.

C. The Planning and Programming Center will send the information to the Regional Administrator for preparation of a project summary. The Regional Administrator will work with the State Patrol to identify the specific location of the facility, prepare a design decision estimate, and submit it to the Planning and Programming Service Center for inclusion in the biennial program.

D. The Regional Administrator will negotiate and execute any formal agreements required for design, construction, or maintenance of vehicle weighing and inspection sites.

MOU Related to Vehicle Weighing and Equipment Inspection Facilities on State Highways
Figure 1040-8a

C990477GSC

II. Responsibilities

Vehicle weighing and equipment inspection facilities shall meet highway standards for acceleration and deceleration lanes, on and off ramps, illumination, and other related equipment. These facilities will be provided through the cooperative efforts of the State Patrol and Department of Transportation as needed on state highways.

A. The State Patrol will:

1. Initiate the action and submit recommendations for the addition of a new facility or expansion of an existing facility or the relocation of an existing facility, and negotiate agreements, e.g. siting of a new facility, etc. with the Department of Transportation through the appropriate region and the Olympia Service Center.

2. Perform the preliminary engineering and submit the design and PS&E documents for the scale, WIM, scalehouse, and inspection facility to the Department of Transportation for review and processing for approval with the Federal Highway Administration (FHWA), if applicable, at the State Patrol's expense.

3. Construct, operate, and maintain the weigh station scale, WIM, scalehouse, and equipment inspection facility with all related equipment thereto including lighting, water, heat, telephone, and toilet facilities at the State Patrol's expense.

4. For WIM facilities and for facilities deploying Commercial Vehicle Information Systems and Networks (CVISN), select sites in cooperation with DOT that minimize the need for pavement reconstruction, and, at the State Patrol's expense, install, operate, and maintain any weigh-in-motion signs and related equipment, purchase and install all WIM hardware and software, and provide electrical conduit and an equipment storage room within the scale facility.

5. In the event the State Patrol cannot fulfill the responsibilities specified above for preliminary engineering (design and PS&E documents), construction, or maintenance, they may request that the Department of Transportation perform the work on the basis of a written agreement that includes reimbursement to the Department of Transportation for the costs.

6. Construct the CVISN roadside apparatus at the same time as WIM equipment is installed, e.g.; cantilevered mounting poles, guard rail, conduit/raceway installation at DOT expense. All construction in the state or interstate right-of-way will be under the responsibility of a DOT region engineer.

B. The Department of Transportation will:

1. Initiate action for the relocation of an existing installation when necessary because of the relocation of a highway or expansion of an existing highway, and obtain concurrence of the State Patrol.

2. Negotiate agreements with the State Patrol regarding addition, expansion, and relocation of facilities.

MOU Related to Vehicle Weighing and Equipment Inspection Facilities on State Highways

Figure 1040-8b

C990477GSC

3. On all newly located or existing highways, at Department of Transportation expense, acquire the necessary right of way, construct and maintain the required acceleration and deceleration lanes, on and off ramps, driveways, passing lanes, scale approach slabs, and parking areas, including the surfacing thereof, excavate the scale pit, and construct and maintain the inspection, parking, and roadway illumination and standard signing at approved locations.

4. For WIM facilities and for facilities deploying Commercial Vehicle Information Systems and Networks (CVISN), at Department of Transportation's expense, construct the special approaches, provide maintenance of CVISN hardware and software located within the facility, and provide traffic control for installation of the scale and, when closure of any lane is required, for maintenance of the scale.

5. For facilities deploying Commercial Vehicle Information Systems and Networks (CVISN), at WSDOT's expense install mainline hardware (Automated Vehicle Identification equipment) and software for conformance with CVISN standards and provide maintenance of CVISN hardware and software located within the facility.

6. Upon request of the State Patrol, in accordance with a written agreement and on a reimbursement basis, perform other preliminary engineering, construction, and maintenance, which is the sole responsibility of the State Patrol.

Additionally, the State Patrol and the Department of Transportation agree to follow the Federal Highway Administration's *Guidance for Local Agency Roadway Projects within Interstate Rights-of-Way*, as outlined in Attachment A.

III. Conclusions and Approvals

A. The Regional Administrators for the Department of Transportation and the Commercial Vehicle Division Commander for the State Patrol are encouraged to consult with each other and to agree on such matters that fall within their scope of responsibility.

B. This memorandum may be amended or supplemented by mutual agreement between the signers or their successors.

C. Either party may terminate this MOU upon thirty- (30) days' written notification. If this MOU is so terminated, the terminating party shall be liable only for performance in accordance with the terms of the MOU for performance rendered prior to the effective date of the termination.

D. In the event a dispute arises under this MOU, it shall be resolved as follows: The Secretary of WSDOT and the Chief of the WSP shall each appoint a member, not affiliated with either agency, to a conflict resolution board. Then these two members shall appoint a third member. The decision made by this board shall be final and binding on the parties to the MOU.

E. In the event funding from state, federal, or other sources is withdrawn, reduced, or limited in any way after the effective date of this MOU and prior to normal completion, the WSDOT or WSP may terminate the MOU under the TERMINATION clause, subject to renegotiation under those new funding limitations and conditions.

MOU Related to Vehicle Weighing and Equipment Inspection Facilities on State Highways

Figure 1040-8c

C990477GSC

F. We have read the foregoing and agree to accept and abide by the procedures herein.

Annette M. Sandberg, Chief
Washington State Patrol

Date 12/16/99

Sid Morrison, Secretary
Washington State
Department of Transportation

Date 3/9/00

APPROVED AS TO FORM:

Assistant Attorney General

Date 9/7/99

Washington State Patrol
Budget and Fiscal Services

Date 12/27/99

MOU Related to Vehicle Weighing and Equipment Inspection Facilities on State Highways

Figure 1040-8d

C990477GSC

ATTACHMENT A
Guidance for Local Agency Roadway Projects within Interstate Rights-of-Way

Since all projects within the Interstate rights-of-way (ROW) have the potential to impact safety and operations on the Interstate route, they must incorporate Interstate design criteria and construction quality. It is the Federal Highway Administration's (FHWA) policy that the Washington State Department of Transportation (WSDOT) should administer all projects within the Interstate ROW. However, given the scope and extent of non-Interstate projects within the Interstate ROW, it is recognized that local agency administration of some projects may be desirable.

Whenever a local agency proposes a project within the Interstate ROW, they must develop an agreement with WSDOT that clearly outlines their duties and responsibilities to maintain the integrity of the Interstate facility, from both the safety and quality perspectives. The agreement must be executed prior to beginning design and must incorporate the following requirements:

Responsibilities: WSDOT and the local agency must each assign a responsible Project Engineer.

Design: WSDOT must review and approve all highway plans, profiles, deviations structural plans false-work plans, shoring plans, and traffic control plans for any work within the Interstate ROW.

Plans, specification and estimates: WSDOT must review and approve the plans and specifications for any work within Interstate ROW.

Advertising and aware: The local agency must confer with the WSDOT Project Engineer on any pre-aware issues affecting the quality and timing of the contract.

Construction: All construction, materials, and quality control requirements contained in the current editions of the WSDOT Standard Specifications and Construction Manual must be incorporated into the agreement.

Contract changes: All contract changes affecting work within the Interstate ROW must have the prior concurrence of the WSDOT Project Engineer.

Final inspection: The final inspection of the project must be performed by WSDOT Olympia Service Center and must evidence their approval.

Only local agencies with full certification acceptance authority may enter into such an agreement with the WSDOT.

The agreement must be submitted to FHWA for approval. FHWA reserves the right to assume full oversight of the project.

MOU Related to Vehicle Weighing and Equipment Inspection Facilities on State Highways
Figure 1040-8e

1050.01 General

High occupancy vehicle (HOV) facilities include separate HOV roadways, HOV lanes, transit lanes, HOV direct access ramps, and flyer stops. The objectives for the HOV facilities are:

- Improve the capability of corridors to move more people by increasing the number of people per vehicle.
- Provide travel time savings and a more reliable trip time to HOV lane users.
- Provide safe travel options for HOVs without adversely affecting the safety of the general-purpose lanes.

Plan, design, and construct HOV facilities that ensure intermodal linkages. Give consideration to future highway system capacity needs. Whenever possible, design HOV lanes so that the level of service for the general-purpose lanes will not be degraded.

In urban corridors that do not currently have planned or existing HOV lanes, complete an analysis of the need for HOV lanes before proceeding with any projects for additional general-purpose lanes. In corridors where both HOV and general-purpose facilities are planned, construct the HOV lane before or simultaneously with the construction of new general-purpose lanes.

See the following chapters for additional information:

Chapter	Subject
430	general-purpose roadway widths for modified design level
440	general-purpose roadway widths for full design level
640	other cross section data
641	general-purpose turning roadway widths
<u>1055</u>	<u>HOV Direct Access</u>

1050.02 References

Revised Code of Washington (RCW) 46.61.165, High-occupancy vehicle lanes

RCW 47.52.025, Additional powers — Controlling use of limited access facilities — High-occupancy vehicle lanes

Washington Administrative Code (WAC) 468-510-010, High occupancy vehicles (HOVs)

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, Washington State Department of Transportation (WSDOT)

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), 2000, U.S. Department of Transportation, Federal Highway Administration; including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT

Traffic Manual, M 51-02, WSDOT

Guide for the Design of High Occupancy Vehicle Facilities, American Association of State Highway and Transportation Officials (AASHTO)

Design Features of High Occupancy Vehicle Lanes, Institute of Traffic Engineers (ITE)

High-Occupancy Vehicle Facilities: Parsons Brinkerhoff, Inc.

NCHRP Report 414, *HOV Systems Manual*

1050.03 Definitions

buffer-separated HOV lane An HOV lane that is separated from the adjacent same direction general-purpose freeway lanes by a designated buffer.

bus rapid transit (BRT) An express rubber tired transit system operating predominantly in roadway managed lanes. It is generally characterized by separate roadway or buffer-separated HOV lanes, HOV direct access ramps, and a high occupancy designation (3+ or higher).

business access transit (BAT) lanes A transit lane that allows use by other vehicles to access abutting businesses.

enforcement area A place where vehicles may be stopped for ticketing by law enforcement. It also may be used as an observation point and for emergency refuge.

enforcement observation point A place where a law enforcement officer may park and observe traffic.

flyer stop A transit stop inside the limited access boundaries.

high occupancy toll (HOT) lane A managed lane that combines a high occupancy vehicle lane and a toll lane.

high occupancy vehicle (HOV) A vehicle that fits one of the following:

(1) Rubber tired municipal transit vehicles.

(2) Buses with a carrying capacity of sixteen or more persons, including the operator.

(3) Motorcycles.

(4) Recreational vehicles that meet the occupancy requirements of the facility.

(5) All other vehicles that meet the occupancy requirements of the facility, except trucks in excess of 10,000 lb gross vehicle weight.

HOV direct access ramp An on or off ramp exclusively for the use of HOVs that provides access between a freeway HOV lane and a street, transit support facility, or another freeway HOV lane without weaving across general-purpose lanes.

HOV facility A priority treatment for HOVs.

level of service A qualitative measure describing operational conditions within a traffic stream, incorporating factors of speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

managed lane A lane that increases efficiency by packaging various operational and design actions. Lane management operations may be adjusted at any time to better match regional goals.

nonseparated HOV lane An HOV lane that is adjacent to and operates in the same direction as the general-purpose lanes with unrestricted access between the HOV lane and the general-purpose lanes.

occupancy designation The minimum number of occupants required for a vehicle to use the HOV facility.

separated HOV facility An HOV roadway that is physically separated from adjacent general-purpose lanes by a barrier, median, or on a separate right of way.

single occupant vehicle (SOV) Any motor vehicle other than a motorcycle carrying one occupant.

transit lane A lane for the exclusive use of transit vehicles.

violation rate The total number of violators divided by the total number of vehicles on an HOV facility.

1050.04 Preliminary Design and Planning

(1) Planning Elements for Design

In order to determine the appropriate design options for an HOV facility, the travel demand and capacity must first be established; identify suitable corridors, evaluate the HOV facility location and length, and estimate the HOV demand. A viable HOV facility will satisfy the following criteria:

- Be part of an overall transportation plan.
- Have the support of the community and public.

- Respond to demonstrated congestion or near-term anticipated congestion: Level of Service E or F for at least one hour of peak period (traffic approaching a capacity of 1,700 to 2,000 vehicles per hour per lane) or average speeds less than 30 mph during peak periods over an extended distance.
- Except for a bypass of a local bottleneck, be of sufficient length to provide a travel time saving of at least 5 minutes during the peak periods.
- Have sufficient numbers of HOV users for a cost-effective facility and to avoid the perception of under utilization. (HOV volumes of 400 to 500 vehicles per hour on nonseparated lanes and 600 to 800 on separated facilities.)
- Provide a safe, efficient, and enforceable operation.

A queue or bottleneck bypass can be effective without satisfying all of the above. An isolated bypass can be viable when there is localized, recurring traffic congestion, and such treatment will provide a travel time saving to an adequate number of HOV users.

The efficiency of the HOV facility can be affected by the access provisions. Direct access between park and ride/transit facilities and an HOV lane is the most desirable, but it is also an expensive alternative. Direct access options are discussed in Chapter 1055.

Document the need for the HOV lane and how the proposed lane will meet those needs.

(2) HOV Facility Type

Make a determination as to the type of HOV lane. The three major choices are separated roadway, buffer-separated lane, and nonseparated HOV lane.

(a) **Separated Roadway.** The separated roadway can be either a one-way reversible or a two-way operation. The directional split in the peak periods, space available, and operating logistics are factors to be considered. A separated HOV roadway may be located in the median of the freeway, next to the freeway, or on an independent alignment. Separated HOV facilities are more effective for:

- Large HOV volumes.
- Large merging and weaving volumes.
- Long-distance HOV travel.

Reversible, separated roadways operate effectively where there are major directional splits during peak periods. Consider potential changes in this traffic pattern and designing the facility to accommodate possible conversion to two-way operation. The separated roadway is normally more efficient, provides for the higher level of safety, and is more easily enforced. However, it is generally the most expensive type of HOV facility to implement.

(b) **Buffer-Separated.** A buffer-separated HOV lane is similar to a freeway nonseparated HOV lane on the left, but with a buffer between the HOV lane and the general-purpose lanes. The addition of a buffer provides better delineation between the lanes and controls access between the HOV lane and general-purpose lanes to improve operation.

(c) **Nonseparated.** Nonseparated HOV lanes operate in the same direction and immediately adjacent to the general-purpose lanes. They are located either to the left (preferred) or to the right of the general-purpose lanes. Nonseparated HOV lanes are normally cheaper, easier to implement, and provide more opportunity for frequent access. However, the ease of access can create more problems for enforcement and a higher potential for conflicts.

(3) Freeway Operational Alternatives

For an HOV lane on a limited access facility, consider the following operational alternatives:

- Inside (preferred) or outside HOV lane.
- Lane conversion.
- Use of existing shoulder (not recommended for permanent operations).
- HOV direct access ramps.
- Queue bypasses.
- Flyer stops.
- Hours of operation.

When evaluating alternatives, consider a combination of alternatives to provide the best solution for the corridor. Also, incorporate flexibility into the design in order not to preclude potential changes in operation, such as outside-to-inside lane and reversible to two-way operations. Access, freeway-to-freeway connections, and enforcement will have to be accommodated for such changes. Document the operational alternatives.

(a) **Inside Versus Outside HOV Lane.** System continuity and consistency of HOV lane placement along a corridor are important and influence facility development decisions. Other issues include land use, trip patterns, transit vehicle service, HOV volume, ramp volume, congestion levels, safety, enforcement, and direct access to facilities.

The inside (left) HOV lane is most appropriate for a corridor with long distance trip patterns, such as a freeway providing mobility to and from a large activity center. These trips are characterized by long distance commuters and express transit service. Maximum capacity for an effective inside HOV lane is approximately 1,500 vehicles per hour. When the HOVs weaving across the general-purpose lanes cause severe congestion, consider implementing HOV direct access ramps, separated HOV roadways, or a higher occupancy designation. Inside lanes are preferred for HOV lanes on freeways.

The outside (right) HOV lane is most appropriate for a corridor with shorter, widely dispersed trip patterns. These trip patterns are characterized by transit vehicle routes that exit and enter at nearly every interchange. The maximum capacity for an effective outside HOV lane is reduced and potential conflicts are increased by heavy main line congestion and large entering and exiting general-purpose volumes.

(b) **Conversion of a General-Purpose Lane.** The use of an existing general-purpose lane for an HOV lane is not a preferred option; however, conversion of a lane to an HOV lane might be justified when the conversion provides greater people-moving capability on the roadway. Use of an existing freeway lane as an HOV lane will be considered only with a deviation.

Given sufficient existing capacity, converting a general-purpose lane to an HOV lane will provide for greater people moving capability in the future without significantly affecting the existing roadway operations. The fastest and least expensive method for providing an HOV lane is through conversion of a general-purpose lane. Restriping and signing are sometimes all that is needed. Converting a general-purpose lane to HOV use will likely have environmental benefits. This method, however, is controversial from a public acceptance standpoint. Public support might be gained through an effective public involvement program. See Chapter 210, Public Involvement and Hearings.

Lane conversion of a general-purpose lane to an HOV lane must enhance the corridor's people moving capacity. It is critical that an analysis be conducted that includes:

- Public acceptance of the lane conversion.
- Present and long-term traffic impacts on the adjacent general-purpose lanes and the HOV lane.
- Impacts to the neighboring streets and arterials.
- Legal, environmental, and safety impacts.

(c) **Use of Existing Shoulder.** When considering the alternatives in order to provide additional width for an HOV lane, the use of the existing shoulder is not a preferred option. Use of the shoulder on a freeway or freeway ramp as an HOV lane will be considered only with a deviation.

Consider shoulder conversion to an HOV lane when traffic volumes are heavy and the conversion is a temporary measure. Another alternative is to use the shoulder as a permanent measure to serve as a transit-only or queue bypass lane during peak hours and then revert to a shoulder in off peak hours. The use of the shoulder creates special signing, operational, and enforcement problems. An agreement is required with the transit agency to ensure that transit vehicles will only use the shoulder during peak hours. The use of the shoulder must be clearly defined by signs. Institute special operations to ensure the shoulder is clear and available for the designated hours.

The existing shoulder pavement is often not designed to carry heavy volumes of vehicles, especially transit vehicles. As a result, repaving and reconstruction of the shoulder might be required.

(d) **HOV Direct Access Ramps.** To improve the efficiency of an HOV system, exclusive HOV access connections for an inside HOV lane may be considered. See Chapter 1055 for information on HOV direct access connections. Direct access reduces the need for HOVs to cross the general-purpose lanes from right side ramps. Transit vehicles will be able to use the HOV lane and provide service to park and ride lots, flyer stops, or other transit stops by the HOV direct access ramps.

(e) **Queue Bypass Lanes.** A queue bypass lane allows HOVs to save time by avoiding congestion at an isolated bottleneck. An acceptable time saving for a queue bypass is one minute or more. Typical locations for queue bypasses are at ramp meters, signalized intersections, toll plaza or ferry approaches, and locations with isolated main line congestion. By far the most common use is with ramp metering. Queue bypass lanes can be built along with a corridor HOV facility or independently. In most cases, they are relatively low cost and easily implemented. Where practical, include HOV bypasses on ramp metering sites or make provisions for their future accommodation, unless specific location conditions dictate otherwise.

(f) **Flyer Stops.** Flyer stops reduce the time required for express transit vehicles to serve intermediate destinations. However, passengers must travel greater distances to reach the loading platform. For information on flyer stops, see Chapter 1055.

(g) **Hours of Operation.** HOV designation on freeway HOV lanes 24 hours a day provides benefits to users during off peak periods, minimizes potential confusion, makes enforcement easier, and simplifies signing and striping. However, 24-hour operation also might result in a lane not used during off peak periods, negative public opinion, and the need for full time enforcement.

(4) Arterial Street Operational Alternatives

Arterial street HOV lanes also have a variety of HOV alternatives to be considered. Some of these alternatives are site specific or have limited applications. Arterial HOV lanes differ from freeway HOV lanes in slower speeds, little access control (turning traffic can result in right angle conflicts), and traffic signals. Arterial HOV lanes are occasionally designated for transit vehicles only, especially in cities with a large concentration of transit vehicles. When evaluating alternatives consider traffic signal queues and managed access highway class. The alternatives include:

- Type of lane.
- Left side or right side HOV lane.
- Hours of operation.
- Spot treatments.
- Bus stops.

When evaluating alternatives, consider a combination of alternatives to provide the best solution for the corridor. Also, incorporate flexibility into the design in order not to preclude potential changes in operation. Document the operational alternatives.

(a) **Type of lane.** Lanes can be transit only or include all HOVs. Transit only lanes are desirable where bus volumes are high with a high level of congestion. They will increase the speed of transit vehicles through congested areas and improve the reliability of the transit service. Lanes that allow use by all HOVs are appropriate on corridors with high volumes of carpools and vanpools. They can collect carpools and vanpools in business and industrial areas and connect them to the freeway system.

(b) **Left side or right side HOV lane.** Continuity of HOV lane location along a corridor is an important consideration when making the decision whether to locate an arterial street HOV lane on the left or right side of the street. Other issues include land use, trip patterns, transit vehicle service, safety, enforcement, and presence of parking.

The right side is the preferred location for arterial street HOV lanes on transit routes with frequent stops. It is the most convenient for passenger boarding at transit stops. It is also the most common location for HOV lanes on arterial streets. General-purpose traffic must cross the HOV lane to make a right-turn at intersections and to access driveways. These turns across the HOV lane can create conflicts. Minimizing access points that create these conflict locations is recommended. Other issues to consider are on street parking, stopping area for delivery vehicles, and enforcement areas.

Left side arterial street HOV lanes are less common than right side lanes. HOV lanes on the left eliminate the potential conflicts with driveway access, on street parking, and stopping area for delivery vehicles. The result is fewer delays and higher speeds making left side arterial street HOV lanes appropriate for longer distance trips. Disadvantages are the difficulty providing transit stops and the need to provide for left turning general-purpose traffic.

(c) **Hours of operation.** An arterial street HOV lane can either operate as an HOV lane 24 hours a day or during peak hours only. Factors to consider in determining which to use include type of HOV lane, level of congestion, continuity, and enforcement.

HOV lanes operating 24 hours a day are desirable when congestion and HOV demand exists for extended periods throughout the day. The 24 hour operation provides benefits to users during off peak periods, minimizes potential confusion, makes enforcement easier, and simplifies signing and striping. Disadvantages are negative public opinion if the lane is not used during off peak periods, the need for full time enforcement, and the loss of on street parking.

Peak period HOV lanes are appropriate for arterial streets with HOV demand or congestion existing mainly during the peak period. Peak period HOV lanes provide HOV priority at the critical times of the day, lessen the negative public perception of the HOV lane, and allow on street parking or other shoulder uses at other times. The disadvantages include possible confusion to the drivers, more difficult enforcement, increased signing, and the need to institute special operations to ensure the shoulder or lane is clear and available for the designated period.

(d) **Spot Treatments.** A spot HOV treatment is used to give HOVs priority around a bottleneck. It can provide time savings, travel time reliability, and improve access to other facilities. Examples include a short HOV lane to provide access to a freeway on-ramp, one lane of a dual turn-lane, a priority lane at ferry terminals, and priority at traffic signals.

Signal priority treatments that alter the sequence or duration of a traffic signal are techniques for providing preferential treatment for transit vehicles. The priority treatments can range from timing and phasing adjustments to signal preemption. Consider the overall impact on traffic. Preemption would normally not be an appropriate treatment where traffic signal timing and coordination are being utilized or where there are high volumes on the cross streets.

(e) **Bus stops.** Normally, with arterial HOV lanes, there is not a shoulder suitable for a bus to use while stopped to load and unload passengers without blocking the lane. Therefore, bus stops are either in-lane or in a pullout. In-lane bus stops are the simplest type of bus stop. However, stopped buses will block the HOV lane; therefore, in-lane bus stops are only allowed in transit lanes. Bus pullouts provide an area for buses to stop without blocking the HOV lane. Disadvantages include higher cost, reduced width for the sidewalk or other roadside area, and possible difficulty reentering the HOV lane. See Chapter 1060 for additional information on bus stop location and design.

1050.05 Operations

(1) Vehicle Occupancy Designation

Select the vehicle occupancy designation to provide the maximum movement of people in a corridor, provide free-flow HOV operations, reduce the empty lane perception, provide for the ability to accommodate future HOV growth within a corridor, and be consistent with the regional transportation plan and the policies adopted by the metropolitan planning organization (MPO).

An initial occupancy designation must be established. It is WSDOT policy to use the 2+ designation as the initial occupancy designation. Consider a 3+ occupancy designation if it is anticipated during initial operation that the volumes will be 1,500 vehicles per hour for a left-side HOV lane, or 1,200 vehicles per hour for a right-side HOV lane, or that a 45 mph operating speed cannot be maintained for more than 90 percent of the peak hour.

(2) Enforcement

Enforcement is necessary for the success of an HOV facility. Coordination with the Washington State Patrol (WSP) is critical when the operational characteristics and design alternatives are being established. This involvement ensures that the project is enforceable and will receive their support.

Provide both enforcement areas and observation points for all high-speed HOV lanes and ramp facilities.

Barrier-separated facilities, because of the limited access, are the easiest facilities to enforce. Shoulders provided to accommodate breakdowns may also be used for enforcement. Reversible facilities have ramps for the reverse direction that may be used for enforcement. Gaps in the barrier may be needed so emergency vehicles can access barrier-separated HOV lanes.

Buffer-separated and nonseparated HOV lanes allow violators to easily enter and exit the HOV lane. For this reason, providing strategically located enforcement areas and observation points is essential.

Consider the impact on safety and visibility for the overall facility during the planning and design of enforcement areas and observation points. Where HOV facilities do not have enforcement areas, or where officers perceive that the enforcement areas are inadequate, enforcement on the facility will be difficult and less effective.

(3) Intelligent Transportation Systems

The objective of intelligent transportation systems (ITS) is to make more efficient use of our transportation network. This is done by collecting data, managing traffic, and relaying information to the motoring public.

It is important that an ITS system is incorporated into the HOV project and that the HOV facility fully utilize the ITS features available. This includes providing a strategy of incident management since vehicle breakdowns and accidents have a significant impact on the efficient operation of the HOV facilities. See Chapter 860 for more information on ITS.

1050.06 Design Criteria

(1) Design Procedures

See the design matrices (Chapter 325) for the required design level for the elements of an HOV project.

(2) Design Considerations

HOV lanes are designed to the same criteria as the facilities they are attached. Design nonseparated and buffer-separated HOV lanes to match the vertical alignment, horizontal alignment, and cross slope of the adjacent lane. A deviation is required when any proposed or existing design element does not meet the applicable design level for the project.

(3) Adding an HOV Lane

The options for adding an HOV lane are reconstruction, restriping, combined reconstruction and restriping, and possibly lane conversion.

Reconstruction involves creating roadway width. Additional right of way may be required. Restriping involves reallocating the existing paved roadway to create enough space to provide an additional HOV lane. Restriping of lane or shoulder widths to less than for the design level and functional class of the highway is a design deviation and approval is required.

Reconstruction and restriping can be combined to maximize use of the available right of way. For example, a new lane can be created through a combination of median reconstruction, shoulder reconstruction, and lane restriping. Each project will be handled on a case by case basis. Generally consider the following reductions in order of preference:

(a) Reduction of the inside shoulder width, provided the enforcement and safety mitigation issues are addressed. (Give consideration not to preclude future HOV direct access ramps by over reduction of the available median width.)

(b) Reduction of the interior general-purpose lane width to 11 ft.

(c) Reduction of the outside general-purpose lane width to 11 ft.

(d) Reduction of the HOV lane to 11 ft.

(e) Reduction of the outside shoulder width to 8 ft.

If lane width adjustments are necessary, old lane markings must be thoroughly eradicated. It is desirable that longitudinal joints (new or existing) not conflict with tire track lines. If they do, consider overlaying the roadway before restriping.

(4) Design Criteria for Types of HOV Facilities

(a) **Separated Roadway HOV Facilities.** The separated HOV facility can be single lane or multilane and directional or reversible. (See Figure 1050-2.)

1. **Lane Widths.** See Figure 1050-1 for traveled way width (W_R) on turning roadways.

2. **Shoulder Widths.** The shoulder width requirements are as follows:

- The minimum width for the sum of the two shoulders is 12 ft for one-lane facilities and 14 ft for two-lane facilities.
- One of the shoulders must have a width of at least 10 ft for disabled vehicles. The minimum for the other shoulder is 2 ft for one-lane facilities and 4 ft for two-lane facilities.
- The wider shoulder may be on the left or the right as needed to best match the conditions. Maintain the wide shoulder on the same side throughout the facility.

3. **Total Widths.** To reduce the probability of blocking the HOV facility, make the total width (lane width plus paved shoulders) wide enough to allow an A-BUS to pass a stalled A-BUS. For single lane facilities, the traveled way widths (W_R), given in Figure 1050-1, plus the 12 ft total shoulder width will provide for this passing for radii (R) 100 ft or greater. For R of 75 ft, a total roadway width of 33 ft is needed and for R of 50 ft, a total roadway width of 41 ft is needed to provide for the passing.

R (ft)(1)	W_R (ft)	
	1-Lane	2-Lane
3001 to Tangent	13(2)	24
3000	14	24
2000	14	25
1000	15	26
500	15	27
300	15	28
200	16	29
150	17	31
100	18	34
75	19	37
50	22	45

(1) Radius (R) is on the outside edge of traveled way on 1-lane and center line on 2-lane roadways.
(2) May be reduced to 12 ft on tangent.

Minimum Traveled Way Widths for Articulated Buses
Figure 1050-1

(b) **Nonseparated Freeway HOV Lanes.** For both inside and outside HOV lanes, the minimum lane width is 12 ft and the minimum shoulder width is 10 ft. (See Figure 1050-2.)

When a left shoulder less than 10 ft wide is proposed for distances exceeding 1.5 mi, enforcement and observation areas must be provided at 1- to 2-mi intervals. See 1050.06(7).

Where left shoulders less than 8 ft wide are proposed for lengths of roadway exceeding 0.5 mi, safety refuge areas must be provided at 0.5- to 1-mi intervals. These can be in addition to or in conjunction with the enforcement areas.

Allow general-purpose traffic to cross HOV lanes at on-and off-ramps.

(c) **Buffer-Separated HOV lanes.** Design buffer-separated HOV lanes the same as for inside nonseparated HOV lanes, except for a buffer 2 to 4 ft in width or 10 ft or greater in width with pavement marking, with supplemental signing, to restrict crossing. For buffer-separated HOV lanes with a buffer at least 4 ft wide, the left shoulder may be reduced to 8 ft. Buffer widths between 4 and 10 ft are not desirable since they may be used as a refuge area for which the width is not adequate. Provide gaps in the buffer to allow access to the HOV lane.

(d) **Arterial Street HOV Lanes.** The minimum width for an arterial street HOV lane is 12 ft. Allow general-purpose traffic to cross the HOV lanes to turn at intersections and to access driveways. (See Figure 1050-2.)

For right side HOV lanes adjacent to curbs, provide a 4 ft shoulder between the HOV lane and the face of curb. The shoulder may be reduced to 2 ft with justification.

For HOV lanes on the left, a 1 ft left shoulder between the HOV lane and the face of curb is required. When concrete barrier is adjacent to the HOV lane, the minimum shoulder is 2 ft.

(e) **HOV Ramp Meter Bypass.** The HOV bypass may be created by widening an existing ramp, construction of a new ramp where right of way is available, or reallocation of the existing pavement width provided the shoulders are full depth.

Ramp meter bypass lanes may be located on the left or right of metered lanes. Typically, bypass lanes are located on the left side of the ramp. Consult with local transit agencies and the region's Traffic Office for direction on which side to place the HOV bypass.

Consider the existing conditions at each location when designing a ramp meter bypass. Design a single lane ramp with a single metered lane and an HOV bypass as shown on Figure 1050-4a. Make the total width of the metered and bypass lanes equal to a 2-lane ramp (Chapters 641 and 940). Design a ramp with two metered lanes and an HOV bypass as shown on Figure 1050-4b. Make the width of the two metered lanes equal to a 2-lane ramp (Chapters 641 and 940) and the width of the bypass lane as shown on Figure 1050-3. The design shown on Figure 1050-4b requires that the ramp operate as a single lane ramp when the meter is not in operation.

Both Figures 1050-4a and 4b show an observation point/enforcement area. Document any other enforcement area design as a design exception. One alternative (a design exception) is to provide a 10-ft outside shoulder from the stop bar to the main line.

(5) HOV Direct Access Ramps

HOV direct access ramps provide access between an HOV lane and another freeway, a local arterial street, a flyer stop, or a park and ride facility. Design HOV direct access ramps in accordance with Chapter 1055.

(6) HOV Lane Termination

Locate the beginning and end of an HOV lane at logical points. Provide decision sight distance, signing, and pavement markings at the termination points.

The preferred method of terminating an inside HOV lane is to provide a straight through move for the HOV traffic, ending the HOV restriction and dropping a general-purpose lane on the right. However, analyze volumes for both the HOV lanes and general-purpose lanes, and the geometric conditions, to optimize the overall operational performance of the facility.

(7) Enforcement Areas

Enforcement of the inside HOV lane can be done with a minimum 10 ft inside shoulder. For continuous lengths of barrier exceeding 2 mi, a 12 ft shoulder, for the whole length of the barrier, is recommended.

For inside shoulders less than 10 ft, locate enforcement and observation areas at 1- to 2-mi intervals or based on the recommendations of the WSP. These areas can also serve as safety refuge areas for disabled vehicles. See Figures 1050-5a and 5b.

Provide observation points approximately 1300 ft before enforcement areas. They can be designed to serve both patrol cars and motorcycles or motorcycles only. Coordinate with the WSP during the design stage to provide effective placement and to ensure utilization of the observation points. Median openings give motorcycle officers the added advantage of being able to quickly respond to emergencies in the opposing lanes. (See Figure 1050-5b.) The ideal observation point places the motorcycle officer 3 ft above the HOV lane and outside the shoulder so the officer can look down into a vehicle.

Locate the enforcement area on the right side for queue bypasses and downstream from the stop bar so the officer can be an effective deterrent (Figures 1050-4a and 4b).

An optional signal status indicator for enforcement may be placed at HOV lane installations that are metered. The indicator faces the enforcement area so that a WSP officer can determine if vehicles are violating the ramp meter. The indicator allows the WSP officer to simultaneously enforce two areas, the ramp meter and the HOV lane. Consult with the WSP for use at all locations.

See the *Traffic Manual* regarding HOV metered bypasses for additional information on enforcement signal heads.

(8) Signs and Pavement Markings

(a) **Signs.** Provide post-mounted HOV preferential lane signs next to the HOV lane or overhead mounted over the HOV lane. Make the sign wording clear and precise, stating which lane is restricted, the type of HOVs allowed, and the HOV vehicle occupancy designation for that section of road. The sign size, location, and spacing are dependent upon the conditions under which the sign is used. Roadside signs can also be used to convey other HOV information such as the HERO program, carpool information telephone numbers, and violation fines. Some situations may call for the use of variable message signs.

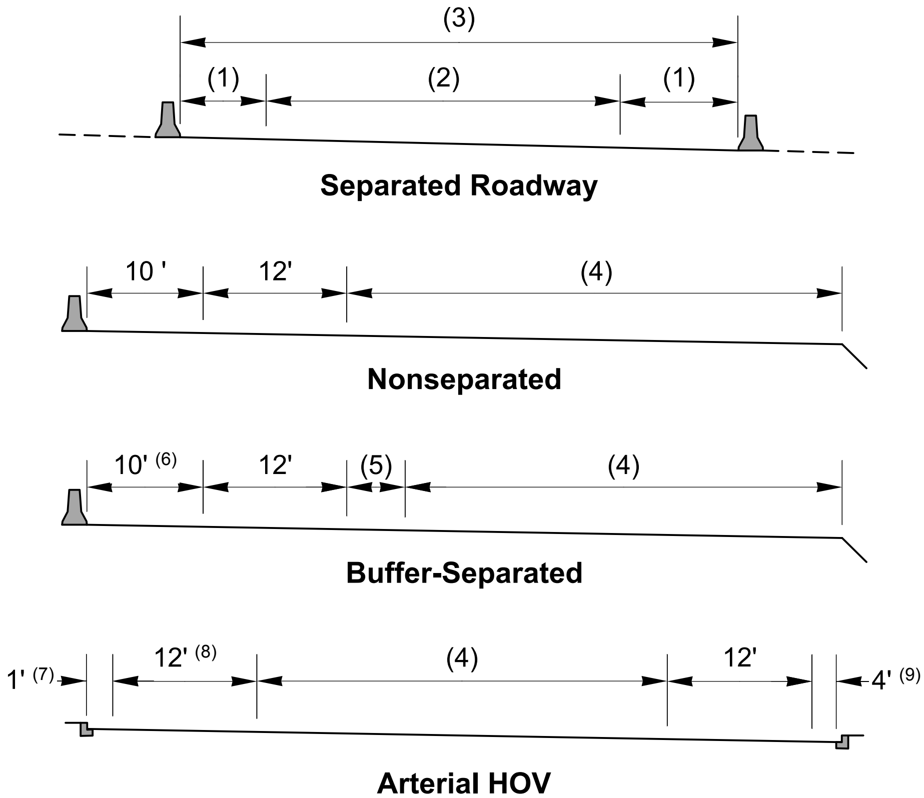
Place overhead signs directly over the HOV lane to provide maximum visibility. Use a sequence of overhead signs at the beginning and end of all freeway HOV facilities. Overhead signs can also be used in conjunction with roadside signs along the roadway.

(b) **Pavement Markings.** Provide pavement markings that conform to the *Traffic Manual* and the Standard Plans.

(c) **Interchanges.** In the vicinity of interchange on and off connections where merging or exiting traffic crosses an HOV lane, make provisions for general-purpose traffic using the HOV lane. These provisions include signing and striping that clearly show the changes in HOV versus general traffic restrictions. See the Standard Plans for pavement markings and signing.

1050.07 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/



Notes:

(1) The sum of the two shoulders is 12 ft for one-lane and 14 ft for two-lane facilities. One of the shoulders must have a width of at least 10 ft for disabled vehicles. The wider shoulder may be on the left or the right as needed to best match the conditions. Maintain the wide shoulder on the same side throughout the facility. See 1050.06(4)(a)2.

(2) 12 ft minimum for single lane, 24 ft minimum for two lanes. Wider width is required on curves. See 1050.06(4)(a)1. and Figure 1050-1.

(3) For total width requirements see 1050.06(4)(a)3.

(4) Width as required for the design level, functional class, and the number of lanes.

(5) Buffer 2 to 4 ft or 10 ft or more.

(6) When buffer width is 4 ft or more, may be reduced to 8 ft.

(7) 2 ft when adjacent to concrete barrier.

(8) Arterial HOV lanes on the left operate in the same direction as the adjacent general-purpose lane.

(9) May be reduced to 2 ft with justification.

Typical HOV Lane Sections

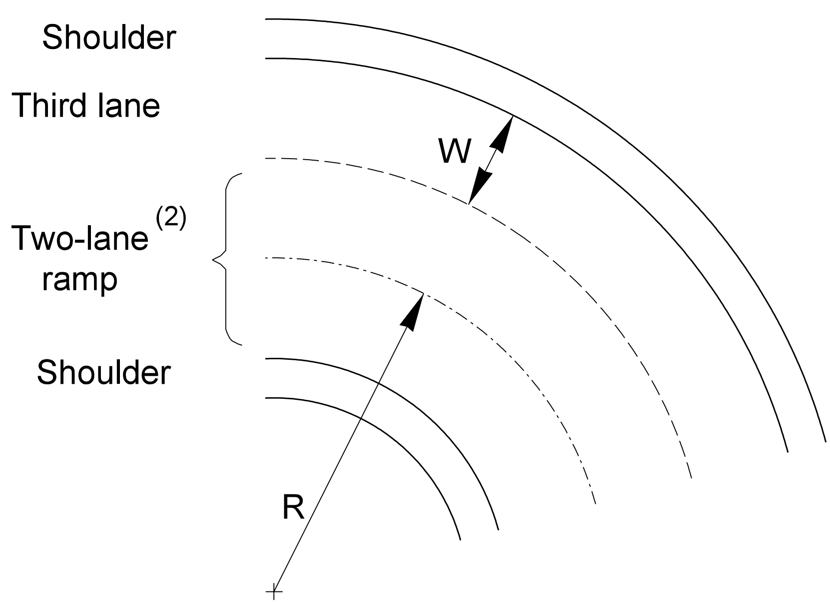
Figure 1050-2

Radius of Two-Lane Ramp R (ft)	Design Width of Third Lane(1) W (ft)
1000 to Tangent	12
999 to 500	13
499 to 250	14
249 to 200	15
199 to 150	16
149 to 100	17

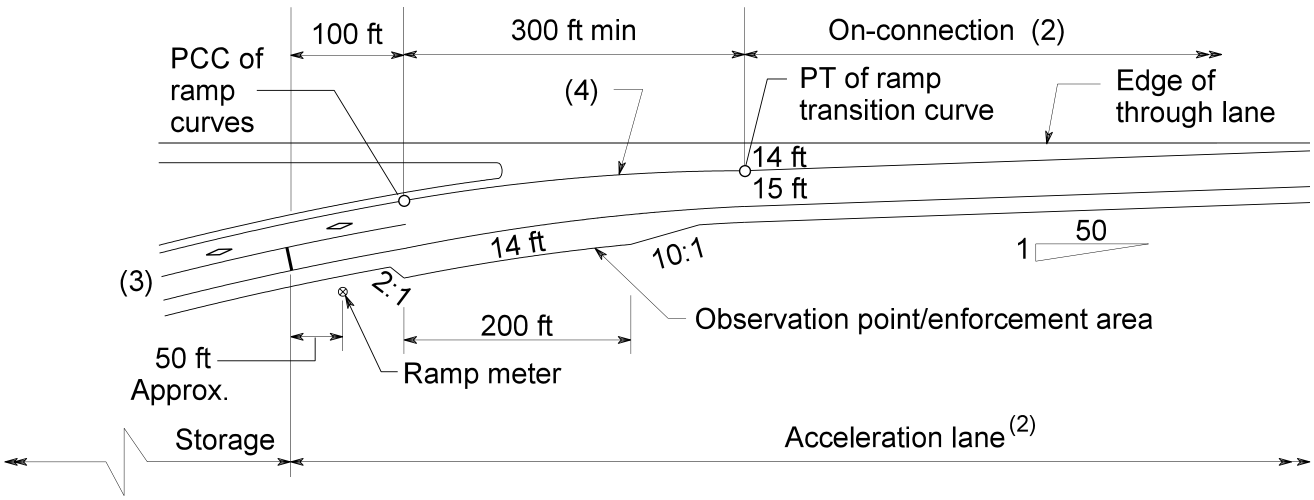
Notes:

(1) Apply additional width to 2-lane ramp widths.

(2) See traveled way width for two-lane one-way turning roadways in Chapter 641 for turning roadway widths.



Roadway Widths for Two-Lane Ramps with an HOV Lane
Figure 1050-3



Notes:

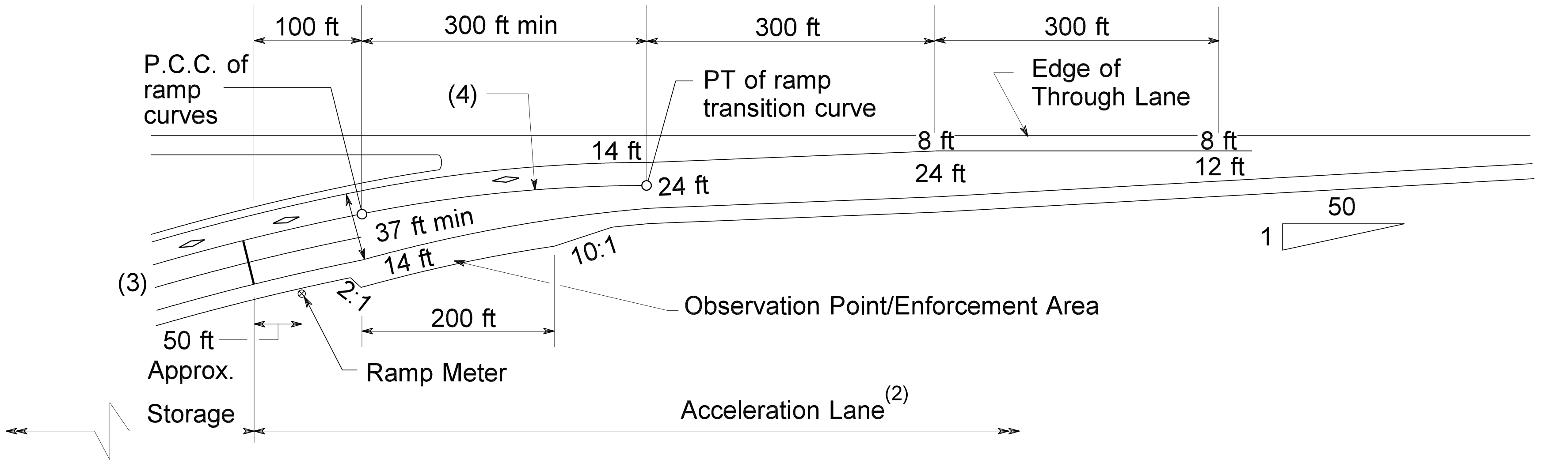
(1) See Standard Plans for striping details.

(2) See Chapter 940 for on-connection details and for acceleration lane length.

(3) See Chapters 940 & 641 for ramp lane and shoulder widths for a 2-lane ramp.

(4) A transition curve with a minimum radius of 3,000 ft is desirable. The minimum length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line.

Single-Lane Ramp Meter With HOV Bypass
Figure 1050-4a



NOTES

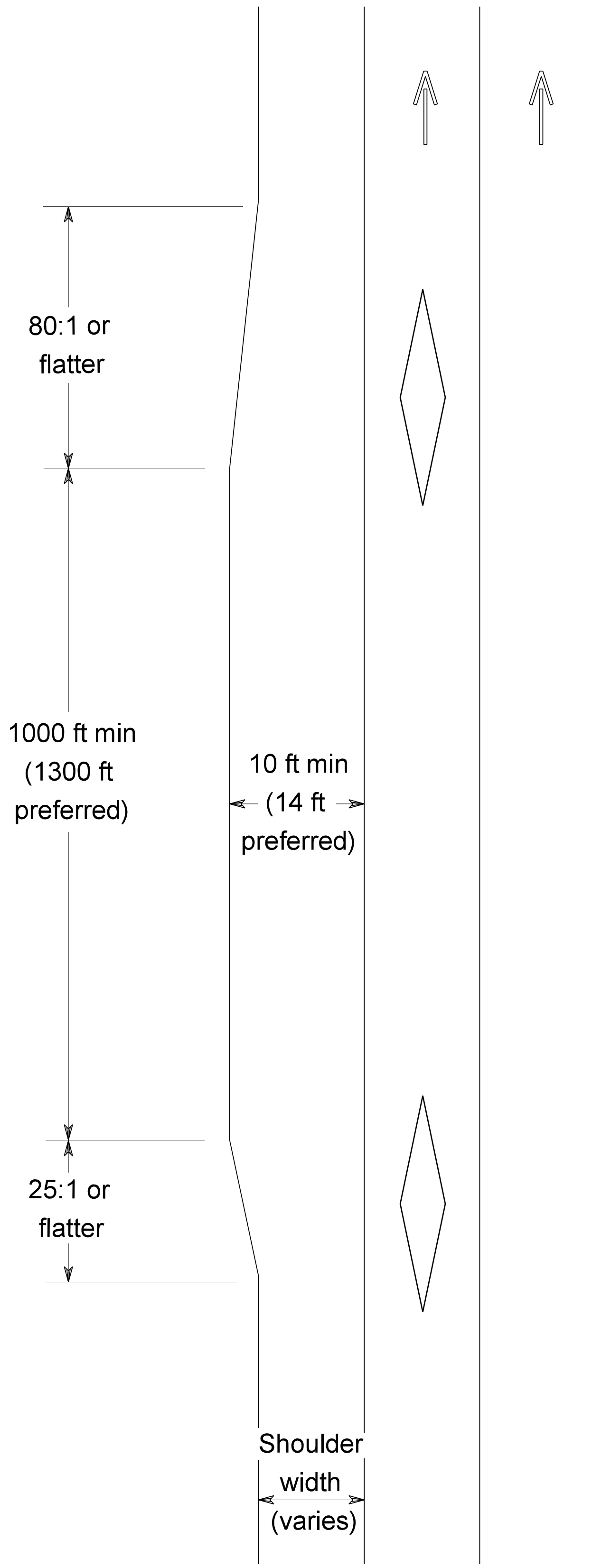
(1) See Standard Plans for Striping Details.

(2) See Chapter 940 for acceleration lane length.

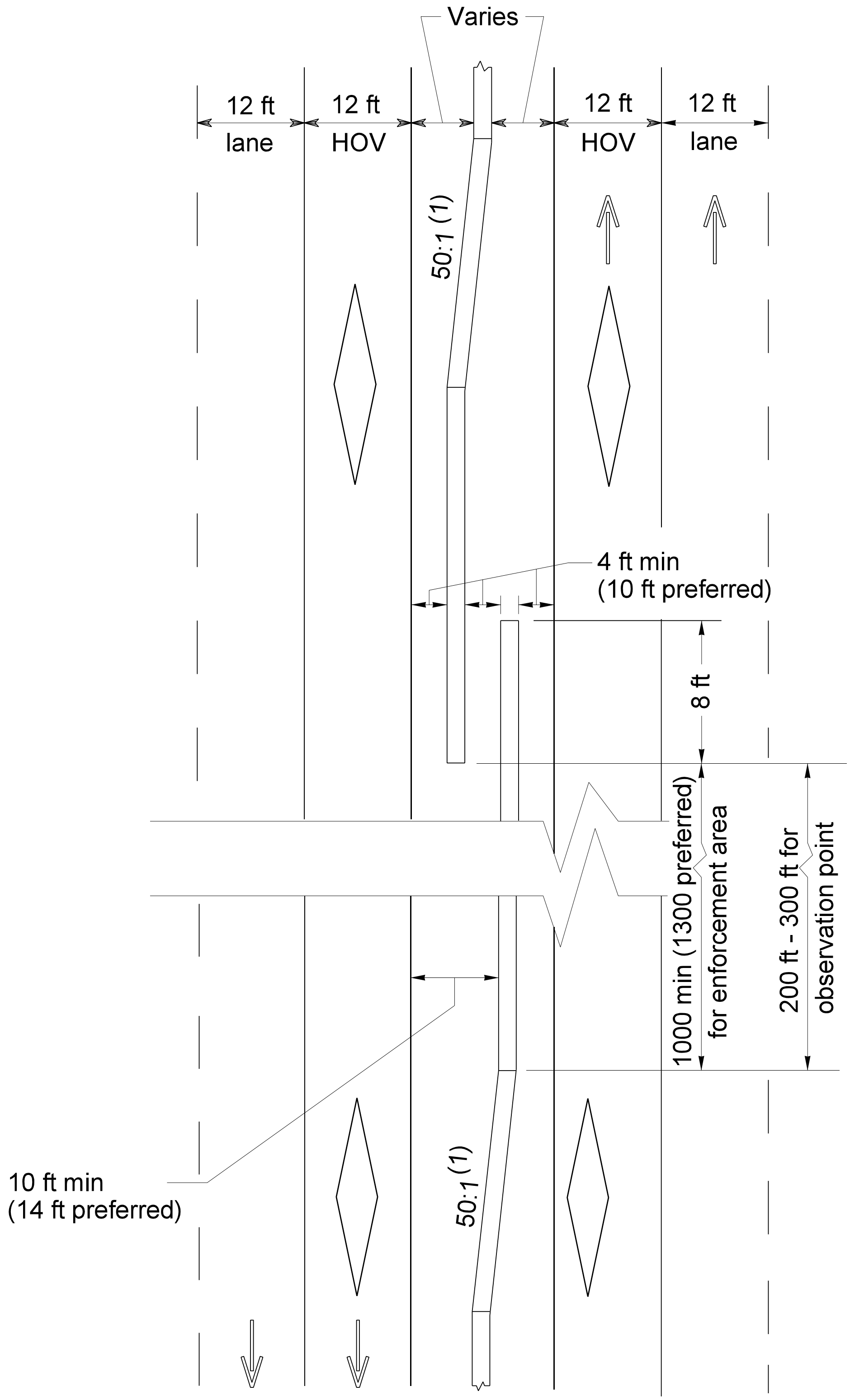
(3) See Chapters 940 & 641 for 2-lane ramp lane and shoulder widths. See Figure 1050-3 for 3rd lane width.

(4) A transition curve with a minimum radius of 3,000 ft is desirable. The minimum length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line.

Two-Lane Ramp Meter With HOV Bypass
Figure 1050-4b



Enforcement Area (One Direction Only)
Figure 1050-5a



Notes:

(1) See Chapter 620 for median width transition.

Enforcement Area (Median)
Figure 1050-5b

1055.01 General

This Chapter provides design guidance for left-side direct access facilities for high occupancy vehicles (HOVs) between freeway HOV lanes and public-transportation passenger facilities within the freeway right of way and facilities outside of the right of way. Design right-side HOV only access facilities per Chapter 940.

Direct access eliminates the HOV user crossing the general-purpose lanes from left-side HOV lanes to the right-side general-purpose ramps. Also, transit vehicles will be able to use the HOV lane and provide service to the HOV direct access facility.

Providing the HOV user access to the inside HOV lane without mixing with the general-purpose traffic saves the user additional travel time and aids in safety, enforcement, incident handling, and overall operation of the HOV facility.

Locations for direct access ramps include HOV facilities on intersecting routes, park and ride lots, flyer stops, and locations with a demonstrated demand. Coordination with the local transit agencies will result in the identification of these key locations. Give priority to locations that serve the greatest number of transit vehicles and other HOVs.

(1) Existing Facilities

When designing an HOV direct access facility, the existing general-purpose facilities must not be degraded. However, there may be opportunities to improve existing geometrics. These opportunities can be identified during the project definition phase.

When an HOV direct access facility project includes work on the existing facilities, apply the new/reconstruction row of the Interstate Design Matrices and the HOV row of the other matrices in Chapter 325.

(2) Reviews, Studies, and Reports

The normal project development process is to be followed when developing an HOV direct access project. Most facets of the project development process remain unchanged despite the unusual nature of the projects that are the focus of this chapter. For example, early coordination with others is always a vital part of developing a project. There are also environmental considerations, public involvement, and Value Engineering studies (Chapter 315). These are all necessary to ensure appropriate scope and costs.

There may also be reviews, studies, and reports required by agreements with regional transit authorities or other agencies.

An Access Point Decision Report (Chapter 1425) is required when there is a proposal to add, delete, or change an access point. Provide the operational analysis from the report for all flyer stops. For left-side connections, include the commitment that the connection will be used solely by HOVs or will be closed.

Throughout the project development phase, ensure that the:

- Project definition and cost estimate are correct.
- Project development process is on schedule.
- Project documents are biddable.
- Project will be constructible.
- Project will be maintainable.

Constructibility of HOV direct access facilities is an important consideration during the design phase. These facilities will typically be constructed on existing highways with traffic maintained on-site. Key goals are to:

- Ensure that the project can be built.
- Plan a construction strategy.
- Provide a safe work zone.
- Minimize construction delays.

Access to these facilities by maintenance crews must be considered. Avoid items that require a significant maintenance effort and might result in lane closure for routine maintenance or repair.

(3) Left-Side Connections

Left-side connections are allowed only when they serve HOVs only and connect to an HOV lane. The higher traffic volume associated with general-purpose traffic is not acceptable for left-side connections. If the demand for an HOV direct access decreases to the point that the HOV direct access connection is no longer desirable, the connection must be closed.

1055.02 References

Americans with Disabilities Act of 1990 (ADA).

ADA Accessibility Guidelines (ADAAG), The Access Board, http://www.access-board.gov/adaag/html/adaag.htm.

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, Chapter 468-95 WAC, (MUTCD).

Sign Fabrication Manual, M 55-05, WSDOT.

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

High-Occupancy Vehicle Facilities A Planning, Design, and Operation Manual, Parsons Brinkerhoff Inc.

FHWA/PB HOV Interactive 1.0 High Occupancy Vehicle Data Base from the U.S., Canada and Europe (CD ROM), USDOT, FHWA and Parsons Brinkerhoff Inc.

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO.

Guide for the Design of High Occupancy Vehicle Facilities, AASHTO.

Transit Implications of HOV Facility Design, WA-RD 396.1, September 1996, WSDOT and USDOT, Federal Transit Administration.

NCHRP 155, *Bus Use of Highways, Planning and Design Guidelines*.

NCHRP 414, *HOV Systems Manual*.

1055.03 Definitions

flyer stop a transit stop inside the limited access boundaries.

high occupancy vehicle (HOV) Vehicles that fit one of the following:

- Rubber tired municipal transit vehicles.
- Buses with a carrying capacity of sixteen or more persons, including the operator.
- Motorcycles.
- Recreational vehicles that meet the occupancy requirements of the facility.
- All other vehicles that meet the occupancy requirements of the facility, except trucks in excess of 10,000 lb gross vehicle weight.

HOV direct access facility a ramp and its connection directly to an HOV lane, exclusively for the use of high occupancy vehicles to move between the ramp and the HOV lane without weaving across general-purpose lanes.

intelligent transportation systems (ITS) a system of advanced sensor, computer, electronics, and communication technologies and management strategies - in an integrated manner – to increase the safety and efficiency of the surface transportation system.

ramp a short roadway connecting a main lane of a highway with another facility, such as a road, parking lot, or transit stop, for vehicular use.

ramp connection the pavement at the end of a ramp, connecting to a main lane of a highway.

ramp terminal the end of a ramp at a local street or road, transit stop, or park and ride lot.

transit stop a facility for loading and unloading passengers that is set aside for the use of transit vehicles only.

transit vehicle a bus or other motor vehicle that provides public transportation (usually operated by a public agency).

1055.04 HOV Access Types and Locations

To provide direct access for high occupancy vehicles from the HOV lane to a passenger loading facility, there are many options and many constraints. Following are some of the options (selected as being usable on Washington's freeways) and constraints to their use.

To select an option, it is necessary to first establish the need, choose possible locations, evaluate site features (such as terrain, existing structures, median widths), and evaluate existing HOV information (such as lanes, park and ride facilities, transit routes and schedules, and origin and destination studies). The chosen location must meet access point spacing requirements and must be proven not to degrade traffic operations on the main line.

Important constraints to transit stop designs are that passenger access routes and waiting areas must be separated from freeway traffic, passenger access to a bus is on its right side only, and passenger access to a loading platform must accommodate the disabled.

(1) Freeway Ramp Connection Locations

(a) **Spacing**

For minimum ramp connection spacing see Chapter 940. Include only left-side connections, in this evaluation.

However, traffic operations can be degraded by the weaving caused by a left-side on-connection followed closely by a right-side off-connection (or a right-side on-connection followed by a left-side off-connection). As a general rule, if the spacing between the HOV direct access ramp and the general-purpose ramp is less than one gap acceptance length [1055.05(6)(c)] per lane, make the HOV lane buffer separated. (See Chapter 1050.)

Conduct an analysis to ensure that the new ramp will not degrade traffic operations. See Chapter 1425 for the studies and report required for a new access point.

When an off-connection follows an on-connection, provide full speed-change lane lengths and tapers or at least sufficient distance for full speed-change lanes that connect at full width with no tapers. See 1055.05(6) and 1055.05(7). An auxiliary lane can be used to connect full-width speed-change lanes if there is not sufficient distance for both tapers.

(b) **Sight Distance**

Locate both on- and off-connections to the main line where decision sight distance exists on the main line. (See Chapter 650.)

(2) Ramp Terminal Locations

(a) **Local Streets and Roads**

Access to the HOV lane can be provided by a ramp that terminates at a local street or road. The local street or road may incorporate HOV lanes, but they are not required. See 1055.07 for signing and pavement markings.

Consider traffic operations on the local road. Locate the terminal where:

- It will have the least impact on the local road.
- Intersection spacing requirements are satisfied.
- Queues from adjacent intersections will not block the ramp.
- Queues at the ramp will not block adjacent intersections.
- Wrong way movements are discouraged.

When off-ramps and on-ramps are opposite each other on the local road, consider incorporating a transit stop with the intersection.

(b) **Park and Ride Lots**

HOV direct access ramps that connect the HOV lane with a park and ride lot provide easy access for express transit vehicles between the HOV lane and a local service transit stop at the park and ride facility. Other HOV traffic using the access ramp must enter through the park and ride lot, which can create operational problems.

(c) **Flyer Stops**

Median flyer stops do not provide general access to the HOV lane. Access is from the HOV lane to the transit stop and back to the HOV lane. No other vehicle access is provided. Ramps to and from the flyer stops are restricted to transit vehicles only.

(3) Ramp Types

(a) **Drop Ramps**

Drop ramps are generally straight, staying in the median, and connecting the HOV lane with a local road or flyer stop (Figure 1055-3).

(b) **T Ramps**

A T ramp is a median ramp, serving all four HOV access movements, that comes to a T intersection within the median, usually on a structure. The structure then carries the HOV ramp over the freeway to a local road or directly to a park and ride lot (Figure 1055-4). Through traffic is not permitted at the T; therefore, flyer stops are not allowed.

(c) **Flyover Ramps**

A flyover ramp is designed to accommodate high speed traffic by using flat curves as the ramp crosses from the median over one direction of the freeway to a local road, a park and ride lot, or an HOV lane on another freeway (Figure 1055-5).

(4) Transit Stops

(a) **Flyer Stops**

Flyer stops are transit stops inside the limited access boundaries for use by express transit vehicles using the freeway. They may be located in the median at the same grade as the main roadway or on a structure, on a ramp, or on the right-side of the main line.

The advantage of a median flyer stop is that it reduces the time required for express transit vehicles to serve intermediate destinations. A disadvantage is that passengers must travel greater distances to reach the loading platform.

With left-side HOV lanes, flyer stops located on the right side will increase the delay to the express transit vehicles by requiring them to cross the general-purpose lanes. However, these stops improve passenger access from that side of the freeway.

See Chapter 1060 for additional design information.

1. **Side-Platform Flyer Stops** Side-platform flyer stops are normally located in the median (Figure 1055-6) and have two passenger loading platforms, one on each side between the bus loading lane and the through HOV lane. This design provides the most direct movement for the express transit vehicle and is the preferred design for median flyer stops.

This design is relatively wide. Where space is a concern, consider staggering the loading platforms longitudinally.

Consider tall barrier to divide the directions of travel or staggering the loading platforms to prevent unauthorized at-grade movement of passengers from one platform to the other. (See 1055.07(1).)

2. **At-Grade Passenger Crossings** This design is similar to the side-platform flyer stop, except that passengers are allowed to cross, from one platform to the other, at-grade (Figure 1055-7). This design might eliminate the need for passenger access to one of the loading platforms with a ramp or an elevator and simplifies transfers. The passenger crossing necessitates providing a gap in the barrier for the crosswalk.

Only transit vehicles are allowed. Passenger/pedestrian accommodations must comply with the ADA.

Consider an at-grade passenger crossing flyer stop only when passenger volumes are expected to be low. Design at-grade passenger crossing flyer stops as the first stage of the stop, with the ultimate design being side-platform flyer stops with grade separated access to both platforms.

3. **Ramp Flyer Stops** When ramp flyer stops are located on an HOV direct access drop ramp (Figure 1055-8), the delay for the express transit vehicle will not be much more than that for a median stop, and passenger access and connectivity to local service transit routes, on the local street or road, are improved. A flyer stop on a right-side ramp works well with right-side HOV lanes and diamond interchanges in which express transit vehicles can use the off-ramp to connect with a bus route on the local road and the on-ramp to return to the HOV lane. However, a stop on a general-purpose right-side ramp with a

left-side HOV lane will increase the delay by requiring the express transit vehicle to use the general-purpose lanes and possibly degrade main line traffic operations by increasing weaving movements.

(b) **Off-Line Transit Stops**

1. **Park and Ride Stops** Transit stops located at park and ride lots provide transfer points between the express transit system and the local transit system, and there is convenient passenger access to the park and ride lot. When a direct access ramp is provided, express transit delays from the HOV lane to the stop are reduced. These delays can be reduced more by providing a median flyer stop with passenger access facilities connecting the park and ride lot to the flyer stop; however, this might be more inconvenient for the passengers.

2. **Stops at Flyer Stop Passenger Access Points** To minimize the distance a passenger must travel between express and local service transit stops, locate local system transit stops near passenger access facilities for the flyer stops (Figure 1055-9).

(5) Enforcement Areas

For HOV facilities to function as intended, it is necessary to enforce the vehicle occupancy requirement. Law enforcement officers need areas for observation that are near pull-out areas where both the violator and the officer can pull safely out of the traffic flow.

Consider locating observation and pull-out areas near any point where violators can enter or exit an HOV direct access facility. Examples of potential locations are:

- Freeway on- and off-connections for HOV direct access ramps.
- HOV direct access ramp terminals at parking lots.

For freeway HOV lanes, locate enforcement areas on the adjacent shoulders so officers and violators are not required to cross several lanes of traffic.

Enforcement area guidance and designs are in Chapter 1050.

1055.05 Direct Access Geometrics

HOV direct access ramps are different from other ramps because they are frequently on the left-side of the through lanes and they have a high percentage of buses. Design right-side HOV direct access using the procedures given in Chapter 940. The following procedures are for the design of left-side HOV direct access.

Because left-side ramps are rare and are therefore less expected, signing is an important issue. (See 1055.07(2), for signing requirements.)

When the bus percentage is high, there are several needs to be met.

- When a bus enters the through lanes from the left, the driver has a relatively poor view of the through traffic.
- A bus requires a longer distance to accelerate than other vehicles.
- A bus requires a longer deceleration length for passenger comfort.

For these reasons, use the following design values when designing left-side HOV direct access facilities.

(1) Design Vehicles

Use AASHTO's A-BUS vehicle for horizontal design.

Use AASHTO's BUS vehicle for vertical clearance 13.5 ft.

Use AASHTO's P vehicle for stopping sight distance.

See Chapters 910 and 1060 for vehicle descriptions, dimensions, and turning templates.

(2) Design Speeds

See Chapter 940 for the design speeds for the ramps. Use the design speed of the general-purpose lanes for the main line design speed.

(3) Sight Distance

Provide stopping sight distance per Chapter 650. This provides sight distance for an automobile. The longer distance required for a bus to stop is compensated for by the greater eye height of the driver with the resulting vertical curve length requirement about equal to that for an automobile.

Sag vertical curves may be shortened where necessary. See Chapter 630 for guidance.

(4) Grades

Grades for ramps are covered in Chapter 940. Deviations will be considered for:

- Downgrade on-ramps with grades increased by an additional 1%.
- Upgrade off-ramps with grades increased by an additional 2%.

These increased grades help when geometrics are restricted and assist transit vehicles with the acceleration when entering and the deceleration when exiting the freeway.

(5) Ramp Widths

(a) **Lane Widths**

Use widths for separated roadway HOV facilities, see Minimum Traveled Way Widths for Articulated Buses, in Chapter 1050.

On tangents, the minimum lane width may be reduced to 12 ft.

(b) **Shoulder Widths**

Ramp shoulder width requirements are modified as follows:

- The minimum width for the sum of the two shoulders is 10 ft for one-lane ramps and 12 ft for two or more lanes.
- One of the shoulders must have a width of at least 8 ft for disabled vehicles. The minimum for the other shoulder is 2 ft. See Chapter 710 for shy distance requirements at barrier.
- The wider shoulder may be on the left or the right as needed to best match the conditions. Maintain the wide shoulder on the same side throughout the ramp.

(c) **Total Ramp Widths**

Make the total width of the ramp (lane width plus shoulders) wide enough to allow an A-BUS to pass a stalled A-BUS. This width has two components:

- The vehicle width (U = 8.5 ft on tangent) for each vehicle.
- Lateral clearance (C = 2 ft) for each vehicle.

The vehicle width and the lateral clearance are about the width of an A-BUS from edge of mirror to edge of mirror.

Figure 1055-1 gives the minimum ramp width (W_R) at various radii (R) for an articulated bus. For ramp locations on a tangent section or on a curve with a radius greater than 150 ft, consider the W_R width when requesting a reduced lane or shoulder width. For ramp curves with a radius less than 150 ft, check the total ramp width and, if necessary, widen the shoulders to provide the W_R width.

R (ft)*	W_R (ft)
Tangent	21
500	23
400	23
300	24
200	26
150	27
100	30
75	34
50	40

* R is to the curve inside edge of traveled way

Minimum Ramp Widths for Articulated Buses
Figure 1055-1

(6) On-Connections

(a) **Parallel On-Connections**

For left-side on-connections, use the parallel on-connection. See Figure 1055-10.

A parallel on-connection adds a parallel lane that is long enough for the merging vehicle to accelerate in the lane and then merge with the through traffic. This merge is similar to a lane change and the driver can use side and rear view mirrors to advantage.

(b) **Acceleration Lanes**

Figure 1055-11 gives the minimum acceleration lane length (L_A) for left-side HOV direct access on-connections.

The numerous buses using HOV direct access ramps must merge with high speed traffic. Acceleration lanes that are longer than normally required are needed.

For left-side on-connections, provide at least the normal 10 ft (14 ft preferred) wide left shoulder for the main line for a minimum length of 500 ft (1000 ft preferred) beyond the end of the on-connection taper. This gives additional room for enforcement, merging, and erratic maneuvers.

(c) **Gap Acceptance Length**

Gap acceptance length is a minimum distance traveled while a merging driver finds a gap in the through traffic and begins the merge. For left-side parallel on-connections the gap acceptance length is added to the acceleration length. The L_g values are given in Figure 1055-2. These values are larger than for right-side on-connections to account for drivers' visibility constraints.

Highway Posted Speed (mph)	Gap Acceptance Length L_g (ft)
45	550
50	625
55	700
60	775
65	850
70	925

Gap Acceptance Length for Parallel On-Connections
Figure 1055-2

(d) **Design of Urban On-Connections**

Design left-side HOV direct access on-connections in urban areas as follows:

1. Use the parallel design for all left-side on-connections.

2. Add the Gap Acceptance Length for Parallel On-Connections (Figure 1055-2) for a freeway speed of 60 mph to the acceleration length.

3. Use Acceleration Length for Buses (Figure 1055-11) with a 60 mph freeway speed and the ramp design speed [1055.05(2)] for acceleration length.

(e) **Design of Rural On-Connections**

Design left-side HOV direct access on-connections in rural areas using a freeway design speed as determined using Chapter 440.

(7) Off-Connections

(a) **Parallel Off-Connection**

The parallel off-connection (Figure 1055-12) is preferred for left-side direct access off-connections. For freeway to freeway off-connections, provide a parallel lane with a length sufficient for signing and deceleration. The desirable minimum length is not less than the gap acceptance length (Figure 1055-2).

(b) **Tapered Off-Connection**

The tapered off-connection may be used for off-connections with justification. See Chapter 940 for the design of tapered off-connections.

(c) **Deceleration Lanes**

Bus passenger comfort requires longer deceleration lanes. Use the deceleration lane lengths from Figure 1055-14 for HOV direct access facilities.

(d) **Design of Urban Off-Connections**

Design left-side HOV direct access off-connections in urban areas as follows:

1. Either the parallel (preferred) or the taper (with justification) design may be used.

2. Use the longer deceleration length of: the Deceleration Length for Buses (Figure 1055-14) from a 60 mph freeway speed to the ramp design speed [1055.05(2)], or the Minimum Deceleration Length given in Chapter 940 from the freeway design speed to the ramp design speed.

(e) **Design of Rural Off-Connections**

Design left-side HOV direct access off-connections in rural areas using a freeway design speed as determined using Chapter 440.

(8) Vertical Clearance

Vertical clearance for a structure over a road is measured from the lower roadway surface, including the usable shoulders, to the bottom of the overhead structure.

See Chapter 1120 for information on vertical clearance. For a new structure and for a new ramp under an existing structure, the minimum vertical clearance is 16.5 ft. A deviation will be considered for 14.5 ft minimum vertical clearance for a new HOV direct access ramp under an existing bridge.

The minimum vertical clearance for a pedestrian grade separation over any road is 17.5 ft.

(9) Flyer Stops

Design flyer-stop-ramp on-connections as given in 1055.05(6) and design off-connections as given in 1055.05(7). Flyer stop connections are included in the access point spacing discussed in 1055.04(1)(a).

Design the ramp to the flyer stop per 1055.05(3), 1055.05(4), and 1055.05(5).

The minimum width for the roadway at a flyer stop is 24 ft.

When a flyer stop is in the median, provide enough median width for the flyer stop roadway, the passenger facilities, and barrier separation without reducing the width of the through lanes or shoulders. (See 1055.06.)

The approval of a flyer stop requires the operational analysis portion of the Access Point Decision Report (Chapter 1425).

(10) T Ramps

A T ramp example and design is given on Figure 1055-15

1055.06 Passenger Access

When designing transit stops, accessibility (compliance with the ADA), safety, and the comfort of the passengers must be included. Minimize pedestrian/vehicle conflict points. Design the whole facility with security in mind by keeping lines of sight as open as possible. Traffic barriers, fencing, illumination, landscaping, seating, windscreens, shelters, enclosed walkways, telephones, and posted schedules are examples of factors that contribute to passenger safety and well-being. See Chapter 1060 for passenger amenities at transit stops.

(1) Passengers

To encourage use of the passenger access facility for an express transit stop, provide a route that is the shortest distance to travel from the park and ride lot, or local transit stop. Failure to do so might generate the use of undesirable shortcuts. To encourage local use of the passenger access facilities, provide direct access from surrounding neighborhoods.

To access a transit stop in the median or to move about within the facility, grade separations are required for all flyer stop designs except the at-grade crossing flyer stop. Consider stairways, ramps, elevators, and escalators, but provide at least one access for the disabled at every loading platform, as required by the American Disabilities Act of 1990. See Chapter 1025 for guidance when designing pedestrian grade separations.

The ADA Accessibility Guidelines for Buildings and Facilities includes: "Platform edges bordering a drop-off and not protected by platform screens or guard rails shall have a detectable warning … 24 inches wide running the full length of the platform drop-off." See the Standard Plans for the detectable warning pattern.

In transit stops, at-grade crosswalks are only permitted in the at-grade crossing flyer stop layout described in 1055.04(4)(a)2. Use traffic calming techniques, such as horizontal alignment, textured pavement and crosswalk markings, barrier openings, and other treatments, to channelize pedestrian movements and slow the transit vehicle movements. Illuminate transit stop crosswalks. (See Chapter 840.)

Where at-grade crosswalks are not permitted, steps must be taken to minimize unauthorized at-grade crossings. Fencing, taller concrete traffic barrier, enclosed walkways, and ramps are examples of steps that may be taken.

(2) Bicycles

Bike lanes on nearby streets and separate trails encourage people to bicycle from surrounding neighborhoods. Provide these bicyclists direct access to passenger access facilities.

For bike-bus-bike commuter access to a transit facility, design bicycle access facilities in conjunction with the access for the disabled. (See Chapters 1020 and 1025.)

Locate bicycle parking outside of the passenger walkways. See Chapter 1060.

Locations near colleges and universities and locations with good bicycle access, especially near trails, will attract bicyclists. Contact the region Bicycle Coordinator for information on the predicted number of bicycle parking spaces needed and the types of bicycle racks available.

1055.07 Traffic Design Elements

Traffic design elements are critical to the safe and efficient use of HOV direct access facilities. The following discusses the elements of traffic design that might be different for HOV direct access facilities.

(1) Traffic Barriers

Separate the main line from the HOV direct access facilities with a traffic barrier. Whenever possible, separate opposing traffic lanes in the facility by using traffic barrier. (See Chapter 710.) This is especially important in areas where opposing traffic is changing speeds to or from main line speeds. Concrete barrier is generally preferable on these facilities due to lower maintenance requirements.

The approach ends of traffic barriers must have crashworthy end treatments. In areas where the operating speed is greater than 35 mph, an impact attenuator is required. (See Chapter 720.) Consider concrete barrier and low maintenance impact attenuators, such as the REACT 350 or QuadGuard Elite, where there is a potential for frequent impacts, such as in gore areas.

When the operating speed is 25 mph or less, and where an at-grade pedestrian crossing transit stop has an opening in a concrete barrier, a sloped-down end as shown in the Standard Plans is acceptable.

When a break in the barrier is required for turning maneuvers, consider the sight distance requirements when determining the location for stopping the barrier. (See Chapter 650.)

In areas where headlight glare is a concern, consider glare screens, such as taller concrete barrier. Other glare screen options that mount on the top of a barrier tend to be high maintenance items and are discouraged.

Taller barrier might also be desirable in areas where pedestrian access is discouraged such as between opposing flyer stops and between a flyer stop and the main line.

(2) Signing

It is essential that the design and placement of HOV signing clearly indicate whether the signs are intended for motorists in the HOV lane or the general-purpose lanes. The purposes of the signs include:

- To enhance safety.
- To convey the message that HOV lanes are restricted to HOVs.
- To provide clear directions for entrances and exits.
- To define vehicle occupancy requirements or other restrictions.

Because HOV facilities are not found in many regions, the signing not only considers the commuter but also the occasional user of the facility who might be unfamiliar with the HOV facility and its operation.

(a) **Safety**

Much of HOV signing relates to enhancing safety for the motorists. Not only are geometrics often minimized due to the lack of right of way, but there are unusual operational characteristics such as the differential speed between the HOV vehicle and the adjacent general purpose traffic. The lack of passing opportunities in the HOV lane and the necessity for frequent merging and weaving actions require designers to use messages that are clear and concise, and use symbols wherever possible.

Because left-side off-connections are unusual, advance warning signing that an exit is on the left becomes more important.

For T ramps, provide traffic control at the T to assign priority to one of the conflicting left-turn movements and to avert wrong way movements.

(b) **Diamond Symbols**

The diamond symbol is used to designate all HOV facilities where carpools are allowed. For all signs, whether regulatory, guide, or warning, the symbol is always white on a black background to convey the restrictive nature of the HOV lane and to make the signs more uniformly recognizable. The use of the symbol with all HOV signs also informs drivers that the message is intended for HOVs. The diamond symbol is only for HOV lanes where carpools are allowed, not used for bus, taxi, or bicycle preferential lanes.

(c) **Selection and Location**

The signing details, Figures 1055-16 through 17b, provide for the HOV geometric configurations used within the right of way. Signing for other types of HOV facilities (such as those used for reversible-flow, and HOV direct access between freeways and temporary HOV lanes used during construction) is designed on a case-by-case basis requiring consultation with the appropriate Headquarters and region traffic personnel. The design of signing for HOV direct access between freeways will include HOV guide signs, both advance and action, in addition to the normal regulatory signs.

(d) **Regulatory Signs**

Regulatory signs for HOV facilities follow the normal regulatory signing principles; black legend with a white reflective background on a rectangular panel. Keep in mind that messages conveyed by the HOV signs (such as signs concerning violations and those indicating the beginning of an HOV lane downstream) are not necessarily intended only for the HOV vehicle. Therefore, it might be prudent to place additional signs on the right side of the freeway where this conforms to sound engineering practice.

(e) **Guide Signs**

Guide signs for the HOV facilities are generally used at intermediate on and off locations to inform HOV motorists of upcoming freeway exits and the appropriate location to exit the HOV lane. For HOV direct access to and from arterials, guide signs are used in a fashion similar to normal arterial interchange signing practice. The guide signs for HOV facilities have a black nonreflective legend on a white reflective background. The exception is the diamond, where the white reflective symbol is on a black nonreflective background. For all HOV related guide signs, the diamond is placed in the upper left-hand corner of the sign.

(3) Lighting

Illumination of HOV direct access facilities is required for ramps, loading platforms at transit stops, major parking lots, and walkways as defined in Chapter 840.

(4) Intelligent Transportation Systems

Intelligent transportation systems (ITS) are used to collect traffic data, maintain freeway flow, and disseminate traveler information. Transit information systems for passengers and transit facility surveillance are not normally a part of WSDOT's ITS system, but implementation of these components may be considered for some locations.

Design of HOV direct access facilities, like all HOV facilities, should fully utilize available ITS elements. Need for ITS elements vary depending on project features, such as facility design and operation, and whether the site has existing ITS components.

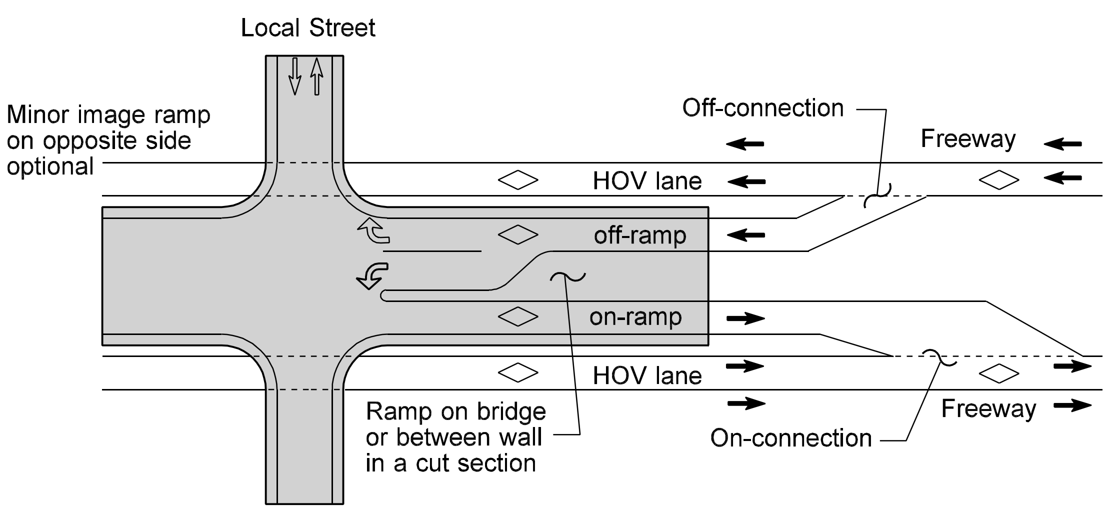
ITS elements that might be applicable to HOV direct access facilities include: closed circuit television surveillance, ramp metering, data collection, exit queue detection and override, dynamic signing, transit signal priority, and automatic vehicle identification and location.

Guidance on the development of ITS elements is found in Chapter 860. Include the region's Traffic Office, transit operator, and affected local agency in the coordination for design and implementation of ITS elements.

1055.08 Documentation

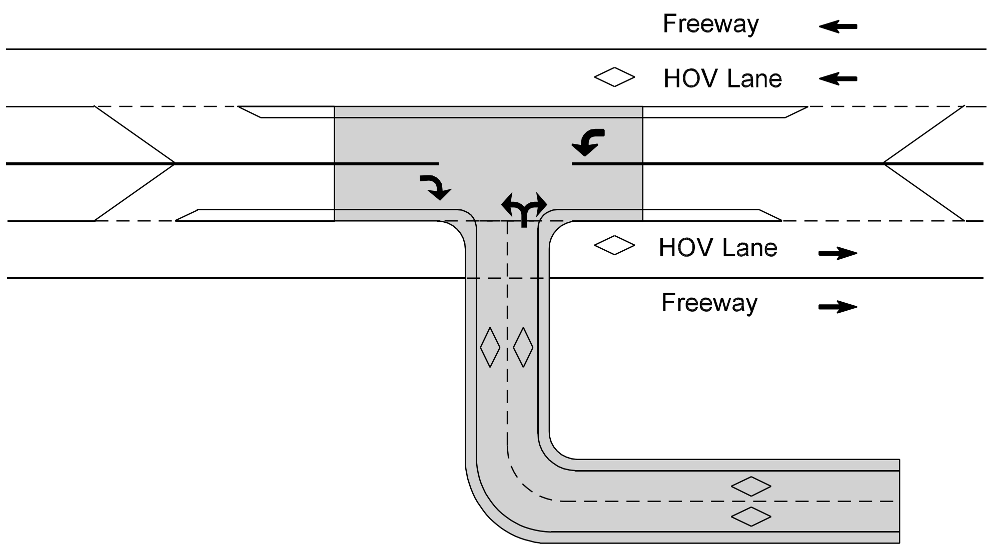
A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

Photograph from *FHWA/PB HOV Interactive 1.0 High Occupancy Vehicle Data Base from the U.S., Canada and Europe*



Drop Ramp

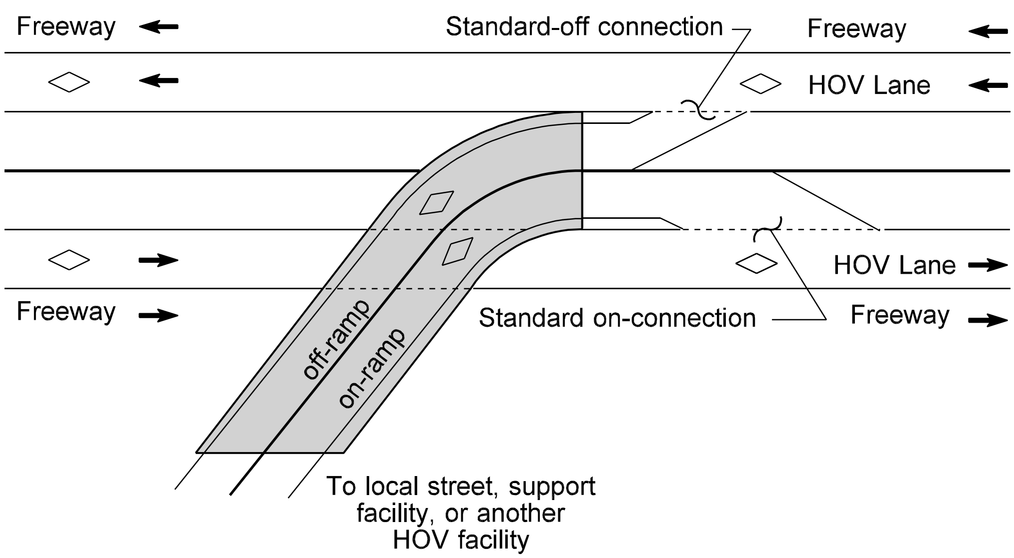
Figure 1055-3



See Figure 1055-15 for additional design information.

T Ramp
Figure 1055-4

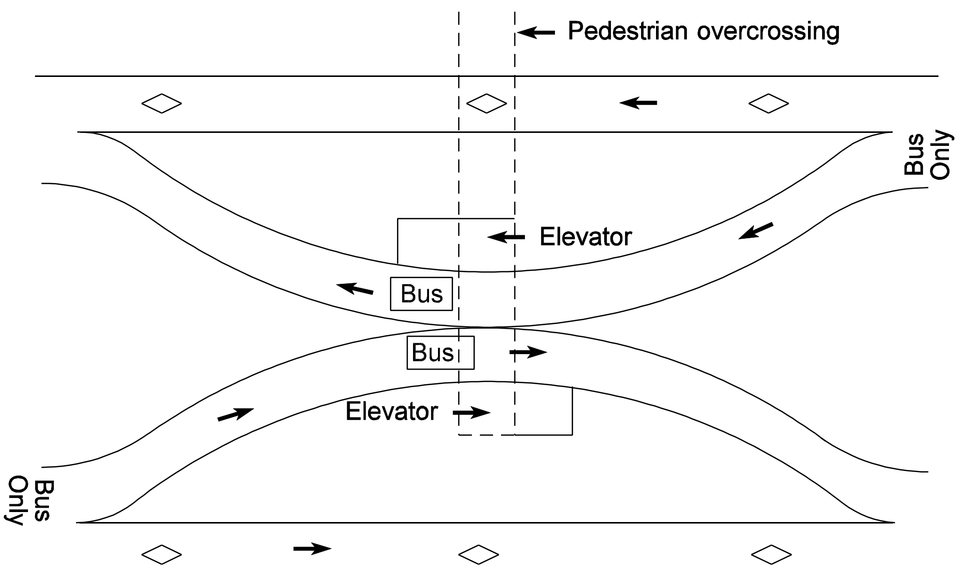
Photograph from *FHWA/PB HOV Interactive 1.0 High Occupancy Vehicle Data Base from the U.S., Canada and Europe*



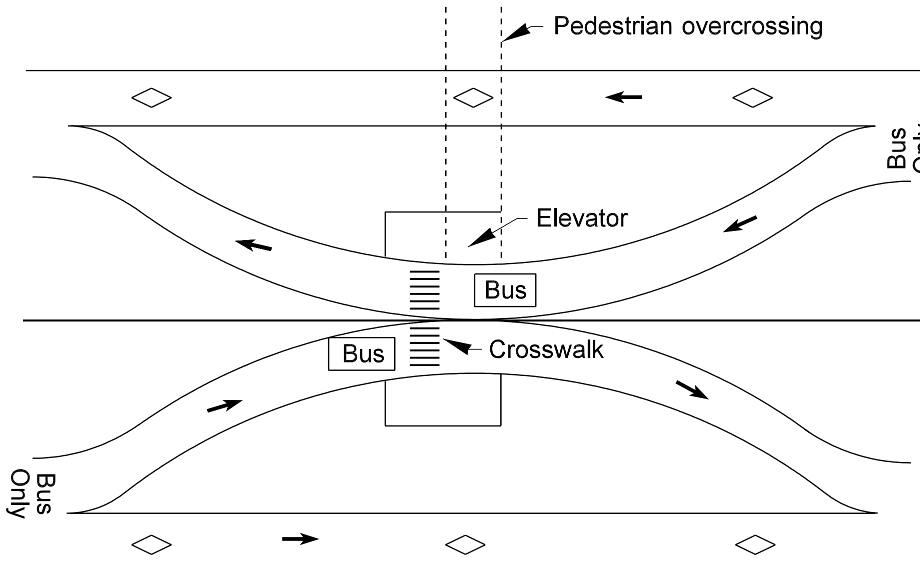
Flyover Ramp
Figure 1055-5

Photograph from *FHWA/PB HOV Interactive 1.0 High Occupancy Vehicle Data Base from the U.S., Canada and Europe*

The side platform flyer stop with grade separated access to each platform is the preferred design.



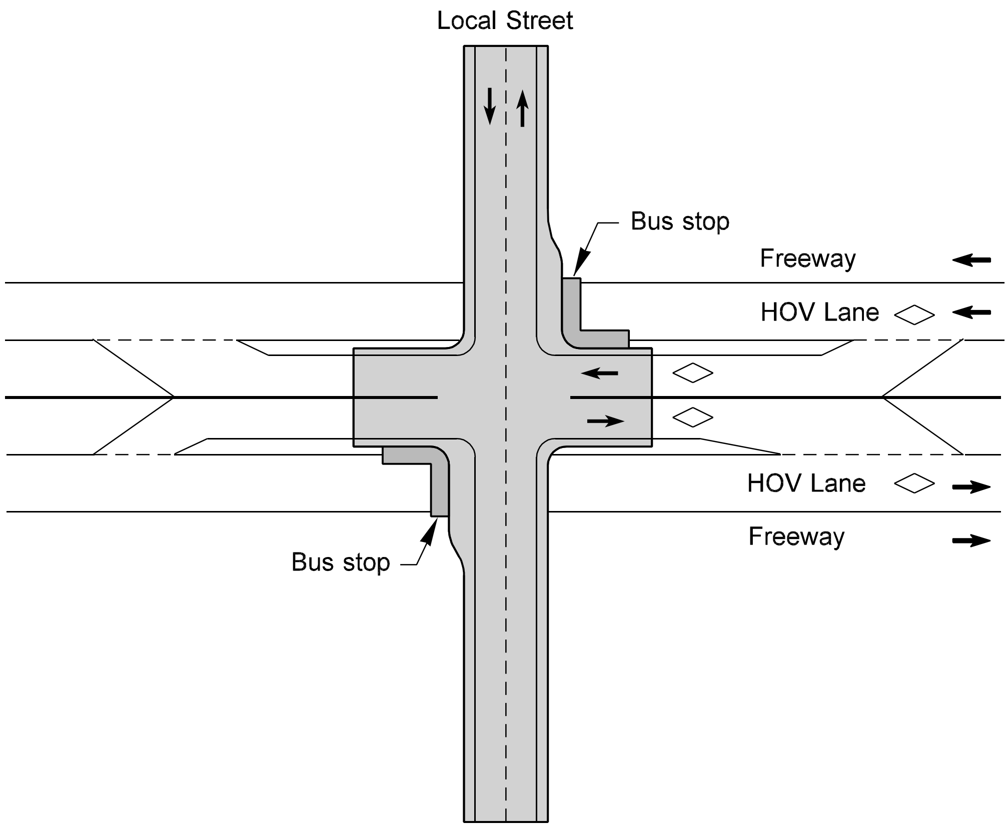
Side Platform Flyer Stop
Figure 1055-6



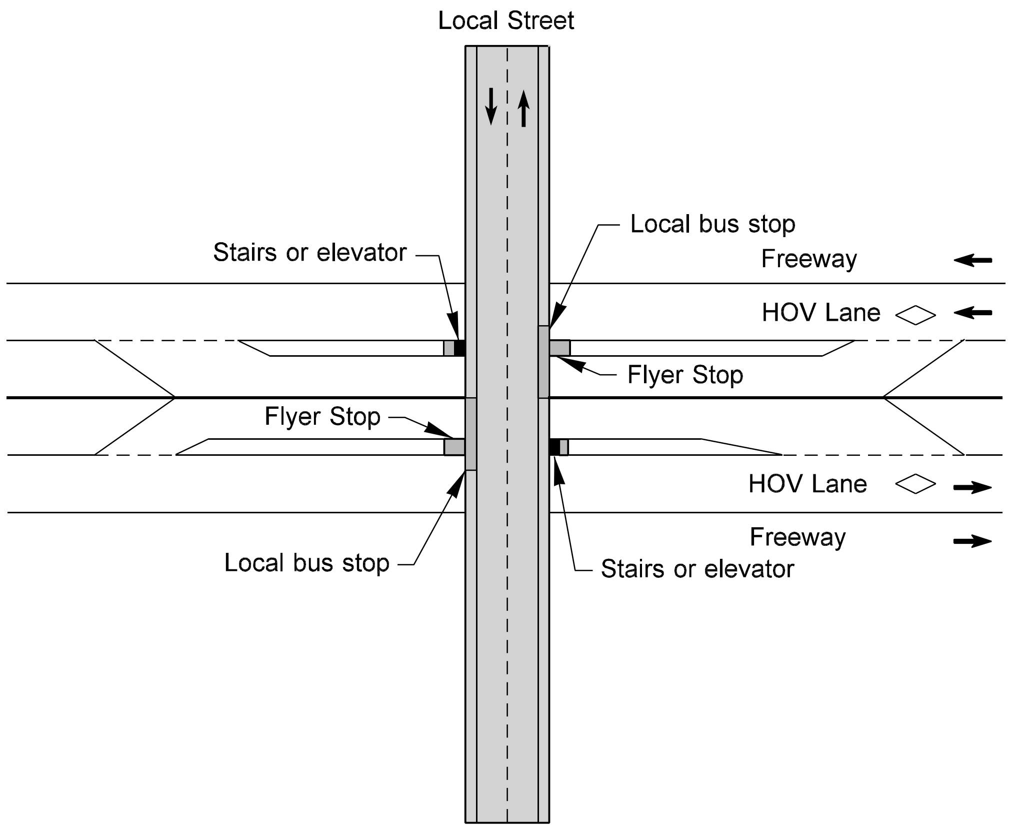
Consider flyer stops with at-grade pedestrian crossing only when anticipated volumes are low. The design must allow for the future addition of grade separated access to both platforms. See side platform flyer stop design, Figure 1055-6.

Photograph from *FHWA/PB HOV Interactive 1.0 High Occupancy Vehicle Data Base from the U.S., Canada and Europe*

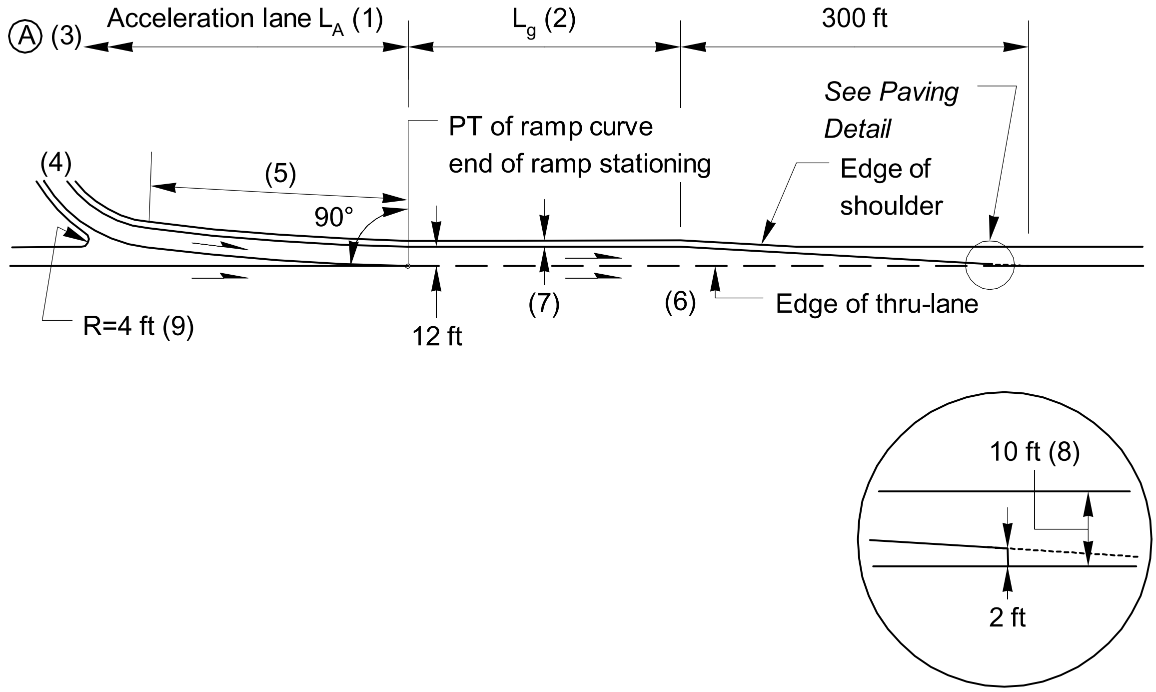
At-Grade Crossing Flyer Stop
Figure 1055-7



Transit Stops at Ramps
Figure 1055-8



Other Transit Stops
Figure 1055-9



Paving Detail

Notes:

(1) See Figure 1055-11 for acceleration lane length L_A.
Check L_A for each ramp design speed.

(2) L_g is the gap acceptance length. Begin L_g at the beginning of the parallel lane, as shown, but not before the end of the acceleration lane L_A. See Figure 1055-2 for the length L_g.

(3) Point A is the point controlling the ramp design speed or the end of the transit stop zone or other stopping point.

(4) See 1055.05(5) for ramp lane and shoulder widths.

(5) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the right, the transition may vary from a 3,000 ft radius to tangent to the main line. The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.

(6) Angle point for width transitions, when required. See Chapter 620 for pavement transitions.

(7) See 1055.05(5)(b) for ramp shoulder width.

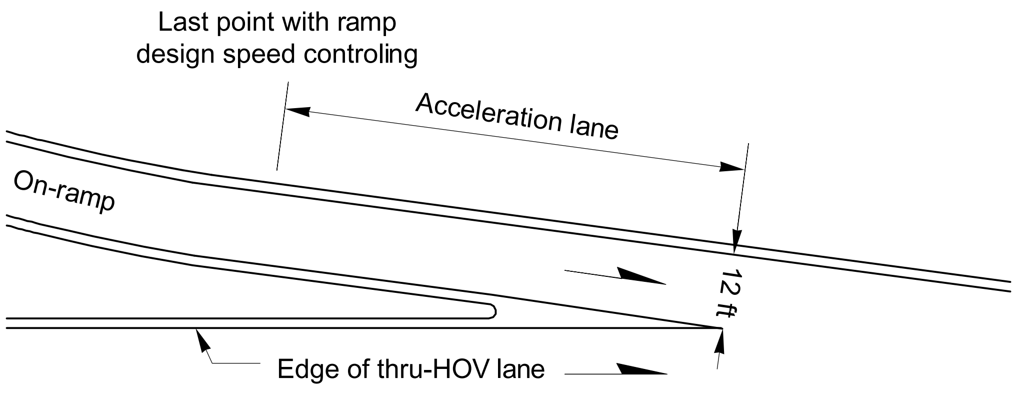
(8) The 10 ft left shoulder is the minimum width; 14 ft is preferred. Maintain this shoulder width for at least 500 ft; 1,000 ft is preferred.

(9) Radius may be reduced when concrete barrier is placed between the ramp and main line.

(10) For striping, see the Standard Plans.

Single Lane Parallel On-Connection

Figure 1055-10

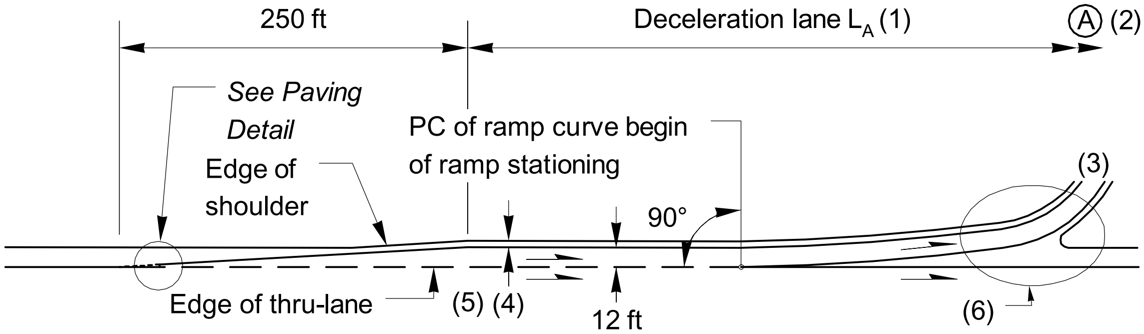


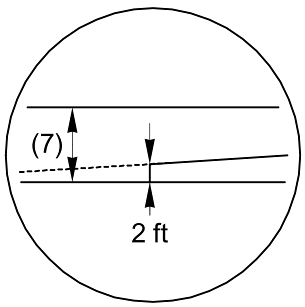
Freeway Speed (mph)	Ramp Design Speed								
	0	15	20	25	30	35	40	45	50
40	555	480	420	340	185				
45	835	760	700	615	470	290			
50	1230	1160	1100	1020	865	685	310		
55	1785	1715	1655	1575	1420	1235	875	410	
60	2135	2085	2040	1985	1875	1735	1440	995	460
70	3045	3015	2985	2945	2860	2745	2465	2050	1515
80	4505	4465	4420	4370	4250	4095	3745	3315	2780

Acceleration Length (L_A) for Buses (ft)

For the adjustment factors for grade, see Acceleration lane length in Chapter 940.

HOV Direct Access Acceleration Lane Length
Figure 1055-11





Paving Detail

Notes:

(1) See Figure 1055-14 for deceleration lane length L_D.
Check L_D for each ramp design speed.

(2) Point (A) is the point controlling the ramp design speed or the end of the transit stop zone or other stopping point.

(3) See 1055.05(5) for ramp lane and shoulder widths.

(4) See 1055.05(5)(b) for ramp shoulder width.

(5) Angle point for width transitions, when required. See Chapter 620 for pavement transitions.

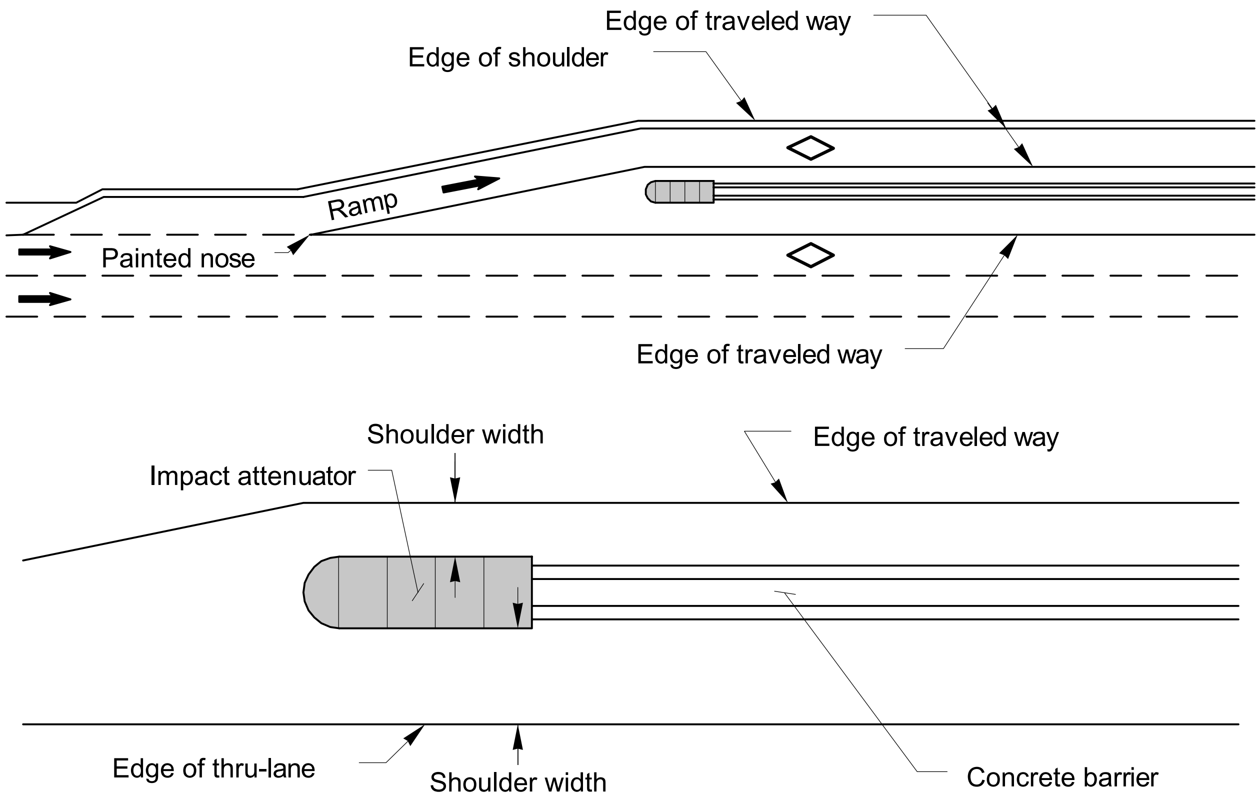
(6) Gore area details at drop ramp connections (Figure 1055-3) are shown on Figure 1055-13. See Chapter 940 for gore details at other connection types.

(7) The desirable shoulder width is 10 ft.

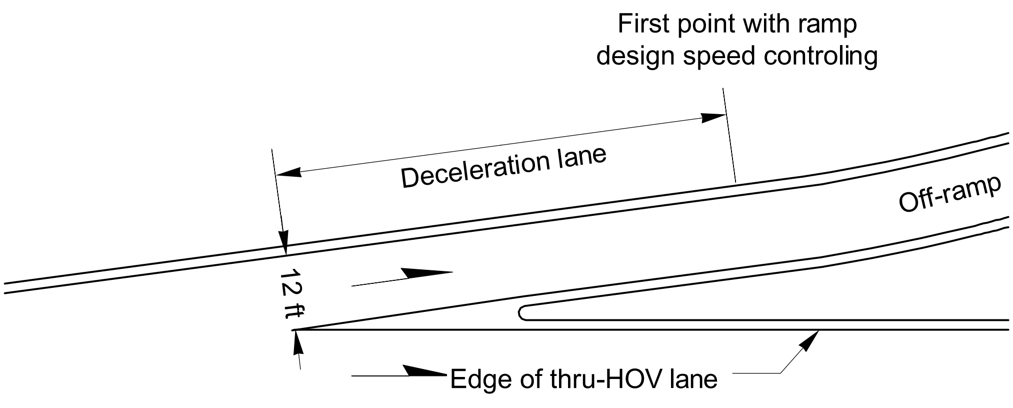
(8) For striping, see the Standard Plans.

Single Lane Parallel Off-Connection

Figure 1055-12



Drop Ramp Gore Area Characteristics
Figure 1055-13

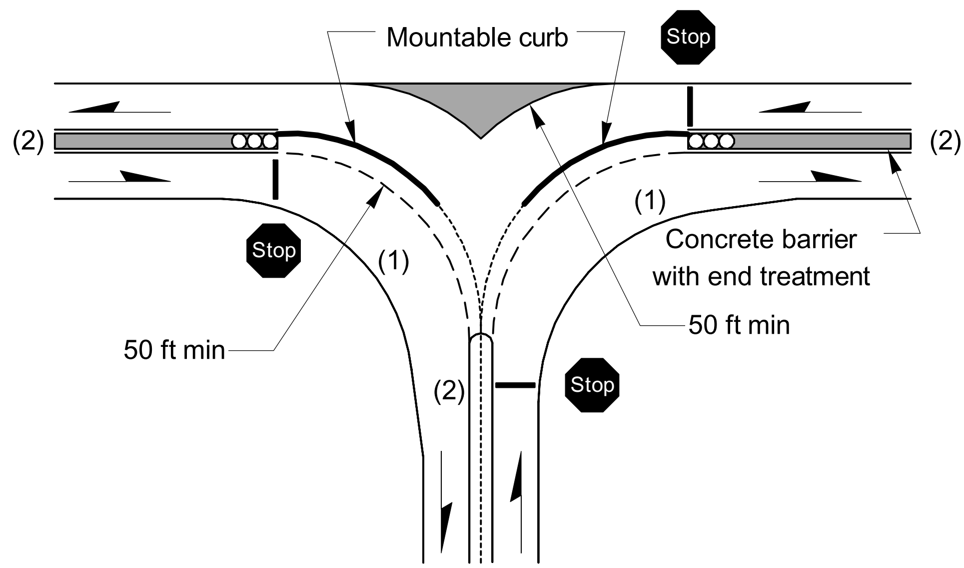


Highway Speed (mph)	Ramp Design Speed (mph)								
	0	15	20	25	30	35	40	45	50
40	390	330	290	240	170	100			
45	470	420	380	330	260	190	90		
50	570	520	480	430	360	290	190	100	
55	680	620	590	540	470	400	300	210	110
60	800	740	700	660	580	520	420	330	230
70	990	930	900	850	780	710	610	520	420
80	1210	1150	1110	1060	990	920	830	740	640

Deceleration Length (LD) for Buses (ft)

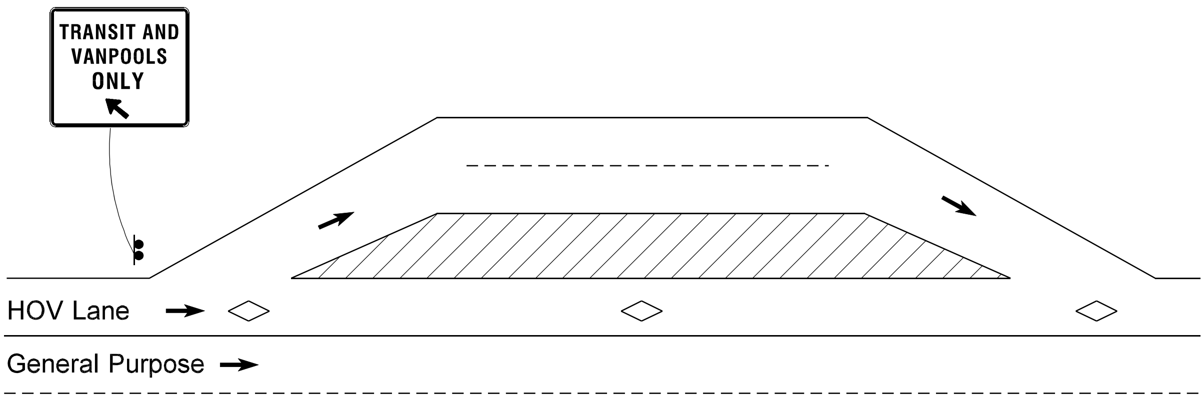
For the adjustment factors for grade, see deceleration lane length in Chapter 940.

Deceleration Lane Length for Buses
Figure 1055-14

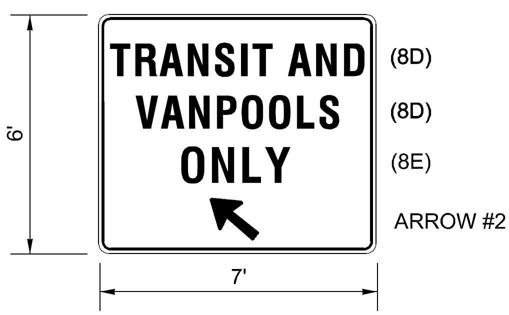


Notes:
(1) See Chapter 910 for intersection corner design. Use the right-turn corner design for the WB-40 for both the left and right turns.
(2) See 1055.05(5) for ramp lane and shoulder widths.

T Ramp Design
Figure 1055-15



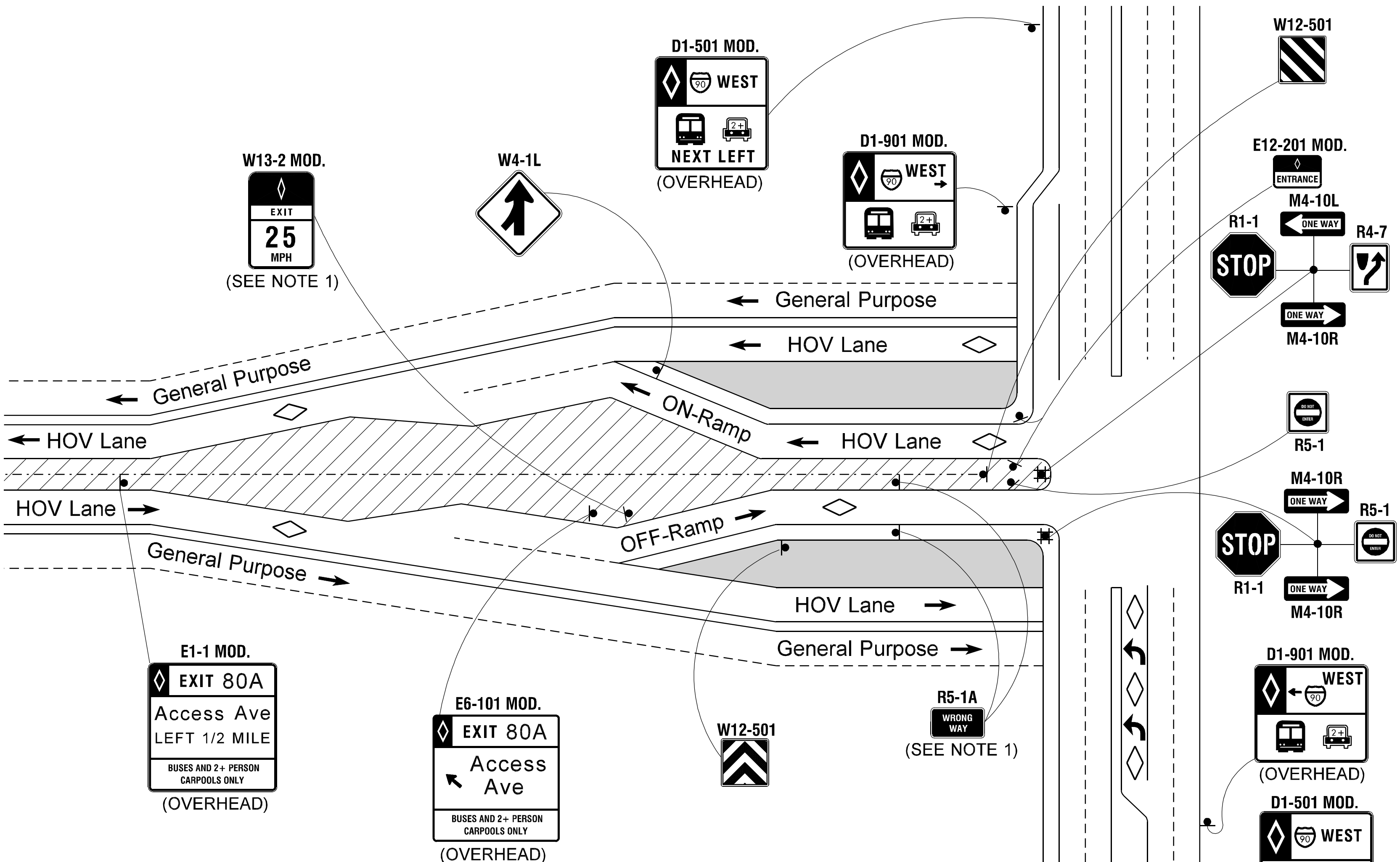
Typical Signing for Flyer Stop



SPECIAL
BLACK ON WHITE

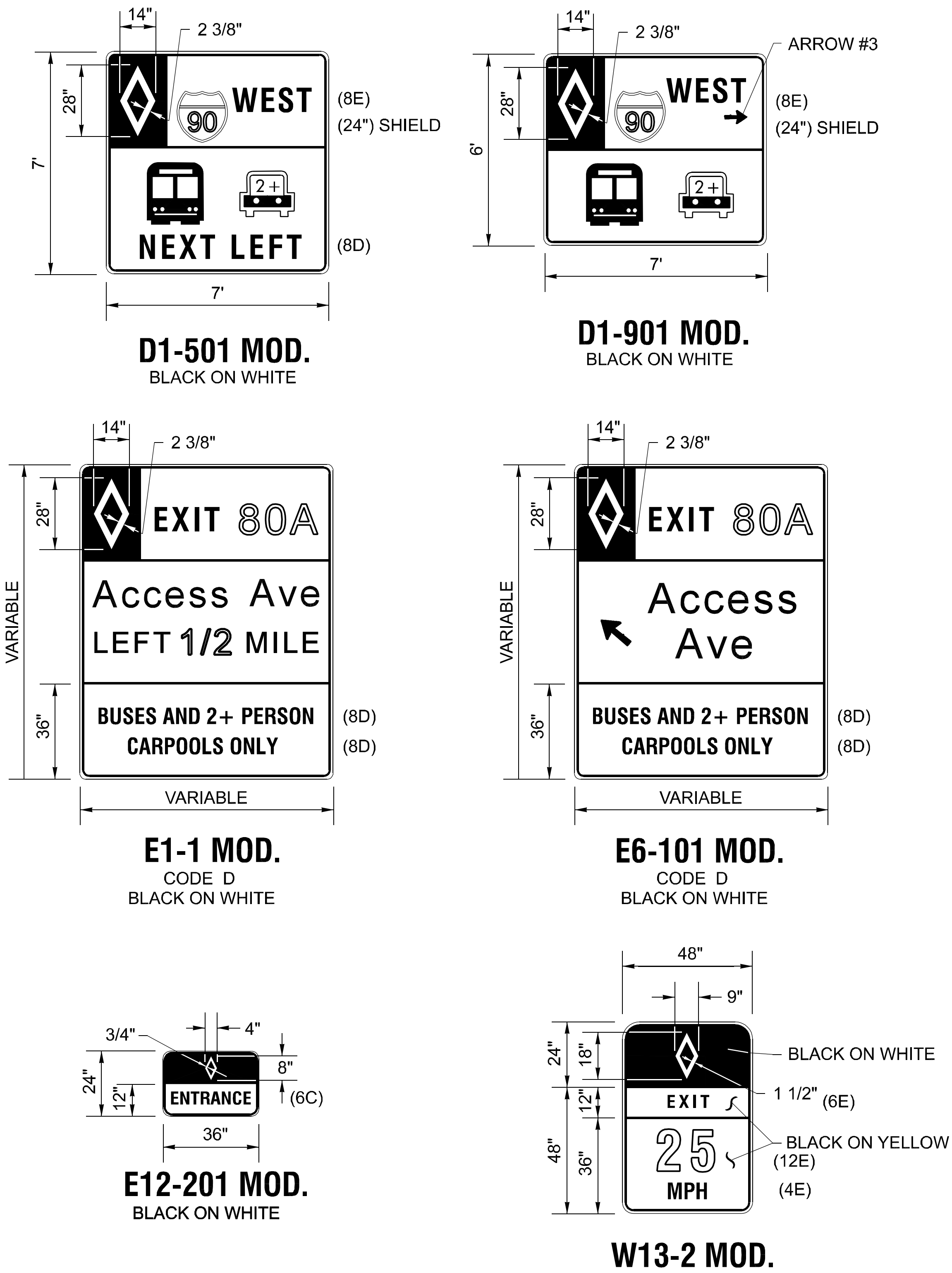
Special Flyer Stop Sign

Flyer Stop Signing
Figure 1055-16



Notes:
(1) Sign placement shall be in accordance with the MUTCD.
(2) See the *Sign Fabrication Manual* (M 55-05) for non-HOV sign detail.
(3) See Figure 1055-17b for modified sign details.

HOV Direct Access Signing
Figure 1055-17a



HOV Direct Access Signing

Figure 1055-17b

1060
TRANSIT BENEFIT FACILITIES

1060.01 INTRODUCTION

(1) Purpose of Chapter

The purpose of this chapter is to provide operational guidance and information for designing transit benefit facilities for WSDOT, local agencies, and developers on public or private property within Washington.

The design criteria presented represent recognized principles based mainly upon criteria developed by AASHTO. The information presented should not substitute for sound engineering judgement. It must be recognized that some situations encountered will be beyond the scope of this section, since it is not a comprehensive textbook on public transportation engineering.

Private development, which incorporates transit benefit facilities into its design, should use this section as a guide at the direction of staff from the appropriate public jurisdiction.

Coordination between agencies in the location and design of transit benefit facilities has often been catch-as-catch-can" at best. Where transit benefit facilities have been required as a condition of development, there has been some confusion as to what design criteria apply. This chapter, along with the referenced "A Guide to Land Use and Public Transportation," provides guidance for the design and location of transit benefit facilities.

The design information which follows can help WSDOT, local jurisdictions, and developers assure that transit provides efficient and cost effective service to the public and the community.

1060.02 DEFINITIONS

articulated bus a two-section bus that is permanently connected at a joint. An articulated bus is 50 percent longer than a standard bus, has three axles, and can bend around corners.

bus pull-out a dedicated parking area for in-service coaches on specified routes, where coaches do not have independent pull-in and pull-out areas.

bus shelter a facility which provides seating and protection from the weather for passengers waiting for a bus.

bus stop a place where passengers wait to board a bus.

car/vanpool a group of people who share the use and cost of a car or van for transportation, on a regular basis.

feeder service bus service providing connections with other bus or rail services.

high occupancy vehicle (HOV) a vehicle which carries a specified minimum number of persons (Chapter 1050).

kiss and ride when patrons of a park and ride lot are dropped off or picked up by private auto or taxi. These are sometimes called drop and ride.

public transportation passenger transportation services available to the public, including buses, ferries, rideshare, and rail transit.

sawtooth berth a series of bays that are off-set from one another by connecting curblines. They are constructed at an angle from the bus bays. This configuration minimizes the amount of space needed for vehicle pull-in and pull-out.

standard bus a bus that is approximately 40 feet in length.

transit a general term applied to passenger rail and bus service used by the public.

transit benefit facility capital facilities, along with the necessary design considerations, which improve the efficiency of public transportation or encourage the use of public transportation and other HOVs.

1060.03 PARK AND RIDE LOTS

(1) General

Park and ride lots provide parking for people who wish to transfer from private vehicles to public transit or carpools/vanpools. These lots are intended to increase highway efficiency, reduce energy demands, and increase highway safety by reducing traffic congestion. Most park and ride lots located within urban areas are served by transit; however, the smaller lots may only have local transit service. Smaller leased lots, usually at churches or shopping centers, may have no bus service, and only serve carpools and vanpools. Park and ride lots, located in rural areas not served by buses, also serve carpools and vanpools.

Early and continuous coordination with the local transit authority and local government agencies is critical. When a memorandum of understanding (MOU) exists, which outlines design, funding, maintenance and operations of the lot program, it must be checked for requirements for new lots. If the requirements cannot be met, the MOU must be renegotiated.

(2) Site Selection

Present and future needs are the main considerations in determining the location of a park and ride lot. Public input is a valuable tool. The demand for and the size of a park and ride lot is dependent on a number of factors. Many of these factors vary with the state of the economy, energy availability and cost, perceived congestion, and public attitude, and are somewhat difficult to predict. Therefore, consider sizing the facility to allow for a conservative first-stage construction with expansion possibilities. As a rule of thumb, one acre can accommodate approximately 90 vehicles in a park and ride lot. This allows about 40 percent of the area for borders, landscaping, passenger amenities, bus facilities for larger lots, and future expansion.

Primary concerns during the design stage include:

- Safe and efficient traffic flows, both on and adjacent to the site, for all modes: transit, carpools, vanpools, pedestrians, and bicycles.
- Adequate lighting and good visibility to enhance security and surveillance of the facility to reduce criminal activity.
- Adequate number of parking spaces.
- Comfortable and attractive facilities.
- Facilities that accommodate use by elderly and disabled users and meet state barrier free design codes.

Local transit authority input is critical because, in some cases, the need for a park and ride lot and its location may already have been determined in the development of their comprehensive transit plan. Failure to obtain transit input could result in a site which does not work well for transit vehicle access.

A list of potential sites should be developed. This can be simplified by the use of existing aerial photos, detailed land use maps, or property maps. The goal is to identify properties which can most readily be developed for parking and which have suitable access.

Factors influencing site selection and design of a park and ride facility include:

- Local transit authority master plan.
- Regional transportation plan.
- Local public input.
- Need.
- Traffic.
- Commuter distance.
- Local government zoning.
- Economic, social, and environmental impacts.
- Cost and cost effectiveness.
- Access by all modes of travel.
- Security and appearance.
- Maintenance.
- Available utilities.
- Existing right of way or sundry site.
- Capability for future expansion.

Purchasing or leasing property increases costs substantially. Therefore, state-owned right of way should be the first choice, assuming the other selection criteria are favorable. The use of city or county-owned right of way should also receive prime consideration. The site selected should not jeopardize the present and future integrity of the highway facility.

Each potential site should be further investigated in the field. The field survey serves to confirm or revise impressions gained from the office review. Consider the following when making the review:

- Physical characteristics of the site.
- Current use of surrounding area (zoning).
- Whether the site is visible from adjacent street(s) to enhance security and surveillance of the facility.
- Potential for additional expansion.
- Accessibility for motorists and other modes of travel including transit.
- Proximity of any existing parking facilities, such as church or shopping center parking lots, that are underutilized during the day.
- Potential for joint use of facilities with businesses or land uses compatible with park and ride patrons, such as day care centers or dry cleaners.
- Congestion problems and other design considerations.

After establishing the best potential sites, public meetings and environmental procedures should be completed prior to preparing the design report. Follow environmental procedures as outlined in Chapter 220.

The design report should address the public meetings and environmental processes completed, as well as the preferred and alternate sites considered.

(3) Design

A design report (Chapter 330) is required for all federally funded projects and for WSDOT facilities that are to be paved.

Design features must be in compliance with applicable design standards, specifications, and operating procedures and with any local requirements that may apply. In some cases, variances to local design standards may be necessary to ensure the safety and security of facility users.

Design components may include:

- Geometric design of access points.
- Internal and external circulation.
- Parking space layout.
- Pavements.
- Shelters.
- Exclusive High Occupancy Vehicle (HOV) facilities.
- Bicycle facilities.
- Motorcycle facilities.
- Traffic control devices, including signs, signals, and permanent markings.
- Illumination.
- Drainage and erosion control.
- Security of facility users and vehicles.
- Environmental mitigation.
- Landscape preservation and development.
- Restroom facilities.
- Telephone booths.
- Trash receptacles.
- Traffic data.
- Barrier free design for the disabled.

The degree to which the desirable attributes of any component are sacrificed to obtain the benefits of another component can only be dealt with on a site specific basis.ˇHowever, these guidelines present the optimum requirements of each factor.

Large park and ride lots use private automobiles as the primary collector distributor mode and transit buses as the line haul mode. The basic principles are also used in designing smaller park and ride lots used primarily for carpools and vanpools with limited or no bus service.

(a) Access. Six basic transportation modes are used to arrive at and depart from park and ride lots: walking, bicycle, motorcycle, private automobile including carpools, vanpools, and bus. All these modes should be provided for.

Access to a park and ride lot should not increase congestion on the facility it serves. For this reason, direct access by private automobiles to a freeway or ramp should be avoided. However, direct access for transit is often desirable as long as this access does not add a major conflict point. Often the most efficient access point to a park and ride lot will be on an intersecting collector or local street. If the intersection is already signalized, excellent access can often be provided. Entrances and exits should be located with regard to adjacent intersections, so that signal control at these intersections can be reasonably installed at a later time, if necessary. Storage for vehicles entering the lot and adequate storage for exiting vehicles should be planned. Ease of access will encourage use of the facility.

When it is necessary to provide direct access to an arterial, the location must be carefully considered. It should be located to avoid queues from nearby intersections. Field observation of traffic patterns and queuing at the site is recommended prior to establishing an access point.

The facility should be located to allow the most users possible to make a right turn into the lot, thus reducing the hazard of crossing opposing traffic.

Entrances and exits should be at least 150 feet apart and not closer than 150 feet to a public intersection, all measured curb to curb (minimum standard): 350ˇfeet is desirable. Where the capacity of the parking area does not exceed 150 stalls, the above spacings may be reduced to 100 feet.

Park and ride lots located along one-way couplets should be located between the two one-way streets with access from both streets. When access cannot be provided directly to both streets, it may be necessary to provide additional signing to guide users to and from the facility.

When a park and ride lot has more than 300 parking stalls, at least two entrances and two exits should be provided. The volume per entrance or exit should not exceed 300 vehicles per hour. With lot sizes larger than 500 stalls, two lane exits with traffic signals should be considered for exits onto heavy volume two-way streets. It is desirable for park and ride lots with capacities greater than 1,000 parking stalls to have entrance and exit points to two or more adjacent streets in order to avoid congestion. Entrances should be located so that a vehicle approaching the site from any direction could miss one entrance and find a second one without circuitous routing.

Entrances and exits that will be used by buses should have a minimum width of 15 feet per lane. See Section 1060.08 for corner radii requirements for buses. See Chapter 920 and the standard plans for design of other access points.

All entrances and exits should conform to WSDOT design standards or other published design standards used by the local agency.

The transit route from the freeway or arterial to a park and ride lot, circulation patterns within the lot, and return route should be designed to minimize transit travel time. Exclusive ramp connections for buses and vanpools, both to and from the freeway or street, may be justified by time savings to riders and reduced transit costs. All transit routing should be coordinated with the transit authority.

(b) Internal Circulation. Major circulation routes within a park and ride lot should be located at the periphery of the parking area to minimize vehicle-pedestrian conflicts. Circulation within the lot should accommodate all modes using that part of the facility. Care should be taken to see that an internal intersection is not placed too close to a street intersection. A separate loading area, with priority parking areas, should be considered for vanpools. Whenever possible, buses should not be mixed with cars. Bus circulation routes should be designed to provide for easy movement, with efficient terminal operations and convenient passenger transfers. A one-way roadway with two lanes to permit passing of stopped buses is desirable, with enough curb length and/or saw-tooth type loading areas to handle the number of buses that will be using the facility under peak conditions (see Section 1060.04). Close coordination with the local transit authority is critical in the design of internal circulation for buses and vanpools.

The passenger waiting area should be located either:

1. In a central location with parking for the various user modes surrounding the waiting area, or
2. Located near the end of the facility with parking for the various user modes extending radially from the waiting area.

Large lots may require more than one waiting area.

In shared-type lots, such as shopping centers and churches, the waiting area should be located away from main building(s) so pedestrian and vehicle traffic from the lot will not interfere with the other facility activities.

In an undersized or odd-shaped lot, circulation may have to be compromised in order to maximize utilization of the lot. The general design for the individual user modes should be based on the priority sequence of pedestrians, bicycles, feeder buses, and park and ride area. Traffic circulation should be designed to minimize vehicular travel distances, conflicting movements, and number of turns. Vehicular movements within the parking area should be dispersed by strategic location of entrances, exits, and aisles. Aisles should be aligned to facilitate convenient pedestrian movement toward the bus loading zone.

Any of the internal layout that will be used by buses, including entrance and exit driveways, must be designed to the turning radius of the bus. Additional considerations for internal circulation are:

- All users (auto, pedestrian, bicycle, and bus) should be able to understand how the lot works.
- Drivers should not be confronted with more than one decision at a time.
- Adequate capacity should be provided at entrances and exits.
- Signing should be clear.
- Flexibility to adjust to changes in transit volume and operations should be provided.

(c) Stall Size. Internal circulation should be two-way with 90-degree parking. However, due to geometrics of smaller lots, one-way aisles with angled parking may be advantageous. Automobile stall dimensions should be 8.5 feet x 18 feet. When space for vehicle overhang is provided, some of the stalls may be 8.5 feet x 16 feet when parking at 90 degrees. When justified, some of the stalls may be designed for compact cars, 8 feet x 16 feet minimum. Include justification of the percentage of compact stalls.

For additionally information on parking stall size requirements for the disabled, see Section 1060.09.

If possible, aisle lengths should not exceed 400 feet. The greatest efficiency can generally be obtained by placing aisles and rows of parking parallel to the long dimension of the site. All parking should be head-in only. Vehicles and other objects should be excluded from corners where it is necessary to provide adequate intersection sight distances. It is also desirable to have parking on both sides of the aisle. This provides the most efficient design in terms of land use.

(d) Pedestrian Movement. Pedestrian movement in parking areas is normally by way of the aisles. Additional provision for pedestrian movement by means of walkways is desirable and could be required in certain situations, as described below. A pedestrian path from any parking stall to the loading zone should be as direct as possible.

Pedestrian walkways should be provided to minimize pedestrian use of a circulation road or an aisle, and to minimize the number of points at which pedestrians cross a circulation road. Where pedestrians originate from an outlying part of a large parking lot and use aisles or circulation roads to approach the loading zone, they will have to travel along an irregular path for a considerable distance. In such cases, consideration should be given to the provision of a walkway which extends toward the loading zone in a straight line.

The maximum distance a pedestrian will have to walk from his car to a loading zone should be in the range of 600 to 800 feet. Longer walking distances require consideration of centrally located or additional loading zones.

Pedestrian crossings should have good visibility both for pedestrians and drivers. Pedestrian walkways and crossings shall be clearly marked.

Facilities for disabled patrons must also be included. All pedestrian walkways shall have curb cuts, built in accordance with the Standard Plans, at all curbs or other sudden elevation changes. The sidewalk grade should be 12:1 or less. For additional disabled accessibility information, see Section 1060.09.

Sidewalks intended for use by pedestrians should have a minimum width of 5 feet. When it is anticipated that both pedestrians and bicycles will use the sidewalks, the minimum width is 8 feet. They should be compatible with existing sidewalks in the area and follow local codes.

The minimum width of a sidewalk adjacent to a loading zone should be 12 feet or the adjacent sidewalk width plus 7 feet, whichever is greater. Pedestrian barriers should be provided where unusual hazards or unreasonable interference with vehicular traffic would result. The barriers may be railings, berms, fencing, walls, or landscaping. These barriers should be installed with sight distance in mind. Minimum horizontal clearance between a barrier and vehicle should be 2 feet. A good parking lot design will minimize the need for pedestrian barriers.

(e) Bicycle Facilities. Encouraging the bicycle commuter is important. Each bicycle used to commute to the park and ride lot potentially frees up one parking space. An evaluation should be made to determine if the lot is going to be used by bicyclists and, if bicycles are expected, bicycle lockers or locking racks should be provided. All paved lots that are accessible by bicycle and are served by public transit should have lockers or a rack for a minimum of three bicycles. The bike parking area should be located relatively close to the transit loading area, separated from motor vehicles by curbing or other physical barriers, and have a direct route from the feeding streets. The bicycle parking area should be designed to prevent pedestrians from inadvertently walking into it and tripping. For bicycles, the layout normally consists of stalls 2 feet x 6 feet, at 90 degrees to aisles, with a minimum aisle width of 5 feet. For additional information on bicycle facilities, see Chapter 1020.

(f) Motorcycle Facilities. Motorcycle stalls should be 4 feet x 7 feet. Motorcycle storage should be on a Portland cement concrete slab to prevent stands from sinking into the asphalt pavement. Motorcycle stalls should be located relatively close to the transit loading areas.

(g) Drainage. Ponding of water in a lot is undesirable both for vehicles and pedestrians. Therefore, adequate slope should be provided for surface drainage. This is particularly true in cold climates where freezing may create icy spots. Recommended grade is 2 percent (0.02 ft/ft). Curb, gutter, and surface drains and grates should be installed where needed. Drainage grates with short, narrow openings, placed perpendicular to traffic direction, should be used in traffic areas to allow safe passage over the grate. Drainage design should be coordinated with the local agency to ensure that appropriate codes are followed (Chapter 1210).

Raised islands shall be held to a minimum so as not to hinder cleaning and snow removal.

(h) Pavement Design. Pavement design shall conform to state design specification for each of the different uses and loadings that a particular portion of a lot or roadway is expected to handle. The surfacing typeˇshall have the concurrence of the Materials Laboratory (Chapterˇ520).

(i) Traffic Control. Control of traffic movement can be greatly improved by proper pavement markings. Typically, reflectorized markings for center lines, lane lines, channelizing lines, and lane arrows will be necessary to guide or separate patron traffic and transit traffic. Signing and pavement markings shall conform to Chapters 820 and 830 and to the MUTCD. Park and Ride identification signs should be installed.

(j) Shelters. Pedestrian shelters should be considered in areas where the magnitude of transit service and environmental conditions warrant. Consider shelters when 50 or more riders per day are anticipated. Shelters may be individually designed or selected from a variety of commercially available designs to satisfy local needs. The following features should be considered in selecting shelter designs:

- Select open locations with good visibility to minimize potential for criminal activity.
- If enclosed, the open side should be away from nearby vehicle splashing.
- Doors are not recommended, unless need dictates otherwise, because of maintenance and vandalism potential.
- Allow for a small air space below side panels to permit air circulation and prevent the collection of debris.
- Optional features that may be provided are lighting, heat, telephone, travel information (schedules), and trash receptacles.
- Ease of field assembly and repair of components. Contact WSDOT's Architecture Office or local transit agency for shelter designs. Shelters are usually provided by the serving transit authority with the state providing only the shelter pad. Coordination with the local transit authority is essential in shelter design and placement.
- Design shelters to accommodate the disabled.
- See Section 1060.06, Passenger Amenities, for additional information on this subject.

(k) Illumination. Adequate lighting is important from a safety standpoint and as a deterrent to criminal activity in both the parking area and the shelters. Illumination should be considered for all park and ride lots (Chapter 840). Only security lighting is provided during hours of low usage. Locate poles so that vehicle movements and parking are not obstructed. If raised islands are used to separate adjacent parking rows, place the poles on the islands. In determining the locations of luminaire poles, plan for future expansion of the facility.

(l) Landscape Preservation and Development. Selective preservation of existing vegetation is often a cost-effective means to provide a balanced environment for the park and ride lot user. Preservation may reduce environmental impacts and give "instant" results. Landscaping of park and ride lots is desirable for aesthetic as well as ecological reasons and should consist of plantings that will be compatible with the operation of the facility. Landscaping shall be cost-effective, comply with the local requirements, and satisfy the functional needs of the park and ride lot. The type of plantings and their placements should not interfere with:

- Adequate lighting for the area, thus resulting in a potential safety hazard to the patron.
- Adequate sight distance for cars and transit vehicles, especially at intersections and pedestrian crossings.
- The proper placement of the traffic control devices.
- The ability of pedestrians, bicyclists, and the disabled to use the facility.
- Security of patrons and their property.

Trees provide shade and visual interest, reduce glare, and are less costly to maintain than shrubs and ground cover. Therefore, trees should be the dominant plant material. Trees should be placed only where they will not block sight distance for cars or buses and proper clearances can be maintained as they mature. Landscaping should be designed in such a manner that hiding places for vandals are minimized. Landscaping can provide an effective means for establishing pedestrian paths and walking patterns within the site. In parking zones, sufficient setback must be provided for all plants so the front or rear overhang of cars does not damage them. Earth forms, such as berms, mounds, and swales are a good design tool to provide for low-cost screening, delineation, visual interest, and drainage. Landscaping should be designed so that security patrols can see into the lot from adjacent streets without entering. Landscape design shall keep maintenance requirements to a minimum.

It is desirable that one tree be planted per 12 parking stalls so that no parking stall is farther than 75 feet from a tree. These trees provide luminaire light diffusion for adjacent property owners.

Irrigation also needs to be addressed in the landscape design.

(m) Fencing. See Chapter 1460 for guidelines for fencing.

(n) Maintenance. A comprehensive maintenance plan should be developed as per established state policy either as part of a memorandum of understanding with the local authority or for use by state maintenance forces. Maintenance of park and ride lots outside state right of way shall be the responsibility of the local transit authority. It is encouraged that park and ride lots inside state right of way should also be maintained by the local transit authority. Agreements for maintenance by others shall be negotiated during the design phase and documented in the design report (Chapter 330).

Maintenance cost estimates, funding source, and legal responsibilities for accidents and security are to be addressed in the maintenance plan and documented in the design report. The location and type of site (new or existing), and method of performing maintenance, will generally determine the extent of the maintenance program.

The following maintenance activities should be considered:

- Periodic inspection.
- Pavement repair.
- Traffic control devices (signs and pavement markings).
- Lighting.
- Mowing.
- Cleaning of drainage structures.
- Sweeping/trash pickup.
- Landscaping.
- Shelters.
- Snow and ice control.

A sound maintenance program should be established well ahead of the date a park and ride lot is placed into operation.

1060.04 TRANSFER/TRANSIT CENTERS

(1) Introduction

Transfer centers are essentially large bus stops where buses on a number of routes converge to allow riders the opportunity to change buses. Transfer centers are of particular importance in many transit systems, since riders in many areas are served by a "feeder" route; to travel to area destinations not served by the feeder, residents must transfer.

Transit centers are frequently associated with a major activity center. In this case, the activity is beyond simply a transfer between buses but also involves the center as a destination point.

This section provides general design considerations of transfer and transit centers. The development of a particular center requires consideration of such features as passenger volume, number of buses on site at one time, and local auto and pedestrian traffic levels. These factors will dictate the particular requirements of each center.

(2) Bus Berths

Where several transit routes converge and where buses congregate, multiple bus berths or spaces are sometimes required. Parallel and shallow sawtooth designs are the options available when considering multiple berths.

An important aspect in multiple bus berthing is proper signing and marking for the bus bays. Each bay should clearly delineate the route served. In addition, the pavement should be marked with striping to indicate correct stopping positions.

Consideration should be given to using Portland Cement Concrete Pavement where pedestrians will walk for ease of cleaning.

Where buses are equipped with a bicycle rack, the design should provide for loading and unloading of bicycles.

Figure 1060-1 shows typical parallel and sawtooth designs for parking standard 40-foot buses for loading and unloading passengers at a transfer center. The sawtooth design does not require buses to arrive or depart in any order. The parallel design shown requires that the buses either arrive or depart in order.

Where space is a consideration, the sawtooth design can be used for independent arrival but dependent departure. Figure 1060-2 is an example of a sawtooth transit center. In an in-line berthing design, space requirements are excessive if this same access is to be provided. More commonly, in an in-line design, buses pull into the forward-most available berth. Buses must then leave in the order of arrival. The local transit authority should be involved throughout the design process and must concur with the final design.

In the design of parallel bus berths, additional roadway width is required for swing-out maneuvers if shorter bus loading platforms are utilized. The roadway width and amount of lineal space at the bus loading platform are directly related where designs allow departing buses to pull out from the platform around a standing bus. For example, a 40-foot bus with a 16-foot forward clearance requires 22 feet of roadway width for its pull-out maneuver. This condition requires a roadway width of at least 24 feet and a total minimum berth length of 56 feet for each bus. Thus, five buses would require 264 feet of linear distance. The shorter the berth length allowed, the wider the roadway must be.

Considerable linear space is necessary in a parallel design to permit a bus to overtake and pull into a platform ahead of a parked bus. For example, a 40-foot bus requires approximately 92 feet to pull in, assuming the rear end of the bus is 1 foot out from the platform curb and 56 feet when a 5-foot “tailout” is permitted.

Parallel designs, even if signed properly, require strict parking enforcement, since they give the appearance of general curbside parking areas. Pavement marking is most critical for parallel design. Sawtooth designs offer the advantage of appearing more like a formal transit facility, which tends to discourage unauthorized parking.

(3) Flow/Movement Alternatives

Two primary alternatives for vehicle and passenger movement are possible for transfer centers, regardless of the type of bus berths used. As shown in Figure1060-3, all buses may line up along one side of the transfer center. This type of arrangement is generally only suitable for a limited number of buses, due to walking distances required for transferring passengers. For a larger number of buses, an arrangement similar to Figure 1060-4 can minimize transfer time requirements by consolidating the buses in a smaller area.

1060.05 BUS STOPS AND PULLOUTS

(1) Introduction

The bus stop is the point of contact between the passenger and the transit services. The simplest bus stop is a location by the side of the road. The highest quality bus stop is an area that provides passenger amenities such as a bench and protection from the weather.

Bus pullouts allow the transit vehicle to pick up and discharge passengers in an area outside the traveled way. The interference between buses and other traffic can be reduced by providing bus pullouts.

(2) Bus Stops Designation and Location

The location of bus stops should be standardized within the system to avoid undue confusion. However, standardization should not be a substitute for sound judgement whenever conditions render standard practice inappropriate. It is imperative that bus stops be of adequate length and located so that the adverse effect on traffic (including pedestrians) is kept to a minimum.

The following should be considered when locating bus stops:

- Bus stop placement requires the consent of the jurisdiction having authority over the affected right of way and the local transit authority.
- The physical location of any bus zone should be primarily determined by the following considerations: maximizing safety, operational efficiency, minimizing adjacent property impacts, and user destination points.
- Public transportation agencies are typically responsible for maintenance of transit facilities within the public right of way.

These elements are discussed in the following subsections.

The proper spacing for bus stops represents a trade-off between passenger convenience and bus operating speed. Closer spacing reduces passenger walking distance, while longer spacing permits faster and less expensive bus operations. The proper spacing in any specific area depends on the nature and layout of adjoining land uses and the number of passengers expected. Bus stops should be as close as possible to passenger origins and destinations.

If activity along the bus route is uniform, the typical bus stop spacing should be about 1,000 feet. A general minimum spacing should be 500 to 600 feet within the central business district (every 2 to 3 blocks). In this range, stops should be provided where streets intersect or where walkways from the surrounding areas reach the main street. Evaluation of pedestrian walking distances as a design issue in subdivision layout may yield short walking distances to bus stops and encourage transit use.

In suburban areas (mostly single-family housing with pockets of open space and undeveloped land), bus stops should be located approximately every 1,250 feet (four per mile). Stops are generally not provided where residential density drops below four units per acre.

If commercial, residential, or industrial activity along the bus route is not clustered, bus stops need not be located uniformly along routes, but can be sited at the activity nodes. Greater spacings, 1,500 to 2,500 feet (approximately two to four per mile), may be possible in these circumstances.

In order to evaluate a new route and build ridership, placement of bus zones may initially depart from the above guidelines.

(3) Bus Stop Placement

Where traffic volume is low, on-street parking is prohibited, and a stopped bus will not impede traffic, the bus stop may simply be a designated location where the bus can pull up to the curb or to the edge of the roadway. The location will be dictated by patronage, the intersecting bus routes or transfer points, security of the rider, and the need for convenient service.

The specific bus stop location is influenced not only by convenience to patrons, but also by the design characteristics and operational considerations of the highway or street. Bus stops are usually located in the immediate vicinity of intersections. Where blocks are exceptionally long, or where bus patrons are concentrated well removed from intersections, midblock bus stops, along with midblock crosswalks, may be used.

Bus stop capacity of one bus will typically be adequate for up to 30 buses per hour.

Where on-street auto parking is permitted, a designated area where the bus can pull in, stop, and pull out must be provided. Figure 1060-5 illustrates several types of bus stops.

- Far-side, with a stop located just past an intersection;
- Near-side, with a stop located just prior to an intersection; and
- Mid-block, with a stop located away from any intersections.

In general, a far-side stop is preferred, however, examine each case separately and determine the most suitable location giving consideration to such things as service to patrons, efficiency of transit operations, and traffic operation in general. Near-side and mid-block bus stops may be suitable in certain situations. Bus stops should utilize sites which discourage unsafe pedestrian crossings, offer proximity to activity centers, and satisfy the general spacing requirements discussed previously. Following are descriptions of the advantages and disadvantages of each type of site.

(a) Far-Side Bus Stops. Advantages:

- Right turns can be accommodated with less conflict.
- A minimum of interference is caused at locations where traffic is heavier on the approach side of the intersection.
- Will cause less interference where the cross street is one-way street from left to right.
- Stopped buses do not obstruct sight distance for vehicles entering or crossing from a side street.
- At a signalized intersection, buses can find a gap to enter the traffic stream without interference, except where there are heavy turning movements into the street with the bus route.
- Waiting passengers assemble at less-crowded sections of the sidewalk.
- Buses in the bus stop will not obscure traffic control devices or pedestrian movements at the intersection.

Disadvantages:

- Intersections may be blocked if other vehicles park illegally in the bus stop, or if the stop is too short for occasional heavy demand.
- Stops on a narrow street or within a traffic lane may block the intersection.

(b) Near-Side Bus Stops. Advantages:

- A minimum of interference is caused at locations where traffic is heavier on the leaving side than on the approach side of the intersection.
- Will cause less interference where the cross street is one-way from right to left.
- Passengers generally exit the bus close to crosswalk.

- There is less interference with traffic turning into the bus route street from a side street.

Disadvantages:

- Heavy vehicular right turns can cause conflicts, especially where a vehicle makes a right turn from the left of a stopped bus.
- Buses often obscure sight distance stop signs, traffic signals, or other control devices, as well as pedestrians crossing in front of the bus.
- Where the bus stop is too short for occasional heavy demand, the overflow will obstruct the traffic lane.

(c) **Mid-Block Bus Stops.** Advantages:

- Buses cause a minimum of interference with sight distance of both vehicles and pedestrians.
- Stops can be located adjacent to major bus passenger generators.
- Waiting passengers assemble at less-crowded sections of the sidewalk.

Disadvantages:

- Pedestrian jaywalking is more prevalent.
- Patrons from cross streets must walk farther.
- Buses may have difficulty re-entering the flow of traffic.

Some general guidelines for the location of bus stops are:

- At intersections controlled by signals, stop, or yield signs, when transit is critical but traffic and parking are not critical, a near-side stop is preferable.
- At intersections where heavy left or right turns occur, a far-side bus stop should be used. If a far-side bus stop is impractical, the stop should be moved to an adjacent intersection or to a mid-block location in advance of the intersection.
- It is important that the bus stop be clearly marked as a no parking zone with signs and/or curb painting.
- For safety and accessibility, all loading and unloading should be made from the curb, not in the street/traffic lane.
- At intersections where bus routes and heavy traffic movements diverge, a far-side stop can be used to advantage.
- Mid-block stop areas are recommended under the following conditions: (1) where traffic or physical street characteristics prohibit a near or far-side adjacent to an intersection; or (2) where large factories, commercial establishments, or other large bus passenger generators exist. A mid-block stop should be located at the far-side of a pedestrian crosswalk (if one exists) so that standing buses will not block an approaching motorist's view of pedestrians in the crosswalk.
- Sight distance conditions generally favor far-side bus stops, especially at unsignalized intersections. A driver approaching a cross street on the through lanes can see any vehicles approaching from the right. With near-side stops the view to the right may be blocked by a stopped bus. Where the intersection is signalized, the bus may block the view of one of the signal heads.
- For security purposes the availability of adequate off-street lighting is an important consideration.

(4) Bus Pullouts

Bus pullouts are generally most appropriate when one or more of the following situations exits:

- Traffic in the curb lane exceeds 250 vehicles during the peak hour.
- Passenger volume at the stop exceeds 20 boardings an hour.
- Traffic speed is greater than 45 miles per hour.
- Accident patterns are recurrent.

The separation of transit and passenger vehicles is critical in cases of high bus or traffic volumes or high speeds. Bus stops in the travel lane may be unsafe or impede the free flow of traffic. Bus pullouts should also be considered at locations with high bus passenger loading volumes that cause traffic to back up behind the stopped bus.

To be fully effective, the pullout should incorporate a deceleration lane or taper, adequate staging area for all anticipated buses, and a merging lane or taper. As roadway operating speeds increase, the taper length should increase accordingly. Many times, high traffic volumes will not allow sufficient gaps for the bus operator to returnˇthe vehicle safely to the traffic stream. When this happens, the operator may opt not to use the turnout.

Figure 1060-6 illustrates the dimensions and design features of bus pullouts associated with near-side, far-side, and mid-block bus pullouts.

There are no absolute criteria for locating bus pullouts. Where a pullout is being considered, the transit agency must be involved. Factors controlling the appropriate location and eventual success of a pullout include:

- Operating speed.
- Traffic volume.
- Number of passenger boardings.
- Available right of way.
- Roadway geometrics (horizontal and vertical).
- Construction costs.
- Location of curb ramps.

Figure 1060-7 illustrates the dimension and design requirements of far-side bus zones and pullouts where buses will stop after making a right turn. Adherence to these designs should allow safe stopping of buses with minimal interference with legally parked vehicles.

It is important in the design of bus pullouts to consider the need to provide structurally adequate pavement for the bus pullout (Chapter 520), otherwise the surfacing may be damaged by the weight of the buses.

1060.06 PASSENGER AMENITIES

(1) Introduction

Providing an attractive, pleasant setting for the walk and wait are important elements in attracting bus users.

A passenger arriving at a bus stop desires a comfortable place to wait. Important elements of a bus stop are:

- Safety from passing traffic.
- Adequate lighting.
- Security.
- Paved surface.
- Protection from the environment.
- A seat (if the wait may be long).
- Information about the routes serving the stop.

Providing safety from passing traffic involves locating stops where there is adequate space, so passengers can wait away from the edge of the traveled roadway. The buffering distance required from the roadway increases with traffic speed and traffic volume. Three to 5 feet is adequate where vehicle speeds are 30 miles per hour. A heavy volume arterial with speeds of 45 miles per hour can require a distance of 8 to 10 feet for passenger comfort.

Passengers arriving at bus stops, especially infrequent riders, want information and reassurance. Information provided should include the numbers or names of routes serving the stop. Other important information may include a system route map, the hours and days of service, schedules, and a phone number for information. The information provided and format used is typically the responsibility of the local transit system.

At busier stops, including park and ride lots, a public telephone should be provided. For all paved park and ride lots, a desirable site for a public telephone should be selected and conduit provided whether or not a telephone is currently planned. Where shelters are not provided, a bus stop sign and, depending on weather conditions, passenger bench are desirable. The sign indicates to passengers where to wait and can provide some basic route information.

(2) Passenger Shelters

Passenger shelters should provide protection for waiting transit users. In accomplishing this task, the shelter itself must be located conveniently for users without creating hazards — such as blocking the line of sight of automobile drivers or blocking the sidewalk. Figure 1060-8 illustrates a clear sight triangle that will permit shelter siting withˇminimal impact on sight distances at urban arterial intersections without traffic controls. The dimensions may vary by local jurisdiction — check local zoning ordinances or with appropriate officials.

State Motor Vehicle Funds cannot be used for design or construction of shelters, except for the concrete pad. Funding of shelters must be handled by the transit agency or some other local agency.

Adequate lighting is necessary to enhance passenger security. Lighting makes the shelter visible to passing traffic and allows waiting passengers to read information provided. General street lighting is usually adequate. Where street lights are not in place, additional street lights or transit shelter lights should be considered.

A properly drained, paved surface is necessary so that passengers will not traverse puddles and mud in wet weather. Protection from the environment is typically provided by a shelter that provides shade from the sun, protection from rain and snow, and a wind break. Shelters can range from simple to elaborate. The latter type may serve as an entrance landmark for a residential development or employment complex and be designed to carry through the architectural theme of the complex. If a nonpublic transportation entity shelter is provided, its design and siting must be approved by the local transit operator. The reasons for this approval requirement include safety, barrier-free design and long-term maintenance concerns.

Simple shelters, such as that illustrated in Figure 1060-9, may be designed and built by the transit agency or purchased from commercial vendors. The WSDOT Architecture Office may be contacted for more complex designs.

If resources permit, shelter placement should be considered at most bus stops in new commercial and office developments and in places where large numbers of elderly and disabled persons may wait, i.e., hospitals, senior centers, etc. In residential areas, shelters are placed only at the highest volume stops.

1060.07 ROADWAY AND VEHICLE DESIGN CRITERIA CHARACTERISTICS

(1) Paving Sections

The pavement design (type and thickness) of a transit benefit project, whether initiated by a public transportation agency or a private entity, must be coordinated with WSDOT or the local agency public works department depending on highway, street, or road jurisdiction. These agencies play a major role in determining the paving section for the particular project. Early and frequent coordination is required.

Paving section design is determined by the volume and type of traffic, design speed, soil characteristics, availability of materials, construction costs, and maintenance cost. Important characteristics of good pavement design are the ability to retain shape and dimensions, the ability to drain, and the ability to maintain adequate skid resistance.

See Chapterˇ510 “Investigation of Soils and Surfacing Materials” and Chapterˇ520 “Design of Pavement Structure” for guidance in the design of pavements.

(a) Grades. Roadway grades refer to the maximum desirable slope or grade, or the maximum slope based upon the minimum design speed that a standard 40-foot transit bus can negotiate safely. Guidance on roadway grades is in Chapterˇ440 or in the *Local Agency Guidelines*. Public transportation agencies or private developers should coordinate their needs with WSDOT or the appropriate local agency.

Speed of buses on grades is directly related to the weight/horsepower ratio. Grades should be selected to permit uniform operation at an affordable cost. In cases where the roadway is steep, a climbing lane for buses and trucks may be needed. Abrupt changes in grade should be avoided due to bus overhangs and ground clearance requirements.

(b) Lane Widths. Roadway and lane widths are generally regulated by WSDOT or the *Local Agency Guidelines*, based upon the functional class of highway or road under their respective jurisdiction.

Private developers should contact these agencies early in the design process to ensure that roadway and lane widths are consistent with applicable standards.

Roadway capacity is directly affected by lane width. As lanes narrow, anticipated capacity is lowered. Controls determining adequate lane width include design speed, anticipated traffic volume, types of user vehicles, available right of way, and roadside obstructions, i.e., retaining walls, light poles, and street furniture.

For lanes to be used by High Occupancy Vehicles (HOV), buses, vanpools, and carpools, the recommended width is 12 feet. Lane widths should not be less than 12 feet when transit volumes are high. Chapter 1050 provides additional information on HOV facilities.

(2) Vehicle Characteristics/Specifications

Most transit agencies operate several types of buses within their system. Vehicle sizes range from the articulated bus to passenger vans operated for specialized transportation purposes and vanpooling.

Each manufacturer within each of the general classifications may vary dimensions such as wheelbase, height, and vehicle overhang. The total gross vehicle weight rating (GVWR) varies considerably among manufacturers for the type of general vehicle classification. Because of these differences, more specific design information should be obtained from the local transit authority.

The principal dimensions affecting design are the minimum turning radius, the tread width, the wheelbase, and the path of the inner rear tire. Effects of driver characteristics and the slip angle of the wheels are minimized by assuming that the speed of the vehicle for the minimum radius (sharpest) turn is less than 10 miles per hour.

(a) Large Transit Buses. These traditional urban transit service vehicles are typically 40 feet long and have a wheelbase of approximately 25 feet. Many agencies operate 35-foot buses which have a 19-foot wheelbase.

Many of these vehicles are equipped with either front or rear door wheelchair lifts, or a front “kneeling” feature that reduces the step height for mobility impaired patrons.

(b) Articulated Transit Bus. Because articulated buses are hinged between two sections, these vehicles can turn on a relatively short radius. Articulated buses are typically 60 feet in length with a wheelbase of 19 feet from the front axle to mid-axle and 24 feet from the mid-axle to the rear axle.

(c) Small Transit Buses. Some of the smaller transit agencies operate 26 to 30-foot transit coaches which are designed for use in low volume situations. Modified vans are used for transportation of the elderly and disabled persons and shuttle services. Passenger vans are a third type of small bus, used for specialized transportation and vanpooling. Some of these vans have been modified to provide special seating arrangements. Since the vehicle specifications vary so widely within this category, consult the local transit authority or bus manufacturer for specifications of the particular vehicle in question.

1060.08 INTERSECTION RADII

A fundamental characteristic of transit accessible development is safe, convenient access and circulation for transit vehicles. It is important that radii at intersections be designed to accommodate turning buses. Adequate radii will reduce conflicts between automobiles and buses, reduce bus travel time, and provide maximum comfort for the passengers.

The following major factors should be taken into consideration in designing intersection radii:

- Right of way availability.
- Angle of intersection.
- Width and number of lanes on the intersecting streets.
- Design vehicle turning radius.

- Parking at the intersection.
- Allowable bus encroachment.
- Operating speed and speed reductions.
- Pedestrians.
- Bicycles.

Because of space limitations and generally lower operating speeds in urban areas, curve radii for turning movements may be smaller than those normally used in rural areas. It is assumed that buses making turns are traveling at speeds of less than 10 miles per hour. Figures 1060-10 and 11 illustrate the Turning Templates and design vehicle specifications for a standard 40-foot bus and an articulated bus.

Figure 1060-12 illustrates appropriate radii at intersections for four types of parking configurations which may be associated with an intersection. Radii less than minimum result in encroachment into adjoining lanes or curbs. As intersection radii increase, pedestrian crossing distances increase.

To ensure efficient transit operation on urban streets, it is desirable to provide corner radii of from 35 to 50 feet (based on the presence of curb parking on the streets) for right turns to and from the through lanes. Where there are curb parking lanes on both of the intersecting streets and parking is restricted for some distance from the corner, the extra width provided thereby serves to increase the usable radius.

Angle of intersection also influences the turning path of the design vehicle. Figure 1060-13 shows the effect of the angle of intersection on the turning path of the design vehicle on streets without parking. Figure 1060-13 also illustrates different cases; when a vehicle turns from proper lane and swings wide on the cross street, and when the turning vehicle swings equally wide on both streets.

1060.09 DISABLED ACCESSIBILITY

(1) Introduction

Public transportation providers have an obligation under both state and federal laws to create and operate capital facilities and vehicles that are usable by the wide variety of residents in the service area. A major need arising from this obligation is to provide transportation service to the transit dependent, among whom are disabled individuals.

According to the report titled "Persons of Disability in Washington State — A Statistical Profile 1970-1980" by the Washington State Employment Security Department, the percentage of persons with disabilities within the state in the working age years of 16 to 64 was 8.7 percent in 1980. The number of elderly people with disabilities that affect mobility is far higher.

Federal law requires all new or significantly rehabilitated buses to be accessible to the disabled. Transit agencies are also required to provide demand response service comparable with the fixed route service.

Barrier-free design means more than just accommodating wheelchairs. Care needs to be given not to create hazards or barriers for people who have vision or hearing impairments. They key is to design clear pathways without obstacles and signs that are simple with large print.

Transit Benefit facilities are designed for accessibility aspects under the Uniform Federal Accessibility Standards (UFAS) and/or, Chapter 51-10 WAC "Washington State Regulations for Barrier-Free Facilities" or local agency standards where applicable.

(2) Park and Ride Lots

Parking stalls for the disabled should be located in close proximity to the transit loading and unloading area. Stalls shall be at least 8 feet wide with a 5-foot adjacent loading aisle on each side with sidewalk curb cuts (see Standard Plans). Two accessible parking stalls may share a common access aisle. Provide disabled stalls according to the following table:

Total Parking Stalls in Lot	Required Disabled Parking Stalls
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1,000	2% of total
1,001 and over	20 plus 1 for each 100 over 1,000

No more than two of these stalls need be striped and signed for disabled use at the time of initial operation. The remaining stalls may be striped for standard usage, but the curb cuts for wheelchair ramps should be provided for each future stall. Additional stalls shall be made available for use by disabled patrons when demand indicates the need.

A parking stall for disabled persons shall be signed according to the requirements of RCW 46.61.581.

- Disabled facilities should be in accordance with the following:
- Disabled patrons should not have to cross access roads enroute to the bus loading zone.
- Disabled patrons should not be forced to travel behind parked cars (in their circulation path).
- Wheelchair ramps shall be provided to facilitate the movement of physically disabled patrons.

- Parking stalls and access aisles shall be level with surface slopes not exceeding 2 percent.

(3) Bus Stops and Shelters

In order to use buses which are accessible, bus stops must also be accessible to disabled persons. The nature and condition of streets, sidewalks, passenger loading pad, curb ramps, and other bus stop facilities can constitute major obstacles to mobility and accessibility. State, local, public and private agencies need to work closely with public transportation officials to enhance accessibility for people with disabilities. A significant component of bus stop accessibility is in the provision of "pads" for the deployment of wheelchair lifts. The terrain where a wheelchair pad is located should be level. The pad should be constructed of cement concrete, asphalt concrete pavement, or a similar impervious surface. The approach to the pad should not consist of grass, gravel, or any surface where a wheelchair might lose traction. The pad should have a minimum slope toward the curb sufficient for drainage purpose. The stop pad should measure at least 10 feet in length and 8 feet in width. When right of way or other limitations restrict the pad size, a smaller pad may be provided, but it must be able to accommodate a wheelchair.

The local public transit agency should be involved in the pad design to help ensure that lifts can actually be deployed at this site.

In order to access a bus stop, it is important that the path to these facilities also be accessible by the use of sidewalks with curb ramps. The Standard Plans contain design and construction information for cement concrete sidewalks and curb ramps. A continuous curb ramp is used for accessibility of disabled park and ride users as part of the accessible path to the bus stop and shelter.

In the design of bus stops and/or shelters the following should be considered:

- Inclusion of bus stop disabled access as a critical factor in the selection of locations for pedestrian improvements within the safety component of the state's or local agency capital improvement program.
- Ensure that curb ramps are properly sloped and sized for safe wheelchair usage and that they have textured surfaces to warn blind persons (see the Standard Plans).
- Identification of places that require sidewalks.
- Encouragement that property owners keep existing sidewalks in a good state of repair.
- Encouragement and continued emphasis of standards requiring all new street construction or reconstruction to include sidewalk or pedestrian walkway and curb ramps.

V:DM10

- Bus stop should be identified with curb painting and/or bus stop signs. Both disabled and nondisabled persons will benefit from this.
- All bus stops that can be made accessible should be made accessible, whether or not the paths to them are accessible, as future improvements may make the paths accessible.
- All bus stop signs along a route served by accessible vehicles should be marked with the blue international accessibility symbol conforming to the requirements of RCW 70.92.120 for easier identification by users.
- Existing as well as future park and ride locations must, by state law, include reserved parking for disabled persons, marked with signs as outlined in RCW 46.61.581.

1060.10 REFERENCES

AASHTO, *Guide for the Design of High Occupancy Vehicle and Public Transfer Facilities, 1983*.

Performance Criteria and Design Standards for Park and Ride Lots, Metro Guidelines, April 1974.

An Illustrated Handbook of Barrier Free Design, Washington State Rules and Regulations, November 1989.

Uniform Federal Accessibility Standard, Accommodations for the Physically Handicapped, FHWA, April 1984.

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

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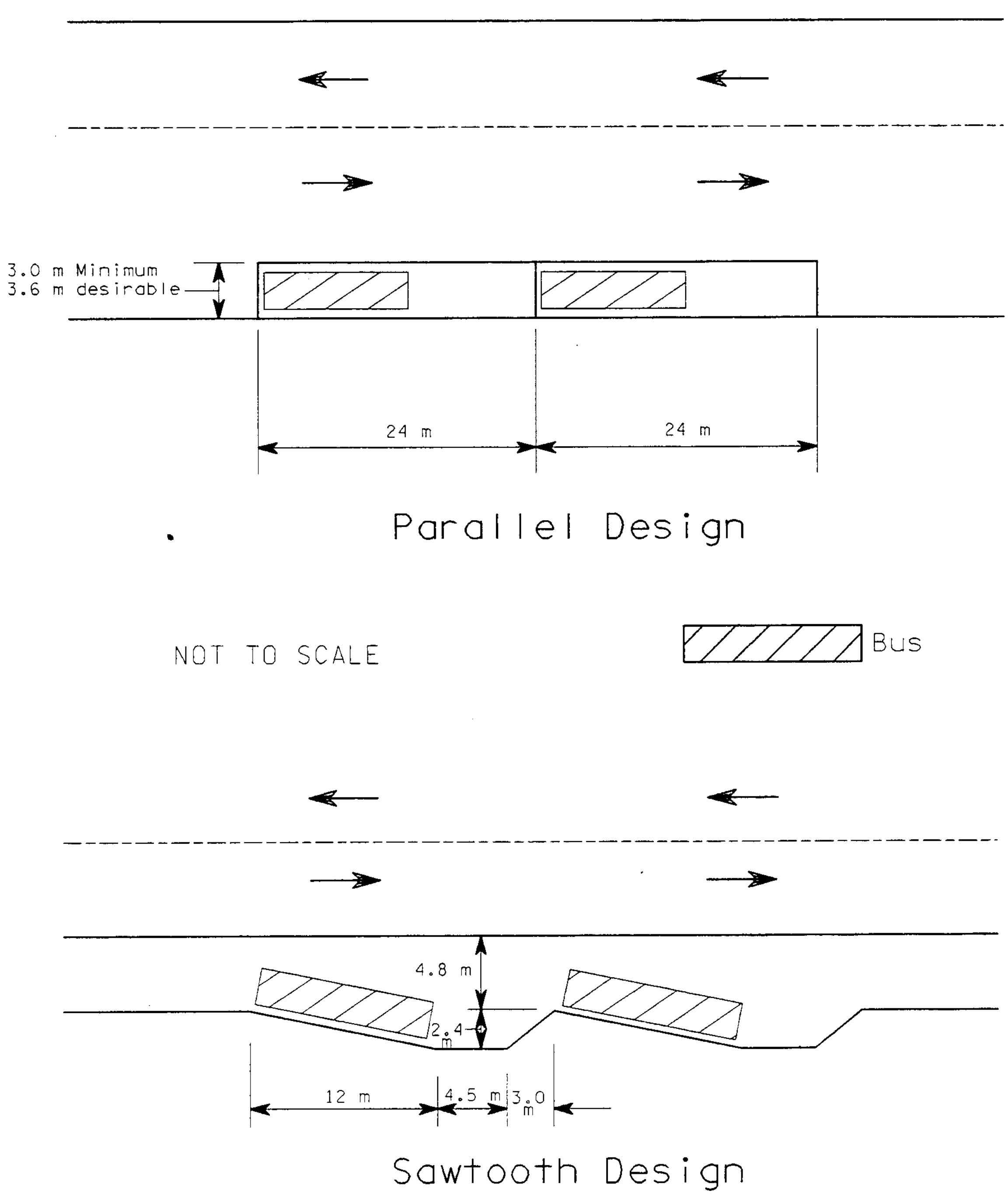
Access By Design: Transit's Role in Land Development, Mass Transit Administration, Maryland Department of Transportation, September 1988.

Public Transportation Facilities Design Manual, Thurston Regional Planning Council, January 1986.

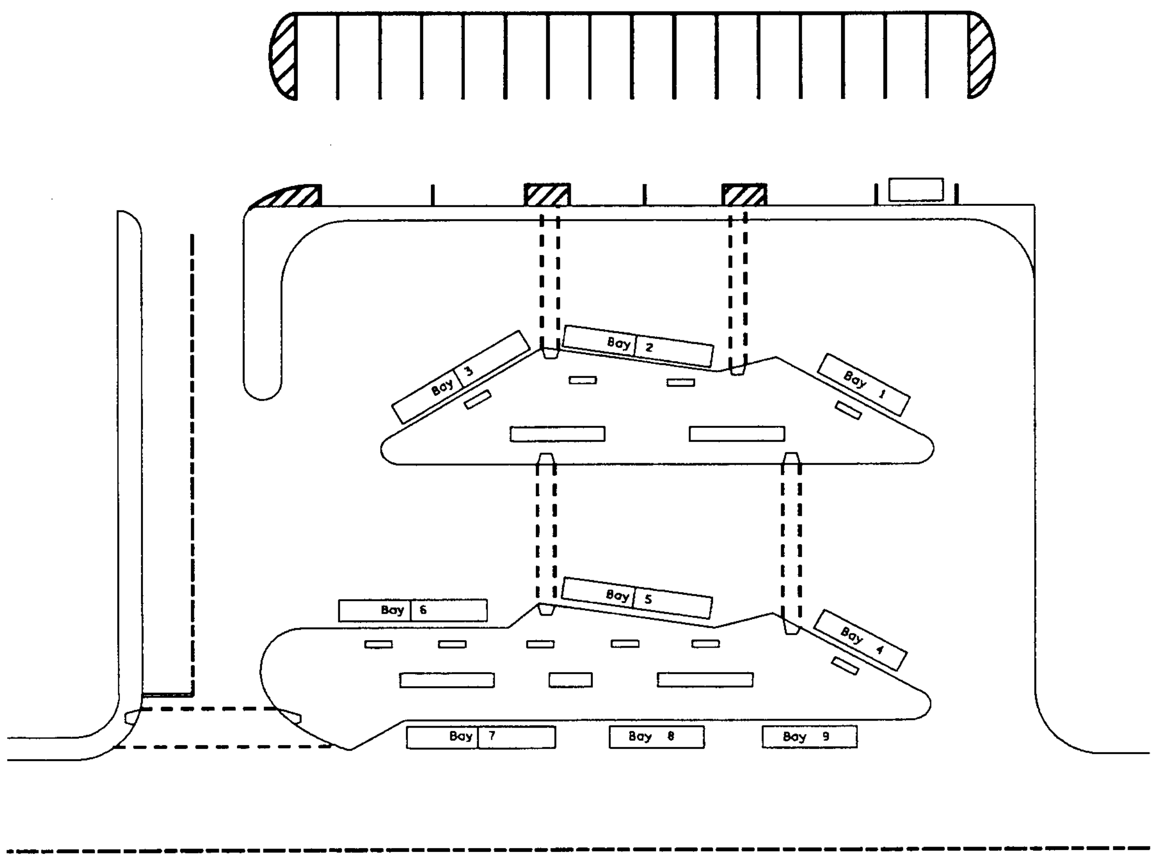
Bus Use of Highways: Planning and Design Guidelines, National Cooperative Highway Research Program Report 155, Transportation Research Board, 1975.

A Policy on Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials, 1984.

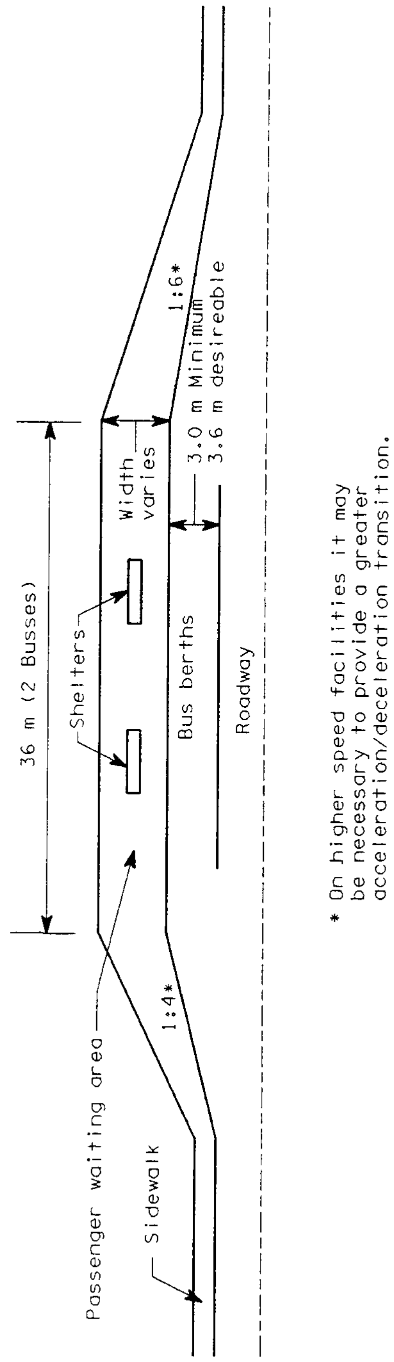
A Guide for Transportation Landscape and Environmental Design, American Association of State Highway and Transportation Officials, 1991.



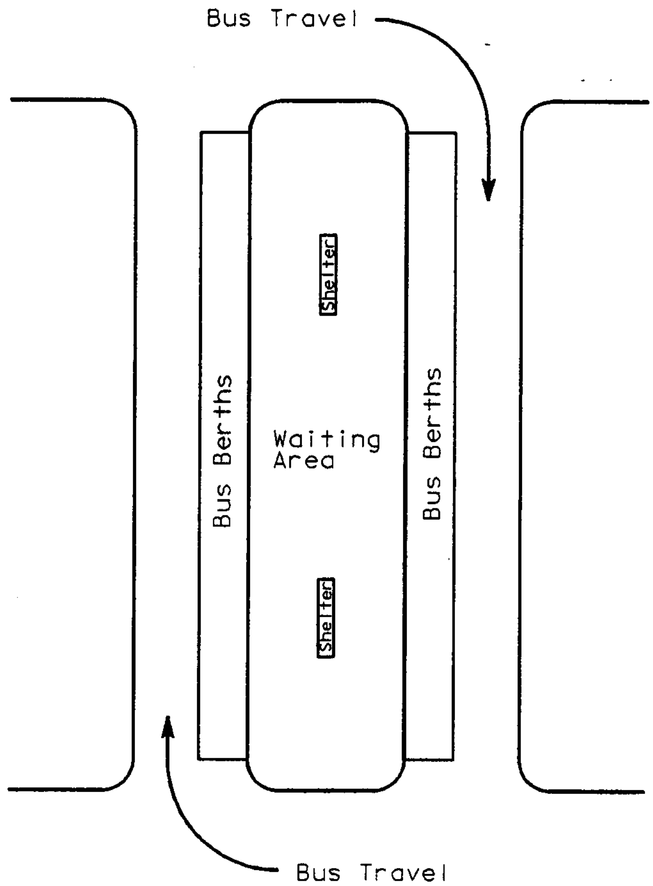
BUS BERTH DESIGNS
Figure 1060-1
(Metric)

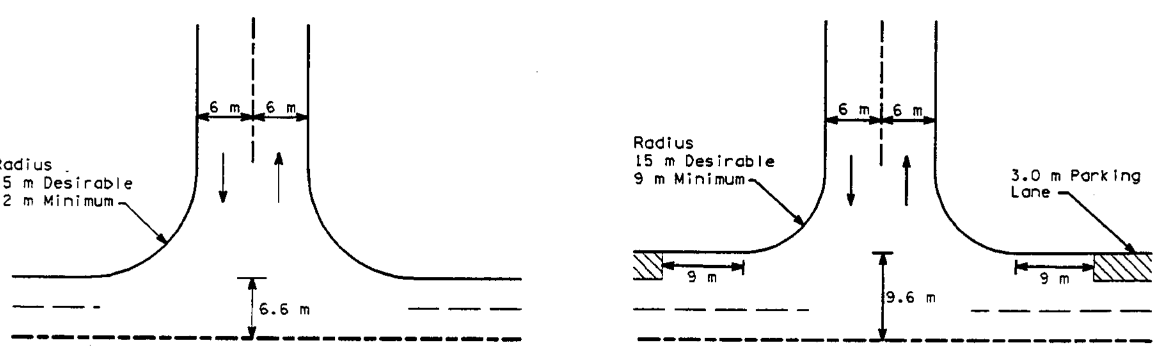


TRANSIT CENTER
SAWTOOTH BUS BERTH
DESIGN EXAMPLE
Figure 1060-2

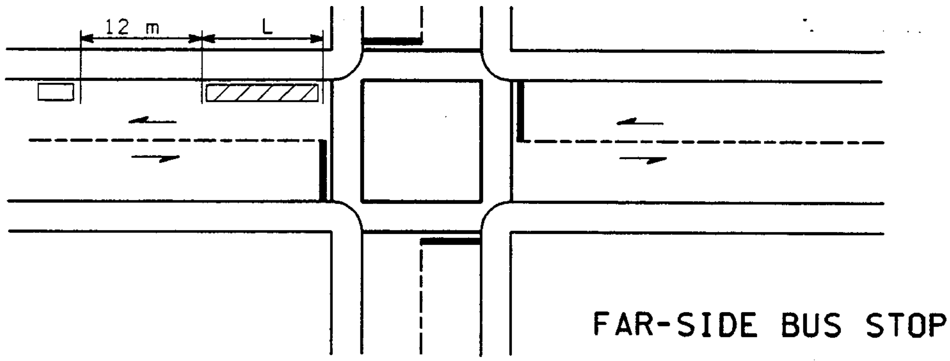


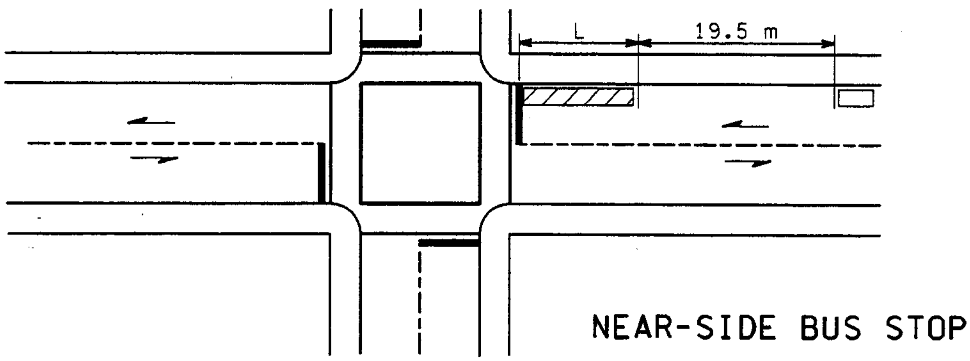
BUS TURNOUT TRANSFER CENTER
Figure 1060-3
(Metric)

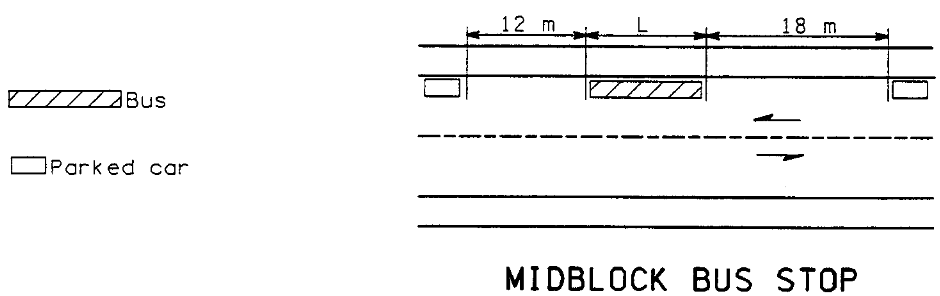




OFF-STREET TRANSFER CENTER
Figure 1060-4
(Metric)







Minimum Lengths for Bus Curb Loading Zones (L)[1]

Approx. Bus Length(L)	Loading Zone Length (meters)					
	One Bus Stop			Two Bus Stops		
	Near Side[2,3]	Far Side[2]	Mid Block	Near Side[2,3]	Far Side[2]	Mid Block
7.5	27	19.5	37.5	36	27	45
9	28.5	21	39	39	30	48
10.5	30	22.5	40.5	42	33	51
12	31.5	24	42	45	36	54
18	37.5	30	48	57	48	66

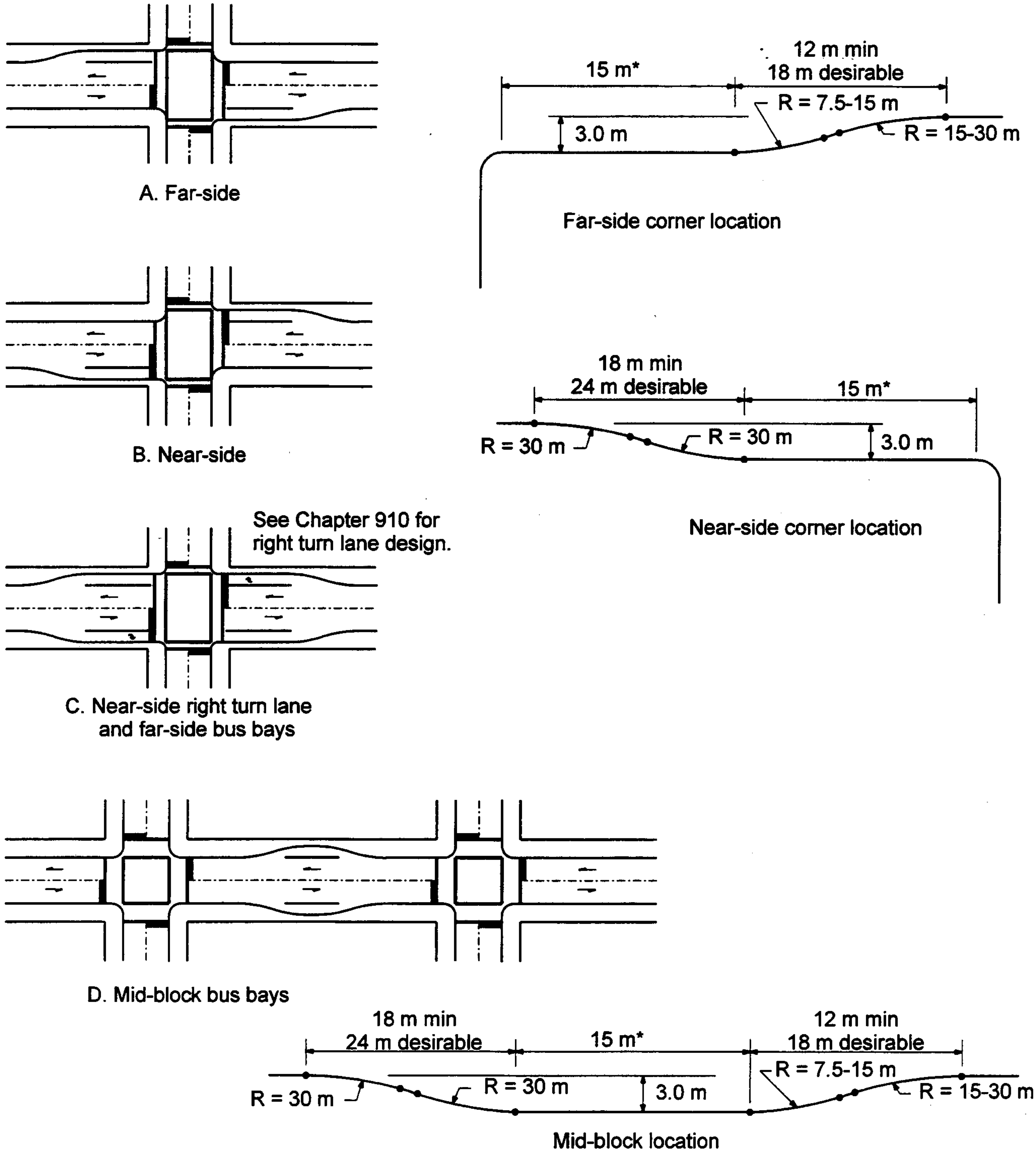
[1]Based on bus 0.3 m from curb. When bus is 0.15 m from curb, add 6.0 m near side, 4.5 m far side, and 6.0 m midblock. Based on streets 12.0 m wide, add 4.5 m when 10.5 m wide and 9.0 m when 9.6 m wide.

[2]Measured from extension of building line or established stop line. Add 4.5 m where buses make a right turn.

[3]Add 9.0 m where right turn volume is high for other vehicles.

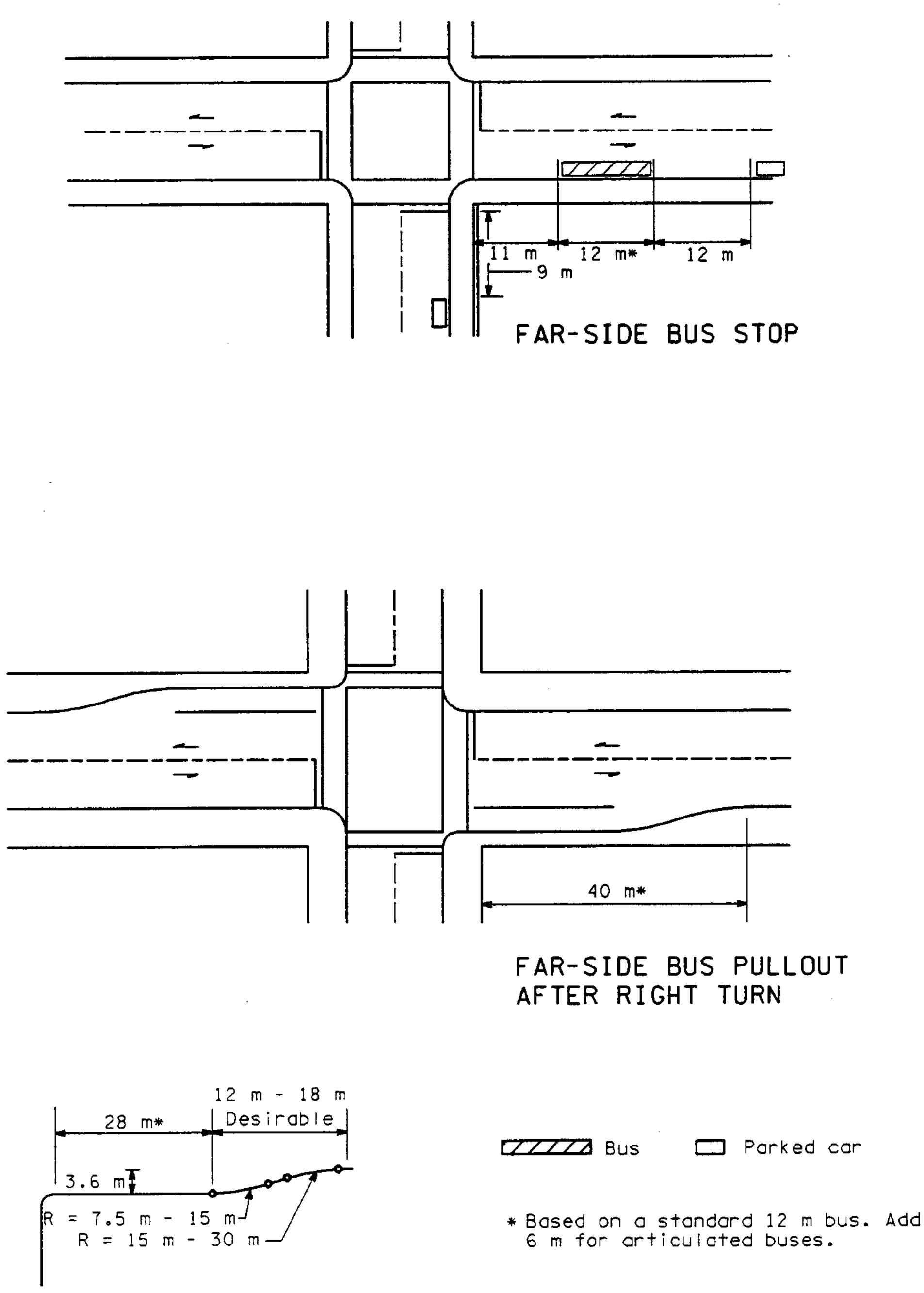
MINIMUM BUS ZONE DIMENSIONS

Figure 1060-5
(Metric)



* 15 m Bay is for one standard 12 m bus.
Add 13.5 m for each additional standard bus.
Articulated buses require 21 m bays, with
19.5 m for each additional.

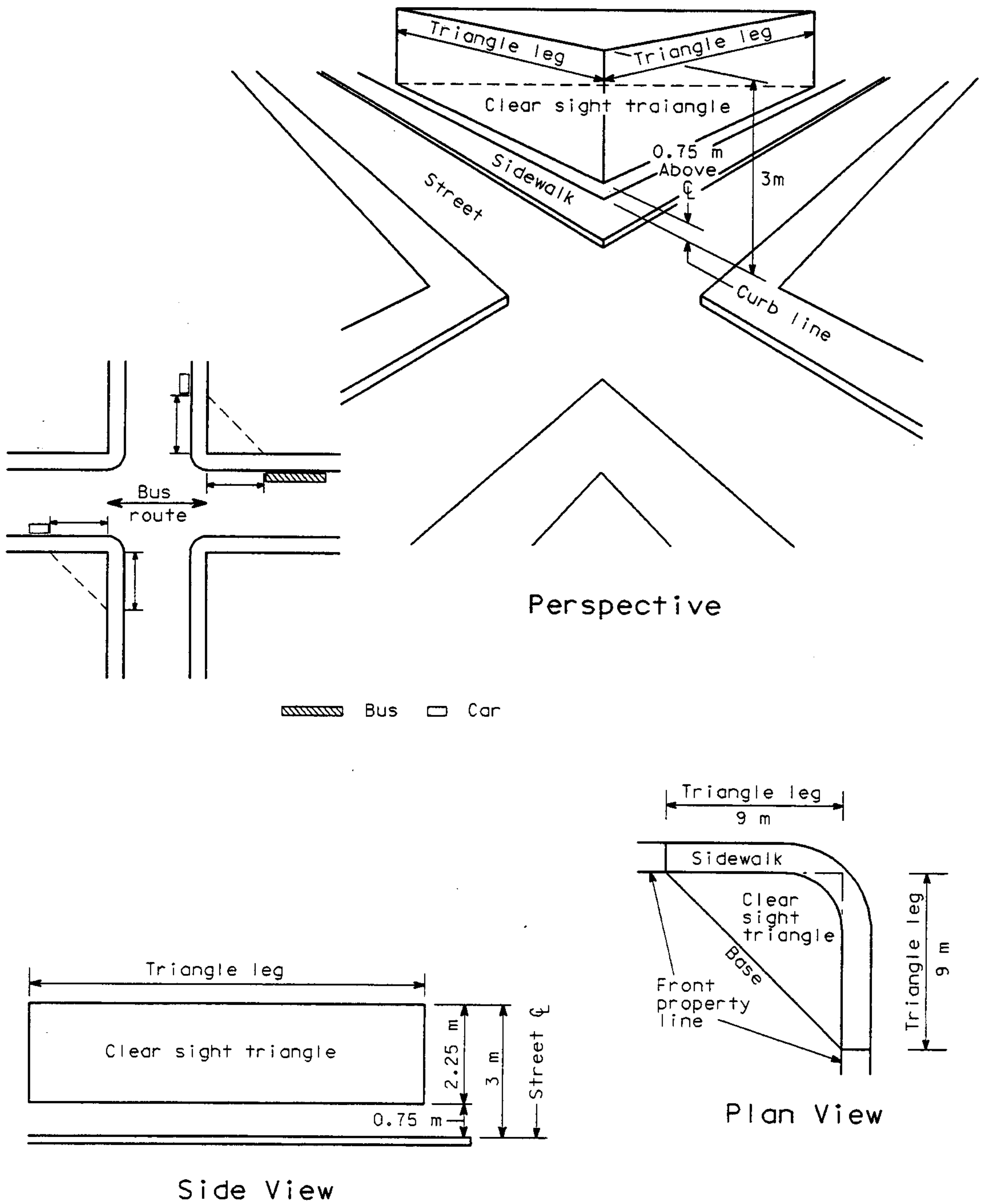
Bus Stop Pullouts, Arterial Streets
Figure 1060-6
(Metric)



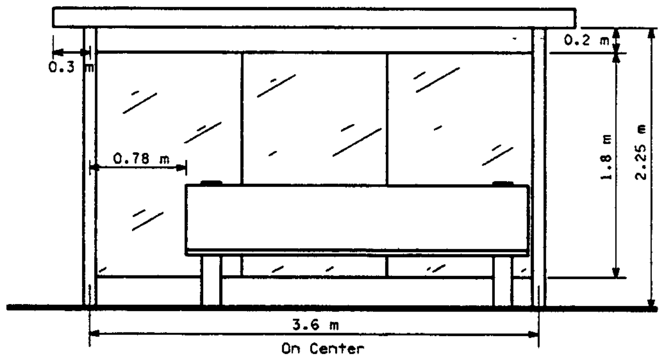
MINIMUM BUS ZONE AND PULLOUT AFTER RIGHT TURN DIMENSIONS

Figure 1060-7

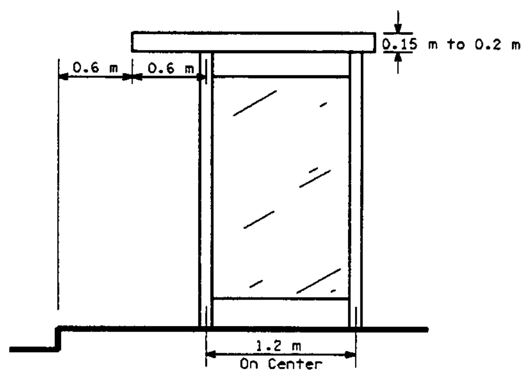
(Metric)



SHELTER SITING
Figure 1060-8
(Metric)

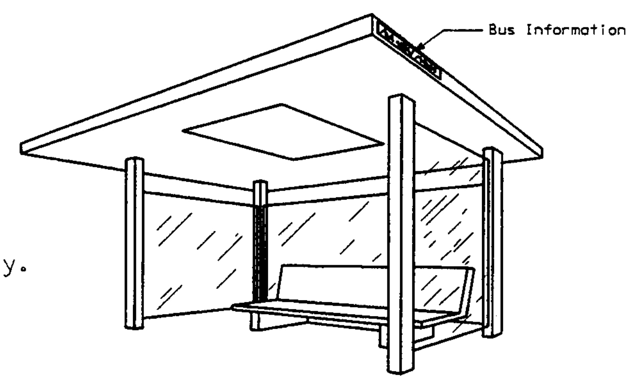


Front View



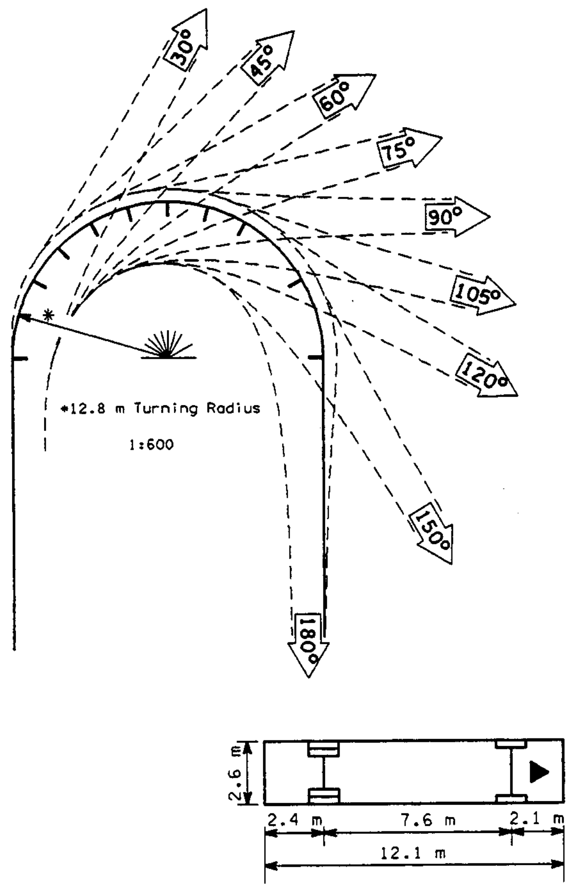
Side View

Note: Bench style can vary.

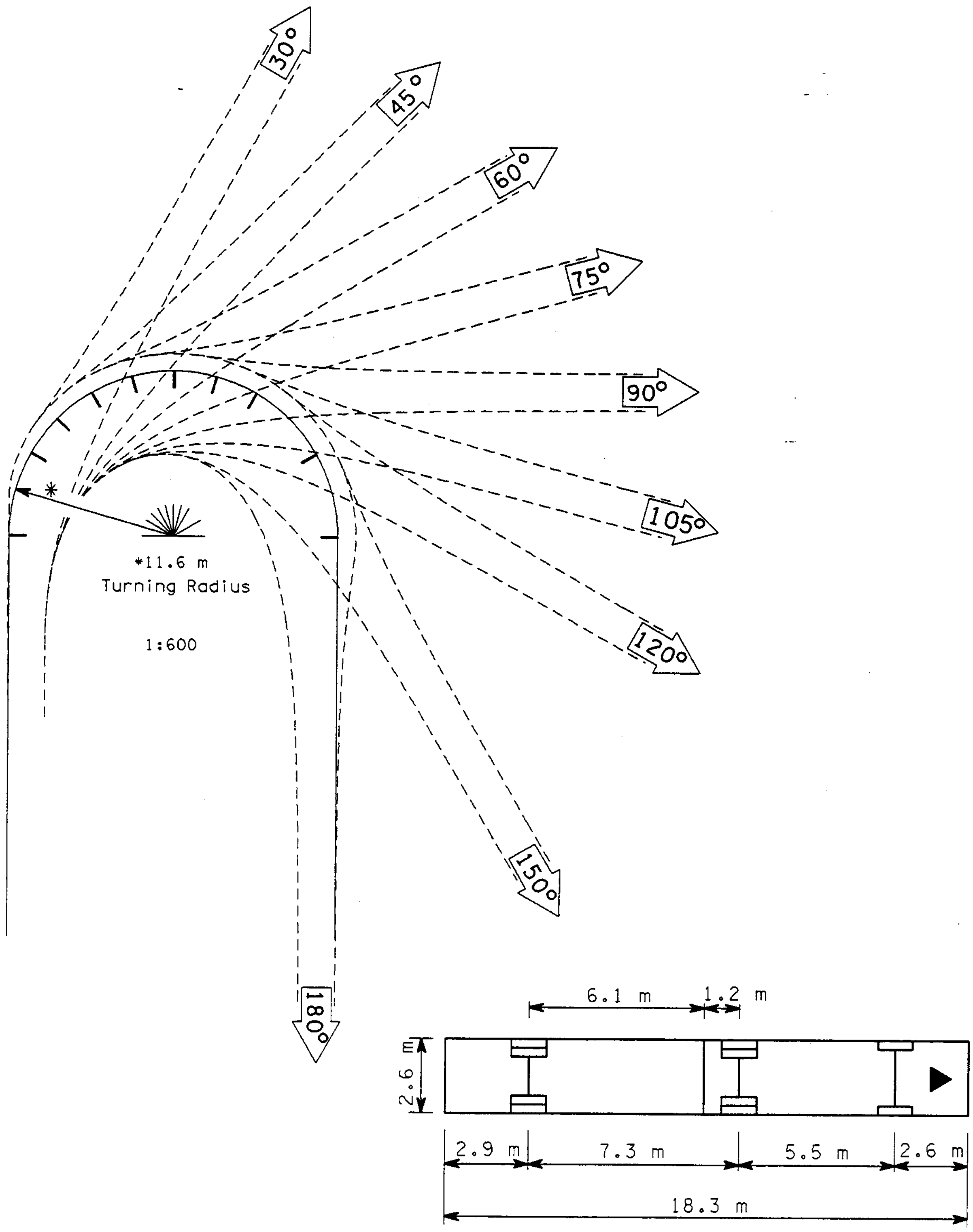


TYPICAL BUS SHELTER DESIGN

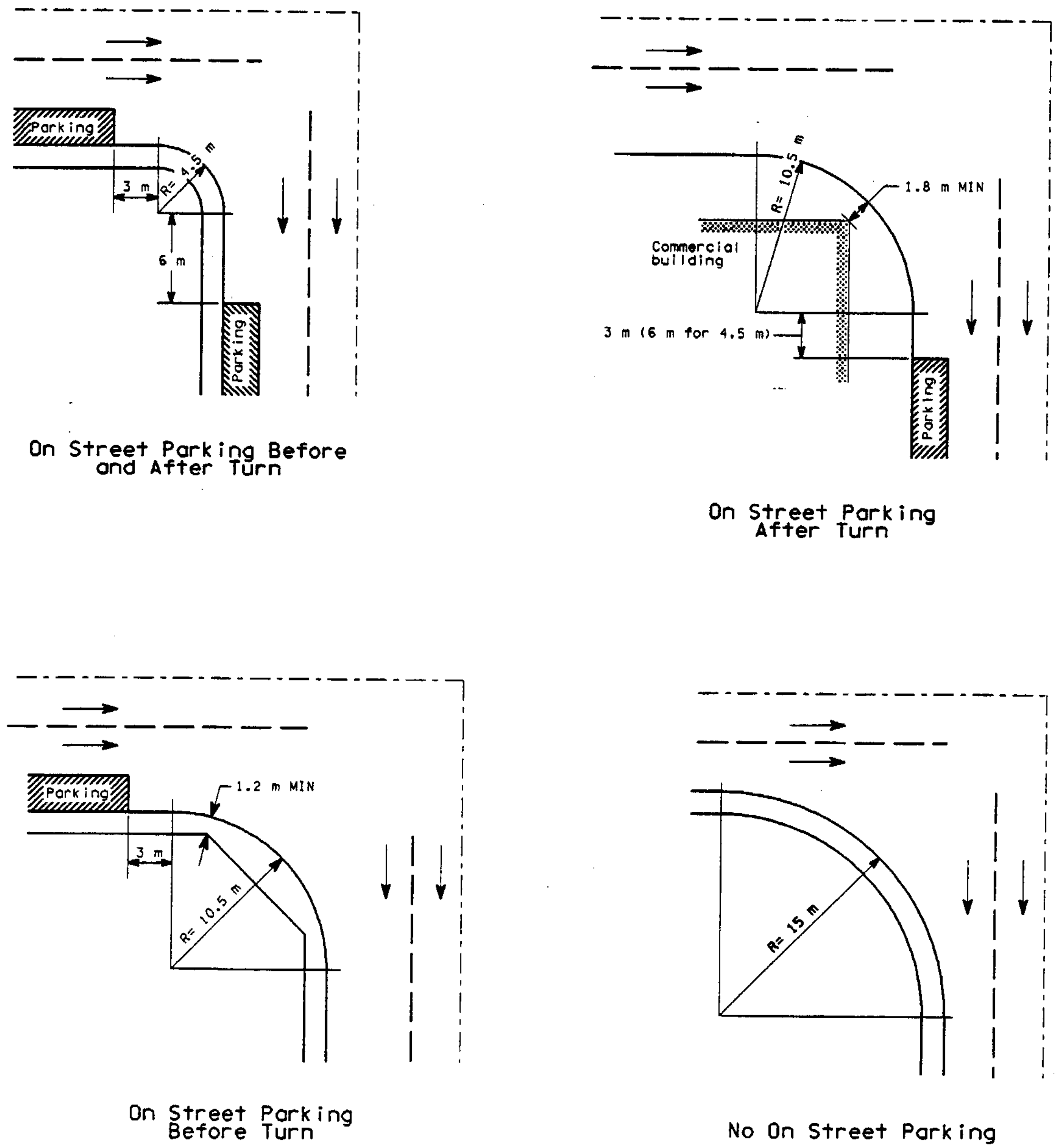
Figure 1060-9
(Metric)



Design Vehicle Turning Movements
Figure 1060-10
(Metric)

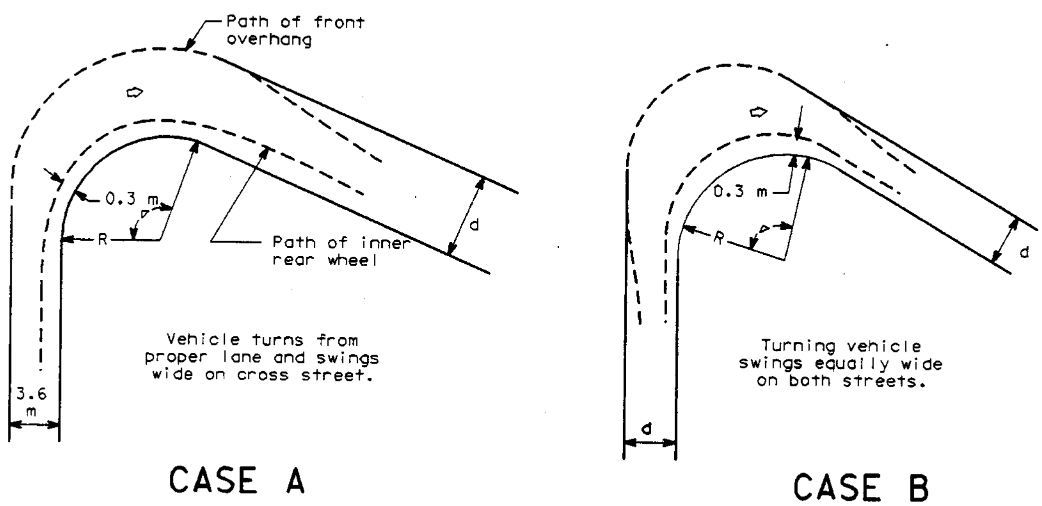


Turning Template for Articulated Bus
Figure 1060-11
(Metric)



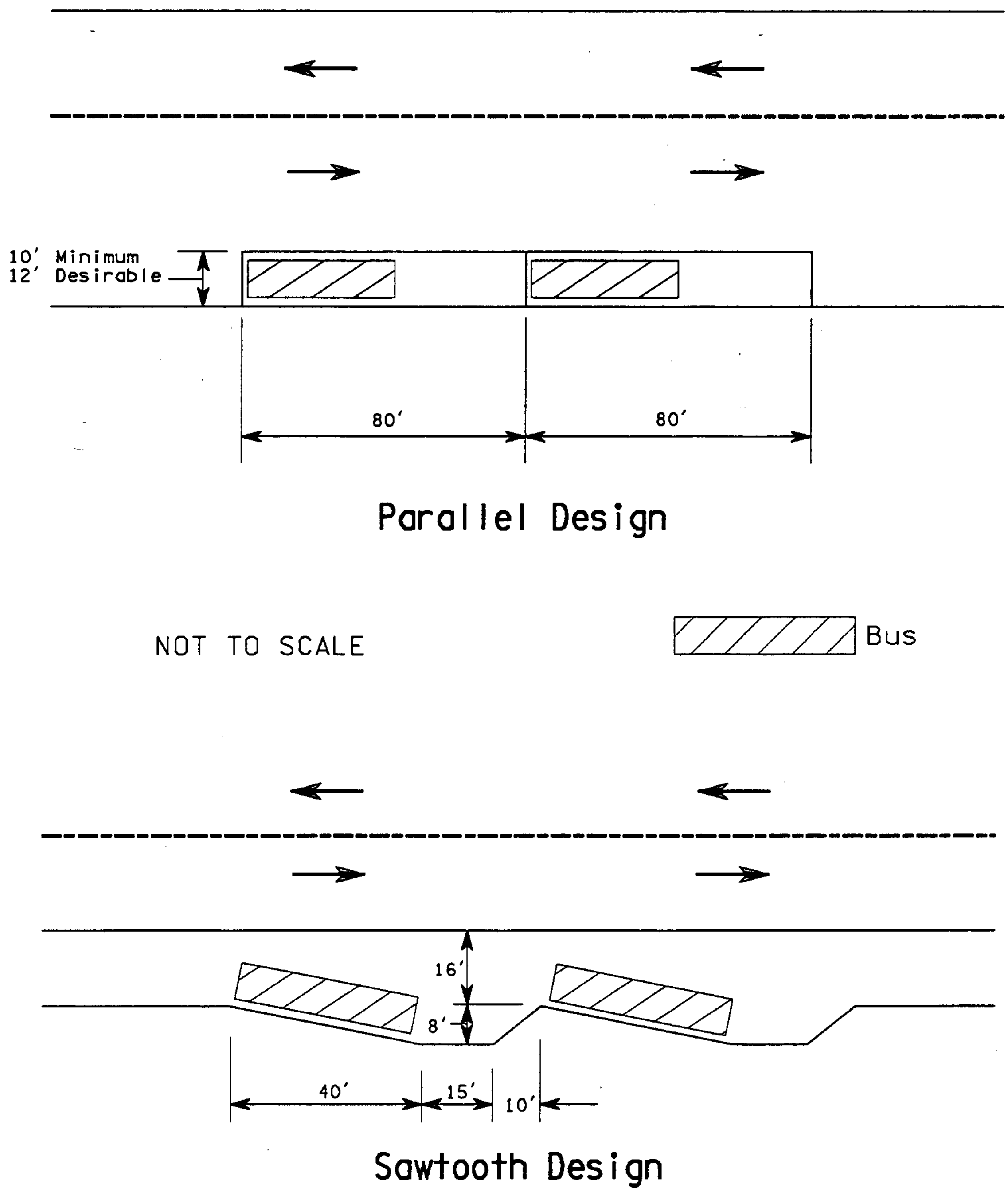
INTERSECTION DESIGN
Figure 1060-12
(Metric)

△ Design Vehicle	d (m) for Clases A and B Where:									
	R = 4.5 m		R = 6 m		R = 7.5 m		R = 9 m		R = 12 m	
	A	B	A	B	A	B	A	B	A	B
30°	6.6	5.1	5.7	5.1	5.7	5.1	5.7	5.1	5.4	5.1
60°	8.4	6.3	7.8	6.0	7.2	6.0	6.9	5.7	6.6	5.4
90°	11.4	6.9	9.9	6.6	9.0	6.6	7.5	6.3	6.3	5.4
120°	13.8	8.4	12.0	7.5	9.6	6.9	7.8	5.7	5.7	5.4
150°	14.4	8.4	12.0	7.5	9.6	6.9	6.6	5.4	5.1	4.8

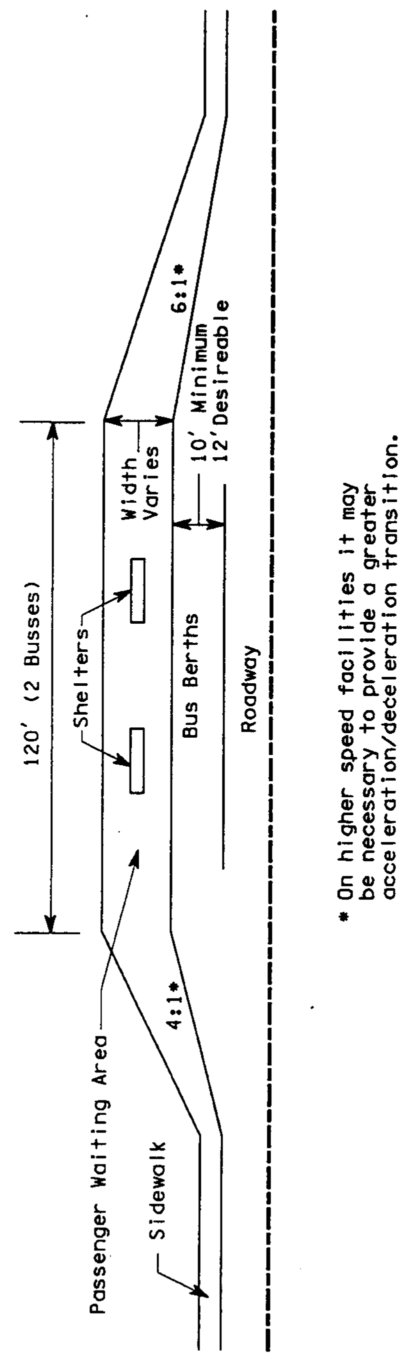


CROSS-STREET WIDTH OCCUPIED BY TURNING VEHICLE FOR VARIOUS ANGLES OF INTERSECTION AND CURB RADII

Figure 1060-13
(Metric)

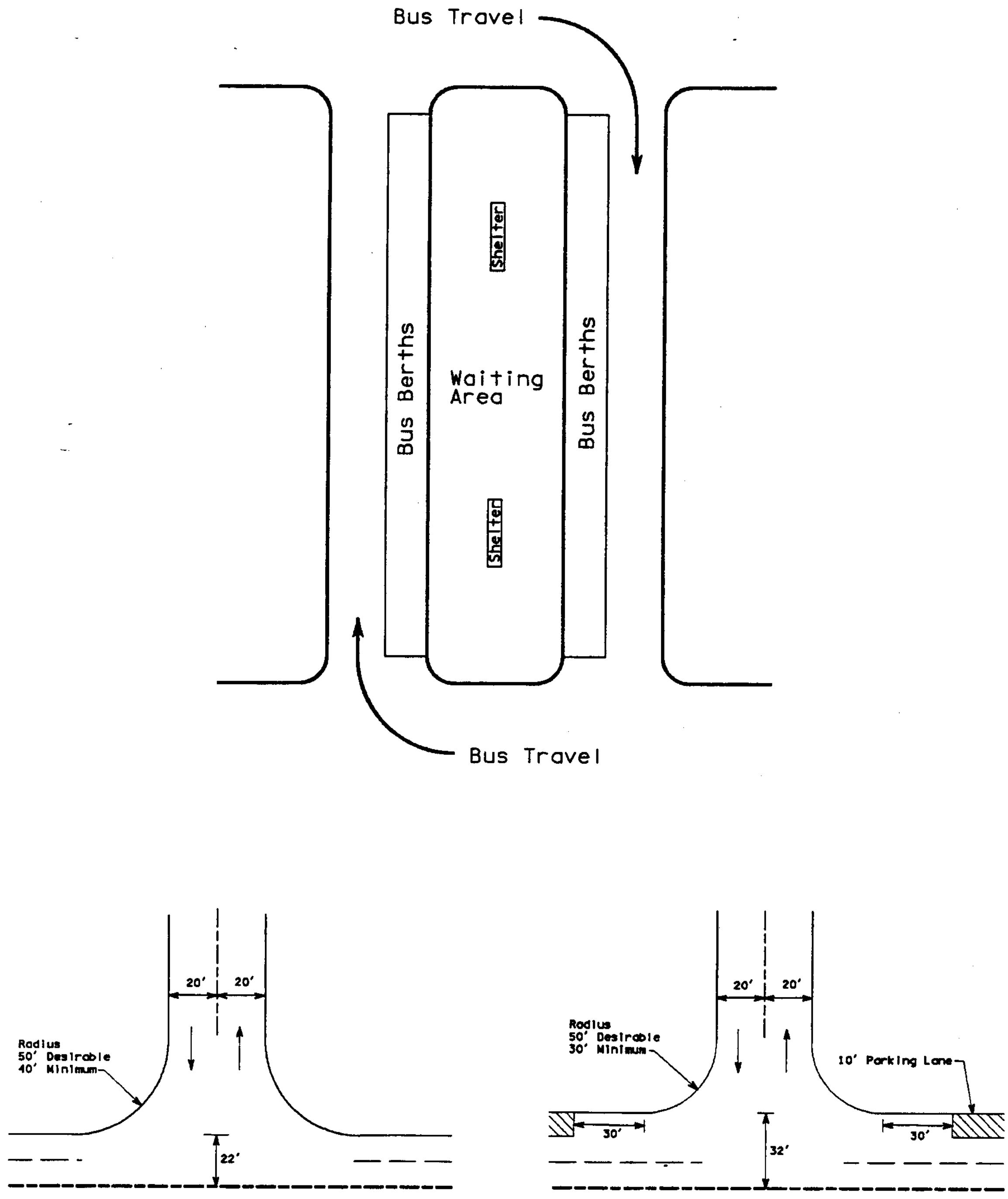


BUS BERTH DESIGNS
Figure 1060-1

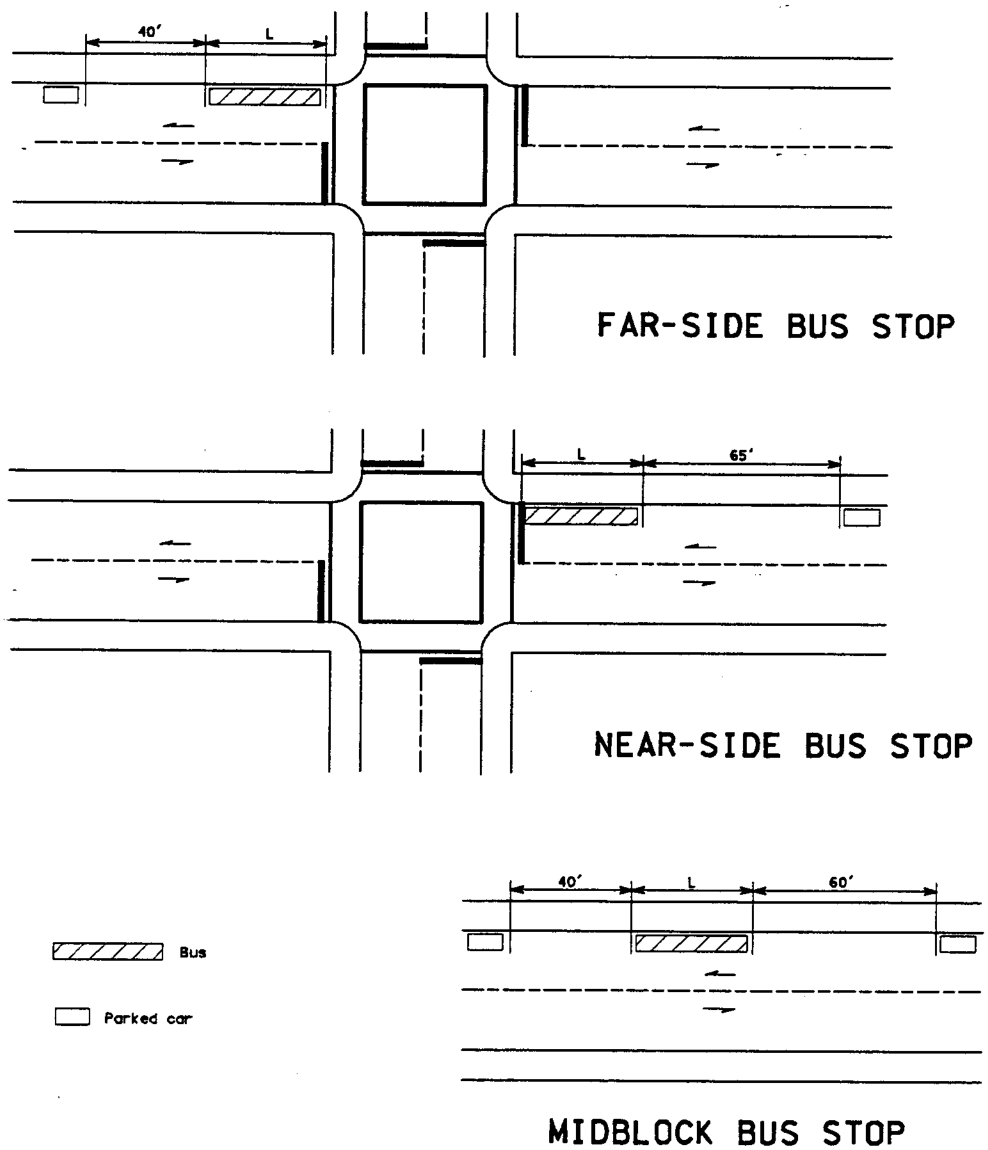


BUS TURNOUT TRANSFER CENTER

Figure 1060-3



OFF-STREET TRANSFER CENTER
Figure 1060-4



Minimum Lengths for Bus Curb Loading Zones (L)[1]

Approx. Bus Length(L)	Loading Zone Length (feet)					
	One Bus Stop			Two Bus Stops		
	Near Side[2,3]	Far Side[2]	Mid Block	Near Side[2,3]	Far Side[2]	Mid Block
25	90	65	125	120	90	150
30	95	70	130	130	100	160
35	100	75	135	140	110	170
40	105	80	140	150	120	180
60	125	100	160	190	160	220

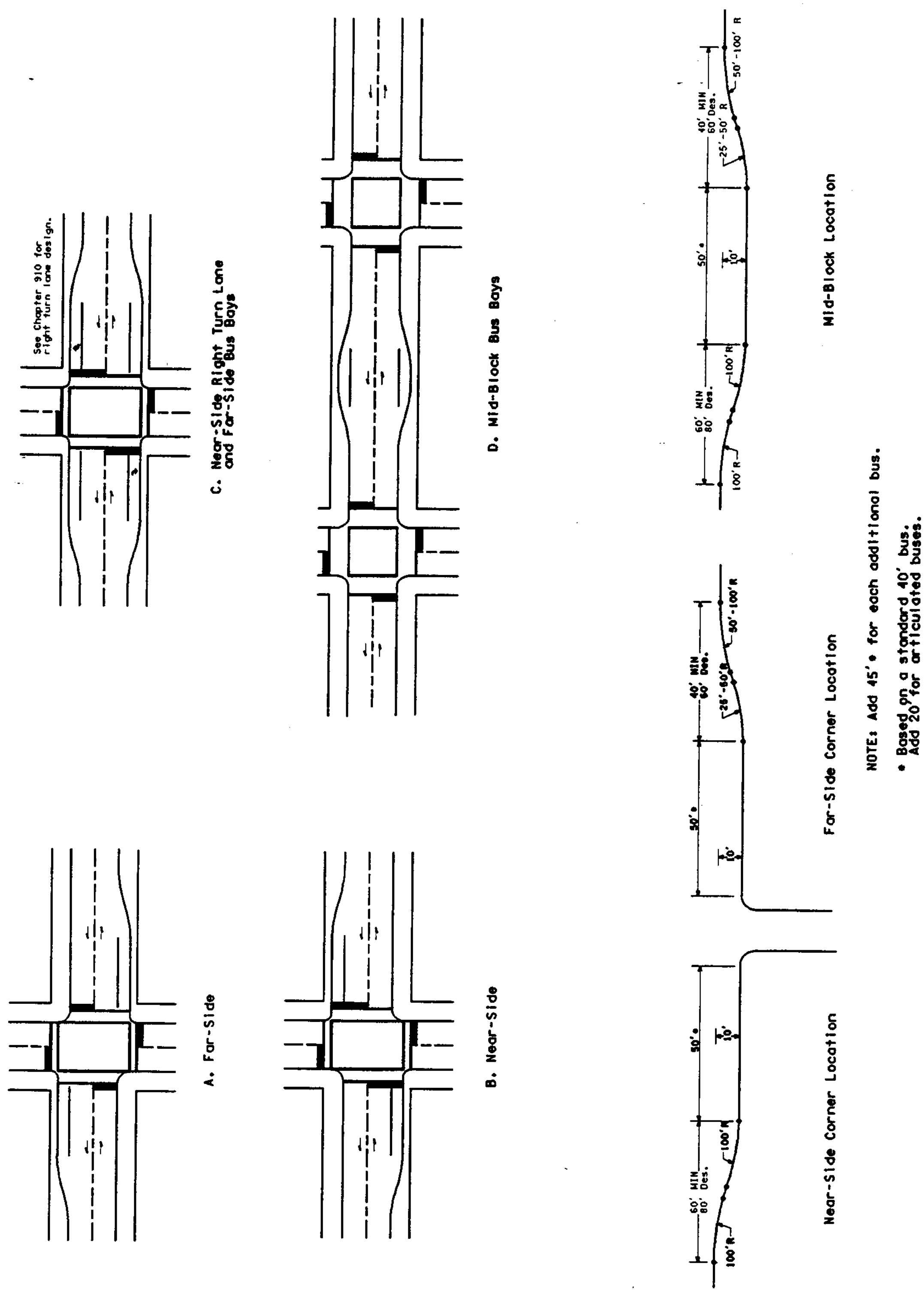
[1]Based on bus 1 foot from curb. When bus is 0.5 feet from curb, add 20 feet near side, 15 feet far side, and 20 feet midblock. Based on streets 40 feet wide, add 15 feet when 35 feet wide and 30 feet when 32 feet wide.

[2]Measured from extension of building line or established stop line. Add 15 feet where buses make a right turn.

[3]Add 30 feet where right turn volume is high for other vehicles.

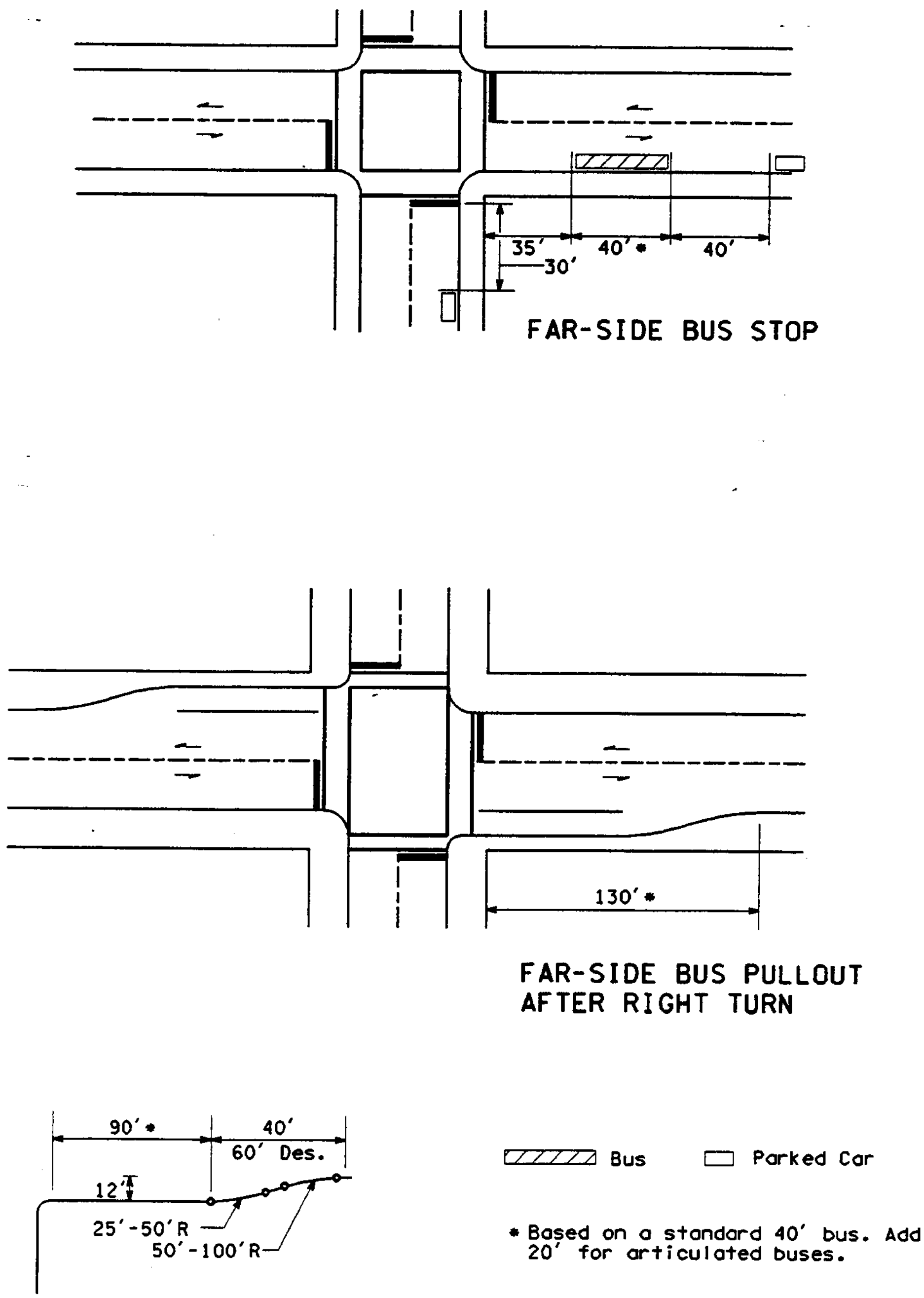
MINIMUM BUS ZONE DIMENSIONS

Figure 1060-5



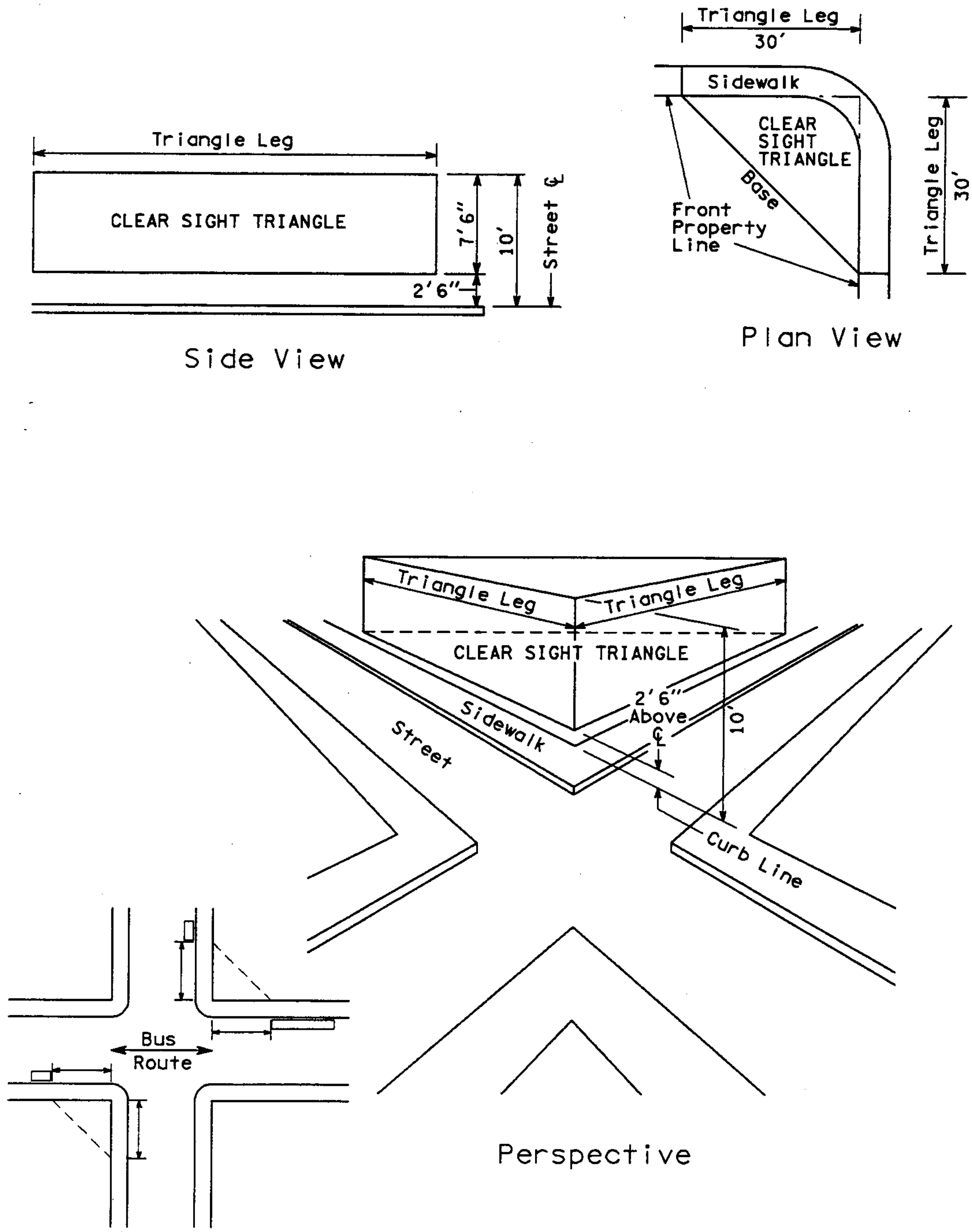
BUS STOP PULLOUTS, ARTERIAL STREETS

Figure 1060-6

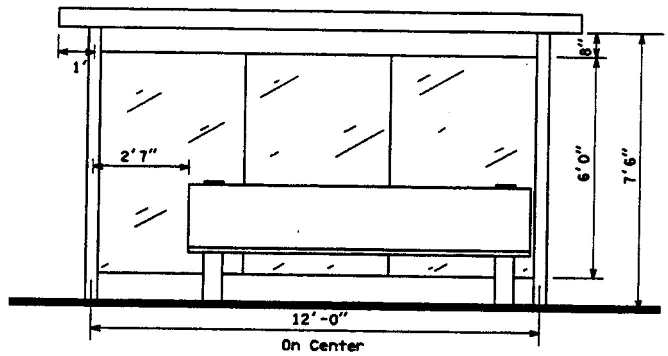


MINIMUM BUS ZONE AND PULLOUT AFTER RIGHT TURN DIMENSIONS

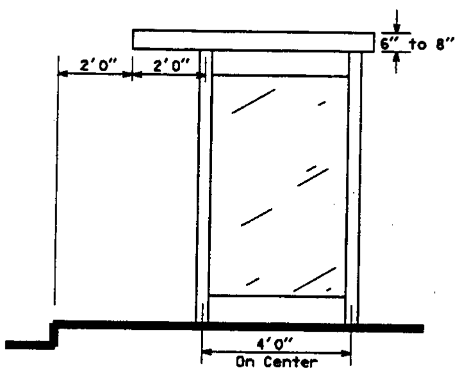
Figure 1060-7



SHELTER SITING
Figure 1060-8

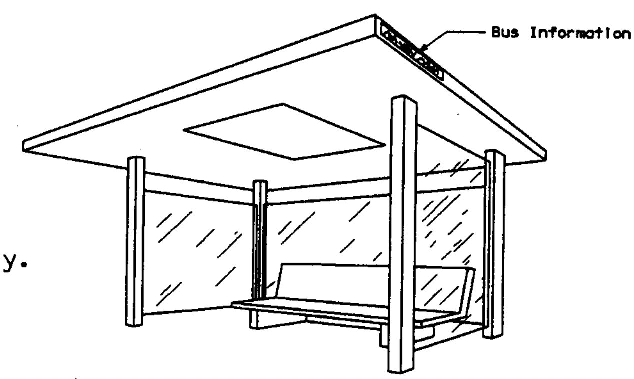


Front View



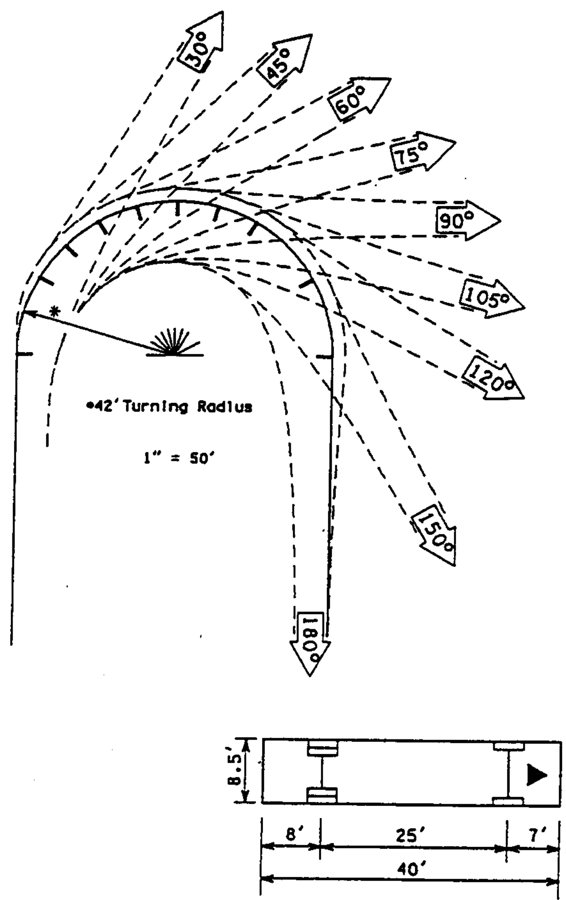
Side View

Note: Bench style can vary.

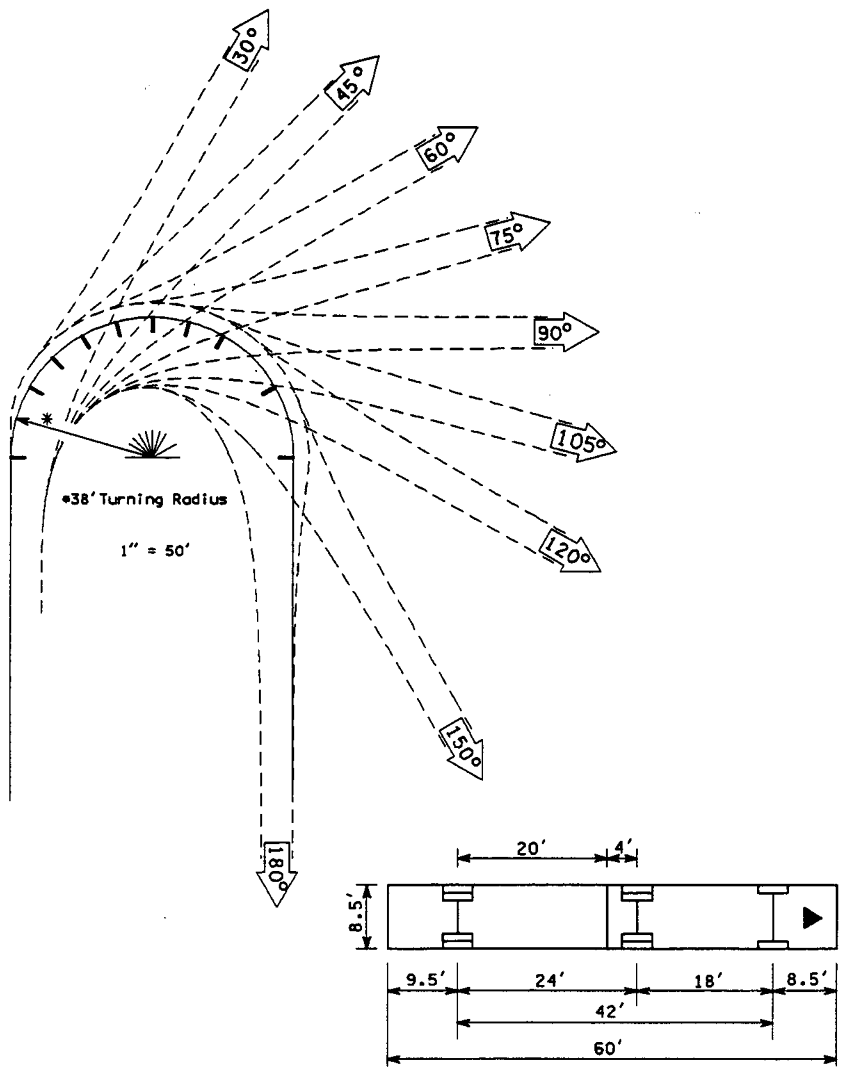


TYPICAL BUS SHELTER DESIGN

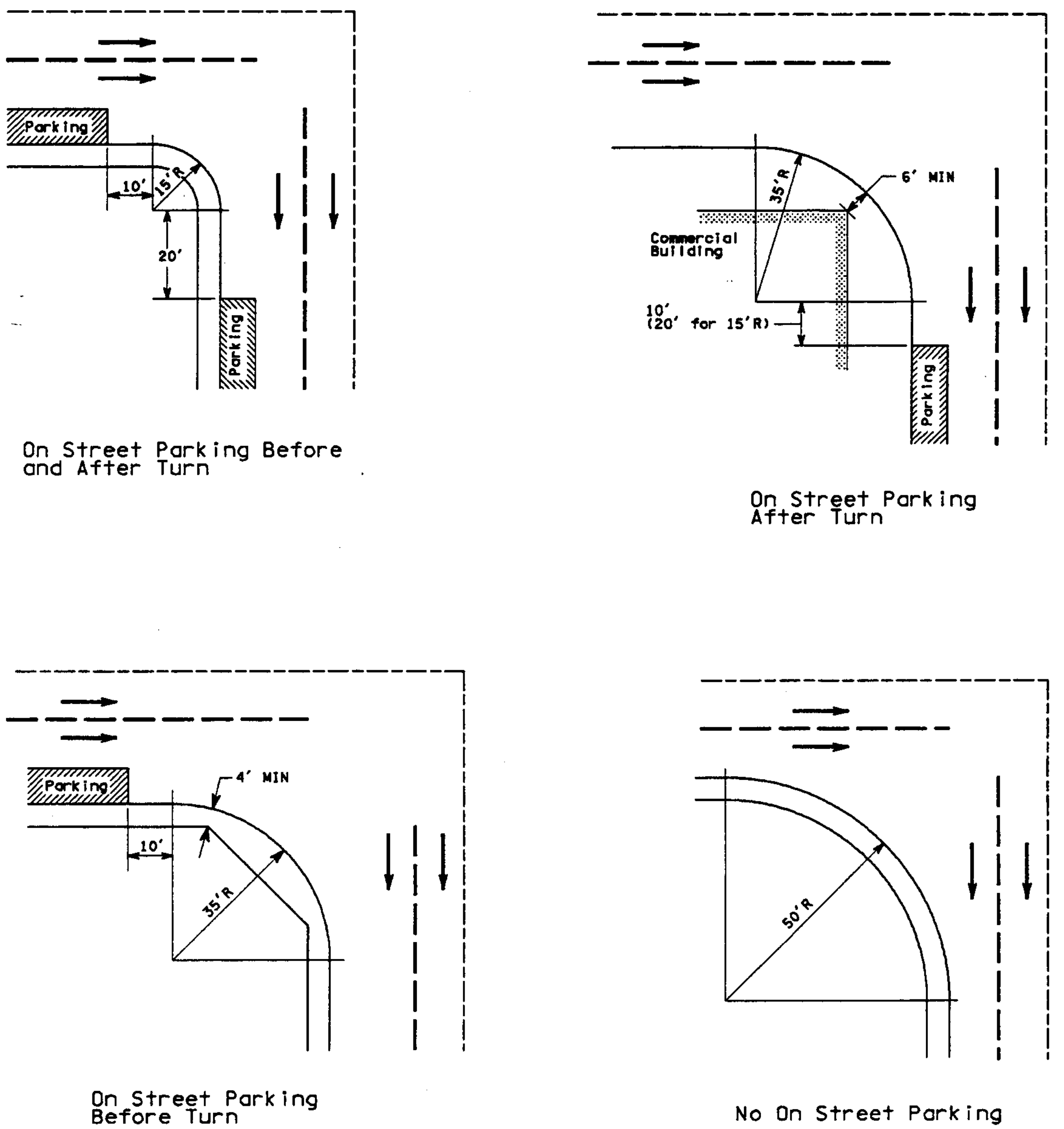
Figure 1060-9



Design Vehicle Turning Movements
Figure 1060-10



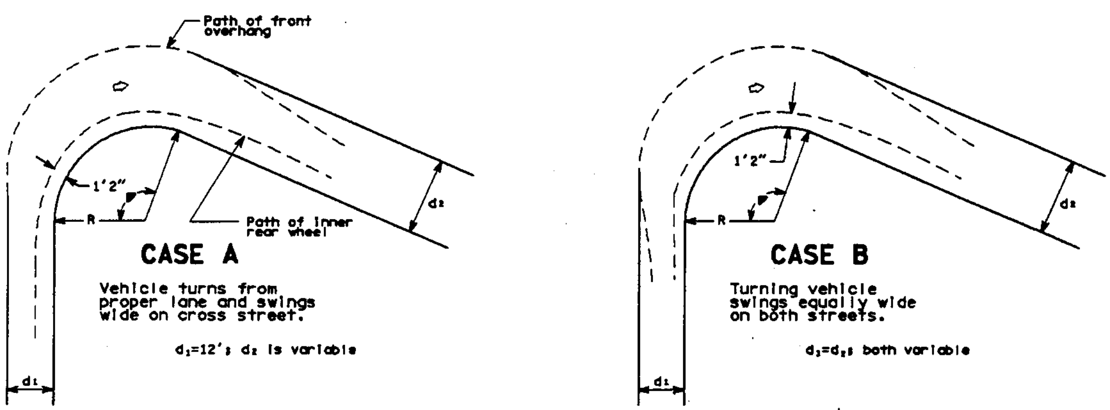
Turning Template for Articulated Bus
Figure 1060-11



INTERSECTION DESIGN
Figure 1060-12

d_2 (ft) for Cases A and B Where:

Design Vehicle	R=15′		R=20′		R=25′		R=30′		R=40′	
	A	B	A	B	A	B	A	B	A	B
30°	22	17	19	17	19	17	19	17	18	17
60°	28	21	26	20	24	20	23	19	22	18
90°	38	23	33	22	30	22	25	21	21	18
120°	46	28	40	25	32	23	26	19	19	18
150°	48	28	40	25	32	23	22	18	17	16



CROSS-STREET WIDTH OCCUPIED BY TURNING VEHICLE FOR VARIOUS ANGLES OF INTERSECTION AND CURB RADII

Figure 1060-13

1110.01 General

The Headquarters (HQ) Bridge and Structures Office provides structural design services to the regions. This chapter describes the information required by the HQ Bridge and Structures Office to perform this function.

1110.02 References

Bridge Design Manual, M 23-50, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

1110.03 Required Data for All Structures

Submit the bridge site data to the HQ Bridge and Structures Office. Provide a cover memo that gives general information on the project, describes the attachments, and transmits the forms and data included in the submittal. Submit site data as a CAD file, supplemental drawings, and a report. See Figure 1110-1 for items to include in a bridge site data submittal. Direct any questions relating to the preparation of bridge site data to the HQ Bridge and Structures Office. The *Bridge Design Manual* shows examples of required WSDOT forms.

(1) CAD Files and Supplemental Drawings

The HQ Bridge and Structures Office uses the microGDS Computer-Aided Drafting (CAD) system. CAD files prepared for use as bridge site data will be accepted in standard DGN, DXF, or DWG format.

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

Use a complete and separate CAD file for each structure. See the *Plans Preparation Manual* for information regarding drawing levels and use the Bridge and Structures format. The *Bridge Design Manual* contains examples of completed Bridge Preliminary Plans. These plans show examples of the line styles and drawing format for site data in CAD.

Include the following information in the CAD files or in the supplemental drawings:

(a) **Plan**

- Drawing scales for the bridge site plan:

Length of Structure	**Scale**
20 ft to 100 ft	1″=10′
100 ft to 500 ft	1″=20′
500 ft to 800 ft	1″=30′
800 ft to 1,100 ft	1″=40′
more than 1,100 ft	1″=50′

  The bridge site data is used to prepare the bridge layout plan which is to be used in the contract plans. The drawing scales shown are for the full-sized contract plan format and are a guide only. Consider the width and general alignment of the structure when selecting the scale. For structures on curved alignments or where the bridge width is nearly equal to or greater than the bridge length, consult the HQ Bridge and Structures Office for an appropriate plan scale.

- Vertical and horizontal datum control. See Chapters 1440 and 1450.
- Contours of the existing ground surface. Use intervals of 1, 2, 5, or 10 ft depending on terrain and plan scale. The typical contour interval is 2 ft. Use 1 ft intervals for flat terrain. Use 5 ft or 10 ft intervals for steep terrain or small scales. Show contours beneath an existing or proposed structure and beneath the water surface of any waterway.
- Alignment of the proposed highway and traffic channelization in the vicinity.
- Location by section, township, and range.

- Type, size, and location of all existing or proposed sewers, telephone and power lines, water lines, gas lines, traffic barriers, culverts, bridges, buildings, and walls.
- Location of right of way lines and easement lines.
- Distance and direction to nearest towns or interchanges along the main alignment in each direction.
- Location of all roads, streets, and detours.
- Stage construction plan and alignment.
- Type, size, and location of all existing and proposed sign structures, light standards, and associated conduits and junction boxes. Provide proposed signing and lighting items when the information becomes available.
- Location of existing and proposed drainage.
- Horizontal curve data. Include coordinates for all control points.

(b) **Profile**

- Profile view showing the grade line of the proposed or existing alignment and the existing ground line along the alignment line.
- Vertical curve data.
- Superelevation transition diagram.

(c) **Section**

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

(2) Report

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

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

(3) Video and Photographs

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

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

1110.04 Additional Data for Waterway Crossings

Coordinate with the Headquarters (HQ) Hydraulics Branch and supplement the bridge site data for all waterway crossings with the DOT Form 235-001, “Bridge Site Data for Stream Crossings” and the following:

- Show riprap or other slope protection requirements at the bridge site (type, plan limits, and cross section) as determined by the HQ Hydraulics Branch.
- Show a profile of the waterway. The extent will be determined by the HQ Hydraulics Branch.
- Show cross sections of the waterway. The extent will be determined by the HQ Hydraulics Branch.

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

Many waterway crossings require a permit from the U.S. Coast Guard. (See Chapter 240.) Generally, ocean tide influenced waterways and waterways used for commercial navigation require a Coast Guard permit. These structures require the following additional information:

- Names and addresses of the landowners adjacent to the bridge site.
- Quantity of new embankment material within the floodway. This quantity denotes, in cubic yards, the material below normal high water and the material above normal high water.

Some waterways may qualify for an exemption from Coast Guard permit requirements if certain conditions are met. See the *Bridge Design Manual*. If the waterway crossing appears to satisfy these conditions, then submit a statement explaining why this project is exempt from a Coast Guard permit. Attach this exemption statement to the Environmental Classification Summary prepared for the project and submit it to the HQ Design Office for processing to FHWA.

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

1110.05 Additional Data for Grade Separations

(1) Highway-Railroad Separation

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

(a) **Plan**

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

(b) **Profile**

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

(2) Highway-Highway Separation

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

(a) **Plan**

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

(b) **Profile**

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

(c) **Section**

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

1110.06 Additional Data for Widenings

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

Supplement bridge site data for structures involving bridge widenings by the following:

- Submit DOT Form 235-002A, "Supplemental Bridge Site Data-Rehabilitation/Modification."

(a) **Plan**

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

(b) **Profile**

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

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

1110.07 Documentation

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

Review Chapter 1110 of the *Design Manual*
for further information and description of the items listed below.

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

TABLES (In tabular format in CAD file.)
- _____ Curb Line Elevations at Top of Existing Bridge Deck
- _____ Undercrossing Roadway Existing Elevations
- _____ Undercrossing Railroad Existing Elevations
- _____ Curve Data

OTHER SITE DATA (May be in CAD or may be on supplemental sheets or drawings.)
- _____ Superelevation Diagrams
- _____ End Slope Rate
- _____ Profile Grade Vertical Curves
- _____ Coast Guard Permit Status
- _____ Railroad Agreement Status
- _____ Highway Classification
- _____ Design Speed
- _____ ADT, DHV, and % Trucks

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

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

Bridge Site Data for Stream Crossings
- _____ Water Surface Elevations and Flow Data
- _____ Riprap Cross Section Detail

Supplemental Bridge Site Data-Rehabilitation/Modification

BRIDGE, CROSSROAD, AND APPROACH ROADWAY CROSS SECTIONS
(May be in CAD or separate drawings.)
- _____ Bridge Roadway Width
- _____ Lane and Shoulder Widths
- _____ Profile Grade and Pivot Point
- _____ Superelevation Rate
- _____ Survey Line
- _____ PB/Pedestrian Rail Dimensions
- _____ Stage Construction Lane Orientations
- _____ Locations of Temporary Barrier
- _____ Conduits/Utilities in Bridge
- _____ Location and Depth of Ditches
- _____ Shoulder Widening for Barrier
- _____ Side Slope Rate

Bridge Site Data Check List
Figure 1110-1

Chapter 1120 Bridges

1120.01 General

A bridge is a structure having a clear span of 20 ft or more. Bridge design is the responsibility of the Bridge and Structures Office in Olympia. A project file is required for all bridge construction projects. The Bridge Office develops a preliminary bridge plan for a new or modified structure in collaboration with the region. This chapter provides basic design considerations for the development of this plan. Unique staging requirements, constructibility issues, and other considerations are addressed during the development of this plan. Contact the Bridge Office early in the planning stage on issues that might affect the planned project. See Chapter 141, Roles and Responsibilities for Projects with Structures, and Figures 141-1a and 1b, Determination of the Roles and Responsibilities for Projects with Structures (Project Development Phase).

1120.02 References

Bridge Design Manual, M 23-50, WSDOT

Local Agency Guidelines, M 36-63, WSDOT

Manual on Uniform Traffic Control Devices for Streets and Highways USDOT, Washington DC, including the *Washington State Modifications to the MUTCD*, WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

LRFD Bridge Design Specifications, third edition, Washington D.C.: AASHTO 2004

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

Traffic Manual, M 51-02, WSDOT

1120.03 Bridge Location

Bridges are located to conform to the alignment of the highway. Providing the following conditions can simplify design efforts, minimize construction activities, and reduce structure costs:

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

1120.04 Bridge Site Design Elements

(1) Structural Capacity

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

(a) **New Structures.** All new structures that carry vehicular loads are designed to HL-93 notional live load in accordance with AASHTO LRFD Bridge Design Specifications or HS-25 live loading in accordance with the AASHTO Standard Specifications for Highway Bridges.

(b) **Existing Structures.** When the Structural Capacity column of a design matrix applies to the project, request a Structural Capacity Report from the Risk Reduction Engineer in the HQ Bridge and Structures Office. The report will state:

- The structural capacity status of the structures within the project limits.
- What action, if any, is appropriate.
- Whether a deficient bridge is included in the six-year or 20 year plans for replacement or rehabilitation under the P2 program and, if so, in which biennium the P2 project is likely to be funded.

Include the Structural Capacity Report in the design documentation file.

The considerations used to evaluate the structural capacity of a bridge are as follows:

1. On National Highway System (NHS) routes (including Interstate routes):

- Operating load rating is at least 36 tons (which is equal to HS-20).
- The bridge is not permanently posted for legal weight vehicles.
- The bridge is not permanently restricted for vehicles requiring overweight permits.

2. On non-NHS routes:

- The bridge is not permanently posted for legal weight vehicles.
- The bridge is not permanently restricted for vehicles requiring overweight permits.

(2) Bridge Widths for Structures

(a) **New Structures.** Full design level widths are provided on all new structures. See Chapter 440. All structures on city or county routes crossing over a state highway must conform to the *Local Agency Guidelines*. Use local city or county adopted and applied criteria when their minimums exceed state criteria.

(b) **Existing Structures.** See the design matrices in Chapter 325 for guidance.

(3) Horizontal Clearance

Horizontal clearance for structures is the distance from the edge of the traveled way to bridge piers and abutments, bridge rail ends, or bridge end embankment slopes. Minimum distances for this clearance vary depending on the type of structure. The *Bridge Design Manual* provides guidance on horizontal clearance.

(4) Medians

For multilane highways, the minimum median widths for new bridges are as shown in Chapters 430 and 440. An open area between two bridges is undesirable when the two roadways are separated by a median width of 26 ft or less. The preferred treatment is to provide a new, single structure that spans the area between the roadways. When this is impractical, consider widening the two bridges on the median sides to reduce the open area to 6 in. When neither option is practical, consider installing netting or other elements to enclose the area between the bridges. Consideration and analysis of all site factors are necessary if installation of netting or other elements is proposed. Document this evaluation in the design documentation file and obtain the approval of the State Design Engineer.

(5) Vertical Clearance

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

(a) **Minimum Clearance for New Structures.** For new structures, the minimum vertical clearances are as follows:

1. A bridge over a roadway. The minimum vertical clearance is 16.5 ft.

2. A bridge over a railroad track. The minimum vertical clearance is 23.5 ft. A lesser clearance may be considered for closed or dedicated rail corridors that do not intermix with general freight rail traffic. Any such reduced clearance established for a corridor requires an agreement between the department and the railroad company and approval of the Washington State Utilities and Transportation Commission (WUTC). Vertical clearance is provided for the width of the railroad freight car. (See Figure 1120-2a.) Coordinate railroad clearance issues with the WSDOT Railroad Liaison Engineer.

3. A pedestrian bridge over a roadway. The minimum vertical clearance is 17.5 ft.

(b) **Minimum Clearance for Existing Structures.** The criteria used to evaluate the vertical clearance of existing structures depends on the work that is being done on or under that structure. When evaluating an existing structure on the Interstate system, see 1120.04(5)(d) "Coordination." This guidance applies to bridge clearances over state highways and under state highways at interchanges. For state highways over local roads and streets, city or county vertical clearance requirements may be used as minimum design criteria. See Figure 1120-1 for a table of bridge vertical clearances.

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

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

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

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

3. For other projects that include an existing bridge where no widening is proposed on or under the bridge, and the project does not affect vertical clearance, the clearance can be as little as 14.5 ft. For these projects, document the clearance to the design documentation file. For an existing bridge with less than 14.5 ft vertical clearance in this situation, an approved deviation request is required.

4. For an existing structure over a railroad track, the vertical clearance can be as little as 22.5 ft. (See Figure 1120-2b.) A lesser clearance can be used with the agreement of the railroad company and approval of the Washington State Utilities and Transportation Commission. Coordinate railroad clearance issues with the WSDOT Railroad Liaison Engineer.

(c) **Signing.** Low clearance warning signs are necessary when the vertical clearance of an existing bridge is less than 15 ft 3 in. Other requirements for low clearance signing are contained in the *Manual on Uniform Traffic Control Devices* and the *Traffic Manual*.

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

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

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

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

Notes:
1. Applies to all bridge vertical clearances over highways and under highways at interchanges
2. No documentation required
3. Document to design documentation file
4. Approved deviation required
5. Requires written agreement between railroad company and <u>the department and the approval via petition from the</u> Washington State Utilities and Transportation Commission
6. Use the same criteria as other existing bridges previously listed in the figure
7. See Figure 1120-2a and 2b

Bridge Vertical Clearances
Figure 1120-1

(6) Pedestrian and Bicycle Facilities

When pedestrians or bicyclists are anticipated on bridges, provide facilities consistent with guidance in Chapters 1020 and 1025.

(7) Bridge Approach Slab

Bridge approach slabs are reinforced concrete pavement installed across the full width of the bridge ends. They provide a stable transition from normal roadway cross section to the bridge ends and compensate for differential expansion and contraction of the bridge and the roadway. Bridge approach slabs are provided on all new bridges. If an existing bridge is being widened and it has an approach slab, slabs are required on the widenings. The region, with the concurrence of the State Geotechnical Engineer and the State Bridge Engineer, may decide to omit bridge approach slabs.

(8) Bridge Rail End Treatment

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

(9) Bridge End Embankments

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

The end slope is determined by combining the recommendations of several technical experts within the department. Figure 1120-3 illustrates the factors taken into consideration and the experts who are involved in the process.

(10) Bridge Slope Protection

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

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

Slope protection is usually not provided under pedestrian structures. The type of slope protection is selected at the bridge preliminary plan stage. Typical slope protection types are concrete slope protection, semi-open concrete masonry, and rubble stone.

(11) Slope Protection at Watercrossings

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

(12) Protective Screening for Highway Structures

The Washington State Patrol classifies the throwing of an object from a highway structure as an assault, not an accident. Therefore, records of these assaults are not contained in the Patrol's accident databases. Contact the region's Maintenance Engineer's office and the Washington State Patrol for the history of reported incidents.

Protective screening might reduce the number of incidents but will not stop a determined individual. Enforcement provides the most effective deterrent.

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

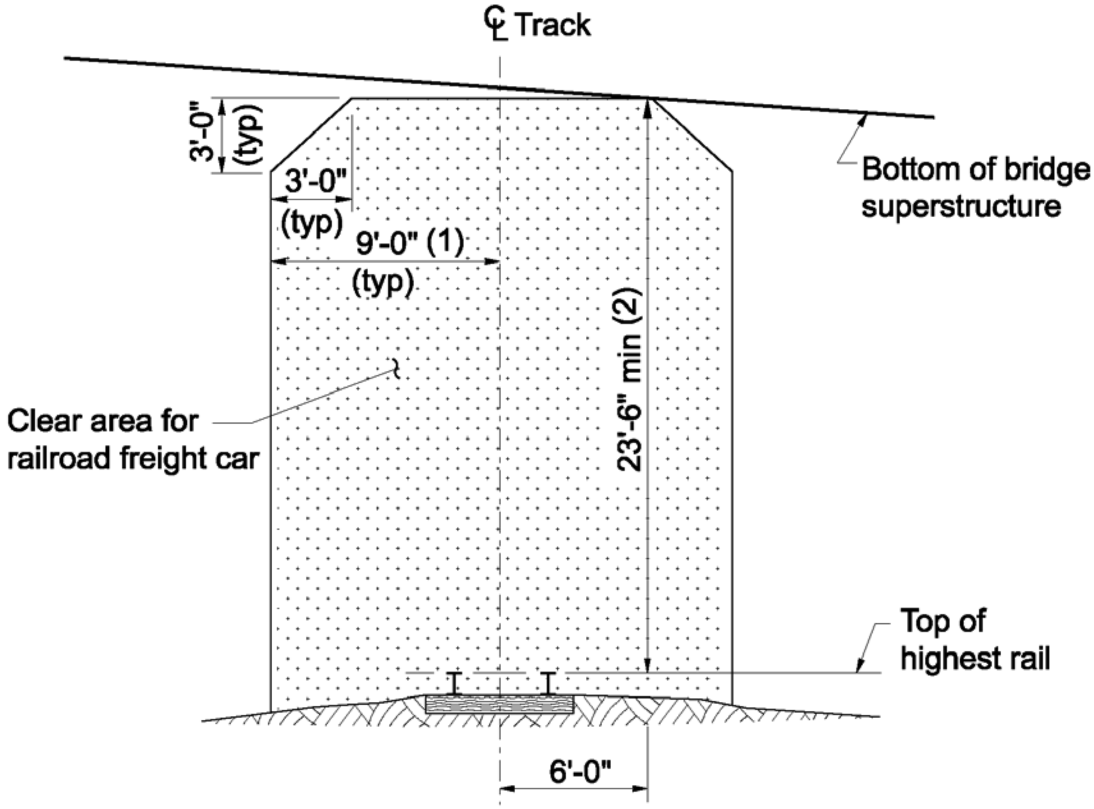
- On existing structures where there is a history of multiple incidents of objects being dropped or thrown and enforcement has not changed the situation.
- On a new structure near a school, a playground, or where frequently used by children not accompanied by adults.
- In urban areas, on a new structure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

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

Submit all proposals to install protective screening on structures to the State Design Engineer for approval. Contact the Bridge and Structures Office for approval to attach screening to structures and for specific design and mounting details.

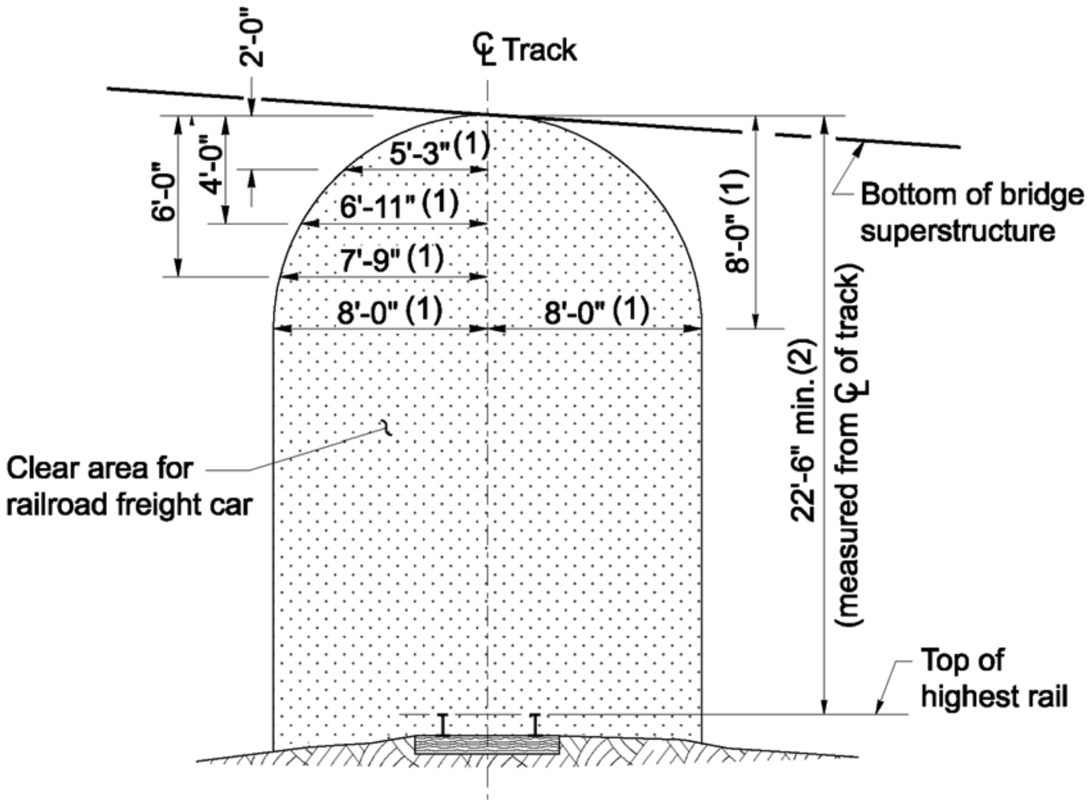
1120.05 Documentation

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



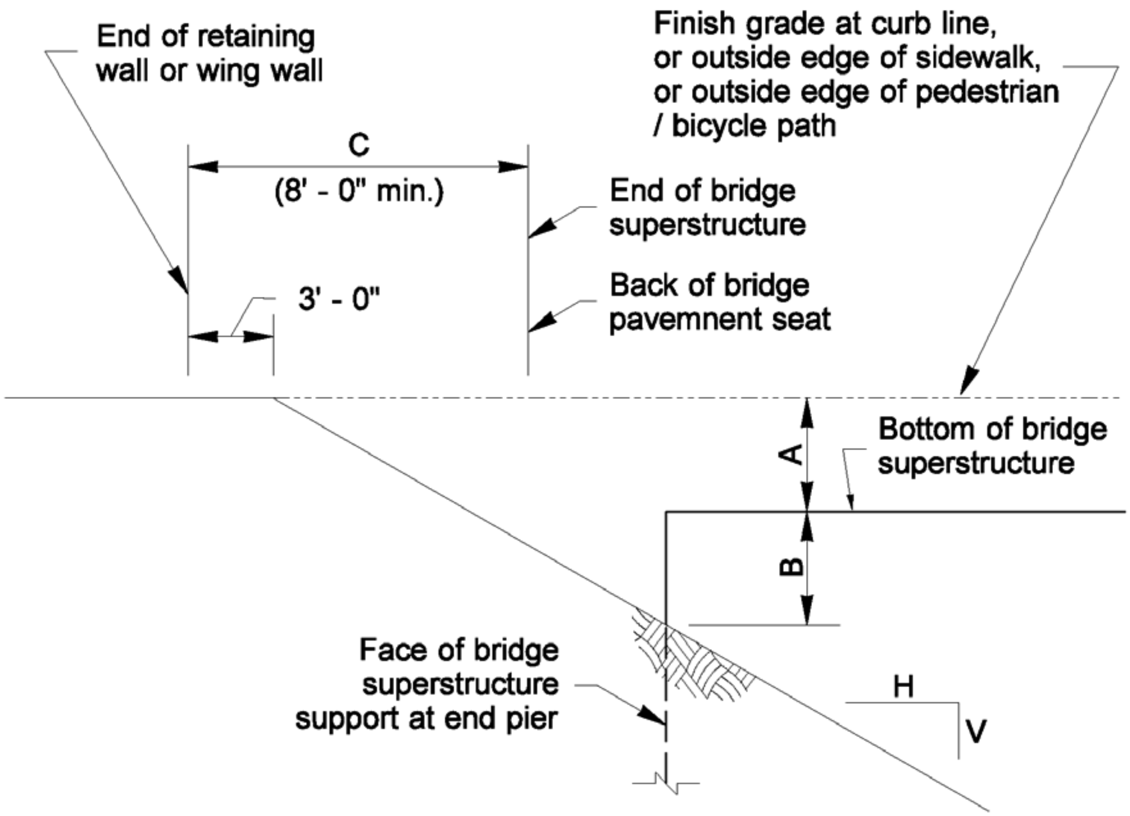
(1) Increase 1.5" for each degree of railroad alignment curve.
(2) Minimum clearances less than 23'-6" may be considered for closed or dedicated rail corridors, that do not intermix with general purpose freight rail traffic. Any such reduced clearance established for a corridor, must be approved by the railroad company and the WUTC.

Railroad Vertical Clearance for New Bridge Construction
Figure 1120-2a



(1) Increase 1.5” for each degree of railroad alignment curve.
(2) Minimum clearances less than 22’-6” may be considered for closed or dedicated rail corridors, that do not intermix with general purpose freight rail traffic. Any such reduced clearance established for a corridor, must be approved by the railroad company and the WUTC.

Railroad Vertical Clearance for Existing Bridge Modifications
Figure 1120-2b



BRIDGE END ELEVATION

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

LEGEND

A = Superstructure depth: Recommended by Bridge Design Office
B = Vertical clearance from bottom of superstructure to embankment: Recommended by Bridge Preservation Engineer
C = Distance from the end of retaining wall or wing wall to back of pavement seat: Recommended by Bridge Design Office
H & V = Embankment slope: Recommended by Geotechnical Engineer

Embankment Slope at Bridge Ends
Figure 1120-3

Chapter 1130 Retaining Walls and Steep Reinforced Slopes

1130.01 References

Bridge Design Manual, M 23-50, WSDOT

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

Plans Preparation Manual, M 22-31, WSDOT

Roadside Manual, M 25-39, WSDOT

1130.02 General

The function of a retaining wall is to form a nearly vertical face through confinement and/or strengthening of a mass of earth or other bulk material. Likewise, the function of a reinforced slope is to strengthen the mass of earth or other bulk material such that a steep (up to 1H:2V) slope can be formed. In both cases, the purpose of constructing such structures is to make maximum use of limited right of way. The difference between the two is that a wall uses a structural facing whereas a steep reinforced slope does not require a structural facing. Reinforced slopes typically use a permanent erosion control matting with low vegetation as a slope cover to prevent erosion. See the *Roadside Manual* for more information.

To lay out and design a retaining wall or reinforced slope, consider the following items:

- Functional classification
- Highway geometry
- Design Clear Zone requirements (Chapter 700)
- The amount of excavation required
- Traffic characteristics
- Constructibility
- Impact to any adjacent environmentally sensitive areas
- Impact to adjacent structures
- Potential added lanes
- Length and height of wall
- Material to be retained
- Foundation support and potential for differential settlement
- Ground water
- Earthquake loads
- Right of way costs
- Need for construction easements
- Risk
- Overall cost
- Visual appearance

If the wall or toe of a reinforced slope is to be located adjacent to the right of way line, consider the space needed in front of the wall/slope to construct it.

(1) Retaining Wall Classifications

Retaining walls are generally classified as gravity, semigravity, nongravity cantilever, or anchored. Examples of the various types of walls are provided in Figures 1130-1a through 1c.

Gravity walls derive their capacity to resist lateral soil loads through a combination of dead weight and sliding resistance. Gravity walls can be further subdivided into rigid gravity walls, prefabricated modular gravity walls, and Mechanically Stabilized Earth (MSE) gravity walls.

Rigid gravity walls consist of a solid mass of concrete or mortared rubble and use the weight of the wall itself to resist lateral loads.

Prefabricated modular gravity walls consist of interlocking soil or rock filled concrete, steel, or wire modules or bins (gabions, for example). The combined weight resists the lateral loads from the soil.

MSE gravity walls use strips, bars, or mats of steel or polymeric reinforcement to reinforce the soil and create a reinforced soil block behind the face. The reinforced soil block then acts as a unit and resists the lateral soil loads through the dead weight of the reinforced mass. MSE walls may be constructed as fill walls, with fill and reinforcement placed in alternate layers to create a reinforced mass, or reinforcement may be drilled into an existing soil/rock mass using grouted anchor technology to create a reinforced soil mass (soil nail walls).

Semigravity walls rely more on structural resistance through cantilevering action of the wall stem. Generally, the backfill for a semigravity wall rests on part of the wall footing. The backfill, in combination with the weight of the wall and footing, provides the dead weight for resistance. An example of a semigravity wall is the reinforced concrete wall provided in the Standard Plans.

Nongravity cantilever walls rely strictly on the structural resistance of the wall in which vertical elements of the wall are partially embedded in the soil or rock to provide fixity. These vertical elements may consist of piles (soldier piles or sheet piles, for example), caissons, or drilled shafts. The vertical elements may form the entire wall face or they may be spanned structurally using timber lagging or other materials to form the wall face.

Anchored walls derive their lateral capacity through anchors embedded in stable soil or rock below or behind all potential soil/rock failure surfaces. Anchored walls are similar to nongravity cantilevered walls except that anchors embedded in the soil/rock are attached to the wall facing structure to provide lateral resistance. Anchors typically consist of deadmen or grouted soil/rock anchors.

Reinforced slopes are similar to MSE walls in that they also use fill and reinforcement placed in alternate layers to create a reinforced soil mass. However, the face is typically built at a 1.2H:1V to 1H:2V slope.

Rockeries (rock walls) behave to some extent like gravity walls. However, the primary function of a rockery is to prevent erosion of an oversteepened but technically stable slope. Rockeries consist of large well-fitted rocks stacked on top of one another to form a wall.

An example of a rockery and reinforced slope is provided in Figure 1130-1d.

The various wall types and their classifications are summarized in Table 1(a-f).

1130.03 Design Principles

The design of a retaining wall or reinforced slope consists of seven principal activities:

- Developing wall/slope geometry
- Adequate subsurface investigation
- Evaluation of loads and pressures that will act on the structure
- Design of the structure to safely withstand the loads and pressures
- Design of the structure to meet aesthetic requirements
- Wall/slope constructibility
- Coordination with other design elements

The structure and adjacent soil mass must also be stable as a system, and the anticipated wall settlement must be within acceptable limits.

1130.04 Design Requirements

(1) Wall/Slope Geometry

Wall/slope geometry is developed considering the following:

- Geometry of the transportation facility itself
- Design Clear Zone requirements (Chapter 700)
- Flare rate and approach slope when inside the Design Clear Zone (Chapter 710)

- Right of way constraints
- Existing ground contours
- Existing and future utility locations
- Impact to adjacent structures
- Impact to environmentally sensitive areas
- For wall/slope geometry, also consider the foundation embedment and type anticipated, which requires coordination among the various design groups involved.

Retaining walls must not have anything (such as bridge columns, light fixtures, or sign supports) protruding in such a way as to present a potential for snagging vehicles.

Provide a traffic barrier shape at the base of a new retaining wall constructed 12 ft or less from the edge of the nearest traffic lane. The traffic barrier shape is optional at the base of the new portion when an existing vertical-faced wall is being extended (or the existing wall may be retrofitted for continuity). Standard Concrete Barrier Type 4 is recommended for both new and existing walls except when the barrier face can be cast as an integral part of a new wall. Deviations may be considered but require approval as prescribed in Chapter 330. For deviations from the above, deviation approval is not required where sidewalk exists in front of the wall or in other situations where the wall face is otherwise inaccessible to traffic.

(2) Investigation of Soils

All retaining wall and reinforced slope structures require an investigation of the underlying soil/rock that supports the structure. Chapter 510 provides guidance on how to complete this investigation. A soil investigation is critical for the design of any retaining wall or reinforced slope. The stability of the underlying soils, their potential to settle under the imposed loads, the usability of any existing excavated soils for wall/reinforced slope backfill, and the location of the ground water table are determined through the geotechnical investigation.

(3) Geotechnical and Structural Design

The structural elements of the wall or slope and the soil below, behind, and/or within the structure must be designed together as a system. The wall/slope system is designed for overall external stability as well as internal stability. Overall external stability includes stability of the slope of which the wall/reinforced slope is a part and the local external stability (overturning, sliding, and bearing capacity). Internal stability includes resistance of the structural members to load and, in the case of MSE walls and reinforced slopes, pullout capacity of the structural members or soil reinforcement from the soil.

(4) Drainage Design

One of the principal causes of retaining wall/slope failure is the additional hydrostatic load imposed by an increase in the water content in the material behind the wall or slope. This condition results in a substantial increase in the lateral loads behind the wall/slope since the material undergoes a possible increase in unit weight, water pressure is exerted on the back of the wall, and the soil shear strength undergoes a possible reduction. To alleviate this, adequate drainage for the retaining wall/slope must be considered in the design stage and reviewed by the region's Materials Engineer during construction. The drainage features shown in the Standard Plans are the minimum basic requirements. Underdrains behind the wall/slope must daylight at some point in order to adequately perform their drainage function. Provide positive drainage at periodic intervals to prevent entrapment of water.

Native soil may be used for retaining wall and reinforced slopes backfill if it meets the requirements for the particular wall/slope system. In general, use backfill that is free-draining and granular in nature. Exceptions to this can be made depending on the site conditions as determined by the Geotechnical Services Branch of the Headquarters (HQ) Materials Laboratory.

A typical drainage detail for a gravity wall (in particular, an MSE wall) is shown in Figure 1130-2. Always include drainage details with a wall unless otherwise recommended to be deleted by the region's Materials Engineer or HQ Geotechnical Services Branch.

(5) Aesthetics

Retaining walls and slopes can have a pleasing appearance that is compatible with the surrounding terrain and other structures in the vicinity. To the extent possible within functional requirements and cost effectiveness criteria, this aesthetic goal is to be met for all visible retaining walls and reinforced slopes.

Aesthetic requirements include consideration of the wall face material, the top profile, the terminals, and the surface finish (texture, color, and pattern). Where appropriate, provide planting areas and irrigation conduits. These will visually soften walls and blend walls with adjacent areas. Avoid short sections of retaining wall or steep slope where possible.

In higher walls, variations in slope treatment are recommended for a pleasing appearance. High, continuous walls are generally not desirable from an aesthetic standpoint, as high, continuous walls can be quite imposing. Consider stepping high or long retaining walls in areas of high visibility. Plantings may be considered between wall steps.

Approval from the State Bridge and Structures Architect is required on all retaining wall aesthetics including finishes, materials, and configuration.

(6) Constructibility

Consider the potential effect that site constraints might have on the constructibility of the specific wall/slope. Constraints to be considered include, but are not limited to, site geometry, access, time required to construct the wall, environmental issues, and impact on traffic flow and other construction activities.

(7) Coordination with Other Design Elements

(a) **Other Design Elements.** Retaining wall and slope designs must be coordinated with other elements of the project that might interfere with or impact the design and/or construction of the wall/slope. Also consider drainage features, utilities, luminaire or sign structures, adjacent retaining walls or bridges, concrete traffic barriers, and beam guardrails. Locate these design elements in a manner that will minimize the impacts to the wall elements. In general, locate obstructions within the wall backfill (such as guardrail posts, drainage features, and minor structure foundations) a minimum of 3 ft from the back of the wall facing units. Greater offset distances may be required depending on the size and nature of the interfering design element. If possible, locate these elements to miss reinforcement layers or other portions of the wall system. Conceptual details for accommodating concrete traffic barriers and beam guardrails are provided in Figure 1130-3.

Where impact to the wall elements is unavoidable, the wall system must be designed to accommodate these impacts. For example, it may be necessary to place drainage structures or guardrail posts in the reinforced backfill zone of MSE walls. This may require that holes be cut in the upper soil reinforcement layers, or that discrete reinforcement strips be splayed around the obstruction. This causes additional load to be carried in the adjacent reinforcement layers due to the missing soil reinforcement or the distortion in the reinforcement layers.

The need for these other design elements and their impact on the proposed wall systems must be clearly indicated in the wall site data that is submitted so that the walls can be properly designed. Contact the Bridge and Structures Office (or the Geotechnical Services Branch, for geosynthetic walls/slopes and soil nail walls) for assistance regarding this issue.

(b) **Fall Protection.** Department of Labor and Industries regulations require that, when employees are exposed to the possibility of falling from a location 10 ft or more above the roadway (or other lower area), the employer is to ensure that fall restraint or fall arrest systems are provided, installed, and implemented.

Consider fall protection when a wall retains 10 ft or more of material. Any need for maintenance of the wall's surface or the area at the top can expose employees to a possible fall. If the area at the top will be open to the public, see Chapter 1025, "Pedestrian Design Considerations," and Chapter 1460, "Fencing."

For maintenance of a tall wall's surface, consider harness tie-offs if other protective means are not provided.

For maintenance of the area at the top of a tall wall, a fall restraint system is required when all of the following conditions will exist:

- The wall is on a cut slope.
- A possible fall will be of 10 ft or more.
- Periodic maintenance will be performed on the area at the top.
- The area at the top is not open to the public.

Recommended fall restraint systems are:

- Wire rope railing with top and intermediate rails of one-half inch diameter steel wire rope.
- Brown vinyl coated chain link fencing.
- Steel pipe railing with one and one-half inch nominal outside diameter pipe as posts and top and intermediate rails.
- Concrete as an extension of the height of the retaining wall.

A fall restraint system must be 36 in to 42 in high, measured from the top of the finished grade, and capable of withstanding a 200 lb force from any direction, at the top, with minimal deflection. Post spacing is no more than 8 ft on centers.

During rail system selection, the designer is to contact Maintenance regarding debris removal considerations.

Contact the Bridge and Structures Office for design details for any retrofit to an existing retaining wall and for any attachments to a new retaining wall.

1130.05 Guidelines for Wall/Slope Selection

Wall/slope selection is dependent on the following considerations:

- Whether the wall/slope will be located primarily in a cut or fill (how much excavation/shoring will be required to construct the wall or slope?)
- If located in a cut, the type of soil/rock present
- The need for space between the right of way line and the wall/slope or easement
- The amount of settlement expected
- The potential for deep failure surfaces to be present
- The structural capacity of the wall/slope in terms of maximum allowable height
- The nature of the wall/slope application
- Whether or not structures or utilities will be located on or above the wall
- Architectural requirements
- Overall economy

(1) Cut and Fill Considerations

Due to the construction technique and base width required, some wall types are best suited for cut situations whereas others are best suited for fill situations. For example, anchored walls and soil nail walls have soil reinforcements drilled into the in-situ soil/rock and, therefore, are generally used in cut situations. Nongravity cantilevered walls are drilled or cut into the in-situ soil/rock, have narrow base widths, and are also well suited to cut situations. Both types of walls are constructed from the top down. Such walls are also used as temporary shoring to allow other types of walls or other structures to be constructed where considerable excavation will otherwise be required.

MSE walls and reinforced slopes, however, are constructed by placing soil reinforcement between layers of fill from the bottom up and are therefore best suited to fill situations. Furthermore, the base width of MSE walls is typically on the order of 70 percent of the wall height, which requires considerable excavation in a cut situation. Therefore, in a cut situation, base width requirements usually make MSE structures uneconomical and possibly unconstructible.

Semigravity (cantilever) walls, rigid gravity walls, and prefabricated modular gravity walls are free-standing structural systems built from the bottom up but they do not rely on soil reinforcement techniques (placement of fill layers with soil reinforcement) to provide stability. These types of walls generally have a narrower base width than MSE structures, (on the order of 50 percent of the wall height). Both of these factors make these types of walls feasible in fill situations as well as many cut situations.

Reinforced slopes generally require more room overall to construct than a wall because of the sloping face, but are typically a feasible alternative to a combination wall and fill slope to add a new lane. Reinforced slopes can also be adapted to the existing ground contours to minimize excavation requirements where fill is placed on an existing slope. Reinforced slopes might also be feasible to repair slopes damaged by landslide activity or deep erosion.

Rockeries are best suited to cut situations, as they require only a narrow base width, on the order of 30 percent of the rockery height. Rockeries can be used in fill situations, but the fill heights that they support must be kept relatively low as it is difficult to get the cohesive strength needed in granular fill soils to provide minimal stability of the soil behind the rockery at the steep slope typically used for rockeries in a cut (such as 1H:6V or 1H:4V).

The key considerations in deciding which walls or slopes are feasible are the amount of excavation or shoring required and the overall height. The site geometric constraints must be well defined to determine these elements. Another consideration is whether or not an easement will be required. For example, a temporary easement might be required for a wall in a fill situation to allow the contractor to work in front of the wall. For walls in cut situations, especially anchored walls and soil nail walls, a permanent easement may be required for the anchors or nails.

(2) Settlement and Deep Foundation Support Considerations

Settlement issues, especially differential settlement, are of primary concern for selection of walls. Some wall types are inherently flexible and can tolerate a great deal of settlement without suffering structurally. Other wall types are inherently rigid and cannot tolerate much settlement. In general, MSE walls have the greatest flexibility and tolerance to settlement, followed by prefabricated modular gravity walls. Reinforced slopes are also inherently very flexible. For MSE walls, the facing type used can affect the ability of the wall to tolerate settlement. Welded wire and geosynthetic wall facings are the most flexible and the most tolerant to settlement, whereas concrete facings are less tolerant to settlement. In some cases, concrete facing can be placed, after the wall settlement is complete, such that the concrete facing does not limit the wall's tolerance to settlement. Facing may also be added for aesthetic reasons.

Semigravity (cantilever) walls and rigid gravity walls have the least tolerance to settlement. In general, total settlement for these types of walls must be limited to approximately 1 in or less. Rockeries also cannot tolerate much settlement, as rocks can shift and fall out. Therefore, semigravity cantilever walls, rigid gravity walls, and rockeries are not used in settlement prone areas.

If very weak soils are present that will not support the wall and that are too deep to be overexcavated, or if a deep failure surface is present that results in inadequate slope stability, the wall type selected must be capable of using deep foundation support and/or anchors. In general, MSE walls, prefabricated modular gravity walls, and some rigid gravity walls are not appropriate for these situations. Walls that can be pile supported such as concrete semigravity cantilever walls, nongravity cantilever walls, and anchored walls are more appropriate for these situations.

(3) Feasible Wall and Slope Heights and Applications

Feasible wall heights are affected by issues such as the capacity of the wall structural elements, past experience with a particular wall, current practice, seismic risk, long-term durability, and aesthetics.

See Table 1 for height limitations.

(4) Supporting Structures or Utilities

Not all walls are acceptable to support other structures or utilities. Issues that must be considered include the potential for the wall to deform due to the structure foundation load, interference between the structure foundation and the wall components, and the potential long-term durability of the wall system. Using retaining walls to support other structures is considered to be a critical application, requiring a special design. In general, soil nail walls, semigravity cantilever walls, nongravity cantilever walls, and anchored walls are appropriate for use in supporting bridge and building structure foundations. In addition to these walls, MSE and prefabricated modular gravity walls may be used to support other retaining walls, noise walls, and minor structure foundations such as those for sign bridges and signals. On a project specific basis, MSE walls can be used to support bridge and building foundations, as approved by the Bridge and Structures Office.

Also consider the location of any utilities behind the wall or reinforced slope when making wall/slope selections. This is mainly an issue for walls that use some type of soil reinforcement and for reinforced slopes. It is best not to place utilities within a reinforced soil backfill zone because it will be impossible to access the utility from the ground surface without cutting through the soil reinforcement layers, thereby compromising the integrity of the wall.

Sometimes utilities, culverts, pipe arches, etc. must penetrate the face of a wall. Not all walls and facings are compatible with such penetrations. Consider how the facing can be formed around the penetration so that backfill soil cannot pipe or erode through the face. Contact the Bridge and Structures Office for assistance regarding this issue.

(5) Facing Options

Facing selection depends on the aesthetic and the structural needs of the wall system. Wall settlement may also affect the feasibility of the facing options. More than one wall facing may be available for a given system. The facing options available must be considered when selecting a particular wall.

For MSE walls, facing options typically include the following:

- Precast modular panels
- In some cases, full height precast concrete panels. (Full height panels are generally limited to walls with a maximum height of 20 ft placed in areas where minimal settlement is expected.)
- Welded wire facing
- Timber facing
- Shotcrete facing with various treatment options that vary from a simple broom finish to a textured and colored finish
- Segmental masonry concrete blocks
- Cast-in-place concrete facing with various texturing options.

Plantings on welded wire facings can be attempted in certain cases. The difficulty is in providing a soil at the wall face that is suitable for growing plants and meets engineering requirements in terms of soil compressibility, strength, and drainage. If plantings in the wall face are attempted, use only small plants, vines, and grasses. Small bushes may be considered for plantings between wall steps. Larger bushes or trees are not considered in these cases due to the loads on the wall face that they can create.

Geosynthetic facings are not acceptable for permanent facings due to potential facing degradation when exposed to sunlight. For permanent applications, geosynthetic walls must have some type of timber, welded wire, or concrete face. (Shotcrete, masonry concrete blocks, cast-in-place concrete, welded wire, or timber are typically used for geosynthetic wall facings.)

Soil nail walls can use either architecturally treated shotcrete or a cast-in-place facia wall textured as needed to produce the desired appearance.

For prefabricated modular gravity walls, the facing generally consists of the structural bin or crib elements used to construct the walls. For some walls, the elements can be rearranged to form areas for plantings. In some cases, textured structural elements might also be feasible. This is also true of rigid gravity walls, though planting areas on the face of rigid gravity walls are generally not feasible. The concrete facing for semigravity cantilever walls can be textured as needed to produce the desired appearance.

For nongravity cantilevered walls and anchored walls, a textured cast-in-place or precast facia wall is usually installed to produce the desired appearance.

(6) Cost Considerations

Usually, more than one wall type is feasible for a given situation. Consider cost throughout the selection process. Decisions in the selection process that may affect the overall cost might include the problem of whether to shut down a lane of traffic to install a low cost gravity wall system that requires more excavation room or to use a more expensive anchored wall system that will minimize excavation requirements and impacts to traffic. In this case, determine if the cost of traffic impacts and more excavation justifies the cost of the more expensive anchored wall system.

Decisions regarding aesthetics can also affect the overall cost of the wall system. In general, the least expensive aesthetic options use the structural members of the wall as facing (welded wire, concrete or steel cribbing or bins, for example), whereas the most expensive aesthetic options use textured cast-in-place concrete facias. In general, concrete facings increase in cost in the following order: shotcrete, segmental masonry concrete blocks, precast concrete facing panels, full height precast concrete facing panels, and cast-in-place concrete facing panels. Special architectural treatment usually increases the cost of any of these facing systems. Special wall terracing to provide locations for plants will also tend to increase costs. Therefore, the value of the desired aesthetics must be weighed against costs.

Other factors that affect costs of wall/slope systems include wall/slope size and length, access at the site and distance to the material supplier location, overall size of the project, and competition between wall suppliers. In general, costs tend to be higher for walls or slopes that are high, but short in length, due to lack of room for equipment to work. Sites that are remote or have difficult local access increase wall/slope costs. Small wall/slope quantities result in high unit costs. Lack of competition between materials or wall system suppliers can result in higher costs as well.

Some of the factors that increase costs are required parts of a project and are, therefore, unavoidable. Always consider such factors when estimating costs because a requirement may not affect all wall types in the same way. Current cost information can be obtained by consulting the *Bridge Design Manual* or by contacting the Bridge and Structures Office.

(7) Summary

For wall/slope selection, consider factors such as the intended application, the soil/rock conditions in terms of settlement, need for deep foundations, constructibility, impact to traffic, the overall geometry in terms of wall/slope height and length, location of adjacent structures and utilities, aesthetics, and cost. Table 1 provides a summary of many of the various wall/slope options available, including their advantages, disadvantages, and limitations. Note that specific wall types in the table may represent multiple wall systems, some or all of which will be proprietary.

1130.06 Design Responsibility and Process

(1) General

The retaining walls available for a given project include standard walls, nonstandard walls, and reinforced slopes.

Standard walls are those walls for which standard designs are provided in the WSDOT Standard Plans. Standard plans are provided for reinforced concrete cantilever walls up to 35 ft in height. The internal stability design, and the external stability design for overturning and sliding stability, have already been completed for these standard walls. However, overall slope stability and allowable soil bearing capacity (including settlement considerations) must be determined for each standard-design wall location.

Nonstandard walls may be either proprietary (patented or trademarked) or nonproprietary. Proprietary walls are designed by a wall manufacturer for internal and external stability, except bearing capacity, settlement, and overall slope stability which are determined by WSDOT. Nonstandard nonproprietary walls are fully designed by WSDOT.

The geosynthetic soil reinforcement used in nonstandard nonproprietary geosynthetic walls is considered to be proprietary. It is likely that more than one manufacturer can supply proprietary materials for a nonstandard nonproprietary geosynthetic wall.

Reinforced slopes are similar to nonstandard nonproprietary walls in terms of their design process.

Some proprietary wall systems are preapproved. Preapproved proprietary wall systems have been extensively reviewed by the Bridge and Structures Office and the Geotechnical Services Branch. Design procedures and wall details for preapproved walls have already been agreed upon between WSDOT and the proprietary wall manufacturers, allowing the manufacturers to competitively bid a particular project without having a detailed wall design provided in the contract plans.

Note that proprietary wall manufacturers might produce several retaining wall options, and not all options from a given manufacturer have necessarily been preapproved. For example, proprietary wall manufacturers often offer more than one facing alternative. It is possible that some facing alternatives are preapproved, whereas other facing alternatives are not preapproved. WSDOT does not preapprove the manufacturer, but specific wall systems by a given manufacturer can be preapproved.

It is imperative with preapproved systems that the design requirements for all preapproved wall alternatives for a given project be clearly stated so that the wall manufacturer can adapt the preapproved system to specific project conditions. For a given project, coordination of the design of all wall alternatives with all project elements that impact the wall (such as drainage features, utilities, luminaires and sign structures, noise walls, traffic barriers, guardrails, or other walls or bridges) is critical to avoid costly change orders or delays during construction.

In general, standard walls are the easiest walls to incorporate into project plans, specifications, & estimate (PS&E), but they may not be the most cost effective option. Preapproved proprietary walls provide more options in terms of cost effectiveness and aesthetics and are also relatively easy to incorporate into a PS&E. Nonstandard state-designed walls and nonpreapproved proprietary walls generally take more time and effort to incorporate into a PS&E because a complete wall design must be developed. Some nonstandard walls (state-designed geosynthetic walls, for example) can be designed relatively quickly, require minimal plan preparation effort, and only involve the region and the Geotechnical Services Branch. Other nonstandard walls such as soil nail and anchored wall systems require complex designs, involve both the Bridge and Structures Office and the Geotechnical Services Branch, and require a significant number of plan sheets and considerable design effort.

The Bridge and Structures Office maintains a list of the proprietary retaining walls that are preapproved. The region consults the Bridge and Structures Office for the latest list. The region consults the Geotechnical Services Branch for the latest geosynthetic reinforcement list to determine which geosynthetic products are acceptable if a critical geosynthetic wall or reinforced slope application is anticipated.

Some proprietary retaining wall systems are classified as experimental by the FHWA. The Bridge and Structures Office maintains a list of walls that are classified as experimental. If the wall intended for use is classified as experimental, a work plan must be prepared by WSDOT and approved by the FHWA.

An approved public interest finding, signed by the State Design Engineer, is required for the use of a sole source proprietary wall.

Gabion walls are nonstandard walls that must be designed for overturning, sliding, overall slope stability, settlement, and bearing capacity. A full design for gabion walls is not provided in the Standard Plans. Gabion baskets are typically 3 ft high by 3 ft wide, and it is typically safe to build gabions two baskets high (6 ft) but only one basket deep, resulting in a wall base width of 50 percent of the wall height, provided soil conditions are reasonably good (medium dense to dense granular soils are present below and behind the wall).

(2) Responsibility and Process for Design

A flow chart illustrating the process and responsibility for retaining wall/reinforced slope design is provided in Figure 1130-4a. As shown in the figure, the region initiates the process, except for walls developed as part of a preliminary bridge plan. These are initiated by the Bridge and Structures Office. In general, it is the responsibility of the design office initiating the design process to coordinate with other groups in the department to identify all wall/slope systems that are appropriate for the project in question. Coordination between the region, Bridge and Structures Office, Geotechnical Services Branch, and the State Bridge and Structures Architect must occur as early in the process as possible.

HQ or region consultants, if used, are considered an extension of the HQ staff and must follow the process summarized in Figure 1130-4a. All consultant designs, from development of the scope of work to the final product, must be reviewed and approved by the appropriate HQ offices.

(a) **Standard Walls.** The regions are responsible for detailing retaining walls for which standard designs are available.

For standard walls greater than 10 ft in height, and for all standard walls where soft or unstable soil is present beneath or behind the wall, a geotechnical investigation must be conducted, or reviewed and approved, by the Geotechnical Services Branch. Through this investigation, provide the foundation design including bearing capacity requirements and settlement determin-ation, overall stability, and the selection of the wall types most feasible for the site.

For standard walls 10 ft in height or less where soft or unstable soils are not present, it is the responsibility of the region materials laboratory to perform the geotechnical investigation. If it has been verified that soil conditions are adequate for the proposed standard wall that is less than or equal to 10 ft in height, the region establishes the wall footing location based on the embedment criteria in the *Bridge Design Manual*, or places the bottom of the wall footing below any surficial loose soils. During this process, the region also evaluates other wall types that may be feasible for the site in question.

Figure 1130-5 provides design charts for standard reinforced concrete cantilever walls. These design charts, in combination with the Standard Plans, are used to size the walls and determine the applied bearing stresses to compare with the allowable soil bearing capacity determined from the geotechnical investigation. The charts provide two sets of bearing pressures: one for static loads, and one for earthquake loads. Allowable soil bearing capacity for both the static load case and the earthquake load case can be obtained from the Geotechnical Services Branch for standard walls over 10 ft in height and from the region materials laboratories for standard walls less than or equal to 10 ft in height. If the allowable soil bearing capacity exceeds the values provided in Figure 1130-5, the Standard Plans can be used for the wall design. If one or both of the 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 design approval of preapproved proprietary walls, 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 design approval authority for nonpreapproved proprietary walls 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 <u>State Bridge and Structures</u> 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 <u>must</u> 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 <u>State Bridge and Structures</u> 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 design approval authority. 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.

Specific Wall Type	Advantages	Disadvantages	Limitations
Segmental masonry concrete block faced walls, generally with geosynthetic soil reinforcement	Low cost; flexible enough to handle significant settlements	Internal wall deformations may be greater than for steel reinforced systems but are still acceptable for most applications; generally requires high quality backfill; wide base width required (70% of wall height)	Applicable primarily to fill situations; in general, limited to wall height of 20 ft or less; greater wall heights may be feasible by special design in areas of low seismic activity and when geosynthetic products are used in which long-term product durability is well defined. (See Qualified Products List.)
Geosynthetic walls with a shotcrete or cast in place concrete face	Very low cost, esp. with shotcrete face; can tolerate large short-term settlements	Internal wall deformations may be greater than for steel reinforced systems but are still acceptable for most applications; generally requires high quality backfill; wide base width required (70% of wall height)	Applicable primarily to fill situations; in general, limited to wall height of 20 ft or less unless using geosynthetic products in which long-term product durability is well defined. (See Qualified Products List.) For qualified products, heights of 33 ft or more are possible.
Geosynthetic walls with a welded wire face	Very low cost; can tolerate large long-term settlements	Internal wall deformations may be greater than for steel reinforced systems but are still acceptable for most applications; generally requires high quality wall backfill soil; wide base width required (70% of wall height)	Applicable primarily to fill situations; in general, limited to wall height of 20 ft or less unless using geosynthetic products in which long-term product durability is well defined. (See Qualified Products List.) For qualified products, heights of 33 ft or more are possible.

Table 1(a) continued

Specific Wall Type	Advantages	Disadvantages	Limitations
Geosynthetic walls with a geosynthetic face	Lowest cost of all wall options; can tolerate large long-term settlements	Internal wall deformations may be greater than for steel reinforced systems but are still acceptable for most applications; generally requires high quality backfill; wide base width required (70% of wall height); durability of wall facing	Applicable primarily to fill situations; use only for temporary applications due to durability of facing; can be designed for wall heights of 40 ft or more
Soil nail walls	Relatively low cost; can be used in areas of restricted overhead or lateral clearance	Soil/rock must have adequate standup time to stand in a vertical cut approximately 6 ft high for at least 1 to 2 days; not feasible for bouldery soils; may require an easement for the nails	Applicable to cut situations only; not recommended in clean or water bearing sands and gravels, in bouldery soils that can interfere with nail installation, or in landslide deposits, especially where deep potential failure surfaces are present; maximum wall heights of 35 ft are feasible, though greater wall heights are possible in excellent soil/rock conditions. A special design is always required.

Table 1(a) continued

Specific Wall Type	Advantages	Disadvantages	Limitations
Concrete crib walls	Relatively low cost; quantity of high quality backfill required relatively small; relatively narrow base width, on the order of 50% to 60% of the wall height; can tolerate moderate settlements	Aesthetics	Applicable to cut and fill situations; reinforced concrete can typically be designed for heights of up to 33 ft and unreinforced concrete up to 16 ft; not used to support bridge or building foundations
Metal crib walls	Quantity of high quality backfill required relatively small; relatively narrow base width, on the order of 50% to 60% of the wall height; can tolerate moderate settlements	Relatively high cost; aesthetics	Applicable to cut and fill situations; can be designed routinely for heights up to 35 ft; not used to support bridge or building foundations
Timber crib walls	Low cost; minimal high quality backfill required; relatively narrow base width, on the order of 50% to 60% of the wall height; can tolerate moderate settlements	Design life relatively short, aesthetics	Applicable to cut and fill situations; can be designed for heights up to 16 ft; not used to support structure foundations
Concrete bin walls	Relatively low cost; narrow base width, on the order of 50 to 60% of the wall height; can tolerate moderate settlements	Aesthetics	Applicable to cut and fill situations; can be designed routinely for heights up to 25 ft; not used to support bridge or building foundations
Gabion walls	Relatively narrow base width, on the order of 50 to 60% of the wall height; can tolerate moderate settlements	Relatively high cost, depending on proximity to source of high quality angular rock to fill baskets	Applicable to cut and fill situations; can be designed routinely for heights up to 15 ft, and by special design up to 21 ft; not used to support structure foundations

Table 1(b) Summary of prefabricated modular gravity wall options available

Specific Wall Type	Advantages	Disadvantages	Limitations
Mortar rubble masonry walls	Quantity of high quality backfill required is relatively small	High cost; relatively wide base width, on the order of 60% to 70% of the wall height; cannot tolerate settlement	Applicable mainly to fill situations where foundation conditions consist of very dense soil or rock; due to expense, only used in areas where other mortar rubble masonry walls are present and it is desired to match aesthetics; typically, can be designed for maximum heights of 25 ft
Unreinforced concrete gravity walls	Quantity of high quality backfill required is relatively small	High cost; relatively wide base width, on the order of 60% to 70% of the wall height; cannot tolerate settlement	Applicable mainly to fill situations where foundation conditions consist of very dense soil or rock; due to expense, only used in areas where other concrete gravity walls are present and it is desired to match aesthetics; typically, can be designed for maximum heights of 25 ft
Reinforced concrete cantilever walls	Relatively narrow base width on the order of 50% to 60% of the wall height; can be used to support structure foundations by special design	High cost; cannot tolerate much settlement; relatively deep embedment might be required on sloping ground due to toe in front of wall face	Applicable to cut and fill situations; can be routinely designed for heights up to 35 ft
Reinforced concrete counterfort walls	Relatively narrow base width on the order of 50% to 60% of the wall height; can be used to support structure foundations by special design	High cost; cannot tolerate much settlement; relatively deep embedment might be required on sloping ground due to toe in front of wall face	Applicable to cut and fill situations; can be routinely designed for heights up to 50 ft; proprietary versions typically 33 ft max

Table 1(c) Summary of rigid gravity and semigravity wall options available

Specific Wall Type	Advantages	Disadvantages	Limitations
Soldier pile wall	Very narrow base width; deep embedment to get below potential failure surfaces relatively easy to obtain	Relatively high cost	Applicable mainly to cut situations; maximum feasible exposed height is on the order of 10 ft; difficult to install in bouldery soil or soil with water bearing sands
Sheet pile wall	Low to moderate cost; very narrow base width	Difficult to get embedment in dense or bouldery soils; difficult to protect against corrosion	Applicable mainly to cut situations in soil; maximum feasible exposed height is on the order of 10 ft
Cylinder pile wall	Relatively narrow base width; can produce stable wall even if deep potential failure surfaces present	Very high cost	Applicable mainly to cut situations; max. feasible exposed height is on the order of 20 to 25 ft, depending on passive resistance available; can be installed in bouldery conditions, though cost will increase
Slurry wall	Relatively narrow base width; can produce stable wall even if deep potential failure surfaces present	Very high cost; difficult construction	Applicable mainly to cut situations; maximum feasible exposed height is on the order of 20 to 25 ft, depending on passive resistance available

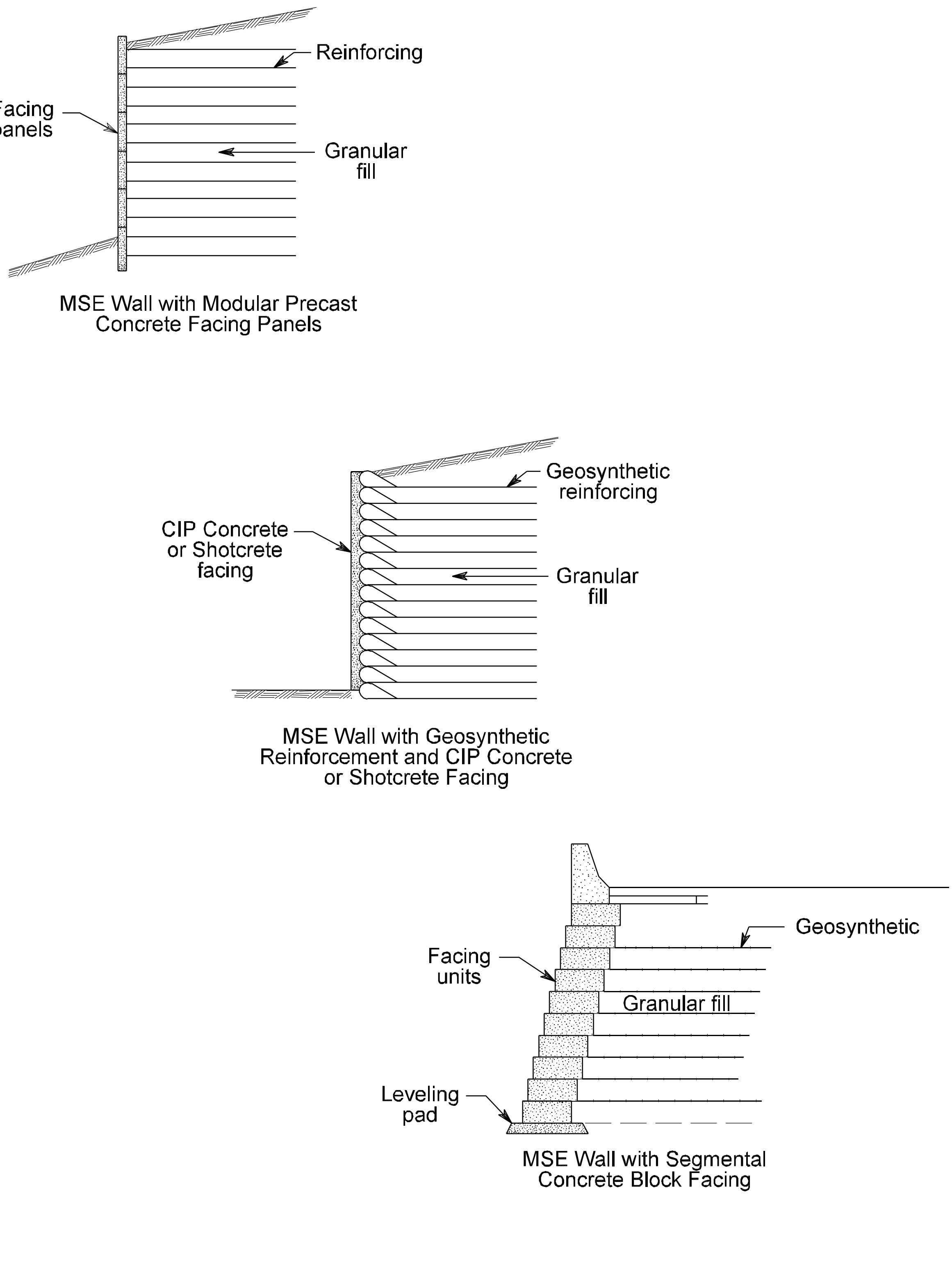
Table 1(d) Summary of nongravity wall options available

Specific Wall Type	Advantages	Disadvantages	Limitations
All nongravity cantilever walls with tiebacks	Relatively narrow base width; can produce stable wall even if deep potential failure surfaces present	Very high cost; difficult to install in areas where vertical or lateral clearance is limited; easements may be necessary; installation activities may impact adjacent traffic	Applicable only to cut situations; can be designed for heights of 50 ft or more depending on the specifics of the structure of the wall
All nongravity cantilever walls with deadman anchors	Relatively narrow base width; can produce stable wall even if deep potential failure surfaces present	Moderate to high cost; must have access behind wall to dig trench for deadman anchor; may impact traffic during deadman installation; easements may be necessary	Applicable to partial cut/fill situations; can be designed for wall heights of approximately 16 ft

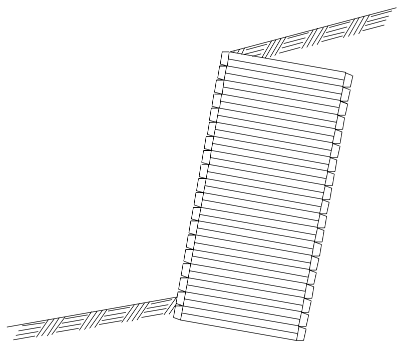
Table 1(e) Summary of anchored wall options available

Wall/Slope Classification	Specific Wall Type	Advantages	Disadvantages	Limitations
Rockeries	Only variations are in rock sizes used and overall wall dimensions	Low cost; narrow base width on the order of 30% of the wall height required	Slope must be at least marginally stable without rockery present; cannot tolerate much settlement	Applicable to both cut and fill situations; max. feasible height in a cut even for excellent soil conditions is approx. 16 ft and 8 ft in fill situations
Reinforced slopes	Only variations are in geosynthetic products used and in erosion control techniques used on slope face	Low cost; can tolerate large settlements; can adapt well to sloping ground conditions to minimize excavation required; high quality fill is not a requirement	Must have enough room between the right of way line and the edge of the shoulder to install a 1H:1V slope	Best suited to sloping fill situations; max. height limited to 30 ft unless geosynthetic products are used in which long-term product durability is well defined. Certain products can be used in critical applications and for greater slope heights on the order of 60 ft or more but consider need, landscaping maintenance, and the reach of available maintenance equipment.

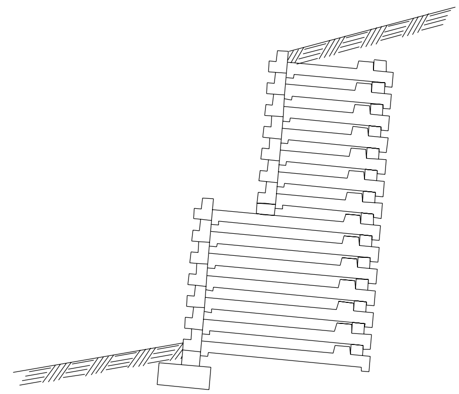
Table 1(f) Other wall/slope options available



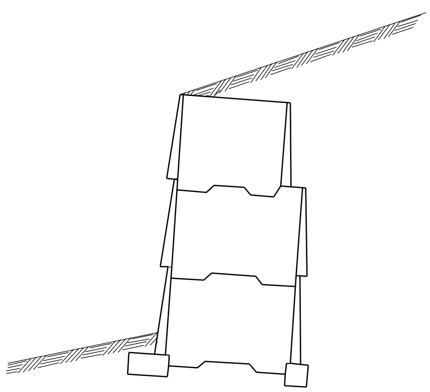
Typical Mechanically Stabilized Earth Gravity Walls
Figure 1130-1a



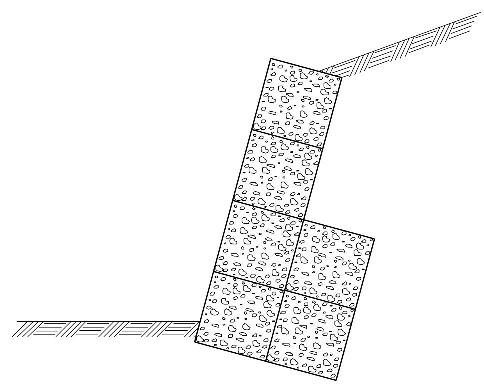
Metal Bin Wall



Precast Concrete Crib Wall

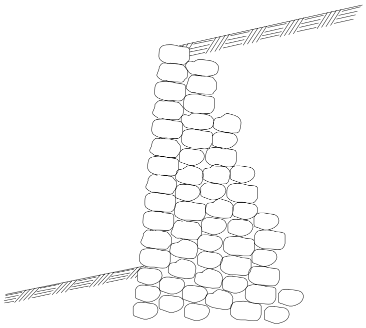


Precast Concrete Bin Wall

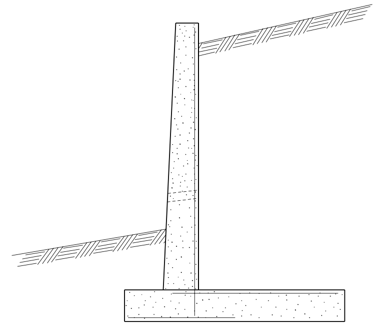


Gabion Wall

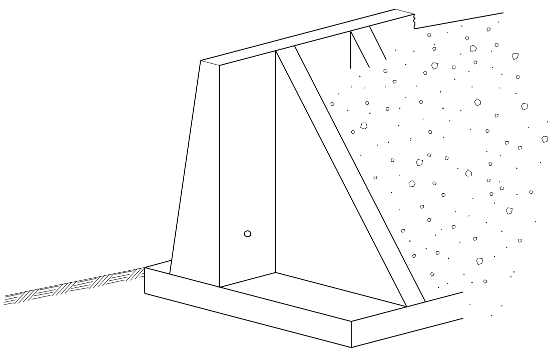
Typical Prefabricated Modular Gravity Walls
Figure 1130-1b



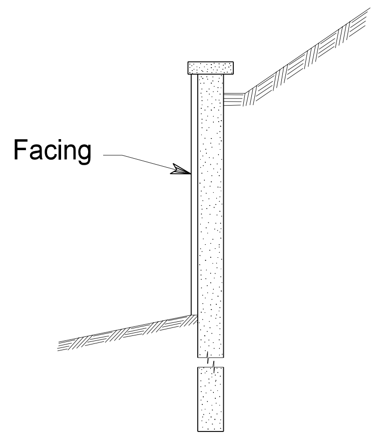
Mortar Rubble Masonry
Ridgid Gravity Wall



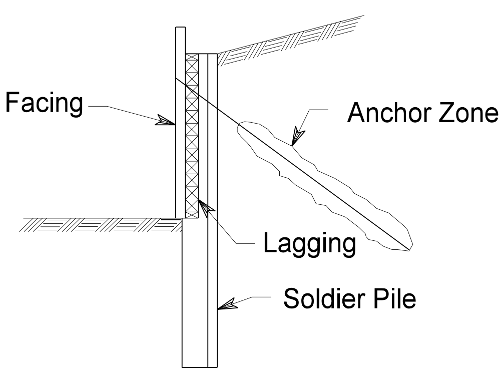
Reinforced Concrete Cantilever
Semigravity Wall



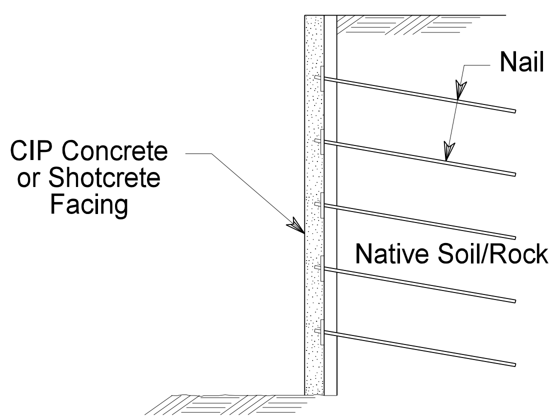
Reinforced Concrete Counterfort
Semigraviaty Wall



Slurry or Cylinder Pile
Nongravity Cantilever Wall

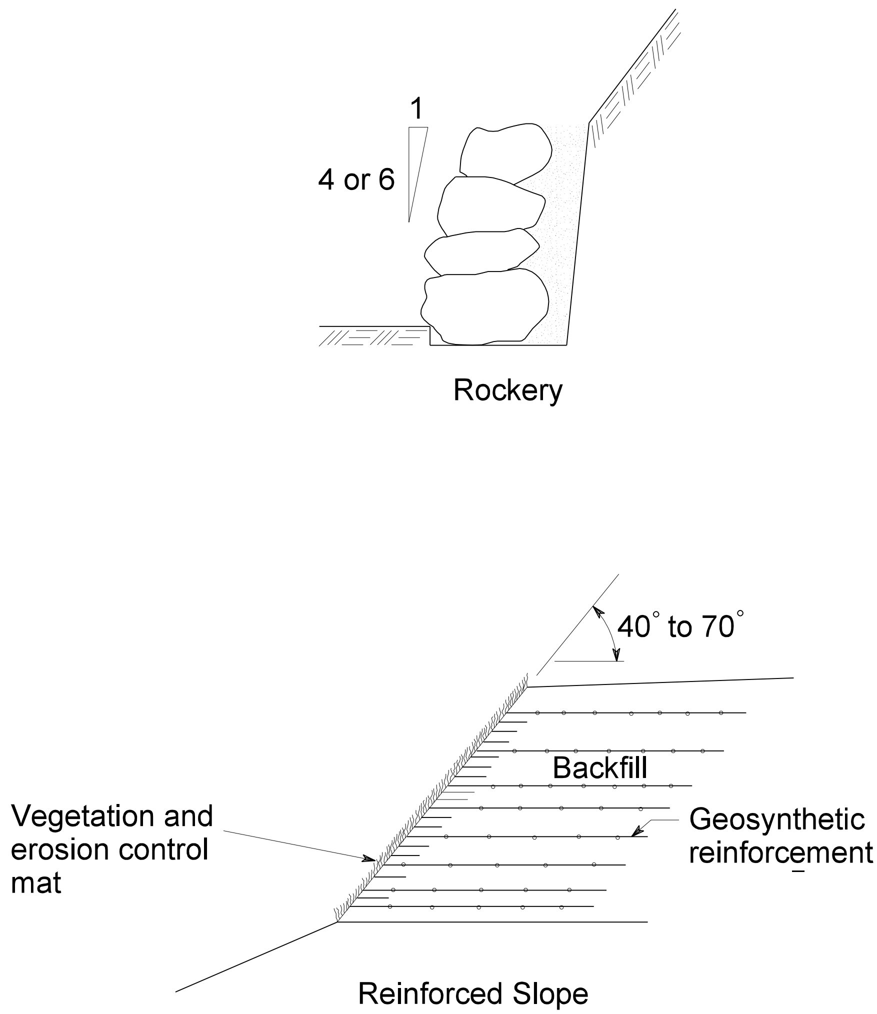


Soldier Pile Tieback Wall

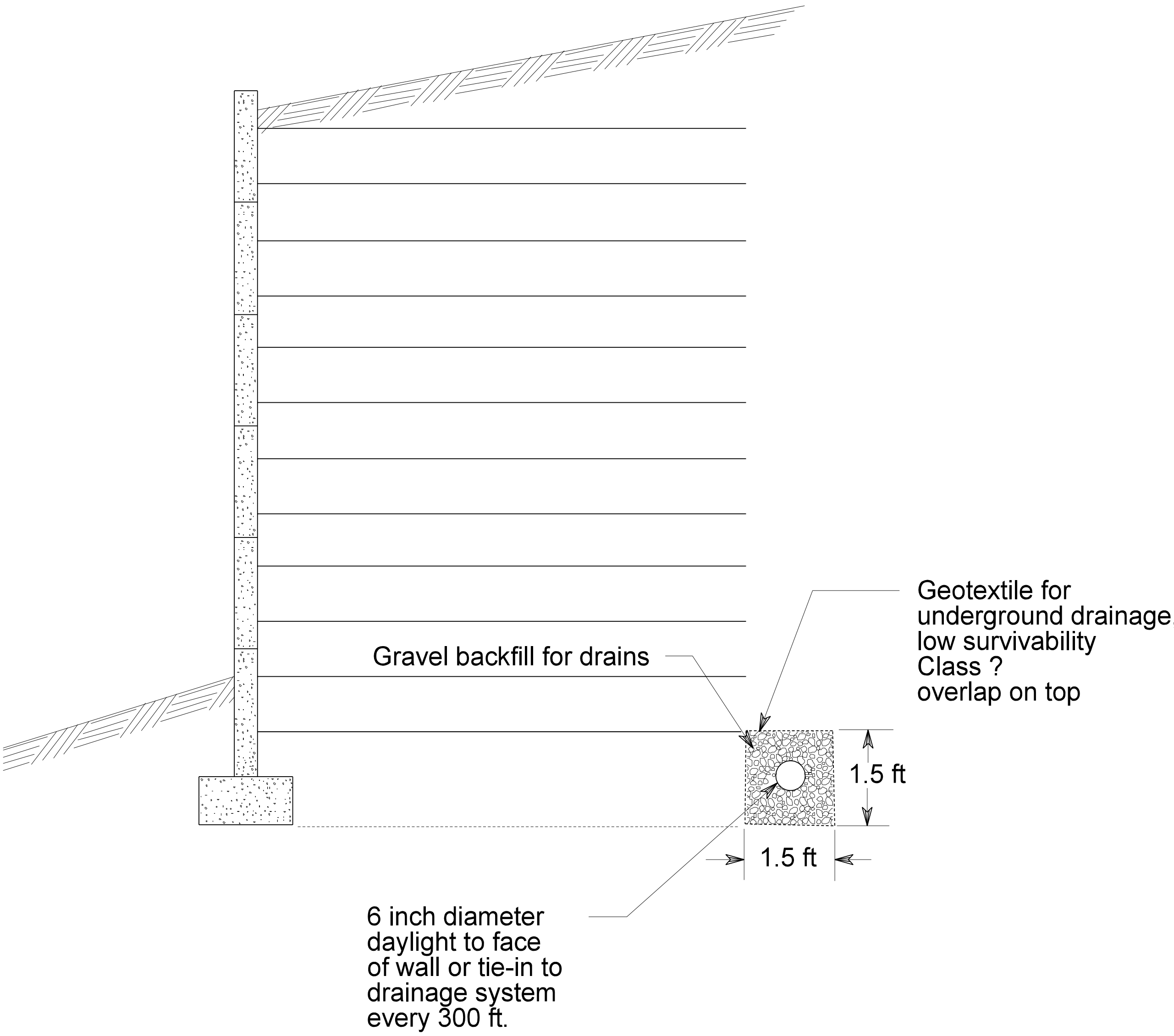


Soil Nail Wall
in Cut

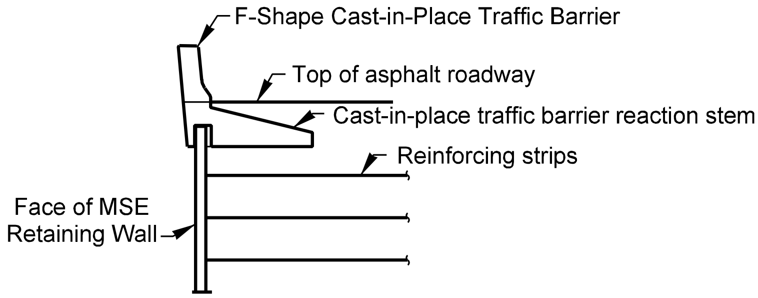
Typical Rigid Gravity, Semigravity Cantilever, Nongravity Cantilever, and Anchored Walls
Figure 1130-1c



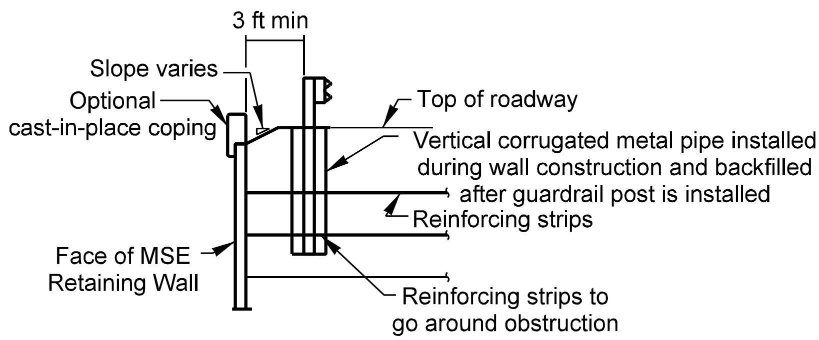
Typical Rockery and Reinforced Slope
Figure 1130-1d



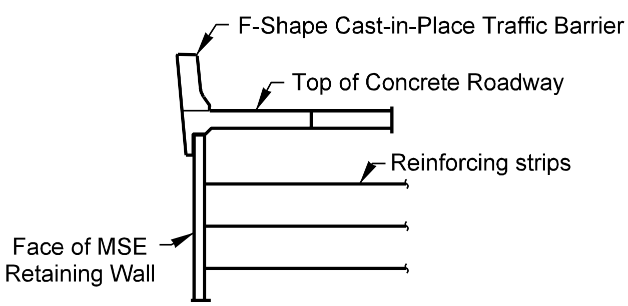
MSE Wall Drainage Detail
Figure 1130-2



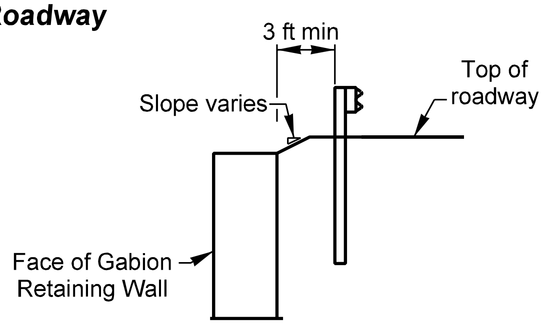
Concrete Traffic Barrier with <u>Asphalt</u> Roadway



Beam Guardrail on Top of MSE Retaining Wall

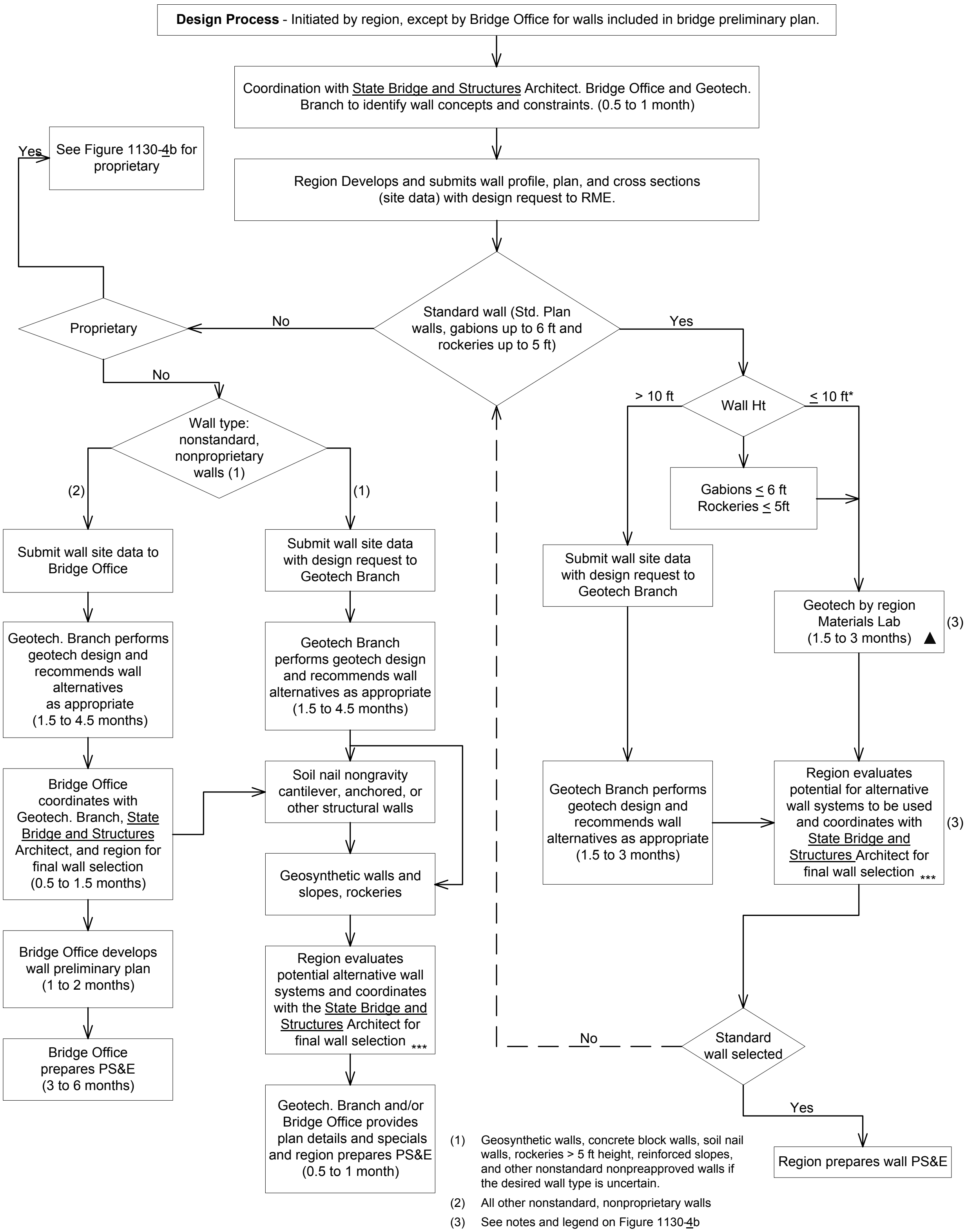


Concrete Traffic Barrier with Concrete Roadway

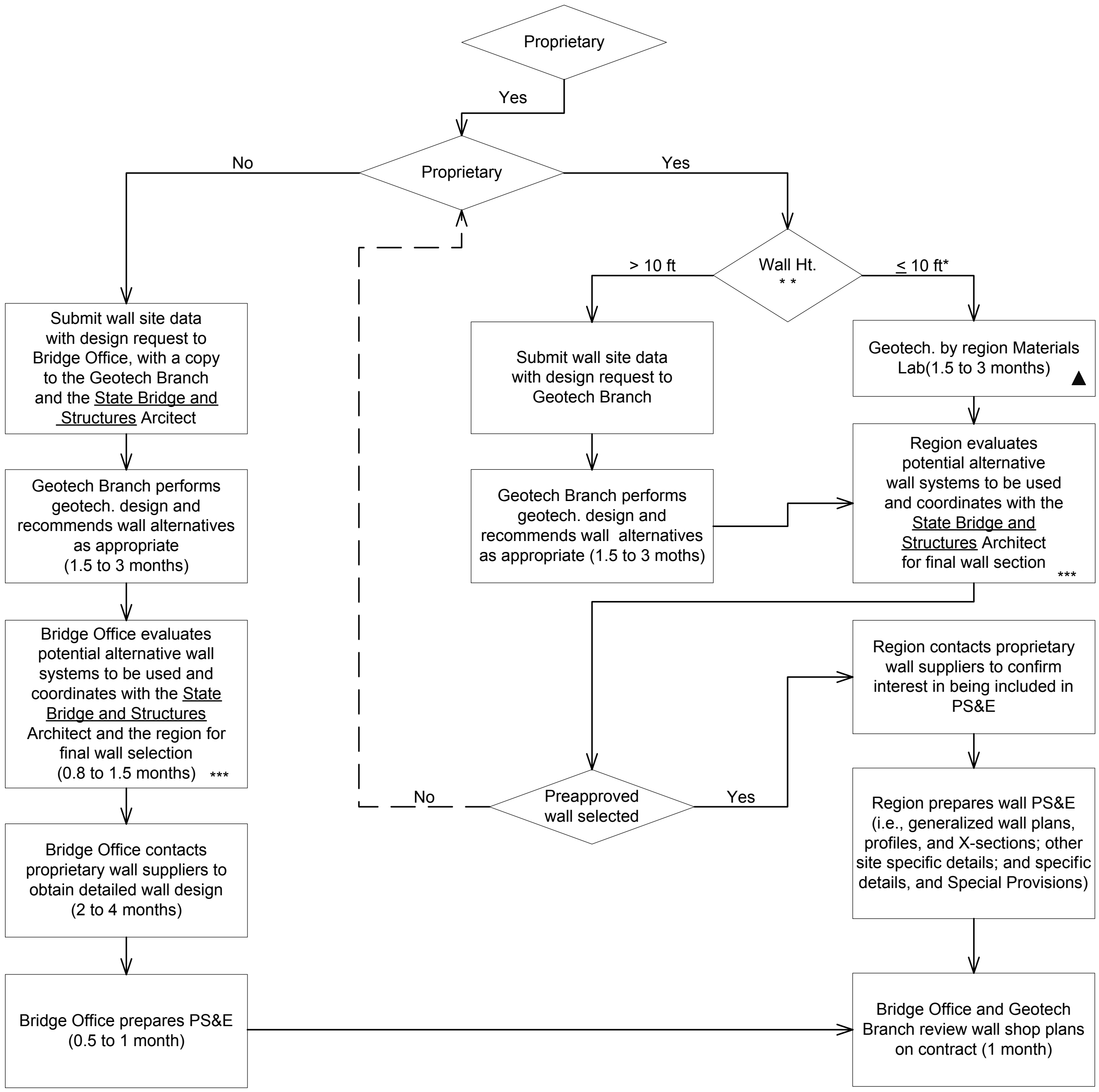


Beam Guardrail on Top of Gabion Wall

Retaining Walls With Traffic Barriers
Figure 1130-3



Retaining Wall Design Process
Figure 1130-4a



Notes:

The "Bridge Office" refers to the WSDOT Bridge and Structures Office in Headquarters.

The "Geotech Branch" refers to the WSDOT Geotechnical Services Branch in Headquarters.

The "State Bridge and Structures Architect" refers to the WSDOT Architecture Section of the Bridge and Structures Office in Headquarters.

Regarding time estimates:

- Assumes no major changes in the wall scope during design.
- Actual times may vary depending on complexity of project.
- Contact appropriate design offices for more accurate estimates of time.

Legend:

▲ Region provides courtesy coy of region's geotechnical report to Geotechnical Branch

* Assumes soft or unstable soil not present and wall does not support other structures.

** The preapproved maximum wall height is generally 33 ft. Some proprietary walls might be less. (Check with the Bridge and Structures Office.)

*** If the final wall selected is a different type than assumed, go back through the design process to ensure that all steps have been taken.

Retaining Wall Design Process - Proprietary

Figure 1130-4b

Ht (ft)	Maximum Soil Pressure (psf) for Reinforced Concrete Retaining Walls											
	Type 1 ①		Type 2 ②		Type 3 ③		Type 4 ④		Type 5 ③		Type 6 ④	
	Static	Earth-quake	Static	Earth-quake	Static	Earth-quake	Static	Earth-quake	Static	Earth-quake	Static	Earth-quake
5	1611	781	1607	770	630	1033	641	1115	702	971	611	798
6	1838	976	1842	974	705	1254	865	1661	908	1322	746	1141
7	1876	1137	1891	1150	797	1558	882	1904	1179	1782	882	1420
8	2178	1431	2213	1465	995	2047	1025	2323	1510	2419	1246	2091
9	2255	1646	2305	1703	1104	2402	1040	2473	1632	2666	1587	2692
10	2492	2078	2492	2063	1216	2786	1065	2651	1924	3224	1635	2918
11	2693	2474	2713	2482	1197	2787	1174	2907	2046	3475	1795	3233
12	2643	2666	2682	2702	1308	3172	1277	3351	2345	4063	1873	3282
13	2732	2999	2693	2923	1458	3560	1304	3158	2384	4041	1955	3377
14	2972	3508	3065	3624	1539	3790	1444	3643	2683	4611	2269	3941
15	3100	3886	3358	4281	1620	4019	1645	4205	2766	4664	2349	4036
16	3166	4128	3420	4552	1752	4305	1748	4466	2818	4715	2668	4603
17	3247	4372	3472	4795	1833	4534	1849	4723	3149	5293	2846	4927
18	3301	4577	3559	5067	2104	5223	2072	5246	3373	5625	2924	5021
19	3399	4825	3405	4877	2217	5457	2208	5534	3691	6417	3175	5551
20	3570	5205	3724	5585	2461	5983	2312	5822	3685	6422	3405	6103
21	3677	5453	3617	5423	2507	6197	2478	6111	3650	6403	3556	6406
22	3752	5659	3696	5664	2635	6473	2610	6547	3778	6672	3737	6741
23	3866	5910	3810	5939	2715	6693	2650	6729	4110	7280	3889	7046
24	4049	6294	3912	6180	2844	6972	2785	7071	4159	7293	4071	7383
25	4166	6544	4058	6457	2973	7252	2949	7462	4492	7894	4228	7689
26	4250	6752	4172	6698	3103	7532	3047	7711	4664	8241	4410	8031
27	4372	7004	4318	6976	3265	7986	3093	7928	4786	8507	4391	8040
28	4496	7258	4463	7254	3394	8264	3106	8115	4956	8832	4575	8385
29	4621	7512	4609	7533	3524	8544	3241	8402	4920	8819	4724	8693
30	4666	7480	4535	7371	3653	8824	3376	8690	4892	8824	4752	8760
31	4795	7734	4682	7648	3816	9280	3536	9130	5068	9158	4901	9068
32	4924	7988	4828	7926			3707	9422	5194	9433	5088	9415
33	5055	8244	4975	8204			3872	9901	5293	9513	5263	9723
34	5186	8500	5122	8483					5328	9603	5191	9536
35	5318	8757	5269	8763					5456	9877	5378	9880

Notes

① 2 ft surcharge or traffic barrier with vertical front face.

② 2 ft surcharge or traffic barrier with sloping front face.

③ 2H:V1 backslope with vertical front face.

④ 2H:1V backslope with sloping front face.

Retaining Wall Bearing Pressure

Figure 1130-5

1140.01 General

The function of a noise barrier is to reduce traffic noise levels at adjoining areas. The noise abatement decisions are made during the environmental stage of the project development process. This is a highly interactive process. Before a noise barrier is designed, the department must be confident that there is significant need, a cost effective and environmentally acceptable noise barrier, a source of funds, and acceptance by adjacent property owners, local governmental agencies, and the general public.

The designer will find the following preliminary design information in the noise report:

- Sources of noise
- Noise receiver locations
- Predicted level of noise reduction
- Locations of existing and future noise impacts along the project corridor
- Barrier location and height recommendations based on what is feasible and reasonable

Design of a noise barrier project is the result of a team effort coordinated by the project engineer.

This chapter addresses the factors that are considered when designing a noise barrier and the associated procedures and documentation requirements.

1140.02 References

Environmental Procedures Manual, M 31-11, WSDOT

Guide Specifications for Structural Design of Sound Barriers, AASHTO

Roadside Manual, M 25-30, WSDOT

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

1140.03 Design

The two basic types of noise barriers are the earth berm and the noise wall. An earth berm can be constructed to the full height required for noise abatement or to partial height in conjunction with a noise wall to reach the required height. A noise wall can be made of concrete, masonry, metal, wood, or other approved innovative products, and can be supported by spread, pile, shaft, or trench footings.

Consideration of the noise report and the visual characteristics of adjacent land forms, vegetation, and structural elements (such as buildings, bridges, and retaining walls) will determine whether a proposed noise barrier might be berm, wall, or both.

An earth berm <u>is</u> the primary alternative if the visual and environmental quality of the corridor <u>will</u> be preserved or enhanced and materials and right of way widths are available. See the *Roadside Manual* for criteria for determining if a vegetated earth berm is appropriate.

The region uses the noise report and other environmental documents (see the *Environmental Procedures Manual*) to help determine the location, exposure conditions, length, and heights of the proposed noise barrier.

To design and locate a noise barrier of any kind, consider the following:

- Desired noise abatement
- Future right of way needs
- Cost and constructibility
- <u>Neighborhood character</u>
- Visual character and quality of the corridor
- Future maintenance of the noise barrier and the whole right of way
- Wind

- Supporting soil
- Earthquakes
- Ground water
- Existing drainage systems and water courses
- Exposure to vehicular impacts
- Potential vandalism
- Existing vegetation and roadside restoration required
- Access for maintenance equipment and enforcement, traffic service, and emergency vehicles
- Access to fire hydrants from both sides
- Pedestrian and bicycle access
- Available and attainable width of right of way for berms
- Aesthetic and structural characteristics of available wall designs
- Visual compatibility of each wall design with other transportation structures within the corridor
- Construction limits for footings
- Locations of existing survey monuments
- Access to, and maintenance of, right of way behind a wall, including drainage structures
- Use of right of way and wall by adjacent property owners
- Drainage and highway runoff
- Drainage from adjacent land
- Existing utilities and objects to relocate or remove
- Water and electricity; needs, sources, and access points

A noise barrier must not have anything (such as bridge columns, light fixtures, or sign supports) protruding in such a way as to present a potential for snagging vehicles.

(1) Earth Berm

(a) Berm slopes are a function of the material used, the attainable right of way width, and the desired visual quality. Slopes steeper than 2H:1V (3H:1V for mowing) are not recommended. Design the end of the berm with a lead-in slope of 10H:1V and curve it toward the right of way line.

(b) See Chapter 710 and the Standard Plans for guidance on redirectional land forms if the berm is to function as a traffic barrier.

(c) See the *Roadside Manual* for guidance regarding vegetation on berms and redirectional land forms.

(2) Noise Wall

(a) When feasible, to encourage competitive bidding, include several alternate noise wall designs in the contract and permit the contractor to submit alternate designs under the value engineering specification.

(b) There are standard noise wall designs in the Standard Plans manual. Additional designs are in various stages of development to become standard plans. The draft-standard design sheets and other preapproved plans are available from the Bridge and Structures Office. The Bridge and Structures Office also works with the regions to facilitate the use of other designs as bidding options.

(c) When a noise wall has ground elevations that are independent of the roadway elevations, a survey of ground breaks (or cross sections at 25-ft intervals) along the entire length of the wall is needed for evaluation of constructibility and to assure accurate determination of panel heights.

(d) Size of openings (whether lapped, door, or gated) depends on the intended users. Agencies such as the local fire department can provide the necessary requirements. Unless an appropriate standard plan is available, such openings must be designed and detailed for the project.

(e) When a noise wall is inside the Design Clear Zone, design its horizontal and vertical (ground elevation) alignment as if it were a rigid concrete traffic barrier. See Chapter 710 for maximum flare rates.

(f) Provide a concrete traffic barrier shape at the base of a new noise wall constructed 12 ft or less from the edge of the nearest traffic lane. The traffic barrier shape is optional at the base of the new portion when an existing vertical-faced wall is being extended (or the existing wall may be retrofitted for continuity). Standard Concrete Barrier Type 4 is recommended for both new and existing walls except when the barrier face can be cast as an integral part of a new wall. Deviations may be considered but require approval as prescribed in Chapter 330. For deviations from the above, deviation approval is not required where sidewalk exists in front of the wall or in other situations where the wall face is otherwise inaccessible to traffic.

See Chapter 710, "Traffic Barriers," for flare rates and approach slopes for concrete barriers.

(g) To designate a standard noise wall, select the appropriate general special provisions and state the standard plan number, type, and foundation type. For example: Noise Barrier Standard Plan D-2a, Type 1A, Foundation D1.

Wall type is a function of exposure and wind speed. See Figure 1140-1.

A geotechnical report identifying the angle of internal friction f and the allowable bearing pressure is needed for selection of a standard foundation. The standard spread footing designs require an allowable bearing pressure of 1 Tsf. The standard trench and shaft footing designs require a f of at least 32° for D1 and 38° for D2.

A special design of the substructure is required for noise walls on substandard soil, where winds exceed 90 mph, and for exposures other than B1 and B2 as defined in Figure 1140-1.

(h) For maintenance of the surface of a tall wall (10 ft or more), consider harness tie-offs for the fall protection required by the Department of Labor and Industries.

	Exposure				
	B1		**B2**		**C**
Wind Speed	80 mph	90 mph	80 mph	90 mph	
Wall Type	A	B	C	D	Special Design*

Wind speed is according to Figure 1-2.1.2.A of the (AASHTO) *Guide Specifications for Structural Design of Sound Barriers*. Assume the wind to be perpendicular to the wall on both sides and design for the most exposed side.

Exposure is determined by the nature of the immediately adjacent ground surface and the extension of a plane at the adjacent ground surface elevation for 1,500 ft to either side of the noise wall:

Exposure B1 = Urban and suburban areas with numerous closely spaced obstructions having the size of single-family dwellings or larger that prevail in the upwind direction from the noise barrier for a distance of at least 1,500 ft.

Exposure B2 = Urban and suburban areas with more open terrain not meeting the requirements of Exposure B1.

Exposure C = Open terrain, with scattered obstructions, that includes flat, open country; grasslands; and elevated terrain.

*For a noise wall with Exposure C, on a bridge or overpass, or at the top of a slope, consult the Bridge and Structures Office, as a special design will probably be necessary.

Standard Noise Wall Types
Figure 1140-1

1140.04 Procedures

The noise unit notifies the Project Engineer's Office when a noise barrier is recommended in the noise report.

The Project Engineer's Office is responsible for interdisciplinary teams, consultation, and coordination with the public, noise specialists, maintenance, construction, region's Landscape Architecture Office (or the Roadside and Site Development Services Unit), right of way personnel, Materials Laboratory, State Bridge and Structures Architect (in the Bridge and Structures Office), Bridge and Structures Office, CAE Support Team, Access and Hearings Engineer, consultants, and many others.

The region evaluates the soils (see Chapters 510 and 1110) and, if a noise wall is contemplated, obtains a list of acceptable wall design options by sending information pertaining to soils and drainage conditions, the alignment, and heights of the proposed wall to the State Bridge and Structures Architect.

If a vegetated earth berm is considered, see the *Roadside Manual* for procedures.

The State Bridge and Structures Architect coordinates with the Bridge and Structures Office, Hydraulics Design Branch, Geotechnical Branch, and the region to provide a list of acceptable standard, draft-standard, and preapproved-proprietary noise wall designs, materials, and finishes that are compatible with existing visual elements of the corridor. Only wall designs from this list may be considered as alternatives. Design visualizations of the highway side of proposed walls (available from the CAE Support Team in Olympia) must be limited to options from this list. The visual elements of the private-property side of a wall are the responsibility of the region unless addressed in the environmental documents.

After the noise report, any changes to the dimensions or location of a noise barrier must be reviewed by the appropriate noise unit to determine the impacts of the changes on noise abatement.

On limited access highways, any opening in a wall or fence (for pedestrians or vehicles) must be coordinated with the Access and Hearings Engineer and approved by the State Design Engineer.

On nonlimited access highways, an access connection permit is required for any opening (approach) in a wall or fence.

The Bridge and Structures Office provides special substructure designs to the regions upon request; reviews contract design data related to standard, draft-standard, and preapproved designs; and reviews plans and calculations that have been prepared by others. (See Chapter 1110.)

Approval of the Bridge and Structures Office and the Architecture Office is required for any attachment or modification to a noise wall and for the design, appearance, and finish of door and gate type openings.

Approval of the State Bridge and Structures Architect is required for the final selection of noise wall appearance, finish, materials, and configuration.

1140.05 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/

1210.01 General

Hydraulic design factors can significantly influence the corridor, horizontal alignment, grade, location of interchanges, and the necessary appurtenances required to convey water across, along, away from, or to a highway or highway facility. An effective hydraulic design conveys water in the most economical, efficient, and practical manner to ensure the public safety without incurring excessive maintenance costs or appreciably damaging the highway or highway facility, adjacent property, or the total environment.

This chapter is intended to serve as a guide to highway designers so they can identify and consider hydraulic related factors that impact the design. Detailed criteria and methods that govern highway hydraulic design are in WSDOT's *Hydraulics Manual* and *Highway Runoff Manual*.

Some drainage, flood, and water quality problems can be easily recognized and resolved; others might require extensive investigation before a solution can be developed. Specialists experienced in hydrology and hydraulics can contribute substantially to the planning and project definition phases of a highway project by recognizing potentially troublesome locations, making investigations and recommending practical solutions. Regions may request that the HQ Hydraulics Branch provide assistance regarding hydraulic problems.

Since hydraulic factors can affect the design of a proposed highway or highway facility from its inception, consider these factors at the earliest possible time during the planning phase.

In the project definition phase, begin coordination with all state and local governments and Indian tribes that issue or approve permits for the project.

1210.02 References

(1) Existing Criteria and References

Existing criteria and additional information for hydraulic design requirements, analyses, and procedures are contained in the following references:

Hydraulics Manual, M 23-03, WSDOT

Highway Runoff Manual, M 31-16, 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, Amendments, and General Special Provisions, WSDOT

Utilities Manual, M 22-87, Section 1-19, "Storm Drainage," WSDOT

(2) Special Criteria

Special criteria for unique projects are available on request from the HQ Hydraulics Branch.

1210.03 Hydraulic Considerations

(1) The Flood Plain

Encroachment of a highway or highway facility into a flood plain might present significant problems. A thorough investigation considers the following:

(a) The effect of the design flood on the highway or highway facility and the required protective measures.

(b) The effect of the highway or highway facility on the upstream and downstream reaches of the stream and the adjacent property.

(c) Compliance with hydraulic related environmental concerns and hydraulic aspects of permits from other governmental agencies per Chapters 220 and 240.

Studies and reports published by the Federal Emergency Management Agency (FEMA) and the Corps of Engineers are very useful for flood plain analysis. The HQ Hydraulics Branch has access to all available reports and can provide any necessary information to the region.

(2) Stream Crossings

When rivers, streams, or surface waters (wetland) are crossed with bridges or culverts (including open bottom arches and three-sided box culverts), consider the following:

- Locating the crossing where the stream is most stable.
- Effectively conveying the design flow(s) at the crossing.
- Providing for passage of material transported by the stream.
- The effects of backwater on adjacent property.
- Avoiding large skews at the crossing.
- The effects on the channel and embankment stability upstream and downstream from the crossing.
- Location of confluences with other streams or rivers.
- Fish and wildlife migration.
- Minimizing disturbance to the original streambed.
- Minimizing wetland impact.

Also see the *Hydraulics Manual* Chapter 8 for further design details.

(3) Channel Changes

It is generally desirable to minimize the use of channel changes because ongoing liability and negative environmental impacts might result. Channel changes are permissible when the designer determines that a reasonable, practical alternative does not exist. When used, consider:

(a) Restoration of the original stream characteristics as nearly as practical. This includes:

- Meandering the channel change to retain its sinuosity.
- Maintaining existing stream slope and geometry (including meanders) so stream velocity and aesthetics do not change in undisturbed areas.
- Excavation, selection, and placement of bed material to promote formation of a natural pattern and prevent bed erosion.
- Retention of stream bank slopes.
- Retention or replacement of streamside vegetation.

(b) The ability to pass the design flood.

(c) The effects on adjacent property.

(d) The effects on the channel and embankment upstream and downstream from the channel change.

(e) Erosion protection for the channel change.

(f) Environmental requirements such as wetlands, fish migration, and vegetation re-establishment.

Do not redirect flow from one drainage basin to another. (Follow the historical drainage pattern.)

Consult the HQ Hydraulics Branch for the best guidance when channel changes are considered.

(4) Roadway Drainage

Effective collection and conveyance of storm water is critical. Incorporate the most efficient collection and conveyance system considering initial highway costs, maintenance costs, and legal and environmental considerations. Of particular concern are:

(a) Combinations of vertical grade and transverse roadway slopes that might inhibit drainage.

(b) Plugging of drains on bridges as the result of construction projects. This creates maintenance problems and might cause ponding on the structure. The use of drains on structures can be minimized by placing sag vertical curves and crossovers in superelevation outside the limits of the structure.

(c) See Chapter 630 for discussion of the relationship of roadway profiles to drainage profiles.

(5) Subsurface Drainage

Subsurface drainage installations control ground water encountered at highway locations. Ground water, as distinguished from capillary water, is free water occurring in a zone of saturation below the ground surface. The subsurface discharge depends on the effective hydraulic head and on the permeability, depth, slope, thickness, and extent of the aquifer.

The solution of subsurface drainage problems often calls for specialized knowledge of geology and the application of soil mechanics. The region Materials Engineer evaluates the subsurface conditions and includes findings and recommendations for design in the geotechnical report.

Typical subdrain installations control seepage in cuts or hillsides, control base and shallow subgrade drainage, or lower the ground water table (in swampy areas, for example).

Design a system that will keep the stormwater out of the subsurface system when stormwater and subsurface drainage systems are combined.

(6) Subsurface Discharge of Highway Drainage

Consider subsurface discharge of highway drainage when it is a requirement of the local government or when existing ground conditions are favorable for this type of discharge system. Criteria for the design of drywells or subsurface drainage pipe for this type of application are described in Chapter 6 of the *Hydraulics Manual*. The criteria for the design of infiltration ponds are described in the *Highway Runoff Manual.*

(7) Treatment of Runoff

On certain projects, effective quantity control of runoff rates and removal of pollutants from pavement are intended to address flooding and water quality impacts downstream. See the *Highway Runoff Manual* for specific criteria on quantity and quality control of runoff.

1210.04 Safety Considerations

Locate culvert ends outside the Design Clear Zone when practical. See Chapter 700 for culvert end treatments when this is impractical.

See Chapter 1460 regarding fencing for detention ponds and wetland mitigation sites.

1210.05 Design Responsibility

Chapter 1 of the *Hydraulics Manual* describes the responsibilities of the regions and the HQ Hydraulics Branch relative to hydraulic design issues.

1300.01 General

It is WSDOT policy to employ roadside treatments for the protection and restoration of community and roadside character as designated in the *Roadside Classification Plan* (RCP) and described in the *Roadside Manual*. WSDOT is committed to community-based context sensitive design, which is reflected in the Context Sensitive Solutions Executive Order (E 1028.00) and the 2003-2022 Washington Transportation Plan (WTP).

Whenever a project disturbs, or adds elements to, the roadside, the project is responsible for restoring roadside functions. This includes contour grading, visual elements (such as walls, lighting, signs, and bridges), pedestrian movement, vegetation, and stormwater treatment. The extent of restoration is dependent upon the source of funding. Figure 1300-1 and the following paragraph summarize the guidance found in the *Roadside Classification Plan*.

Funding	Restore Roadside Functions Beginning to End of Project R/W Line to R/W Line	Restore Only Roadside Functions That are Impacted by the Project
Mobility (I1) Economic Development (I3)	√	
Safety Improvement (I2) Environmental Retrofit (I4) Preservation (P)		√

Funding Source Determines Extent of Restoration
Figure 1300-1

For Mobility (I1) and Economic Development (I3) programs, the project is responsible for restoring the entire roadside from right of way line to right of way line and from beginning to end of project using the guidelines found in the RCP. For Preservation (P), Safety Improvement (I2), and Environmental Retrofit Program (I4) projects, the project is responsible for restoring roadside functions that are disturbed by the project, using the guidelines found in the RCP.

The *roadside* is the area outside the traveled way. This applies to all lands managed by WSDOT and may extend to elements outside the right of way boundaries. This includes unpaved median strips and auxiliary facilities such as rest areas, roadside parks, viewpoints, heritage markers, pedestrian and bicycle facilities, wetlands and their associated buffer areas, stormwater treatment facilities, park and ride lots, and quarries and pit sites.

The roadside is managed to fulfill operational, environmental, visual, and auxiliary functions. In reality, these functions are interrelated and inseparable. One element, such as vegetation, can provide multiple functions simultaneously. For example, vegetation provides erosion prevention and sediment control, stormwater quality and quantity control, may provide distraction screening, and may provide screening of the road from the view of adjacent residents. Roadside functions are described in detail in the *Roadside Manual,* (M 25-30).

The design of a roadside project incorporates site conditions, commitments, and the extent of need. Roadside development concepts covered elsewhere in the *Design Manual* are:

- Contour grading (Chapter 1310)
- Fencing (Chapter 1460)
- Irrigation (Chapter 1330)
- Jurisdiction (Chapters 325, 330, 700)
- Noise barriers (Chapter 1140)
- Retaining walls (Chapter 1130)

- Roadside safety (Chapter 700)
- Safety rest areas, roadside parks, view-points, and historical markers (Chapter 1030)
- Signs (Chapter 820)
- Traffic barriers (Chapter 710)
- Utilities (*Utilities Manual* and *Utilities Accommodation Policy*)
- Vegetation (Chapter 1320)

1300.02 References

Roadside Design Guide, AASHTO

Roadside Classification Plan, M 25-31, WSDOT

Roadside Manual, M 25-30, WSDOT

Utilities Accommodation Policy, M 22-86, WSDOT

Utilities Manual, M 22-87, WSDOT

Maintenance Manual, M 51-01, WSDOT

Understanding Flexibility in Transportation Design – Washington, WSDOT (Dec 2004)

1300.03 Legal Requirements

The following paragraphs represent a partial list of legal requirements relating to roadside work. Further laws, regulations, and policies can be found in the *Roadside Manual*, Section 200.

Washington Administrative Code (WAC) 173-270-040 requires the department to establish and maintain stable plant communities that resist encroachment by undesirable plants, noxious weeds, and other pests. It also requires a vegetation management plan that includes operational, aesthetic, and environmental standards. http://www.leg.wa.gov/wac/index.cfm?fuseaction=Section&Section=173-270-040

WAC 468-34-340 requires utilities to repair or replace unnecessarily removed or disfigured trees and shrubs, and specifies vegetation management practices when utilities use highway right of way. http://www.leg.wa.gov/wac/index.cfm?fuseaction=Section&Section=468-34-340

Revised Code of Washington (RCW) 47.40.010 states that planting and cultivating of any shrubs, trees, hedges or other domestic or native ornamental growth, the improvement of roadside facilities and view points, and the correction of unsightly conditions upon the right of way of any state highway is declared to be a proper state highway purpose.

RCW 47.40.020 authorizes the department to expend funds for this purpose. http://www.leg.wa.gov/RCW/index.cfm?fuseaction=chapterdigest&chapter=47.40

RCW 47.40.040 requires screening or removal of junkyards, located outside a zoned industrial area and within 1000 feet of the nearest edge of the right of way, so they are not visible from the traveled way. The department is authorized to acquire land for the purposes of screening these junkyards. http://www.leg.wa.gov/RCW/index.cfm?section=47.41.040&fuseaction=section

Code of Federal Regulation (CFR) 23 CFR 752 "Highway Beautification Act" furnishes guidelines and prescribes policies regarding landscaping and scenic enhancement programs, safety rest areas, scenic overlooks, and information centers. Policy statement (a) states "highway esthetics is a most important consideration in the Federal aid highway program. Highways must not only blend with our natural social, and cultural environment, but also provide pleasure and satisfaction in their use." http://frwebgate6.access.gpo.gov/cgi-bin/waisgate.cgi?WAISdocID=44327678878+12+0+0&WAISaction=retrieve

United States Code 23 USC 319, On Federal-aid highways, the costs of landscape and roadside development, including acquisition and development of rest areas and land necessary for the restoration, preservation, and enhancement of scenic beauty adjacent to such highways is authorized. http://uscode.house.gov/uscode-cgi/fastweb.exe?search

For any work in, or near wetlands, **Section 404 of the Clean Water Act** may apply. The act requires a permit to discharge dredged or fill materials into most waters of the United States, including wetlands. The Section 404 permitting process requires advanced planning and coordination with the permitting agency: the U.S. Army Corps of Engineers. Work with the regional environmental office for guidance on the 404 permit.

The *Roadside Classification Plan* and the *Roadside Manual* provide policy and guidance for the manner in which WSDOT implements these laws.

1300.04 *Roadside Classification Plan*

The *Roadside Classification Plan* (M25-31) coordinates and guides the management of Washington State highway roadsides within a framework of roadside character classifications. It provides policy and criteria for roadside restoration and advocates the use of native plants, integrated vegetation management (IVM), and a long-term management approach to achieve sustainable roadsides.

1300.05 *Roadside Manual*

The *Roadside Manual* establishes a common basis for consistent roadside management decisions statewide. It shows the links and coordination necessary between all WSDOT partners responsible for roadside activities.

It also establishes a convenient and accessible reference for new and previously unpublished material related to roadside management including planning, design, construction, and maintenance. In addition, the manual supplements statewide roadside criteria established in the *Roadside Classification Plan*.

A partial example of information to be found in the *Roadside Manual* includes:

- Federal, state, and departmental roadside law and policy.
- Americans with Disabilities Act.
- Safety Rest Areas and Scenic Byways.
- Roadside treatments such as erosion control, landform grading, soil bioengineering, wetland mitigation, and vegetation restoration.

See the *Roadside Manual* table of contents for more information on chapters in the manual.

1300.06 Project Development

The region's Landscape Architect designs, supervises, has approval authority of, and stamps roadside restoration and revegetation plans, and is responsible for coordinating the visual elements within highway corridors. The region's Landscape Architect also designs and supervises other roadside work, such as site design for park and ride lots or safety rest areas, to ensure roadside restoration is designed and constructed to WSDOT standards. The Landscape Architect is also responsible for visual discipline reports for environmental documentation. The Headquarters (HQ) Roadside & Site Development Unit will do roadside design, visual impact assessment, and construction inspection work for the project offices in regions without a Landscape Architect.

There are typically two types of roadside restoration projects pertaining to vegetation that are related to roadway construction projects. The first type is work related to regulatory requirements. This work typically must occur at the time of impact to an identified resource in order to meet permit requirements. These projects will typically be a part of the roadway construction contract. The second type of project is the restoration of construction impacts to meet WSDOT policy requirements as outlined in the RCP. It is often advisable to do this revegetation work as a separate contract because roadside restoration is done after the road construction is completed. At that time, all impacts can be identified that may be different than anticipated during the original project design, the prime contractor can be specialized in roadside work, and plant establishment periods can last between 3 and 10 years and extend the roadway contract period. The Landscape Architect typically administers this contract with funding from the project.

1300.07 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 website: http://www.wsdot.wa.gov/eesc/design/projectdev/

Chapter 1310 Contour Grading

1310.01 General

Contour grading is an important element in achieving operational, environmental and visual functions.

Contour grading plans are required when profiles and cross sections do not provide a complete picture. Examples include stream channel changes, interchanges, noise abatement berms, wetland mitigation sites, and detention/retention ponds. Contour grading plans show the subtle changes in grading that occur between cross sections and can allow for finer grading so that the constructed earthform blends smoothly into the surrounding landscape. While engineered slopes define grades to meet engineering requirements, contours can be used to define a finished grade that will blend the facility into the surrounding landscape and meet the requirements of the *Roadside Classification Plan*.

A detention/retention pond can be designed and constructed to appear as if it were naturally formed. Contour grading plans facilitate this kind of earth sculpting. In addition, contour grading plans can be critical to wetland mitigation sites where inaccurate grading can leave a proposed mitigation site without access to a water source.

See the *Roadside Manual* for more detailed information on grading for roadsides.

1310.02 References

Roadside Manual, M 25-30, WSDOT

Roadside Classification Plan, M 25-31, WSDOT

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

1310.03 Procedures

See Chapter 330 for design approval levels.

When contour grading plans are needed, consult the regional, or Headquarters (HQ) Roadside & Site Development Unit.

Submit plans for contour grading on structures (such as lids) to the HQ Bridge and Structures Office for approval.

1310.04 Recommendations

Consider the following factors when developing a contour grading plan:

- Balancing of cut and fill within project limits.
- Preservation of existing desirable vegetation.
- Preservation of existing topsoil.
- Vehicle recovery areas.
- Sight distance.
- Pedestrian safety and security.
- Impacts to groundwater and surface water both on and off the right of way, including wetlands.
- Slope angle and potential soil erosion.
- Slope rounding.
- Drainage (including detention/retention functions).
- Surrounding landscape.
- Visual factors (a form that blends with the adjacent landforms).
- Grading construction cost.
- On slopes steeper than 2H to 1V it may be difficult to stabilize and establish vegetation.
- Soil properties and angle of repose.
- Maintenance access to drainage and traffic operational features.

- Maintenance requirements for slopes (slopes steeper than 3H:1V cannot be mowed).
- Access along fence line or noise walls, if necessary.
- Maximum allowable cut/fill next to a structure (minimum cover over a footing, maximum fill behind a wall or next to a pier).

Use a known stationing point or baseline as a starting point in drawing contours.

Recommended contour interval:

- 1 ft for highway plan drawings.
- 1 ft contour intervals for noise wall berms, and pedestrian related facilities.
- 0.5 ft contour intervals for wetland mitigation sites, stream mitigation sites, and wetland bank sites. Include two or more cross-sections done at a vertical exaggeration sufficient to communicate the design intent.

1310.05 Documentation

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

1320.01 General

Roadside vegetation provides operational, environmental, and visual benefits to WSDOT roadway users. Vegetation preservation and restoration is an integral part of roadside planning and design. When a project disturbs a roadside segment, that project is responsible for meeting the requirements of the roadside classification for that road segment. This may include working outside the actual disturbed area for buffering and blending into the surrounding landscape.

Consult early in the project process with the region Landscape Architect, or the Headquarters (HQ) Roadside & Site Development Unit for regions without a Landscape Architect, for all projects involving revegetation.

1320.02 References

Roadside Classification Plan, M 25-31, WSDOT

Roadside Manual, M 25-30, WSDOT

Integrated Vegetation Management for Roadsides, WSDOT

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

State Highway System Plan (HSP)

1320.03 Discussion

Operational, Environmental and Visual Functions of Roadside Vegetation

Roadside vegetation serves various functions. Vegetation is used to:

- Prevent soil erosion.
- Enhance water quality.
- Provide for water storage and slow runoff.
- Aid in de-watering soils.
- Stabilize slopes.
- Protect or restore wetlands and sensitive areas.
- Preserve and provide habitat.
- Prevent noxious weed infestation.
- Provide positive driver cues for guidance and navigation.
- Provide for corridor continuity.
- Screen glare and distractions, and buffer view of neighboring properties from the roadway.
- Buffer view of roadway by neighboring property owners.
- Preserve scenic views.
- Reduce driver monotony.
- Provide a transition between the transportation facility and adjacent land uses.
- Provide for a pleasing roadside experience.

1320.04 Design Guidelines

(1) General

The type and extent of vegetation will vary depending on the roadside character classification of the road segment, the approved treatment level of the project, the affected roadside management zone, and the planting environment. Select and maintain vegetation so that it does not present a hazard or restrict sight distances of drivers to other vehicles and to signs.

Apply the following guidelines when designing roadside revegetation projects:

- Meet the requirements of the *Roadside Classification Plan*.
- Review Corridor Master Plans and the *State Highway System Plan* for future projects and corridor goals.

- Design revegetation plans, including wetland mitigation sites and detention/retention ponds, to be sustainable over time and to require a low level of maintenance.
- Design roadside revegetation and restoration plans to reduce pesticide use.
- Select and maintain plants to achieve required clear zone, sight distance, clear sight to signing, and headlight screening.
- Evaluate the mature characteristics of plant species to meet safety requirements. Consider size and extent of vegetation at maturity for sight distance, clear zone, and shading problems.
- Preserve existing desirable vegetation and topsoil to the maximum extent reasonable.
- Select plants adaptable to the site conditions. Select native plants as the first choice, unless conditions warrant non-native species to be sustainable. (See the *Roadside Manual* for more information.)
- Consider stripping, stockpiling, and reapplying topsoil if construction will disturb topsoil. When this is not feasible, amend remaining soil to meet horticultural requirements, to reduce compaction, and to increase moisture retention.
- Consider design speeds in the selection and location of plants. For example, as traffic speed increases, include larger groupings of fewer species in the landscape since the motorist's perception of detail along the roadside diminishes.
- Accommodate existing and proposed utilities.
- When selecting vegetation, consider screening undesirable views, or consider allowing openings to reveal or maintain desirable views.
- Design roadsides, particularly areas under bridges, to reduce potential for homeless encampments. Keep clear lines of sight where this potential exists.

Roadway geometrics will also affect the type and extent of vegetation in specific locations. The maximum allowable diameter of trees within the Design Clear Zone is 4 in. measured at 6 in. above the ground when the tree has matured. Consider limiting vegetation diameters on the outside of curves beyond the Design Clear Zone to improve safety. See the *Roadside Manual* for more information.

(2) Existing Vegetation.

Avoid destruction of desirable existing vegetation, reduce impacts on desirable existing vegetation, and restore desirable damaged vegetation.

- Protect desirable existing vegetation wherever possible.
- Delineate trees that are to remain within the construction zone and provide adequate protection of the root zone (extending from the tree trunk to a minimum of 3 ft beyond the drip line).
- Encourage desirable vegetation by using revegetation techniques to prevent or preclude the establishment of undesirable vegetation. See *Integrated Vegetation Management for Roadsides.*
- Limit clearing and grubbing (especially grubbing) to the least area possible.

Selectively remove vegetation to:

- Remove dead and diseased trees when they are a hazard (including those outside the clear zone).
- Maintain clear zone and sight distance.
- Increase solar exposure and reduce accident rates, if analysis shows that removing vegetation will improve safety.
- Open up desirable views.
- Encourage understory development.
- Encourage individual tree growth.
- Prevent plant encroachment on adjacent properties.
- Ensure long-term plant viability.

Refer to Division 8 of the *Roadside Manual* for more information.

(3) Plant Material Selection.

Select noninvasive vegetation (not having the potential to spread onto roadways, ditches and adjacent lands).

Base plant material selection on:

- Functional needs of the roadside.
- Maintenance requirements.
- Site analysis and conditions expected after the facility is constructed.
- Horticultural requirements.
- Plant availability.
- Plant success rates in the field.
- Plant cost.
- Traffic speed.

The *Roadside Manual* provides more detailed guidelines on plant selection, sizing, and location.

(4) Establishment of Vegetation

Most WSDOT projects have 1 to 3-year plant establishment periods. Wetland mitigation projects often include additional years of monitoring and plant establishment to ensure that mitigation standards of success, defined in the permit conditions, are met. The goal of plant establishment is to promote a healthy, stable plant community and a project that has achieved a reasonable aerial coverage prior to WSDOT Maintenance taking over the responsibility and associated costs.

Soil treatments, for example incorporation of soil amendments such as compost into the soil layer, surface mulching, and the use of slow release fertilizer will improve the success rate of revegetation after highway construction activities have removed or disturbed the original topsoil. Woody native plants will grow faster and require less weed control through the combined use of compost and bark mulch. (Check with the local maintenance office or the local jurisdiction's comprehensive plan for any restrictions on fertilizer use, such as those in well-head protection areas or restricted watershed areas.)

- Use soil amendments based on the soil analysis done for the project. Soil testing is coordinated through the HQ Horticulturist or the Landscape Architect. Soil amendments will enhance the soil's moisture holding capacity.
- Use surface mulches to conserve soil moisture and moderate soil temperatures. Mulches also help keep weeds from competing with desirable plants for water and nutrients, and provide organic matter and nutrients to the soil.
- Permanent irrigation systems are only to be used in urban or semiurban areas where vegetation is surrounded by paved surfaces or it does not have available groundwater. Use temporary systems to establish vegetation when needed. If irrigation is required, see Chapter 1330 for design guidelines and the *Roadside Manual* for more detail.
- Weed control is necessary for plant establishment success. Include funding for weed control in the project budget to cover the full plant establishment period. The duration of this period is dependent upon plant and permit requirements.

1320.05 Documentation

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

1330.01 General

Irrigation provides additional moisture to plants during their establishment (the first 3-5 years), or in special cases, on a continuing basis. Irrigation is a high maintenance and high cost item; use only when absolutely necessary. Permanent irrigation is only used in semiurban and urban character classifications in Treatment Levels two and three. Refer to the *Roadside Classification Plan* for more information. Contact the regional Landscape Architect or the Headquarters (HQ) Roadside & Site Development Unit for assistance with irrigation plans.

1330.02 References

Roadside Classification Plan, M 25-31, WSDOT

Roadside Manual, M 25-30, WSDOT

1330.03 Design Considerations

During the project planning phase:

(a) Determine whether irrigation is necessary.

- Analyze soils
- Determine local climate conditions and microclimates
- Consult with the HQ Horticulturist, regional Landscape Architect, or HQ Roadside & Site Development Unit for regions without landscape architectural expertise for site, soil, and plant recommendations to reduce or eliminate need for irrigation
- Describe where irrigation is needed based on a functional design concept, such as "irrigation is needed to provide green lawn at a safety rest area"

(b) Determine the source of water, and its availability, rate of flow and pressure, and connection fees.

Sources of water for irrigation use include municipal water systems and water pumped from a well, pond, or stream. When selecting a source of water, consider what permits and agreements may be needed as well as the cost and feasibility of bringing water from the source to the site.

(c) Determine applicable laws and regulations regarding water, and backflow prevention.

During the design and implementation phases:

(a) Coordinate with the local water purveyor.

(b) Select durable, readily available, easy to operate, and vandal resistant irrigation components.

(c) Justify any proprietary device selections.

(d) Determine power source and connection fees.

(e) Consider the need for winterization of the irrigation system to avoid freeze damage to system components.

Use this information to document design decisions for the project file.

Show the location and type of water source on the irrigation plan.

For more detailed information on irrigation systems and irrigation documentation, see the *Roadside Manual*.

1330.04 Documentation

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

1350.01 General

Soil bioengineering is a land stabilization technology applied to disturbed sites and on slope and streambank projects. A multidisciplinary partnership is used to implement soil bioengineering techniques. Project managers initiate and design bioengineering features by employing the expertise of WSDOT hydraulic engineers, geotechnical engineers, engineering geologists, landscape architects, horticulturists, biologists, water quality specialists, environmental planners, and others. Soil bioengineering for slope stabilization provides additional environmental benefits such as habitat enhancement and water quality improvement.

Include consideration of slope geometry, climate, water regime, soil properties, and surrounding vegetation in soil bioengineering proposals. Applications of soil bioengineering are divided into three general categories: erosion control, streambank or shoreline stabilization, and upland slope stabilization. Refer to manuals according to the related discipline.

1350.02 References

For more detailed information, see:

Design Manual chapters, M 21-01, WSDOT:

1300 Roadside Development

510 Investigation of Soils, Rock, and Surfacing Materials

640 Geometric Cross Section

1130 Retaining Walls

1210 Hydraulics

Geotechnical Guidance — see geotechnical report for slope/soil stability. If further assistance is needed, contact Regional Materials Engineer.

Hydraulics Manual, M 23-03, WSDOT — for hydrology criteria.

Highway Runoff Manual, M 31-16, WSDOT — for Stormwater Site Plans, Temporary Erosion and Sediment Control Plans, and best management practices.

Roadside Manual, M 25-30, WSDOT — for vegetation and site preparation criteria, plant selection, design configurations, and other related topics.

Roadside Classification Plan, M 25-31, WSDOT — policy and guidelines for roadside treatment. Contact the region's Landscape Architect Office or the HQ Roadside and Site Development Services Unit.

Environmental Procedures Manual, M 31-11, WSDOT — permits.

Internet Bioengineering Drawings, WSDOT Homepage http://www.wsdot.wa.gov/eesc/cae/design/roadside/SBwebsite/mainpage/Design/Techniques/Specdetail.html

1350.03 Uses

(1) General

Soil bioengineering combines the use of live plants or cuttings, dead plant material, and inert structural members to produce living, functioning land stabilization systems. This technique uses living plants to control and prevent soil erosion, sedimentation, and shallow slope instability. The bioengineered solution benefits from engineering techniques that use live plant material.

Soil bioengineering methods can be cost effective and a useful mitigation solution for site specific problems. Soil bioengineering is effective in erosion prevention, streambank stabilization, and some upland instabilities. Soil bioengineering, like other engineering techniques, is not applicable in all situations. Soil bioengineering techniques may not effectively mitigate severe bridge scour, severe roadway erosion conditions, or deep seated slope instabilities. In such cases, soil bioengineering can be used in combination with other engineering techniques.

The use of native vegetation that is adapted to the conditions of the project site will increase the success of the application of soil bioengineering techniques. Over time, native vegetation will encourage the establishment of a diverse plant community and discourage undesirable and invasive plant species.

Other applications of soil bioengineering include:

- Wildlife and fisheries habitat enhancement
- Reinforcement and steepening of cut and fill slopes to limit impacts to adjacent properties and sensitive areas
- Vegetated buffer enhancement on steep slopes
- Enhancement of stormwater treatment areas and stabilization of drainage ways by providing erosion prevention and sediment control
- Site specific mitigations using standard geotechnical solutions in combination with vegetative control

(2) Erosion Prevention

Soil Bioengineering techniques can provide erosion prevention in the top soil layers. Erosion is the detachment and transport of surficial soil particles through the action of water, wind, and ice. Plant shoots and foliage diminish rainfall erosion and remove excess moisture through transpiration. Roots reinforce the soil mantle, allowing the system to grow more stable with age. Vegetative material slows down runoff and traps soil thereby reversing the effects of erosion. Refer to the *Roadside Manual* for more information.

(3) Streambank Stabilization

Soil bioengineering techniques can be used to stabilize streambanks, enhance wildlife habitat, improve water quality by controlling sediments, and protect structures. Bioengineering in the riparian zone (banks of streams, wetlands, lakes, or tidewater) requires an hydraulic study of stream characteristics and changes in stream alignment. Refer to the *Hydraulics Manual* for more information.

(4) Upland Slope Stabilization (generally less than 3 feet in depth)

Upland slope stabilization refers to the use of vegetation and plant materials to reduce or prevent soil erosion caused by wind or water on slopes not directly adjacent to riparian zones.

There are three classifications of unstable slopes:

- **Surface movement** refers to surface erosion caused by wind or water on slopes
- **Shallow-seated instability** is defined as a failure surface less than 3 ft in depth
- **Deep-seated instability** is defined as a failure surface greater than 3 ft in depth

Soil bioengineering is used for slopes that are at risk of shallow landslides, slumps, sloughing, and surface erosion.

Soil bioengineering alone is not appropriate for deep-seated landslides, but can be used in conjunction with other engineering methods to treat associated shallow instabilities.

Soil bioengineering techniques can be used to stabilize the slopes of construction sites or to repair disturbed or damaged slopes. Soil bioengineering is applied to both cut and fill slopes.

(5) Strategies

When planning for site specific soil bioengineering design, consider the factors, parameters, and design considerations/specifications in Figure 1350-1.

Factors	Parameters	Design Considerations/ Specifications
Climate or Microclimate	Growing season Exposure/Aspect	Select suitable plants, methods and construction timing
Physical Properties of Soil	Density and compaction Permeability	Modify soil structures during construction Select suitable plants
Chemical Properties of Soil	pH Fertility Cation Exchange Capacity	Select suitable plants Add soil amendments
Water	Profile available water Water sources	Divert water during construction using drains, ditches, pipes, etc. Amend soil
Erosion Risk	Soil erodibility Rainfall erosivity Channel discharge Slope (height and angle) Wind, water, or ice	Temporary or Permanent covers Select suitable plants Reinforcement with geotextile
Geotechnical	Shear strength Slope Factor of Safety	Select suitable soil materials Structures Soil density and moisture Reinforcement with geosynthetics See (Chapter 530)

Soil Bioengineering Design
Figure 1350-1

1350.04 Design Responsibilities and Considerations

Consider the possible applications for soil bioengineering during the project definition process. Address soil bioengineering applications during the design process as part of the recommendations in the Hydraulic Report (for streambank/shoreline), Stormwater Site Plan (SSP), Geotechnical Report (for slope stabilization), and in the Environmental Documents. These reports provide design criteria and guidelines.

1350.05 Documentation

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

1410.01 General

Real Estate Services personnel participate in the project definition phase of a project to assist in minimizing right of way costs, defining route locations and acquisition areas, and determining potential problems and possible solutions.

Due to the variables in land acquisition, the following categories of right of way costs are considered in the project definition phase.

- Purchase costs (acquisition compensation).
- Relocation assistance benefits payments.
- Other Real Estate Services staff expenses (acquisition services, relocation services, interim property management services).

Right of way cost estimates are made by Real Estate Services specialists. When the parcels from which additional right of way will be acquired are known, title reports (including assessors' land areas) can be requested.

Real Estate Services personnel also "make project field inspections at appropriate times throughout the development of a project to ensure adequate consideration is given to significant right of way elements involved (including possible social, economic, and environmental effects)" in accordance with 23CFR Chapter 1 part 712 subpart B and the *Right of Way Manual*.

During plan development:

- Title reports are examined for easements or other encumbrances that would reveal the existence and location of water lines, conduits, drainage or irrigation lines, etc., that must be provided for in construction.
- Easements that indicate other affected ownerships are added to the right of way/access plan.
- Arrangements are made to obtain utility, railroad, haul road, detour routes, or other essential agreements, as instructed in the *Utilities Manual* and the *Agreements Manual*.
- Right of way acquisition, disposal, and maintenance is planned.
- Easements and permits are planned (to accommodate activities outside of the right of way).

See Chapter 440 concerning design right of way widths. The widths may be modified based on Real Estate Services input but cannot be moved to coincide with property boundaries in anticipation of a total take. Jogs in the final widths of the right of way are held to a minimum. See *Right of Way Manual* Chapter 6 for discussion of remainders.

All acquisition documents are processed through the Headquarters (HQ) Real Estate Services Office except temporary permits that are not shown on the Right of Way Plans and are not needed for the project (such as driveway connections).

1410.02 References

Code of Federal Regulations 23 CFR Chapter 1 part 712 subpart B, General Provisions and Project Procedures

49 CFR Part 24 Uniform Relocation Assistance and Real Property Acquisition Act of 1970

Revised Code of Washington (RCW) RCW 8.26, Relocation Assistance - Real Property Acquisition Policy

Washington Administrative Code (WAC) WAC 468-100. Uniform Relocation Assistance and Real Property Acquisition

Agreements Manual, M 22-99, Washington State Department of Transportation (WSDOT)

Plans Preparation Manual, M 22-31, WSDOT

Right of Way Manual, M 26-01, WSDOT

Utilities Manual, M 22-87, WSDOT

1410.03 Special Features

(1) Road Approaches

On access managed highways, the department will reconstruct legally existing road approaches that are removed or destroyed as part of the highway construction. New approaches required by new highway construction are negotiated by the region with the approval of the Regional Administrator. The negotiator coordinates with the region's design section to ensure that new approaches conform to the requirements of Chapter 920 for road approaches. All new approaches will be by permit through the appropriate regional office.

On limited access highways, road approaches of any type must be approved by the State Design Engineer before there is legal basis for negotiation by the Headquarters (HQ) Real Estate Services Office. When approved, approaches will be specifically reserved in the right of way transaction and will contain the identical limitations set by the State Design Engineer and as shown on the approved Limited Access Plan.

(2) Cattle Passes

The desirability of, or need for a cattle pass will be considered during the appraisal or negotiation process. A cattle pass will be approved only after complete studies of location, utilization, cost, and safety elements have proved its necessity. Upon approval, such an improvement and appurtenant rights will be established. Future right of access for maintenance is negotiated during acquisition.

On limited access highways, approval of the State Design Engineer and the addition of a traffic movement note on the right of way and limited access plan (*Plans Preparation Manual*) are required.

(3) Pit, Stockpile, and Waste Sites

These sites are investigated and planned as outlined in the *Plans Preparation Manual*. Detour and haul road agreements, approved by the Regional Administrator, are necessary when the state proposes to use city streets or county roads for the purpose of detouring traffic or hauling certain materials. See the *Utilities Manual* for detour and haul road agreement guidelines.

(4) International Boundaries

Construction proposed "within a 20-foot strip, 10 feet on each side of the international boundary," must be coordinated between the department and the British Columbia Ministry of Highways and Public Works.

Permission of the International Boundary Commission is required to work "within 10 feet of an international boundary." Their primary concern is monumentation of the boundary line and the line of sight between monuments. They require a written request stating what will be done, when, and why; sent to 1250 23rd Street NW, Washington DC 20037.

1410.04 Easements and Permits

(1) General

If others request rights within existing WSDOT ownership, they are to contact the region's Real Estate Services Office.

Easements and permits to accommodate WSDOT activities outside the right of way usually fall into one of the categories defined below.

Easements and permits are processed in accordance with the requirements of the *Right of Way Manual*. The region's Real Estate Services Office drafts the legal descriptions for all easements and permits for acquisition or disposition of rights. These requests are to be directed through the region's Real Estate Services Manager.

The region's Real Estate Services Office either obtains or assists in obtaining easements and permits. The region is responsible for compliance with and appropriate retention of the final documents. Easements and permits are to be shown on the contract plans in accordance with the *Plans Preparation Manual*.

(2) Perpetual Easements

Perpetual easements are shown on the right of way plans in accordance with the *Plans Preparation Manual*.

(a) **State Maintenance Easement.** Used when the state is to construct a facility and provide all maintenance. Examples are slope and drainage easements.

(b) **Dual Maintenance Easement.** Used when the state is to construct and maintain a facility and the owner is to maintain the remainder. Examples are; the surface area above a tunnel and the area behind a retaining wall or noise wall.

(c) **Transfer Easement.** Used when an easement must be acquired to replace an existing easement for a facility that is to be relocated. The region's Real Estate Services Office obtains or prepares instruments that contain all necessary rights and provide for maintenance by the party to whom the easement will ultimately be conveyed. Easements are conveyed when they remain within state rights of way and are replacing existing property rights. Easements are transferred only when the easement is outside the state right of way and not needed for highway purposes. The right of way/limited access plan is modified to identify the party to whom the easement will be transferred. The department cannot obtain easements for transfer across lands under the jurisdiction of the Department of Natural Resources (DNR). WSDOT cannot condemn for a transfer easement to a private party.

(3) Temporary Easements

Temporary easements are used when the state requires a property right of a temporary nature that involves either more than minor work or construction activities on privately owned property. In the cases where the rights required or the work to be performed is not beneficial to the property owner, just compensation may be paid.

Temporary easements are usually shown on the right of way plans in accordance with the *Plans Preparation Manual* when the encroachment is significant; more than about 5 ft. Consult the region's Plans and Real Estate Services personnel for exceptions. If the easement is not mapped, mark and submit plans as described for construction permits.

(4) Construction Permits

Construction permits are used for temporary rights during construction and not used when WSDOT needs a perpetual right. A construction permit is recommended for rights of entry to publicly owned property. Local agencies might require the use of specific Forms when applying for these rights of entry. Regardless of the Form or its name, the region is responsible for appropriate central storage.

A construction permit is only valid with the current owner and must be renegotiated if property ownership changes before construction begins. For private ownerships, a temporary construction easement is recommended.

The construction permit is usually obtained without the payment of compensation (donation or mutual benefits, for example). Consult the region's Plans and Real Estate Services personnel for exceptions.

Permits are allowed where minor right of way acquisitions are obtained for intersections.

Mapping requirements for a construction permit are as follows:

1. Construction permits are not shown on the right of way plan.

2. The region's Project Coordinator's Office is provided two sets of right of way plans with all required construction permits delineated in red. The region sends one copy of the marked plans and copies of the permits to the HQ Real Estate Services Office. These plan sheets provide the following information:

- Ownership boundaries. (Confirmation of ownership and parcel boundaries may be completed by a search of county records and mapping. A formal title report is not required for construction permits.)
- Parcel number assigned to each ownership.
- Sufficient engineering detail to write legal descriptions.
- Statement of the intended use of each construction permit area.

1410.05 Programming for Funds

The phases in Figure 1410-1, in relation to plan development, apply to the authorization of stage programming.

When federal funds are involved, special attention must be given to Federal Highway Administration (FHWA) requirements. When federal participation in right of way costs is anticipated, specific authorization must be obtained from the FHWA. The rules and procedures provided in RCW 8.26, WAC 468-100, and the *Right of Way Manual* must be followed to ensure federal and state participation. In many cases, for example, federal funds are contingent upon the department setting up a relocation advisory procedure for any owner or tenant who is displaced by an improvement and desires such assistance. Relocation advisory assistance is a function of the HQ Real Estate Services Office.

1410.06 Appraisal and Acquisition

(1) All Highways

The phases in Figure 1410-1, in relation to plan development, apply to the authorization of right of way acquisition for all access highways.

(3) Exceptions

Exceptions can be made to the requirements in Figure 1410-1 if unusual hardships result for the individual or the state. The approval of right of way hardship action will be based on the individual parcel merit and is processed in accordance with hardship acquisition policy (*Right of Way Manual*).

1410.07 Transactions

(1) Private Ownerships

Right of way is ordinarily acquired from private property owners by region-level negotiation between the owner and the right of way agent.

(2) Utilities

The region ascertains ownership of all utilities and makes arrangements for necessary adjustment, including relocation of portions of the utility, if necessary. Provisions for relocation or adjustment are included in the PS&E plans when:

- The items are normal construction items and the department is obligated for the moving expense.
- The utility requests that relocation be performed by the department and the department has approved the request.

Readjustment may require the department to purchase substitute rights of way or easements for eventual transfer to the utility. Such rights of way or easements must be shown on the right of way plans with the same engineering detail as highway right of way.

Because of the considerable time required to obtain approvals, processing of utility relocation agreements must begin as soon as possible.

(3) Railways

Right of way is generally not acquired in fee from a railroad company. Instead, the state acquires a perpetual easement for encroachment or crossing. A construction and maintenance agreement may also be required. The easement must be shown on the right of way plan and identified by both highway and railroad stationing.

The HQ Design Office coordinates with the railroad design staff to determine a mutually agreeable location before the proposed easement is sent to Real Estate Services. The negotiations with the railroads are done by HQ Real Estate Services. Because of the considerable time required to obtain approvals, processing of railroad agreements must begin as soon as possible.

The perpetual easement document is executed by the Director, Real Estate Services.

(4) Federal Agencies

Acquisition of right of way from most federal agencies must be negotiated and processed through several federal offices. Allow at least one year's time for efficient and economical right of way acquisition. Depending upon the particular federal agency involved, special exhibit maps and other documentation may be required, and the right of way may be acquired as an easement rather than in fee.

(5) Other State Agencies

Acquisition from other state agencies must be negotiated and processed through the individual agencies or designees. Negotiations with other state agencies are generally handled by HQ Real Estate Services. As in the case of federal agencies, substantial time must be allowed for compliance with applicable statutes and regulations peculiar to the agency before right of way will be granted.

(6) Condemnations

Condemnation may result from a disagreement between the department and the owner as to a fair settlement or from a faulty title. Since several months might elapse between the filing of a condemnation case and a court decision, the HQ Real Estate Services Office can be requested to investigate the possibility of obtaining a negotiated possession and use agreement as in the case of an emergency project, or when a sundry site is required at once.

1410.08 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/

Plan Approval	Plan Approval	Programming of Funds for Appraisal and Acquisition
Limited Access Highways		
PHASE 1 Acces Report Plan	State Design Engineer* approves Access Report Plan for prehearing discussion with county and/or city officials. The access report plan may be used for preparation of federal-aid program data for appraisals if federal funds are to be used for right of way acquisition. It may be used for requesting advance appraisal funds through the Planning and Capital Program Management for all projects with either state or federal funds.	Program appraisals of total takes. (No acquisition.)
PHASE 2 Acces Hearing Plan	State Design Engineer* approves Access Hearing Plan for use at a public access hearing. R/W information is complete. The access hearing plan may be used for the preparation of federal-aid program data for negotiations on federally funded projects, and for the preparation of true cost estimates and fund requests.	Program all appraisals and acquisitions. Note: Do not appraise or purchase partial takes in areas subject to controversy. Appraise or purchase total takes only if federal design hearing requirements are met.
PHASE 3 Findings and Order Plan	No signature required. Results of Findings and Order Access Hearing are marked in red and green on Access Hearing plan and sent to HQ R/W Plans Branch.	Program appraisals of partial takes where data is available to appraisers. Acquisition of total takes.
PHASE 4 Final R/W and L/A Plan	State Design Engineer* Approves final R/W and L/A plans or approves revisions to established R/W and L/A plans	Program all remaining appraisals and all remaining acquisitions. Note: If appeal period is not complete, delay action in areas subject to controversy and possible appeal.
Managed Access Highways		
PHASE 5 Final R/W Plan	R/W plan submitted to HQ R/W Plans Branch for approval.	Program appraisals
	State Design Engineer* approves new R/W plans or approves revisions to established R/W plans.	Program all appraisals and acquisitions.

*Or a designee.

Appraisal and Acquisition
Figure 1410-1

1420.01 General

The Washington State Department of Transportation (WSDOT) controls access to Washington State highways (with a few exceptions) in order to preserve the safety and efficiency of these highways as well as to preserve the public investment. All Washington State highways are distinguished as being either a *limited access* highway or a *managed access* highway. Control of access is accomplished by either acquiring rights of access from abutting property owners (limited access control) or by regulating access connections to the highway (managed access control). Until limited access rights have been acquired from abutting property owners, the route is a managed access highway. Managed access permits are issued either by a local authority (city or town) or by WSDOT.

Numerous studies have shown that controlling and limiting access to highways is a cost-effective way to help maintain the safety, capacity, and functional integrity of a highway. Adding more lanes to an existing highway is expensive and frequently not possible. Controlling access to our state highways, by promoting the use of frontage roads or other existing county or city roads, and advocating the internal shared circulation within adjacent developments, is a proactive and cost-effective way to accomplish this objective.

WSDOT has been purchasing and implementing limited access control since 1951 (RCW 47.52). While this has been effective, it is an expensive way to control access to the state highway system. Adequate funding to accomplish the purchasing of access rights has not kept up with the state's continuous population growth and land use development over the years. As a result, the lawmakers of this state debated a bill in the early 1990s titled "Highway Access Management," cognizant that controlling access to the state highway system by regulation was a cost-effective means to preserve the safety and capacity of our state highway system.

In 1991, the legislature passed and the governor approved RCW 47.50, titled *Highway Access Management*. This new law directed the Department of Transportation to develop new rules to be included in the Washington Administrative Code (WAC) for those state highways not already limited access highways. The result was a new class of access control called managed access.

Chapter 1430 describes limited access highways in greater detail. Chapter 1435 describes managed access highways in greater detail.

The following references and definitions apply to Washington's access control as presented in Chapters 1430 and 1435.

1420.02 References

Revised Code of Washington (RCW) 46.61, Rules of the Road

RCW 47.17, State Highway Routes

RCW 47.32, Obstructions on Right of Way

RCW 47.50, Highway Access Management

RCW 47.52, Limited Access Facilities

Washington Administrative Code (WAC) 468-51, Highway Access Management Access Permits--Administrative Process

WAC 468-52, Highway Access Management -- Access Control Classification System and Standards

WAC 468-54, Limited Access Hearings

WAC 468-58, Limited Access Highways

Manual On Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Agreements Manual, M 22-99, WSDOT

Highways Over National Forest Lands, MOU between WSDOT and USFS, 2001, M 22-50

Plans Preparation Manual, M 22-31, WSDOT

Right of Way Manual, M 26-01, WSDOT

Utilities Accommodation Policy, M 22-86, WSDOT

1420.03 Definitions

access A means of entering or leaving a public road, street, or highway with respect to abutting property or another public road, street, or highway.

access control The limiting and regulating of public and private access to Washington State's highways, as required by state law.

Access Control Tracking System A database list, related to highway route number and mile posts, that identifies either the level of limited access or the class of managed access at: http://www.wsdot.wa.gov/eesc/design/access under the RELATED SITES heading.

access connection See ***approach and access connection***

access connection permit A written authorization issued by the permitting authority for a specifically designed access connection to a managed access highway at a specific location, for a specific type and intensity of property use, and for a specific volume of traffic for the access connection, based on the final stage of the development of the applicant's property. The actual form used for this authorization is determined by the permitting authority.

access deviation A deviation (Chapter 330) that authorizes deferring or staging acquisition of limited access control, falling short of a 300 ft requirement, or allowing an existing access point to stay within 130 ft of an intersection on a limited access highway. Approval from the State Design Engineer is required. (Chapter 1430)

access hearing plan A limited access plan prepared for presentation at an access hearing.

access point Any point that allows private or public entrance to or exit from the traveled way of a state highway. (This includes "locked gate" access.)

access point spacing On a managed access highway, the distance between two adjacent access points on one side of the highway, measured along the edge of the traveled way from one center line or alignment line intersection to the next. See also *corner clearance*.

access report plan A limited access plan prepared for presentation to local governmental officials at preliminary meetings before preparation of the access hearing plan.

access rights Property rights that allow an abutting property owner to enter and leave the public roadway system.

allowed Authorized.

application for an access connection An application provided by the permitting authority to be completed by the applicant for access to a managed access highway.

approach and access connection These terms are listed under the specific access section they apply to. The first section below is for limited access highways and uses the term approach. The second section below is for managed access highways and uses the term access connection.

Approaches and access connections include any ability to leave or enter a highway other than at an intersection with another road or street.

limited access highways: approach An access point, other than a public road/street, that allows access to or from a limited access highway on the state highway system. There are five types of approaches to limited access highways that are allowed:

- ***Type A approach*** An off and on approach in legal manner, not to exceed 30 feet in width, for the sole purpose of serving a single family residence. It may be reserved by the abutting owner for specified use at a point satisfactory to the state at or between designated highway stations. This approach type is allowed on partial and modified control limited access highways.
- ***Type B approach*** An off and on approach in legal manner, not to exceed 50 feet in width, for use necessary to the normal operation of

a farm, but not for retail marketing. It may be reserved by the abutting owner for specified use at a point satisfactory to the state at or between designated highway stations. This approach type is allowed on partial and modified control limited access highways.

- ***Type C approach*** An off and on approach in legal manner, for special purpose and width to be agreed upon. It may be specified at a point satisfactory to the state at or between designated highway stations. This approach type is allowed on partial and modified control limited access highways.
- ***Type D approach*** An off and on approach in a legal manner not to exceed 50 feet in width for use necessary to the normal operation of a commercial establishment. It may be specified at a point satisfactory to the state at or between designated highway stations. This approach type is only allowed on modified control limited access highways.
- ***Type E approach*** This type is no longer allowed to be constructed because of the requirements that there be only one access point per parcel on a limited access state highway.
- ***Type F approach*** An off and on approach in a legal manner, not to exceed 30 feet in width, for the sole purpose of serving a wireless communication site. It may be specified at a point satisfactory to the state at or between designated highway stations. This approach type is only allowed on partial control limited access highways. See WAC 468-58-080(vi) for further restrictions.

managed access highways: access connection An access point, other than a public road/street, that permits access to or from a managed access highway on the state highway system. There are five types of access connection permits:

- ***conforming access connection*** A connection to a managed access highway that meets current WAC and WSDOT location, spacing, and design criteria.
- ***grand-fathered access connection*** Any connection to the state highway system that was in existence and in active use on July 1, 1990, and has not had a significant change in use.
- ***joint-use access connection*** A single connection to a managed access highway that serves two or more properties.
- ***nonconforming access connection*** A connection to a managed access highway that does not meet current WSDOT location, spacing, or design criteria pending availability of a future conforming access connection.
- ***variance access connection*** A connection to a managed access highway at a location not normally allowed by current WSDOT criteria.

managed access connection category There are four access connection permit categories for managed access connections to state highways: Category I, Category II, Category III, and Category IV. See Chapter 1435.

average annual daily traffic (AADT) The volume of traffic passing a point or segment of a highway, in both directions, during a period of time, divided by the number of days in the period and factored to represent an estimate of traffic volume for an average day of the year.

average weekday vehicle trip ends (AWDVTE) The estimated total of all trips entering plus all trips leaving the applicant's site based on the final stage of proposed development.

connection See ***approach and access connection***

contiguous parcels Two or more pieces of real property under the same ownership with one or more boundaries that touch and have similarity of use.

corner clearance On a managed access highway, the distance from an intersection of a public road or street to the nearest access connection along a managed access highway. The minimum corner clearance distance (Figure 1435-2) is measured from the closest edge of the intersecting road or street to the closest edge of the traveled way of the access connection, measured along one side of the traveled way (through lanes). See also *access point spacing*.

DHV Design hourly volume.

E&EP Environmental and Engineering Programs, a part of the Washington State Department of Transportation (WSDOT).

easement A documented right, as a right of way, to use the property of another for designated purposes.

findings and order (F&O) A legal package containing information based on the hearing record from a limited access hearing. See Chapters 210 and 1430.

findings and order (F&O) plan A limited access plan, prepared after a limited access hearing, that is based on the hearing record.

HQ The Headquarters organization of the Washington State Department of Transportation in Olympia.

intersection An at-grade access point connecting a state highway with a road or street duly established as a public road or public street by the local governmental entity.

limited access Full, partial, or modified access control is planned and established for each corridor and then acquired as the right to limit access to each individual parcel.

limited access highway All highways listed as "Established L/A" on the Master Plan for Limited Access Highways only where the rights of direct access to or from abutting lands have been acquired from the abutting landowners.

- ***full access control*** This most restrictive level of limited access provides access, using interchanges, for selected public roads/streets only, and prohibits highway intersections at grade.
- ***partial access control*** The second most restrictive level of limited access. At-grade intersections with selected public roads are allowed and there may be some crossings and some driveway approaches at grade. Direct commercial access is not allowed.
- ***modified access control*** The least restrictive level of limited access. Characteristics are the same as for partial access control except that direct commercial access is allowed.

managed access highway Any highway not listed as "Established L/A" on the Master Plan for Limited Access Highways and any highway or portion of a highway designated on the Master Plan as "Established L/A" until such time as the limited access rights are acquired. Under managed access legislation, the property owner's access rights are regulated through an access connection permitting process.

Master Plan for Limited Access Highways A map of Washington State that shows established and planned limited access highways. More detail is given in the database list: Access Control Tracking System. (Location given above in the list's definition.)

median The portion of a divided highway separating vehicular traffic in opposite directions; not including speed change lanes, storage lanes for left- or U-turning vehicles, or two-way left-turn lanes.

median opening An opening in a continuous median for the specific purpose of allowing vehicle movement.

MOU Memorandum of Understanding. There is one MOU between the United States Forest Service and the Washington State Department of Transportation (*Highways Over National Forest Lands)* that requires the USFS to obtain a road approach permit for new access to a state highway that is crossing Forest Service land.

permit holder The abutting property owner or other legally authorized person to whom an access connection permit is issued by the permitting authority.

permitted access connection A connection for which an access connection permit has been issued by a permitting authority.

permitting authority The agency having legal authority to issue managed access connection permits: for access connections in unincorporated areas, WSDOT; for access connections within corporate limits, a city or town.

right of way (R/W) A general term denoting land or interest therein, acquired for or designated for transportation purposes. More specifically, lands that have been dedicated for public transportation purposes or land in which WSDOT, a county, or a municipality owns the fee simple title, has an easement devoted to or required for use as a public road/street and appurtenant facilities, or has established ownership by prescriptive right.

right of way and limited access plan (R/W and L/A plan) A right of way plan that also shows limited access control details.

road approach A road or driveway built to provide private access to or from the state highway system.

shoulder The portion of the highway contiguous with the traveled lanes for the accommodation of stopped vehicles for emergency use and, where allowed, for bicycles. (Chapter 1430)

state highway system All roads, streets, and highways designated as state routes in compliance with RCW 47.17.

1420.04 Vocabulary

These entries demonstrate the difference in terminology between limited access and managed access in the applicable WACs. For instance, there is nothing about *permit*, *connection*, *category*, or *class* in the limited access vocabulary and, likewise, nothing about *approach* or *type* in the managed access vocabulary.

Chapter 920's vocabulary uses *road approach* in a generic way, unrelated to WAC legalese, and makes no distinction related to access control.

The entries shown on Figure 1420-1 are examples of suitable wording for the distinctly different types of access control in Chapters 1430 and 1435.

Access Vocabulary	
functional classification of highways intersections at grade, geometrics roundabout geometrics road approach geometrics interchange geometrics freeway access point	Chapter 440 Chapter 910 Chapter 915 Chapter 920 Chapter 940 Chapter 1425
limited access highway (Chapter 1430)	**managed access highway (Chapter 1435)**
access point (ramp) approach (street, road, driveway) road approach (street, road, driveway) driveway approach (not street or road)	access point (public or not) public access point access connection (not public)
(level of) limited access (highway) [full, partial, modified] control limited access highway	managed access highway class Class [1-5] managed access highway
Type [A, B, C, D, F] approach Type A approach = Type A road approach	Category [I-IV] access connection
allowed (policy)	permitted (a document) or allowed (policy)
	conforming access connection permit (etc.)

These words are not used in the respective chapters:

Not:	Not:
class	classification (except functional)
category	type
connection	approach
permit or permitted	

Access Vocabulary
Figure 1420-1

1425 Access Point Decision Report

1425.01 General

It is in the public's interest that the state's freeways be maintained and protected to provide the highest practical level of service in terms of safety and mobility. Federal laws and both FHWA and WSDOT policies require a formal request, with an Access Point Decision Report, for any access point revision that might adversely affect through traffic on a freeway in Washington State. The report is used for a decision-making process and documents the planning, evaluation, design, and coordination that support and justify the request.

In theory, a transportation project such as a new interchange would begin with a study of a large section of the freeway system to determine existing and future access needs. The needs would become part of a statewide plan. Alternatives would be suggested and evaluated. Preliminary proposals would be selected and evaluated. A final proposal would be selected, analyzed, approved, designed, constructed, maintained, and monitored.

But that is not always the source of a proposal.

If a revised access point proposal is not the result of system planning, then the process of evaluating the alternative has to go back to the beginning to study the system throughout the affected area and determine whether or not an access point revision will be the best reasonable alternative. Sometimes it is not — for example, because it would interfere with Interstate travel, or because modifications to the local surface system would be a better and more reasonable solution for accommodating local traffic.

For all but the simplest projects, WSDOT recommends that a support team be used to help integrate the planning, programming, and design efforts that lead to development of a proposal. The Project Definition process, Value Engineering studies, public involvement efforts, environmental analyses, and analyses for the Access Point Decision Report all use similar data and try to find the best way to meet the needs. The team is charged with achieving creative and reasonable identification of possible alternatives — guiding selection of the best from the alternatives to develop a proposal — and providing guidance from potential reviewers to the decision report developers in order to streamline the report-development process and meet the reviewers' requirements.

An Access Point Decision Report is a stand-alone decision document that includes all supporting information for ready reference by those reviewing the request. (For example, information drawn from the planning documents and the Project Summary is included.) It includes information about the proposed project that includes the access point revision and information about all other improvements that are needed for the access revision to function as intended.

After the Access Point Decision Report is reviewed, if the revised access proposal is acceptable it is given a *finding of engineering and operational acceptability* and approved concurrently with the appropriate environmental documents.

For consistency, this chapter provides the sequence of presentation and guidance for developing the required documentation.

1425.02 References

Notice of policy statement: "Additional Interchanges to the Interstate System," Federal Highway Administration notice published in the Federal Register, October 22, 1990. (Vol. 55, No. 204)

Notice of policy statement: “Additional Interchanges to the Interstate System,” Federal Highway Administration notice published in the Federal Register on Wednesday, February 11, 1998. (Vol. 63, No. 28) (Accessible in http://www.access.gpo.gov/su_docs/fedreg/a980211c.html, under FHWA notices, “Interstate system, additional interchanges, policy statement, 7045-7047.”)

United States Code 23 USC section 111

Code of Federal Regulations 23 CFR part 450 (implementing 23 USC section 111)

Code of Federal Regulations 40 CFR parts 51 and 93 (regarding federal conformity with state and federal air quality implementation plans)

Highway Capacity Manual, Special Report No 209 (HCM), Transportation Research Council

Forcasting and Methods Matrix, WSDOT (when available)

1425.03 Definitions

alternatives Possible components of a proposal — including design options, locations, and travel demand management and transportation system management type improvements such as ramp metering, mass transit, and high occupancy vehicle (HOV) facilities.

access point Any point that allows entrance to or exit from the traveled way of a freeway. (This includes “locked gate” access.)

access point revision A new access point, a change in existing interchange/intersection configuration, or the relocation of an existing access point.

freeway For this chapter only, a *freeway* is any multilane divided highway with limited access control that is on the Interstate System or the Washington State Highway System.

need For this chapter only, an existing or anticipated travel demand requiring a change in access to the state’s freeway system.

proposal The combination of alternatives that is being submitted for approval by way of a request and an Access Point Decision Report. A proposal would have one or more projects involving access point revision alternatives and other projects and actions necessary for the needs to be addressed and the access revisions to function as intended.

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.

1425.04 Procedures

Figures 1425-1a and 1b list the project types most likely to affect freeway efficiency, thus requiring a formal request and an Access Point Decision Report. Figure 1425-2 lists the project types least likely to require a request and decision report. If there is any question whether an Access Point Decision Report is required, consult the OSC Access and Hearings Engineer and, if on the Interstate System, the FHWA Transportation and Environmental Engineer.

Gaining acceptance and approval for an access point revision is a multistep process. (See the Access Point Decision Report Flow Chart, Figures 1425-3a and 3b.)

(1) The first step: to identify needs and develop a proposal. When going through the process of developing a proposal, it is important to use the data and analysis methods required for an Access Point Decision Report in order to easily document the process.

(a) Are there existing or anticipated needs? Might a new or revised access point be an appropriate solution (Figure 1425-3a, box 1)?

(b) If the proposed solution includes an access point revision, determine whether the proposed access point revision is reflected in a Regional Transportation Improvement Plan, a Metropolitan Transportation Improvement Plan, or the State Highway System Plan, or whether it is the result of a developer, local agency, or regional request. If needed, conduct a comprehensive freeway study, revisit the land use and transportation plans, and revise the State Highway System Plan to include the need for an access point revision (Figure 1425-3a, boxes 2 and 3).

(c) Establish a support team for all new access points and for major revisions to existing access points (Figure 1425-3a, box 4). The core decision-making team consists of:

- FHWA Transportation and Environmental Engineer (if Interstate)
- Region's Design or Project Development Engineer
- OSC Assistant State Design Engineer
- OSC Access and Hearings Engineer
- OSC Traffic Office representative
- Representative of the proponent
- Recorder

The core team is encouraged to call upon specialists as needed, for example:

- Metropolitan Planning Organization
- WSDOT region
  - Planning
  - Environmental
  - Traffic
  - Maintenance
  - Safety
  - Access Point Decision Report writer
- OSC
  - Design
  - Bridge
  - Geotechnical
- Local agencies
- Transit agencies

The team's role is to:

- Develop a charter that includes the processes for reaching consensus, resolving disputes, and assigning responsibility for final decisions when consensus is not reached.
- Expedite the decision report development and review process through early communication and agreement.
- Provide guidance and support.
- Contribute to identification of possible alternatives.
- Define the study and decision report parameters.
- Ensure compatibility of data used in various studies.
- Agree on impact areas and travel forecasts for each of the alternatives being considered.
- Help integrate the Project Definition process studies, Value Engineering studies, public involvement efforts, environmental analyses, operational analyses, and analyses for the Access Point Decision Report. This can encourage use of consistent data.
- Address deviation issues. (Representatives from approving agencies participate in problem-solving.)
- Provide conclusions promptly, in writing, to the persons preparing the Access Point Decision Report.
- Contribute material for the decision report that documents the opposing point of view when consensus was not reached.
- Review results.

(2) The second step: to prepare a detailed decision report using the guidance in 1425.05 "Access Point Decision Report and Supporting Analyses" (Figure 1425-3a, boxes 5 through 9).

The Access Point Decision Report usually addresses eight specific policy topics in detail. (See Figures 1425-1a and 1b for exceptions.) They are, in order of presentation:

1. Future Interchanges
2. Land Use and Transportation Plans
3. Reasonable Alternatives
4. Need for the Access Point Revision
5. Access Connections and Design
6. Operational and Accident Analyses
7. Coordination
8. Planning and Environmental Processes

The extent of the decision report varies considerably with the scope of the access point revision. For example, for locked gates and emergency temporary access to sites normally accessed by another route, the application for approval may be condensed to a letter format that includes adequate justification.

The Access Point Decision Report is begun early in the environmental process because it's analyses help define the area of impact and the range of alternatives. Since the traffic data required for NEPA or SEPA and the operational analyses of the decision report are similar, these documents are usually developed together using the same data sources and procedures.

(3) The third step: acceptance based on an Access Point Decision Report that defines the proposed access point revision and other needed modifications to the main line and the local surface system to protect freeway operations and safety.

The region, with the help of the support team, prepares the Access Point Decision Report and submits four copies (two for non-Interstate) to the Access and Hearings Engineer (in the Design Office, Olympia Service Center) for review and submittal for acceptance and approval. When the access point revision is on an Interstate freeway, regardless of funding sources, the State Design Engineer submits the decision report to FHWA with a request for acceptance and approval (Figure 1425-3b, box 10).

Acceptance of the proposed access point revision by FHWA or the State Design Engineer is a *finding of engineering and operational acceptability*. For state routes, the State Design Engineer's acceptance is given concurrently with environmental approval (Figure 1425-3b, boxes 11 through 14).

Some Interstate access point revisions are reviewed by FHWA at the local divisional level in Washington State and consequently require less time for a determination of acceptability and final approval. Others are reviewed by the Federal Highway Administrator in Washington, DC, and can require a more protracted review and acceptance process. See Figure 1425-1b for details.

FHWA final approval requires that the National Environmental Policy Act (NEPA) procedures are followed. The NEPA procedures are accomplished as part of the normal project development process and as a condition of the access approval. Final access point approval cannot precede the completion of the NEPA process. To offer maximum flexibility, however, any proposed access point(s) may be submitted for a determination of engineering and operational acceptability prior to completion of the NEPA process. A determination can be made as to whether or not a proposal is acceptable for inclusion as an option in the environmental process.

(4) The fourth step: for Interstate projects, is the FHWA final approval of the access point revision that is given concurrently with the local division level environmental approval (as in the case of a Record of Decision) or as part of the NEPA approval (Figure 1425-3b, box 15).

1425.05 Access Point Decision Report and Supporting Analyses

Begin the Access Point Decision Report with an executive summary. Briefly state what access point revision is being submitted for a decision and why the revision is needed. Include a brief summary of the proposal and the impacts and mitigative measures of the proposal.

For any new access point on an existing freeway to be considered for acceptance and approval, all eight policy points must be addressed in the Access Point Decision Report. If the project modifies an existing access point, see Figures 1425-1a and 1b for the required policy points. (See Figure 1425-2 for project types that might not require a decision report.)

Follow the summary statement with a numbered outline representing the eight policy points being covered in the decision report. In the outline, provide a sentence or two that very briefly answers each policy point's question. If one of the eight policy points is not included, briefly justify its omission. Figure 1425.1a or 1b might be referenced as justification or, for instance, if there are no documents for number seven, its outline entry might read: “**7. Coordination.** No developers are involved and no work on the local system is proposed.”

All eight policy points are provided numbered tabs in the decision report. The Access Point Decision Report must be assembled in the numbered order. An empty tab is justified in the outline.

The following guidance for each policy point is written for the most extreme condition — a new interchange in an urbanized area. The scope of the analyses and documentation need not be as extensive for more modest access point revisions. Factors that affect the scope include location (rural or urban), access points (new or revised), ramps (new or existing), ramp terminals (freeway or surface system), and intersections (revise or replace with interchange or over/undercrossing).

The following guidance on the preparation of the decision report applies to routes in both rural and urban areas.

Each of the policy points is part of the decision report to answer the question given at the beginning of the discussion.

(1) Future Interchanges

Is the proposed access point revision compatible with a comprehensive network plan?

In areas where the potential exists for future multiple interchange additions, support all requests for revised access points by a comprehensive freeway network study with recommendations that address all proposed, reasonable, and desired access points within the context of a long-term plan for that area.

In larger urban areas, regional plans might be too generalized to specify individual interchanges. To plan the relative priority of new access points, a plan refinement study or traffic circulation study must be completed.

The study must demonstrate that the proposed revised access point is compatible with other feasible new access points that have already been proposed.

Reference and summarize any comprehensive freeway network study, plan refinement study, or traffic circulation study.

Explain the consistency of the proposed access point revision with those studies.

(2) Land Use and Transportation Plans

Is the proposed access point revision compatible with all land use and transportation plans for the area?

Show that the proposal is based on consideration of and is consistent with local and regional land use and transportation plans. Before final approval, all requests for access point revisions must be consistent with the metropolitan and/or statewide transportation plan, as appropriate. (See Chapter 120.)

Reference the existing and proposed land use plan and the regional and local transportation plans and studies that apply to the area.

Explain the consistency of the proposed access point revision with those plans and studies, the applicable provisions of 23 CFR Part 450, and the applicable transportation conformity requirements of 40 CFR Parts 51 and 93.

If the proposed access is not specifically referenced in the transportation plans, define its consistency with the plans and indicate the process for the responsible planning agency to incorporate the project. In urban areas, the plan refinement must be adopted by the metropolitan planning organization (MPO) before the project is designed.

The proposed access point revision will affect adjacent land use and, conversely, land use will affect travel demand generated. Therefore, reference and show compatibility with the land use plans, zoning controls, and transportation ordinances in the affected area.

(3) Reasonable Alternatives

Have all reasonable alternatives been assessed and provided for?

Explain how the preferred proposal provides for all reasonable alternatives that are currently justified and includes provisions to accommodate alternatives that meet the identified future (design year) needs. (For example, if ramp metering and an HOV bypass meet future needs, they are provided for by constructing adequate storage or by acquiring adequate right of way for future construction.) Future projects must be coordinated as described in policy point 7 below.

Describe all reasonable alternatives that have been considered — the design options, locations, and transportation system management type improvements (such as ramp metering, mass transit, and HOV facilities) that have been assessed.

Describe alternatives that were proposed and then rejected as being unreasonable.

Explain why omitted reasonable alternatives were dismissed.

(4) Need for the Access Point Revision

What are the current and projected needs and why won't the existing access points and existing or improved local system meet the needs? Is the anticipated demand short or long trip?

Provide a narrative section that describes the need for an access point revision and explains why existing access points do not address the need and how the proposal does meet the anticipated travel demand. Provide the analysis and data to support the access request.

(a) **Narrative.** Describe the needs being addressed and describe the proposal in detail. Include all reasonable alternatives for design options, location, and travel demand management and transportation system management type improvements that are proposed to address the needs. Show that any alternative that might affect the need for the proposal has been considered in the needs analyses.

Show that the existing interchanges/intersections and the local surface system can neither provide the necessary access nor be improved to satisfactorily accommodate the design-year travel demands. Describe traffic mitigation measures considered at locations where the level of service is or will be below service standards.

Show that the access point revision portion of the proposal is primarily to meet regional (not local) travel demands. Distinguish between local and regional traffic (trip link and/or route choice).

(b) **Analysis and Data.** The data analysis procedures and study areas used must be acceptable to the support team.

Show that a preliminary (planning level) analysis, comparing build to no-build data, was conducted and included the following steps:

- Define the study areas. The proposed access point revision will affect adjacent land use and, conversely, land use will affect travel demand generated. For a possible new interchange, there might be more than one study area depending on build/no-build options and the associated land use development levels.
- Develop current and design year (20 years from start of construction) peak hour traffic estimates for the regional and local systems in the subarea of the proposal. Use regional transportation planning organization based forecasts refined, as necessary, by accepted travel demand estimating procedures. Forecasts for specific ramp traffic can require other methods of estimation procedures and must be consistent with the projections of the travel demand models. (See the *Forcasting and Methods Matrix*, when available.)
- Identify the origins and destinations of trips on the local systems, the existing interchange/intersections, and the proposed access.
- Assign the appropriate travel demand to improvements that might be made to:

    - The surface system such as: widen, add new surface routes, coordinate the signal system, control access, improve local circulation, or improve parallel roads or streets.
    - The existing interchanges such as lengthen or widen ramps, add park and ride lots, or add frontage roads.
    - The freeway lanes such as add collector-distributor roads or auxiliary lanes.
    - Transportation system management and travel demand management measures.
- Describe the current and design year level of service at all affected locations within the study area; including local systems, existing ramps, and freeway lanes.

(5) Access Connections and Design

Will the proposal provide fully directional interchanges connected to public roads, spaced appropriately, and designed to full design level geometric control criteria?

Wherever possible, provide for all directions of traffic movements. The intent is to try to provide full movement at all interchanges. Less than fully directional interchanges for special-purpose access for transit vehicles, for HOVs, or to or from park and ride lots will be considered on a case-by-case basis.

A proposed interchange access must connect to a public highway, road, or street.

Discuss interchange spacing and how the proposed access point relates to present and future proposed configurations and the spacing recommendations.

Show that the proposed access point revision will be designed to meet or exceed current full design level (Chapters 325, 440, 640, 940, and 1050, for example). Present the information in sufficient detail to be used for an operational analysis. For example, include the number of lanes, horizontal and vertical curvature, lateral clearance, lane width, shoulder width, weave distance, ramp taper, and all traffic movements, if appropriate. This information is presented as a simple sketch or a more complex layout depending on the complexity of the proposal. Construction plans, specifications, and estimates of quantities are not necessary.

When existing nonstandard features are to be retained, explain why they are nonstandard and justify the decision not to improve them to standard. The support team helps determine the extent of reconstruction to be proposed and rules on any suggestions regarding deviations for new work that are being considered to become part of the proposal.

Show that all new ramp terminals will be designed to meet or exceed current state and local full design level geometric control criteria.

(6) Operational and Accident Analyses

How will the proposal affect safety and traffic operations now and for the next 20 years?

The support team plays a critical role in operational and accident analysis decisions such as selecting appropriate procedures, defining affected areas, selecting appropriate data, and defining “significant adverse impact.” These are project-specific decisions.

The reporting for policy point six is documentation of the procedures used to do the operational and accident analyses and the results that support and justify the proposal.

Once the (preferred) proposed access revision has been selected, show that it will not have a significant adverse impact on the (a) operation and (b) safety of the freeway and the affected surface system, or that the impacts will be mitigated. If this cannot be shown, the needs and alternatives are revisited, using more detailed information, to develop a different proposal.

Show that the analysis procedures and study areas used are acceptable to the support team.

Document the results of the following analyses in the decision report as appropriate:

- An operational analysis for both the opening and design years of the existing freeway and the affected surface system.

- An operational analysis for both the opening and design years of the proposed future freeway and the affected surface system for the preferred proposal.
- An accident analysis for both opening and design years of the existing freeway and the affected surface system, and for the proposed future freeway and affected surface system.

The data used must be consistent with the data used in the environmental documentation. If not, provide justification for the discrepancies.

(a) **Operational Analyses.** Demonstrate that the proposal does not have a significant adverse impact on the operation of the freeway or the adjacent affected surface system or that the impacts will be mitigated.

Use appropriate operational analysis procedures. For complex urban projects, a refined model might be necessary. As a minimum, the latest accepted *Highway Capacity Manual* (HCM) might be appropriate. Any procedure used must provide a measure of effectiveness compatible with the HCM. Include data sufficient to allow independent verification of the results by using the HCM.

All (design level) operational analyses shall be of sufficient detail and include sufficient data and procedure documentation to allow independent analysis and concurrence during FHWA or OSC evaluation of the proposal.

Prepare a sketch or layout displaying adjacent affected facilities and the following data. Include this sketch or layout in the body of the decision report where it is readily available to the reviewers. Show:

- Distances between intersections or ramps of a proposed interchange and that of adjacent interchanges.
- Design speeds.
- Grades.
- Truck volume percentages on the freeway, ramps, and affected roadways.
- Adjustment factors (peak hour factors, etc.).
- Freeway, ramp, and affected surface system traffic volumes (including turning volumes) forecasts for each option, including a "no-build" scenario, in the AM and PM peaks (also, noon peaks, if applicable) and average daily traffic (ADT), for the opening and design year.
- Current year (report year) traffic volumes based on traffic counts.
- Main line, ramp, and affected surface system lane configurations.

The required minimum limits of the analysis on the freeway are through the adjacent and proposed interchanges/intersections on both sides of the access point revision unless it is documented that the proposal has no impacts on the adjacent interchanges/intersections. If the interchanges/intersections are closely spaced, it might be necessary to go beyond adjacent interchanges/intersections. In urban areas, extend the analyses far enough to include the extent of the traffic impacts.

The required limits of the capacity analysis on the surface system are the extent necessary to show that the system can safely and adequately collect and distribute any new traffic loads resulting from the access point revision. Expand the limits of the study area, if necessary, to analyze the coordination required with an in-place or proposed traffic signal system. Document the limits of the analysis as well as how the limits were established.

Document the results of analyzing the existing access and the proposed access point revision at all affected locations within the limits of the study area (such as, weave, merge, diverge, ramp terminals, accident sites, and HOV lanes) along the affected section of freeway (main line and ramps) and on the affected surface system. In the decision report, highlight the following:

- Any location for which there is a significant adverse impact on the operation or safety of the freeway facility (such as causing a reduction of the operational efficiency of a merge condition at an existing ramp, introducing a weave, or significantly reducing the level of service on the main line due to additional travel demand) as well as what will be done to mitigate this adverse impact.

- Any location where a congestion point will be improved or eliminated by the proposal (such as proposed auxiliary lanes or collector-distributor roads for weave sections).
- Any surface system conditions that will affect traffic entering or exiting the freeway. If entering traffic is to be metered, explain the effect on the connecting surface system (for example, vehicle storage).
- When the existing facility does not meet the desired level of service, show how the proposal will improve the level of service or keep it from becoming worse than the future level with no change in access.

(b) **Accident analyses.** Demonstrate that the proposal does not have a significant adverse impact on the safety of the freeway or the adjacent affected surface system or that the impacts will be mitigated.

The required minimum limits of study are the same as for the operational analyses.

Identify all safety program (I2) locations. Where appropriate, identify accident histories, rates, and types for the freeway section and the adjacent affected surface system. Project the rates that will result from traffic flow and geometric conditions imposed by the proposed access point revision. Document the basis for all assumptions.

(7) Coordination

Are all coordinating projects and actions programmed and funded?

When the request for an access point revision is generated by new or expanded development (such as private developer or new park and ride lot), demonstrate appropriate coordination between the development and the changes to the transportation system.

Show that the proposal includes a commitment to complete the other noninterchange/nonintersection improvements that are necessary for the interchange/intersection to function as proposed. For example, the local circulation system must be in place before new ramps are opened to traffic and there must be commitment to the travel demand management and transportation system management concepts included in the proposal. If future reconstruction is part of the mitigation for design year level of service, the reconstruction projects must be in the State Highway System Plan.

All elements for improvements must be shown to include a fiscal commitment and a definite time for completion.

If the access point is to be designed as a left-side connection for HOV use only, include a commitment to close the access, rather than to open it to general use, if the HOV demand is moved to another access point or it declines to a level that no longer justifies the access.

(8) Planning and Environmental Processes

What is the status of the proposal's planning and environmental processes?

All requests for access point revisions on Interstate freeways must contain information on the status of the planning process. Show that the following federal objectives have been considered and report the proposed project's relationship to meeting them.

Federal law (23 USC 111) requires that *"each state carry out a transportation planning process that provides for consideration of projects and strategies that will:*

(a) Support the economic vitality of the United States, the states, and metropolitan areas, especially by enabling global competitiveness, productivity, and efficiency.

(b) Increase the safety and security of the transportation system for motorized and nonmotorized users.

(c) Increase the accessibility and mobility options available to people and for freight.

(d) Protect and enhance the environment, promote energy conservation, and improve quality of life.

(e) Enhance the integration and connectivity of the transportation system, across and between modes throughout the state, for people and freight.

(f) Promote efficient system management and operation.

(g) Emphasize the preservation of the existing transportation system."

All requests for access point revisions on freeways must contain information on the status of the environmental process. The following are just a few examples of status information that might apply.

- Are the environmental documents presently or soon-to-be submitted for approval?
- What applicable permits and approvals have been obtained and are pending?
- Are there hearings still to be held?
- Is the environmental process waiting for an engineering and operational acceptability decision?

1425.06 Documentation

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

Project Type	Support Team	Policy Point								Accept-ance *	Approval *
		1	2	3	4	5	6	7	8		
Full and Partial Access Control (See Chapter 1420.)											
For Interstate Freeways										FHWA	FHWA
For Non-Interstate Freeways										OSC	OSC
New freeway-to-crossroad interchange in a transportation management area (1)	R	S F	S F	S F	S F	S F	S F	S F	S F	N or ✓	L or ✓
New freeway-to-crossroad interchange not in a transport-ation management area (1)	R	S F	S F	S F	S F	S F	S F	S F	S F	L or ✓	L or ✓
New partial interchange	R	S F	S F	S F	S F	S F	S F	S F	S F	N or ✓	L or ✓
New HOV direct access to and/or from the median	R	S F	S F	S F	S F	S F	S F	S F	S F	N or ✓	L or ✓
New freeway-to-freeway interchange	R	S F	S F	S F	S F	S F	S F	S F	S F	N or ✓	L or ✓
Modification to freeway-to-freeway interchange in a transportation management area (1)(2)	R	S F	S F	S F	S F	S F	S F	S F	S F	N or ✓	L or ✓
Modification to freeway-to-freeway interchange not in a transportation management area (1)(2)	R	S F	S F	S F	S F	S F	S F	S F	S F	L or ✓	L or ✓
Modification to interchange (3)	R	S F	S F	S F	S F	S F	S F	S F	S F	L or ✓	L or ✓
Addition of entrance or exit ramps that complete basic movements at existing interchange	R	S F	S F	S F	S F	S F	S F	S F	S F	L or ✓	L or ✓
Abandonment of a ramp (4)	R	S F	S F	S F	S F	S F	S F	S F	S F	L or ✓	L or ✓
Locked gate (Letter Format)	No			B	B	(5)	B			L or ✓	L or ✓
Emergency temporary access to site normally accessed by another route. (Letter Format)	No			B	B	(5)	B			L or ✓	L or ✓

See legend and notes next page.　　　* See legend item next page.

Access Point Decision Report Content and Review Levels

Figure 1425-1a

Project Type	Support Team	Policy Point 1	2	3	4	5	6	7	8	Acceptance ∗	Approval ∗
For Partial and Modified Access Control Freeways (See Chapter 1420.)										OSC	OSC
New intersection or access point, partial access control	R	S	S	S	S	S	S	S	S	✓	✓
New intersection or access point, modified access control	R			S	S	(5)	S			✓	✓
Change intersection to interchange or over/undercrossing (6)	R	S		S	S	S	S			✓••	✓••
Modify interchange with effects	R			S	S		S		(7)	✓	✓
Modify intersection with effects	R			S	S					✓	✓

∗ See 1425(3) regarding acceptance and 1425(4) regarding approval.

•• See Figure 1425-2 for exceptions

FHWA Federal Highway Administration.

OSC Olympia Service Center, Design Office. The Access and Hearings Engineer coordinates acceptance and approval.

B Brief (policy point) report item required.

✓ OSC acceptance and approval.

F On the Interstate system, a (policy point) report item required by FHWA.

L For Interstate, FHWA acceptance or approval at the local division level, which can be expected to take from 1 to 4 months, or longer, depending on the complexity of the project and its environmental processes.

N For Interstate, FHWA acceptance at the national level, which can be expected to take from 3 to 12 months, or longer, depending on the complexity of the project and its environmental processes.

R Recommended.

S On a non-Interstate route, a (policy point) report item required by the state.

Notes:

(1) A transportation management area is a county with a population greater than 200,000. In Washington they are Clark, King, Pierce, Snohomish, Spokane, and Yakima Counties.
(2) “Modification” includes changes in interchange configuration even though the number of access points does not change. Changing from a cloverleaf to a directional interchange is an example of a “modification.” However, for non-Interstate, if the modification does not add new lanes and can be shown to have no adverse impacts, and the spacing and geometric control criteria requirements will be met, omit the request and document justification to the design file.
(3) Modifications that might adversely affect the level of service of the through lanes. Examples: doubling lanes for an on-ramp with double entry to the freeway; adding a loop ramp to an existing diamond interchange, replacing a diamond ramp with a loop ramp.
(4) Unless it is a condition of the original approval.
(5) Sketch only.
(6) Changing an intersection to an over/undercrossing if all conditions on Figure 1425-2 are met.
(7) Only if data is not consistent between the decision report and the environmental analyses.

Access Point Decision Report Content and Review Levels

Figure 1425-1b

Project Type	Comments
Modify existing freeway to freeway interchange	To bring to standard
Revise existing component (lengthening or widening)	To meet current geometric control criteria
Ramp modification at the crossroad with no effect on the through lanes of the freeway	New right turn pocket, for example
Add a lane to a ramp that merges before entering the through lane	Adding a lane at the on/off access point requires a decision report
Reconstruct intersection at grade having HAL, HAC, or FAL concerns	Changing an intersection to an interchange or over/undercrossing requires a report unless all geometric control and policy criteria are met.
Modification of the intersection of a ramp and a crossroad	Signalize, redo radii, for example

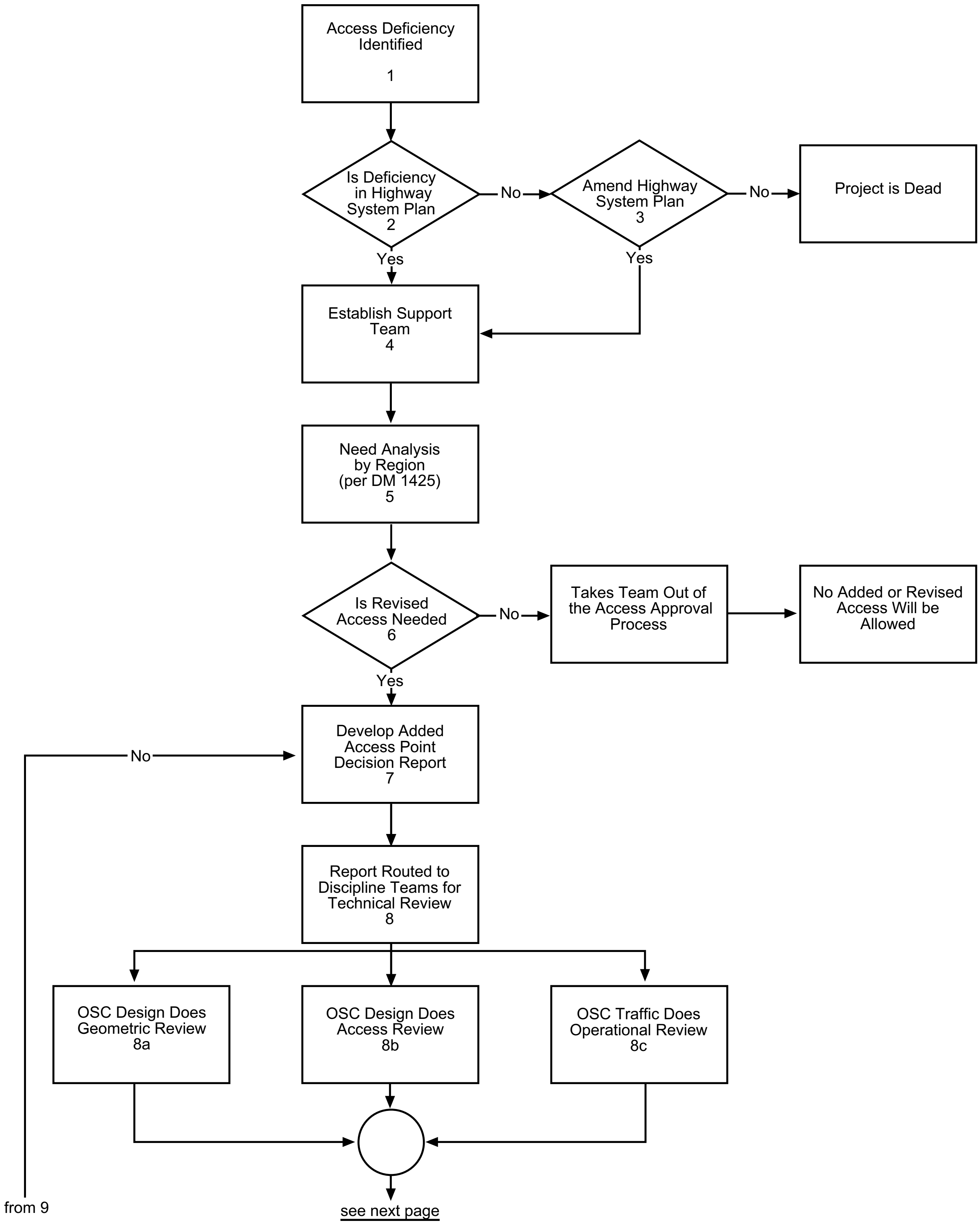
Note:

The table above shows some, but not all, of the types of access revisions that do not require a request and Access Point Decision Report if the following conditions are met.

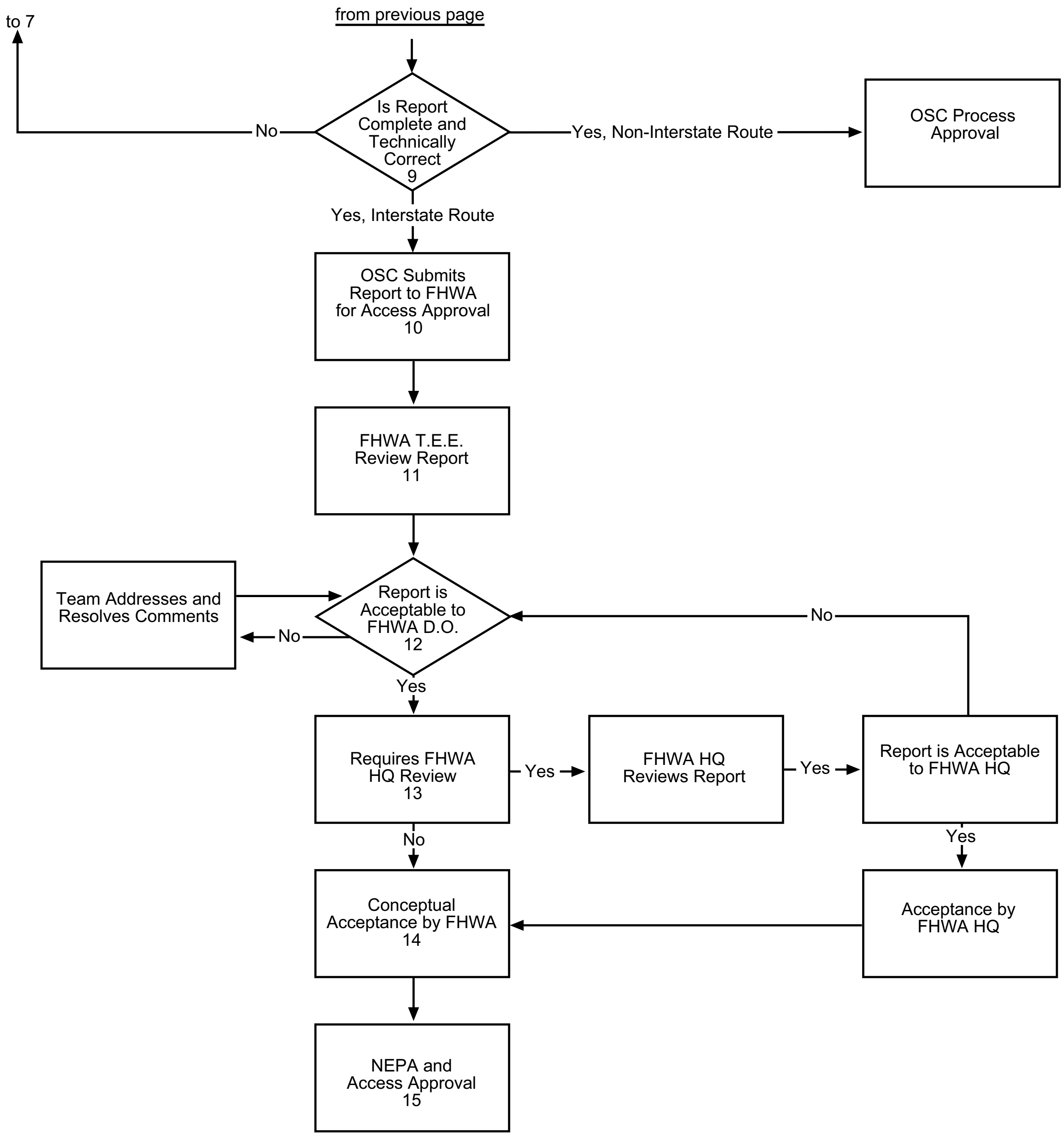
- It is documented that there will be no adverse impact on the freeway.
- The data used is consistent with the data used in the environmental analyses.
- The access is designed to the design level required by the appropriate Design Matrix.
- Access spacing meets requirements in Chapter 940.
- The project is approved per Chapter 330 as part of the Project Summary approval process.
- Omission of the request and decision report is justified to file with a copy sent to the state Access and Hearings Engineer.

Access Point Decision Report Possibly Not Required

Figure 1425-2



Access Point Decision Report Flow Chart
Figure 1425-3a



Access Point Decision Report Flow Chart
Figure 1425-3b

1430.01 General

Chapter 1420, "Access Control," has an overview of access control and the references list and definitions of terminology for this chapter.

Requirements for the establishment of limited access highways are set forth in Revised Code of Washington (RCW) 47.52. The level of limited access is determined during the early stages of design in conformance with this chapter.

Limited access is established to preserve the safety and efficiency of specific highways and to preserve the public investment. Limited access is achieved by acquiring access rights from abutting property owners, and by selectively limiting approaches to the highway.

Highways controlled by acquiring abutting property owners' access rights are termed limited access highways and are further distinguished as having full, partial, or modified control. The number of access points per mile, spacing of interchanges or intersections, and the location of frontage roads or local road/street approaches are determined by:

- The functional classification and importance of the highway.
- The character of the traffic.
- The present and future land use.
- The environment and aesthetics.
- The highway design and operation.
- The economic considerations involved.

The Washington State Department of Transportation (WSDOT) has full jurisdiction on limited access highways, whether they are inside or outside incorporated city limits except that the Federal Highway Administration (FHWA) has jurisdiction on the Interstate System.

WSDOT keeps a record of the status of limited access control, by state route number and mile post, in the database: Access Control Tracking System at http://www.wsdot.wa.gov/eesc/design/access, under the RELATED SITES heading.

The acquisition of full, partial, or modified control is to be evaluated when right of way is being acquired on an existing highway if the route is shown on the Access Control Tracking System list as either established or planned for limited access. The matrices in Chapter 325 list several project types for which acquisition is indicated as a design element.

The cost of acquiring limited access must be evaluated considering future accident costs, future development, and the improved level of service of limited access highways. This cost will be evaluated against the cost to realign the highway in the future if limited access is not acquired at current prices.

Nothing in this chapter is to be construed to prevent acquisition of short sections of full, partial, or modified control of access.

1430.02 Achieving Limited Access

(1) Process

All Washington highways are managed access highways (Chapter 1435) except where limited access rights have been acquired. The right of way and limited access plans show the acquired limited access boundaries along the highways shown on the Access Control Tracking System as "Established Limited Access." The Tracking System list also shows the highways that are "Planned for Limited Access."

To achieve limited access:

(a) The Transportation Commission first identifies a highway as “Planned for Limited Access.”

(b) To establish or revise limited access on new or existing highways, access hearings are held. See Chapter 210, “Public Involvement” regarding hearings, and Chapter 1410 for the phases of appraisal and acquisition.

- Phase 1. The region develops an access report and an access report plan for department approval and presentation to local officials. The plan notes the level of limited access proposed to be established.
- Phase 2. The region develops an access hearing plan for the State Design Engineer or designee approval and for presentation at the hearings.
- Phase 3. After the hearing, the region develops the findings and order and revises the hearing plan to become the findings and order plan. The findings and order is processed to Headquarters (HQ) Access and Hearings Unit for review and approval.

(c) The Transportation Commission or a designee adopts the findings and order and thus establishes the limits and level of limited access control to be acquired.

(d) The findings and order plan is now revised by the Right of Way Plans Office for approval by the State Design Engineer or designee as a Phase 4 final right of way and limited access plan.

(e) Real Estate Services acquires limited access rights from individual property owners based on final design decisions (diamond interchange or single point, for instance) and updates the right of way and limited access plans.

(f) These highways or portions thereof are now limited access highways and no longer fall under the managed access program.

Highways are shown in the Access Control Tracking System as “L/A” in the CURRENT ACCESS column and further listed under ESTABLISHED L/A, PLANNED L/A, or L/A ACQUIRED, based on the current right of way and limited access plans. If not listed under L/A ACQUIRED, the highway section is a managed access highway section until the acquisition is final.

(2) Access Report

The access report is developed by the region to inform local governmental officials of the proposed limited access highway, the principal access features involved, and to secure their approval. This report is not furnished to abutting property owners. Three copies of the report are submitted to the HQ Access and Hearings Unit for review and approval prior to submission to local authorities.

The access report consists of:

(a) A description of the existing and proposed highways. Data on the history of the existing highway (may include references to High Accident Locations (HAL), High Accident Corridors (HAC), Pedestrian Accident Locations (PAL), and Risk locations) and development of the proposed highway(s).

(b) Traffic analyses pertaining to the proposed highway, including available information concerning present and potential future traffic volumes of county roads and city streets crossing or severed by the proposed highway, and sources of information (origin-destination surveys, and so forth).

Traffic data developed for the design decision summary, together with counts of existing traffic directly available from state or local records, is normally adequate. Special counts of existing traffic are obtained only if circumstances indicate that the available data is inadequate or outdated.

(c) A discussion of factors affecting the design of the subject highway, including:

- Design level.
- Level of limited access, with definition.
- Roadway section.
- Interchange, grade separation, and intersection spacing.
- Pedestrian and bicycle trails or paths.

- Operational controls with emphasis on proposed fencing, the general concept of illumination, signing, and other traffic control devices.
- Locations of utilities and how affected.
- Proposed plan for landscaping and beautification, including an artist's graphic rendition or design visualization.

(d) Governmental responsibility, comprehensive planning, land use, and community service relative to the new highway.

(e) The disposition of frontage roads, city street and county road intersections, and excess right of way.

(f) An appendix containing the following:

- A glossary of engineering terms.
- A traffic volume diagram(s).
- Pages showing diagrammatically or graphically the roadway section(s), operational controls, and rest areas (if rest areas are included in the project covered by the report).
- A vicinity map.
- An access report plan and profiles for the project.

  The access report plan shows the effects of the proposed highway on the street and road system by delineating the points of public access. See the *Plans Preparation Manual* for a list of the minimum details to be shown on the plan and for a sample plan.

(h) Conferences and Reviews. Upon receipt of the Environmental and Engineering Programs (E&EP) Director's approval of Phase 1 (Figure 1410-1), the region publishes the necessary copies, submits the access report to the county and/or city officials for review and approval, and meets with all local governmental agencies involved to discuss the report. The region reviews any request for modification and submits recommendations, with copies of any correspondence or minutes relating thereto, to the HQ Access and Hearings Unit.

(3) Access Hearing Plan

The region prepares an access hearing plan to be used as an exhibit at the public hearing (Chapter 210) and forwards it to the HQ Right of Way Plans Office for review. See the *Plans Preparation Manual* for a list of data to be shown on the access hearing plan in addition to the access report plan data.

When the plan review is completed by Headquarters, the access hearing plan is placed on the E&EP Director's calendar for approval of Phase 2 authority (Figure 1410-1).

(4) Documentation

Documentation for the establishment of limited access control is in Chapter 210.

1430.03 Full Control (Most Restrictive)

(1) Introduction

Full control limited access highways provide almost complete freedom from disruption by allowing access only through interchanges at selected public roads/streets, rest areas, viewpoints, or weigh stations, and by prohibiting at-grade crossings and approaches. Gated approaches are occasionally allowed but only with approval of a request that includes an Access Point Decision Report (Chapter 1425).

At times, on state highways where full access control has been established, except Interstate, staged access acquisition may be used (subject to the approval of an access deviation) with initial acquisition as partial or modified control and with ultimate acquisition of full control planned on the highway. Where there is no practical alternative within reasonable cost, the decision to defer acquisition of limited control of access must be documented and is subject to the approval of an access deviation.

(2) Application

Terminate full control limited access sections at apparent logical points of design change. The following guidelines are to be used for the application of full control on limited access highways:

(a) **Interstate.** Full control is required on Interstate highways.

(b) **Principal Arterial.** Documentation assessing the evaluation of full control is required for principal arterial highways requiring four or more through traffic lanes within a 20-year design period unless approved for partial or modified control on existing highways by the Transportation Commission.

(c) **Minor Arterial and Collector.** Minor arterial and collector highways will not normally be considered for development to full control.

(3) Crossroads at Interchange Ramps

The extension of limited access control beyond an intersection is measured from the center line of ramps, crossroads, or parallel roads as shown in Figures 1430-1a, b, and c, from the terminus of transition tapers, Figure 1430-2, and single point urban intersections, Figure 1430-3.

(a) **Ramps.** At-grade intersections and approaches are prohibited within the full length of any off or on interchange ramp. The ramp is considered to terminate at its intersection with the local road or street.

(b) **Frontage Roads.** See Figures 1430-1a, b and c. Direct access from the highway to a local service or frontage road is allowed only via the interchange crossroad.

(c) **Interchange Crossroads.** In both urban and rural areas, full control limited access must be established and then acquired along the crossroad at an interchange for a minimum distance of 300 ft beyond the center line of the ramp or the end of the transition taper.

If a frontage road or local road is located at or within 350 ft of a ramp, limited access will be established and then acquired along the crossroad and for an additional minimum distance of 130 ft in all directions from the center line of the intersection of the crossroad and the frontage or local road (Figures 1430-1a and b) or 130 ft from the ends of the raised splitter islands of a roundabout (Figure 1430-1c).

For interchanges incorporating partial cloverleaf and/or buttonhook ramps (Figure 1430-1b), limited access is required for all portions of the crossroad and frontage roads between the ramp terminals, and for a distance of 300 ft beyond the ramp terminals. If an at-grade intersection for a local road or street is to be served directly opposite the ramp terminals, limited access will be extended additionally for a minimum of 300 ft, along that leg of the intersection.

When the intersection in question is a roundabout, see Figure 1430-1c. This shows extension of full control to be 300 ft measured from the end of the raised splitter island for an intersection with a ramp terminal and 130 ft for three legs of an at-grade intersection at or within 350 ft of a ramp terminal intersection.

Figure 1430-2 shows the terminus of transition taper.

For a single point urban interchange (SPUI) with a right or left turn “ramp branch” (separated by islands), Figure 1430-3, access control is measured (300 ft) from the intersection of the center line of the ramp branch with the center line of the nearest directional roadway.

(d) **Levels of Limited Access, Location of Approaches.** See Figures 1430-1a, b, and c and Figures 1430-2 and 3. Provide full control for 300 ft from the center line of the ramp or terminus of a transition taper.

If the economic considerations to implement full control for the full 300 ft are excessive, then provide full control for the first 130 ft and partial or modified control may be provided for the remaining 170 ft, for a total minimum distance of 300 ft of limited access. Contact the HQ Access and Hearings Unit when considering this option.

An approved access deviation is required if the limited access control falls short of 300 ft and for any access that has been allowed to remain within the first 130 ft.

Ensure that approaches are far enough away from a frontage road intersection to provide efficient intersection operation.

(4) Location of Utilities, Bus Stops, Mailboxes, and Pedestrian Crossings

(a) **Utilities.** See the *Utilities Accommodation Policy* regarding location of and access to utilities. Connecting utility lines are allowed along the outer right of way line between intermittent frontage roads.

(b) **Bus Stops.** Common carrier or school bus stops are not allowed except at:

- Railroad crossings (Chapter 930).
- Locations provided by the state on the interchanges (such as flyer stops).
- In exceptional cases, along the main roadway where pedestrian separation is available.

(c) **Mailboxes.** Mailboxes are not allowed on full control limited access highways. Mail delivery will be from frontage roads or other adjacent local roads.

(d) **Pedestrian Crossings.** At-grade pedestrian crossings are not allowed except at ramp terminal at-grade intersections.

(5) Nonmotorized Traffic

All nonmotorized traffic is prohibited on full control limited access highways. This prohibition does not apply to:

- Pedestrian separations or other facilities provided specifically for pedestrian use.
- Bicyclists using facilities provided specifically for bicycle use (separated paths).
- Bicyclists using the right-hand shoulders, except where such use has been specifically prohibited. Information pertaining to such prohibition is available from the Traffic Branch of the Operations and Maintenance Office.

(6) Trails

Pedestrian and bicycle trails are allowed, consistent with “Rules of the Road” (RCW 46.61), within the limits of full control limited access highways. When trails are allowed (with headquarters approval), they must be documented on the right of way and limited access plan. The plan shows the location of the trail and where the trail crosses limited access, and provides movement notes. See 1430.10(1).

1430.04 Partial Control

(1) Introduction

Partial control may be established, when justified, on any highway except Interstate. Partial control provides a considerable level of protection from traffic interference and protects the highway from future strip-type development.

Upon acquisition of partial control limited access rights, the number, type, and use of the access approaches of abutting property are frozen. The abutting property access rights and type of use are recorded upon the property deed. The rights and use may not be altered by the abutting property owner, the local jurisdiction, or the region. This authority resides with the State Design Engineer. See 1430.10.

(2) Application

Partial control will not normally be used in urban areas, or inside corporate limits on existing principal arterial highways where traffic volumes are less than 700 design hourly volume (DHV). Terminate limited access sections at apparent logical points of design change.

(a) **Principal Arterial.** The minimum route length is all sections not requiring full control. See 1430.03(2)(b).

Partial control is required when the estimated traffic volumes exceed 3,000 average daily traffic (ADT) within a 20-year design period on principal arterial highways requiring two through traffic lanes. For multilane principal arterial highways, see 1430.03(2)(b).

(b) **Minor Arterial.** The minimum route length is: urban, 2 miles; rural, 5 miles; and combination urban and rural, 3 miles.

Partial control is required on rural minor arterial highways on both new and existing locations, and urban minor arterial highways on new locations, requiring four or more through traffic lanes within a 20-year design period, or requiring only two through traffic lanes where the estimated traffic volumes exceed 3,000 ADT within a 20-year design period.

Other rural minor arterial highways with only two lanes may be considered for partial control if any of the following conditions apply:

- The partial control can be acquired at a reasonable cost.
- The route connects two highways of a higher functional classification.
- The potential land development can result in numerous individual approaches, such as encountered in recreational or rapidly developing areas.
- The highway traverses publicly owned lands where partial control is desirable.

(c) **Collector (New Alignment).** Partial control is required on collector highways on new locations requiring four or more through traffic lanes in a 20-year design period.

(d) **Collector (Existing).** Existing collector highways will normally be considered for partial control limited access only when all of the following conditions apply:

- The highway serves an area that is not directly served by a higher functional classification of highway.
- Existing or planned development will result in traffic volumes significantly higher than what is required for partial control on minor arterials.
- Partial control can be established without a major impact on development of abutting properties within the constraints of established zoning at the time when the partial control is proposed.

(3) Interchanges and Intersections

(a) **Interchanges.** When an interchange occurs on a partial control limited access highway, full control applies at the interchange and interchange ramps. Refer to 1430.03(3) and see Figures 1430-1a, b, and c for required minimum lengths of access control.

(b) **Intersections.** At an at-grade intersection on a partial control limited access highway, control will be established and acquired along the crossroad for a minimum distance of 300 ft from the center line of the highway. (Figure 1430-4) If another frontage or local road is located at or within 350 ft of the at-grade intersection, limited access will be established and then acquired along the crossroad for the required minimum 300 ft and for an additional minimum distance of 130 ft in all directions from the center line of the intersection of the frontage or local road or the ends of the raised splitter islands of a roundabout (Figure 1430-5) and the crossroad. On multilane highways, measurements will be made from the center line of the nearest directional roadway.

An approved access deviation is required if the limited access control falls short of 300 ft and for any access that has been allowed to remain within the first 130 ft.

At-grade intersections with public roads are limited to the number allowed for the functional classification of highway involved as follows:

Principal Arterial - If the ADT is less than 2,000, one mile spacing (minimum), center line to center line. If over 2,000 ADT within 20 years, plan for grade separation.

Minor Arterial - If the ADT is less than 2,000, one-half mile spacing (minimum), center line to center line. If over 2,000 ADT within 20 years, plan for grade separation.

Collector - Road (or street) plus property approaches not more than six per side per mile.

However, with approval from the State Design Engineer, shorter intervals may be used where topography or other conditions restrict the design. When intersecting roads are spaced farther apart than one per mile, median crossings may be considered for U-turns in accordance with Chapter 910. Keep U-turns to a minimum, consistent with requirements for operation and maintenance of the highway.

To discourage movement in the wrong direction on multilane highways, locate private approaches 300 ft or more from an at-grade intersection. At a tee intersection, a private approach may be located directly opposite the intersection or a minimum of 300 ft away from the intersection. Ensure that a private approach directly opposite a tee intersection cannot be mistaken for a continuation or part of the public traveled way.

(4) Access Approach

Partial control is exercised to the level that, in addition to intersections with selected public roads, some crossings and private driveways may be allowed.

(a) **Approach Types.** Partial control limited access highways allow at-grade intersections with selected public roads and private approaches using Type A, B, C, and F approaches. See Chapter 1420 for definitions of the approach types.

Type D, commercial approaches, are not allowed direct access to partial control limited access highways. Commercial access is allowed only by way of public roads.

The type of approach provided for each parcel takes into consideration present and potential land use and is based on an economic evaluation. See 1430.05(4) for a list of considerations.

(b) **Design Considerations.** The following considerations are used to determine the number and location of access approaches on partial control limited access highways.

1. Access approaches must be held to a minimum. The number is limited as follows:
    - Principal arterial - 2 per side per mile.
    - Minor arterial - 4 per side per mile.
    - Collector - 6 per side per mile including at-grade intersections
2. Approaches in excess of the number listed in 1., above, may be allowed as stage construction if approved by the State Design Engineer.
3. Approaches are not allowed for parcels that have reasonable access to other public roads unless the parcel has extensive highway frontage.
4. Relocate or close approaches located in areas where sight limitations create undue hazard.
5. Allow only one approach for each parcel except for very large ownerships, or where terrain features do not allow the property to be served by a single approach. This includes contiguous parcels under a single ownership.
6. Where possible, locate a single approach to serve two or more parcels.
7. The approved design is to provide for future development of frontage roads that will eliminate an excessive number of approaches.

(5) Location of Utilities, Bus Stops, Mailboxes, and Pedestrian Crossings

(a) **Utilities.** See the *Utilities Accommodation Policy* regarding location of and access to utilities. Connecting utility lines are allowed along the outer right of way line between intermittent frontage roads.

(b) **Bus Stops.** Bus stops for both common carriers and school buses are not allowed on either two or four-lane highways, except as follows:

- At railroad crossings per Chapter 930.
- At locations of intersections with necessary pullouts to be constructed by the state.
- Where shoulder widening has been provided for mail delivery service.
- For a designated school bus loading zone on the traveled lane or adjacent thereto which has been approved by the Department of Transportation.

Buses are not allowed to stop in the traveled lanes blocking at-grade intersections or private approaches to load or unload passengers.

School bus loading zones on partial control limited access highways must be posted with school bus loading zone signs, in accordance with the latest edition of the *Manual on Uniform Traffic Control Devices*.

(c) **Mailboxes.** Locate mailboxes on frontage roads or at intersections with the following exceptions for properties that are served by Type A or B approaches:

- Locate mailboxes on a four-lane highway only on the side of the highway on which the deeded approach is provided.
- Locate mailboxes on a two-lane highway on the side of the highway that is on the right in the direction of the mail delivery.

Whenever mailboxes are allowed on a partial control limited access highway, provide mailbox turnouts to allow mail delivery vehicles to stop clear of the through traffic lanes. See Chapter 700 for additional information concerning mailbox locations and turnouts.

(d) **Pedestrian Crossings.** Pedestrian crossings are allowed when grade-separated.

At-grade pedestrian crossings are allowed:

- At intersections only where an at-grade crossing is provided in accordance with Chapter 1025.
- On two-lane highways at mailbox locations.
- On two-lane highways not less than 100 ft from a school bus loading zone (pull out) adjacent to the traveled lane, if school district and WSDOT personnel determine that stopping in the traveled lane is hazardous.
- On two-lane highways where the school bus is stopped on the traveled lane to load or unload passengers and the required sign and signal lights are displayed.

(6) Nonmotorized Traffic

On partial control limited access highways, pedestrian and bicycle traffic is allowed, consistent with "Rules of the Road" (RCW 46.61), except when unusual safety conditions support prohibition. Information pertaining to such prohibitions is available from the Traffic Engineering Branch of the Operations and Maintenance Office.

(7) Trails

Pedestrian and bicycle trails are allowed, consistent with "Rules of the Road," on partial control limited access highways. When trails are allowed (with headquarters approval), they must be documented on the right of way and limited access plan. The plan shows the location of the trail and where the trail crosses limited access, and provides movement notes. See 1430.10(1).

1430.05 Modified Control (Least Restrictive)

(1) Introduction

Modified control is intended to prevent further deterioration in the safety and operational characteristics of existing highways by limiting the number and location of access points.

Upon acquisition of modified control limited access, the number, type, and use of access approaches of abutting property are frozen. The abutting property access rights and type of use are recorded upon the property deed. The rights and use may not be altered by the abutting property owner, the local jurisdiction, or the region. This authority resides with the State Design Engineer. See 1430.10.

(2) Application

In general, modified control is applied where some level of control is desired, but existing and potential commercial development precludes the implementation of full or partial control.

(a) **Existing Highways.** Modified control may be established and acquired on existing highways other than Interstate. Priority is given to highway segments where one or both of the following conditions apply:

- Commercial development potential is high, but most of the adjoining property remains undeveloped.
- There is a reasonable expectation that the adjoining property will be redeveloped to a more intensive land use resulting in greater traffic congestion.

(b) **Design Analysis**. Selection of highways on which modified control may be applied is based on a design analysis including the following factors:

- Traffic volumes.
- Level of service.
- Safety.
- Level of Development Plan.
- Route continuity.
- Population density.
- Local land use planning.
- Present and potential land use.
- Predicted growth rate.
- Economic analysis.

(c) **Exceptions.** Where modified control is to be established, developed commercial areas may be excepted from control when all or most of the abutting property has been developed to the extent that few, if any, additional commercial approaches will be required with full development of the area. Contact the HQ Access and Hearings Unit when considering this option. If this exception is within the limits of access control requirements, an approved access deviation is required.

(3) Intersections

At an intersection on a modified control limited access highway, access control will be established and acquired along the crossroad for a minimum distance of 130 ft from the center line of a two-lane highway, from the center line of the nearest directional roadway of a four-lane highway, or from the ends of the raised splitter islands of a roundabout (Figures 1430-5 and 6). Approaches are allowed within this area only when there is no reasonable alternative. An approved access deviation is required for any access that has been allowed to remain within the first 130 ft.

(4) Access Approach

The number and location of approaches on a highway, with modified control, must be carefully planned to provide a safe and efficient highway compatible with present and potential land use.

(a) **Approach Types.** Modified control limited access highways allow at-grade intersections with selected public roads and with private approaches using Type A, B, C, D, and F approaches. See Chapter 1420 for definitions of the approach types.

The type of approach provided for each parcel takes into consideration present and potential land use and is based on an economic evaluation that considers the following:

- Local comprehensive plans, zoning, and land use ordinances.
- Property covenants and/or agreements.
- City or county ordinances.
- The highest and best use of the property.
- Highest and best use of adjoining lands.
- Change in use by merger of adjoining ownerships.
- All other factors bearing upon proper land use of the parcel.

(b) **Design Considerations.** The following considerations are used to determine the number and location of approaches:

1. Parcels that have access to another public road or street are not normally allowed direct access to the highway.
2. Relocate or close approaches located in areas where sight limitations create undue hazard.
3. Hold the number of access approaches to a minimum. Access approaches are limited to one approach for each parcel of land, or when adjoining parcels are under one contiguous ownership.
4. Encourage joint use of access approaches where similar use of land allows.
5. Additional approaches may be allowed for future development consistent with local zoning. Once limited access has been acquired, this will require a value determination process. See 1430.10.
6. Close existing access approaches not meeting the above.

(5) Location of Utilities, Bus Stops, Mailboxes, and Pedestrian Crossings

(a) **Utilities**. See the *Utilities Accommodation Policy* regarding location of and access to utilities. Connecting utility lines are allowed along the outer right of way line between intermittent frontage roads.

(b) **Bus Stops and Pedestrian Crossings.** Bus stops and pedestrian crossings are allowed as follows:

- In rural areas, bus stops and pedestrian crossings are subject to the same restrictions as in 1430.04(5).
- In urban areas, bus stops for both commercial carriers and school buses are allowed. See Chapter 1060 for requirements.

(c) **Mailboxes.** Locate mailboxes adjacent to or opposite all authorized approaches as follows:

- Locate mailboxes on a four-lane highway only on the side of the highway on which the deeded approach is provided.
- Locate mailboxes on a two-lane highway on the side of the highway that is on the right in the direction of the mail delivery. Where mailboxes are allowed, a mailbox turnout is recommended to allow mail delivery vehicles to stop clear of the through traffic lanes. See Chapter 700 for additional information concerning mailbox locations and turnouts.

(6) Nonmotorized Traffic

Pedestrian and bicycle traffic is allowed, consistent with “Rules of the Road” (RCW 46.61), on modified control limited access highways, except where unusual safety considerations support prohibition. Information pertaining to such prohibitions is available from the Traffic Engineering Branch of the Operations and Maintenance Office.

(7) Trails

Pedestrian and bicycle trails are allowed, consistent with “Rules of the Road,” on modified control limited access highways. When trails are allowed, they must be documented on the right of way and limited access plan. The plan shows the location of the trail and where the trail crosses limited access, and provides movement notes. See 1430.10(1)

1430.06 Access Approaches

(1) General

Access approaches may be allowed on limited access highways consistent with the requirements outlined in 1430.03, 1430.04, and 1430.05.

For additional information pertaining to approaches, refer to Chapters 915 (roundabouts), 920 (approach design templates), and 1410 (right of way), and the *Plans Preparation Manual*.

(2) Definitions

See Chapter 1420 for specific definitions of the approach types. The widths for the approach types are negotiated, and only the negotiated width is shown on the right of way and limited access plan.

1430.07 Frontage Roads

Local agency approval is required for any planned frontage roads, county roads, city streets, or cul-de-sacs. The local agency must also agree in writing to accept and maintain the new section as a county road or city street.

(1) General

Frontage roads are provided in conjunction with limited access highways to:

- Limit access to the main line.
- Provide access to abutting land ownerships.
- Restore continuity of the local street or roadway system.

Refer to Chapter 620 for frontage road general policy, and to Chapter 330 for required documentation.

By agreement under which the state is reimbursed for all costs involved, frontage roads that are not the responsibility of the state may be built by the state upon request of a local political subdivision, a private agency, or an individual.

(2) County Road and City Street

To connect roads or streets that have been closed off by the highway, short sections of county roads or city streets that are not adjacent to the highway may be constructed if they will serve the same purpose as, and cost less than, a frontage road.

(3) Cul-de-Sacs

For a frontage road or local street bearing substantial traffic that is terminated or closed at one end, provide a cul-de-sac (or other street or roadway consistent with the local policy or practice) that is sufficient to allow vehicles to turn around without encroachment on private property.

1430.08 Turnbacks

When WSDOT transfers jurisdiction of operating right of way to a city, town, or county a turnback agreement is required. See the *Agreements Manual* for turnback procedures.

Locate the turnback limits at points of logical termination. This will allow WSDOT to retain an adequate amount of right of way for maintenance of the highway and for other operational functions.

In areas where limited access rights have been acquired from the abutting property owners, the limited access rights will continue to be required for highway purposes, thus the limited access rights will not be included as part of a turnback agreement.

When a signalized intersection is in the area of a turnback, locate the turnback limit outside of the detector loops if WSDOT is continuing the ownership, operation, and maintenance of the signal system. For a roundabout, locate the turnback limit at the back of the raised approach splitter island if WSDOT is continuing the ownership, operation, and maintenance of the roundabout.

1430.09 Adjacent Railroads

(1) General

A limited access highway and a railroad are considered adjacent when they have a common right of way border with no other property separating them. The allowed approaches only apply to adjacent railroad property that is directly used for current railroad operation.

(2) Requirements

It is in the public interest to provide access to the railroad right of way, from limited access highways, for maintenance of the railroad and the utilities located on the railroad right of way when other access is not feasible. This applies both to new highways and to existing highways where limited access has been acquired.

Direct access is allowed when local roads are infrequent or there are few highway-railroad crossings from which trail-type access for maintenance purposes is feasible, and when unique topography or other unusual conditions justify its use.

Direct access from the highway is considered unnecessary and is not allowed when:

- There are local roads adjacent to or crossing the railroad.
- A trail-type road can be provided by the railroad between crossroads.
- The limited access highway is paralleled by a frontage road adjacent to the railroad.
- No highway previously existed adjacent to the railroad.

(3) Restrictions

To justify direct approaches to provide access to railroad right of way, all of the following conditions must be met:

- A maximum of one approach is allowed for every 2 miles of highway.
- The approach must not adversely affect the design, construction, stability, traffic safety, or operation of the highway.
- Except when the railroad is located in the median area, the approach is to be accomplished in a legal manner by right turns only to and from the roadway nearest the railroad. Median crossing is not allowed.

- The approach is secured by a locked gate under arrangements satisfactory to the department. (See approach Type C in Chapter 1420, and Chapter 1425.)
- Parking of any vehicles or railroad equipment is prohibited within limited access highway right of way.
- A special emergency maintenance permit must be obtained for periods of intensive railroad maintenance.
- The approach must be closed if the railroad operation ceases.
- Approaches are limited to use by the railroad company unless specific provisions for other use are shown on the right of way and limited access plan and included in the right of way negotiations.

1430.10 Modifications to Limited Access Highways

(1) General

Modifications to limited access highways can only be made by application of current design requirements and with the approval of the E&EP Director or designee and, when appropriate, the Federal Highway Administration.

Any change is a modification to limited access: new fence openings, closing existing fence openings, adding trails that cross into and out of the right of way, and widening existing approaches, for instance. The right of way and limited access plan must be revised and, if private approaches are involved, deeds must be redone.

Consider the following factors when evaluating a request for modification of a limited access highway:

- Existing level of control on the highway.
- Functional classification and importance of the highway.
- Percentage of truck traffic.
- Highway operations.
- Present or future land use.
- Environment or aesthetics.
- Economic considerations.
- Safety considerations.

Evaluate all revisions to limited access highways to determine if access hearings are required.

Also see Chapter 1425, "Access Point Decision Report," for requirements to be met for selected modifications to full control limited access highways such as the Interstate System and multilane state highway.

(2) Modifications for Private Access Approaches

(a) **Requirements.** Examples of access modification requested by abutting property owners include additional road approaches, changes in the allowed use, or additional users of existing road approaches.

Plan revisions that provide for additional access to abutting properties after the department has purchased the access rights are discouraged. However, these revisions may be considered if all of the following can be established:

- There are no other reasonable alternatives.
- The efficiency and safety of the highway will not be adversely impacted.
- The existing situation causes extreme hardship on the owner(s).
- The revision is consistent with the limited access highway requirements.

(b) **Procedures**. The region initiates a preliminary engineering review of the requested modification to or break in limited access. This preliminary review will be conducted with the HQ Access and Hearings Unit to determine if conceptual approval can be granted for the request. If conceptual approval can be granted then:

- The region initiates an engineering review of the requested modification.
- The region prepares and submits to HQ Plans Branch a preliminary right of way and limited access plan revision together with a recommendation for approval by the E&EP Director. When federal aid funds are

involved in any phase of the project, the proposed modification will be sent to FHWA for their review and approval.

- The recommendation will include an item-by-item analysis of the factors listed in 1430.10(1) and 1430.10(2)(a) above.

(c) **Valuation Determination.** Upon preliminary approval, region Real Estate Services prepares an appraisal for the value of the access change using a before and after appraisal.

- The appraisal follows the requirements set forth in the *Right of Way Manual*.
- The appraisal is reviewed by the HQ Real Estate Services Office. If the appraisal data does not support a value of $1,500 or more, a minimum value of $1,500 is used.
- For well documented special cases where it does not appear appropriate to base the charges on the reviewed appraisal, region Real Estate Services documents the circumstances that support granting the requested change at less than the determination of value in an administrative settlement letter.
- The appraisal package is sent to HQ Real Estate Services Office for review and approval.
- If federal aid funds were involved in purchasing access control, HQ Real Estate Services will send a copy of the appraisal package to FHWA for their review and approval.

(d) **Final Processing**.

- Region Real Estate Services informs the requestor of the approved appraised value for the change.
- If requestor is still interested, region prepares a "Surplus Disposal Package" for HQ Real Estate Services Office review and approval.
- At the same time, the preliminary right of way and limited access plan revision previously transmitted is processed for approval.
- After the department collects the payment from the requestor, the region issues a permit for the construction, if required.
- If an existing approach is being surrendered, region Real Estate Services obtains a conveyance from the property owner.
- HQ Real Estate Services Office prepares and processes a deed granting the change to the access rights.

(3) Modifications for Public At-Grade Intersections

(a) **Requirements**.

- Public at-grade intersections on partial control limited access highways serve local arterials that form part of the local transportation network.
- Requests for new intersections on limited access highways must be made by or through the local governmental agency to WSDOT. The region will forward this request, including the data referenced in 1430.10(1) and 1430.10(2)(a) to the HQ Access and Hearings Unit.
- New intersections require full application of current limited access acquisition and conveyance to the WSDOT. The access acquisition and conveyance must be completed prior to beginning construction of the new intersection. The new intersection will meet WSDOT design and spacing requirements.

(b) **Procedures**.

- The region evaluates the request and contacts the HQ Access and Hearings Unit for conceptual approval.
- The region submits an intersection plan for approval (Chapter 910) and right of way and limited access plan revision request *(Plans Preparation Manual*). This plan includes the limited access design requirements along the proposed public at-grade intersection.

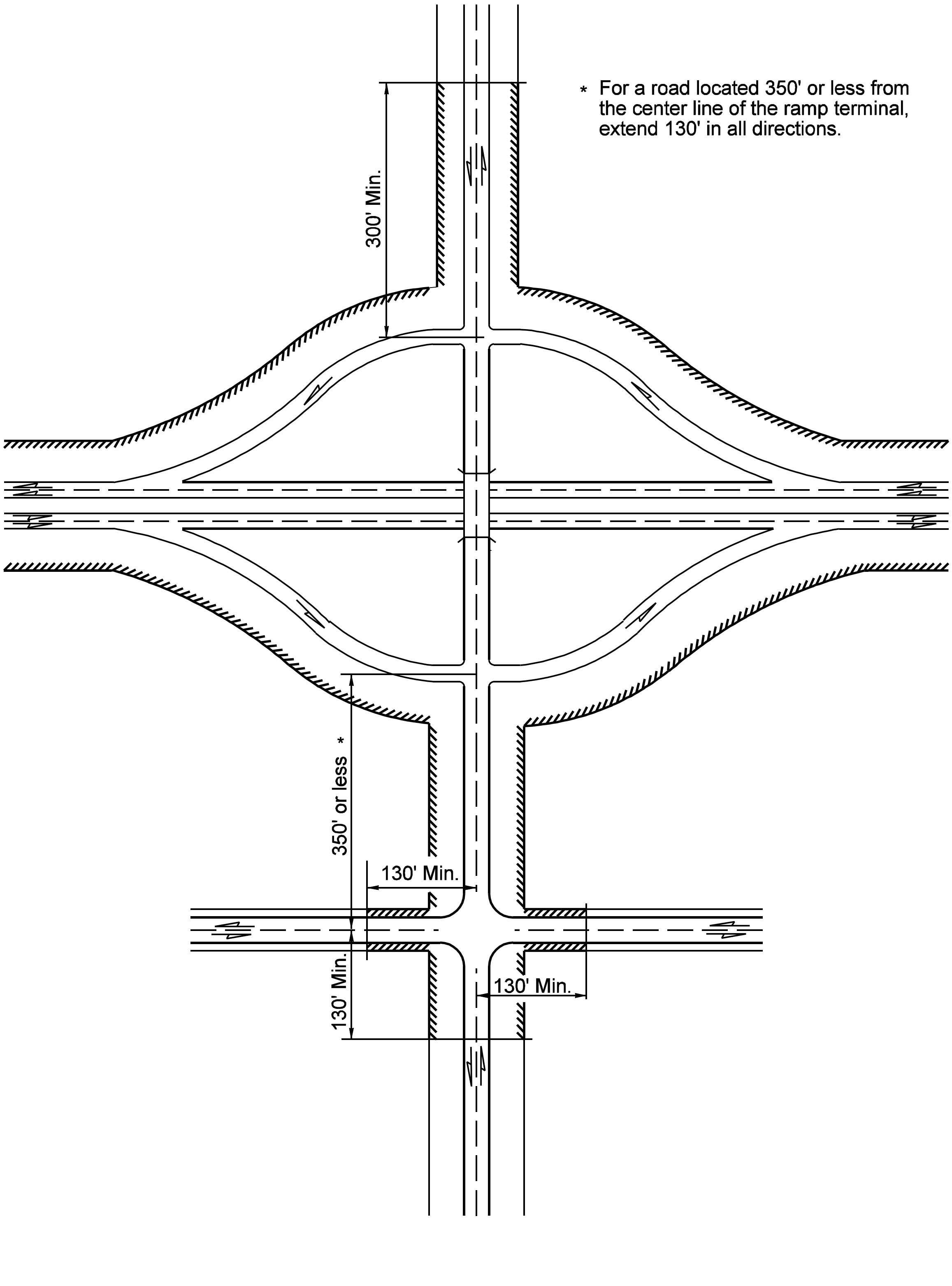
- The State Design Engineer approves the intersection plan.
- The E&EP Director approves the access revision.
- The region submits the construction agreement to the State Design Engineer. (See the *Agreements Manual.*)
- The E&EP Director approves construction agreement.

(c) **Valuation Determination**.

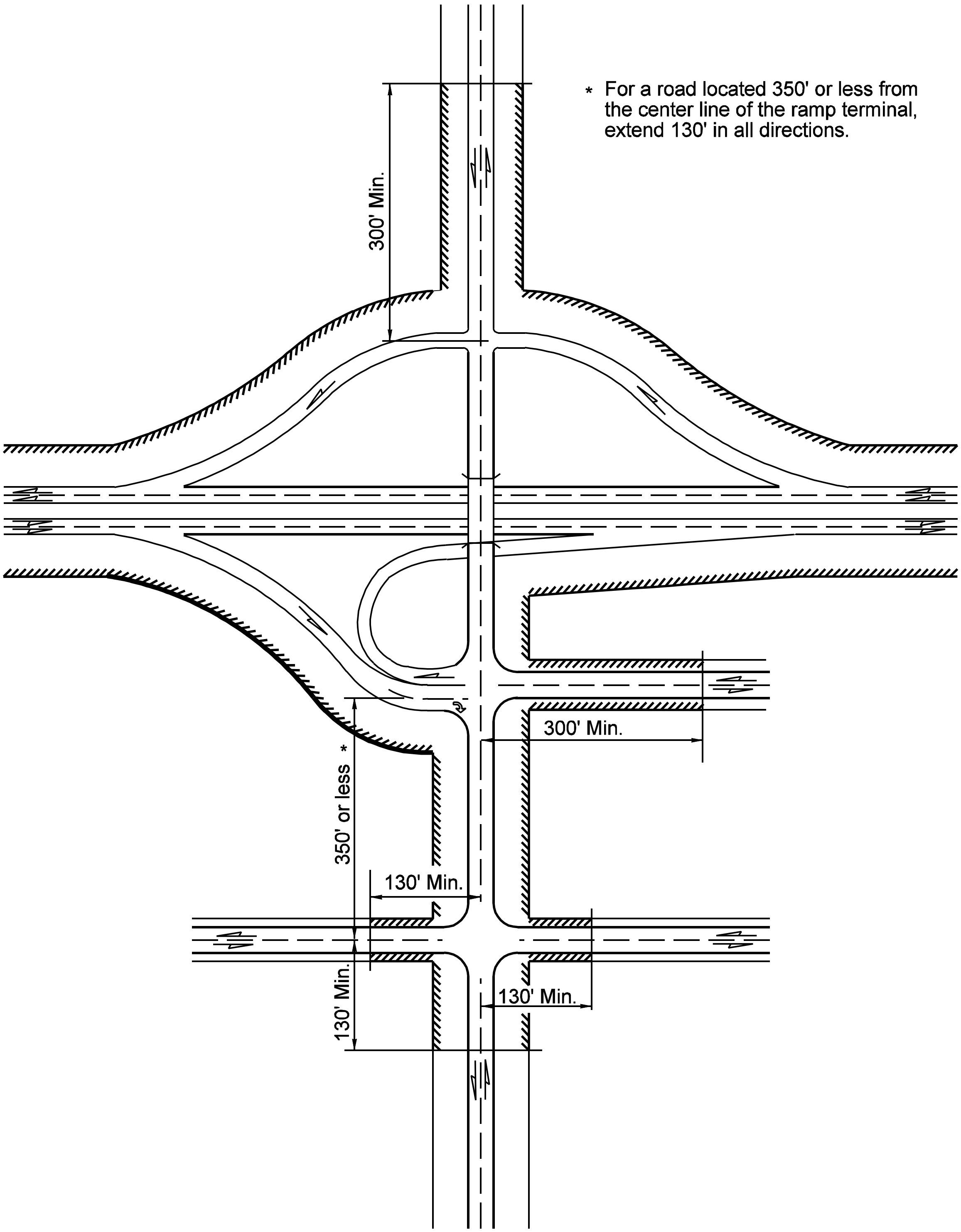
- When a requested public at-grade intersection will serve a local arterial that immediately connects to the local transportation network, compensation will not be required.
- When a requested public at-grade intersection will serve only a limited area, does not immediately connect to the local transportation network, or is primarily for the benefit of a limited number of developers, compensation for the access change will be addressed in the plan revision request. In these situations, compensation is appropriate and a value will be determined as outlined in 1430.10(2)(c) above.

1430.11 Documentation

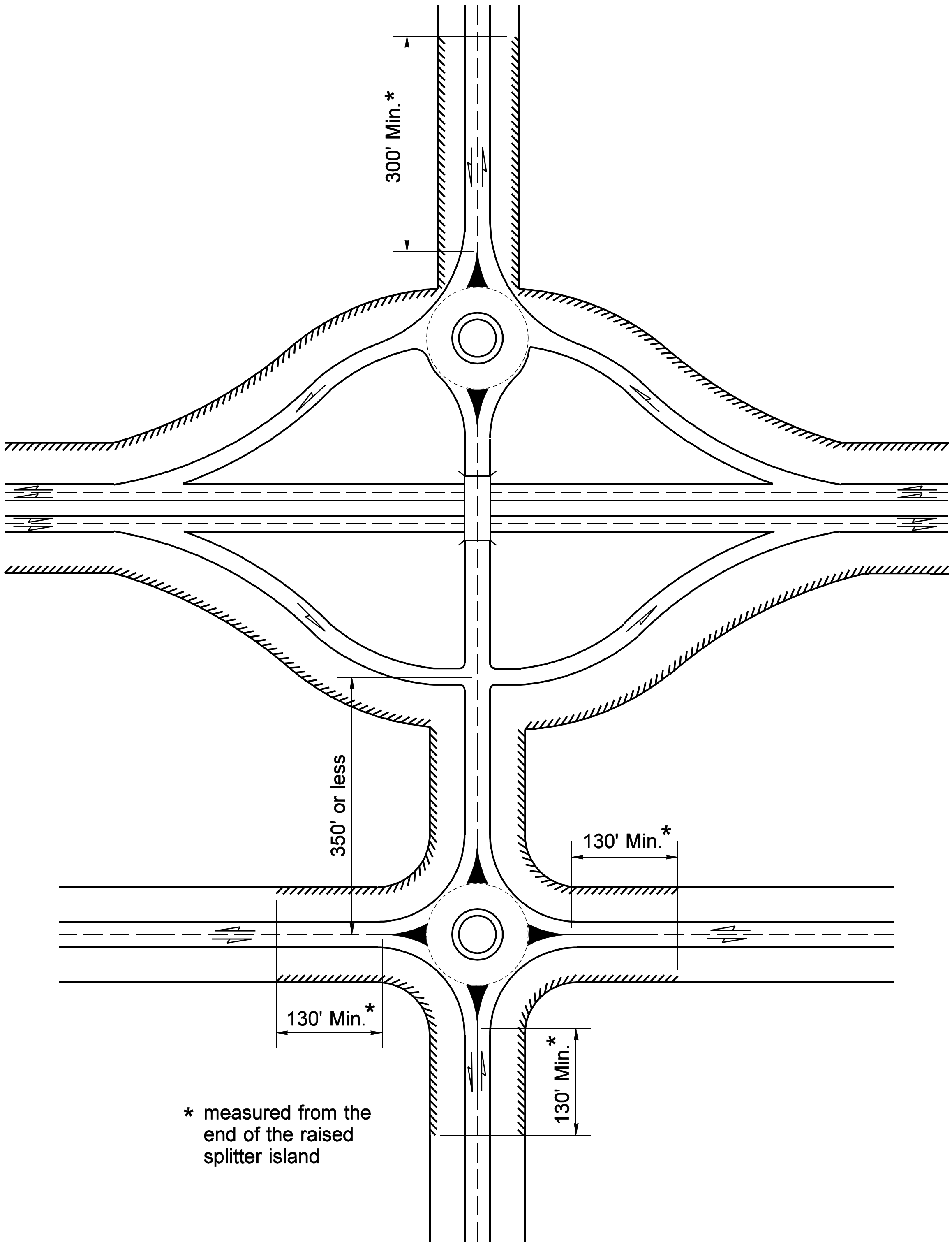
A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/



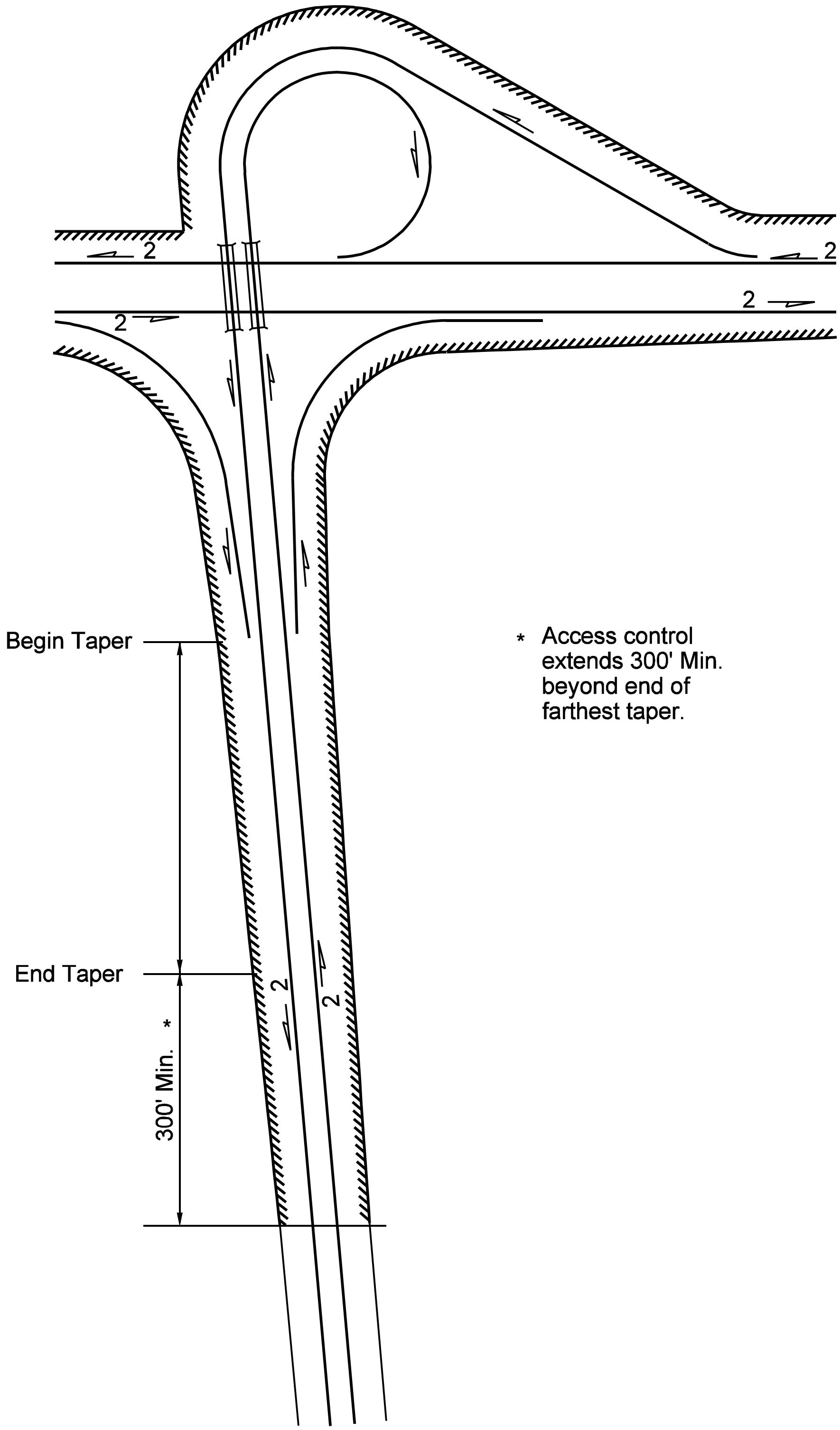
Full Access Control Limits - Interchange
Figure 1430-1a



Full Access Control Limits - Interchange
Figure 1430-1b

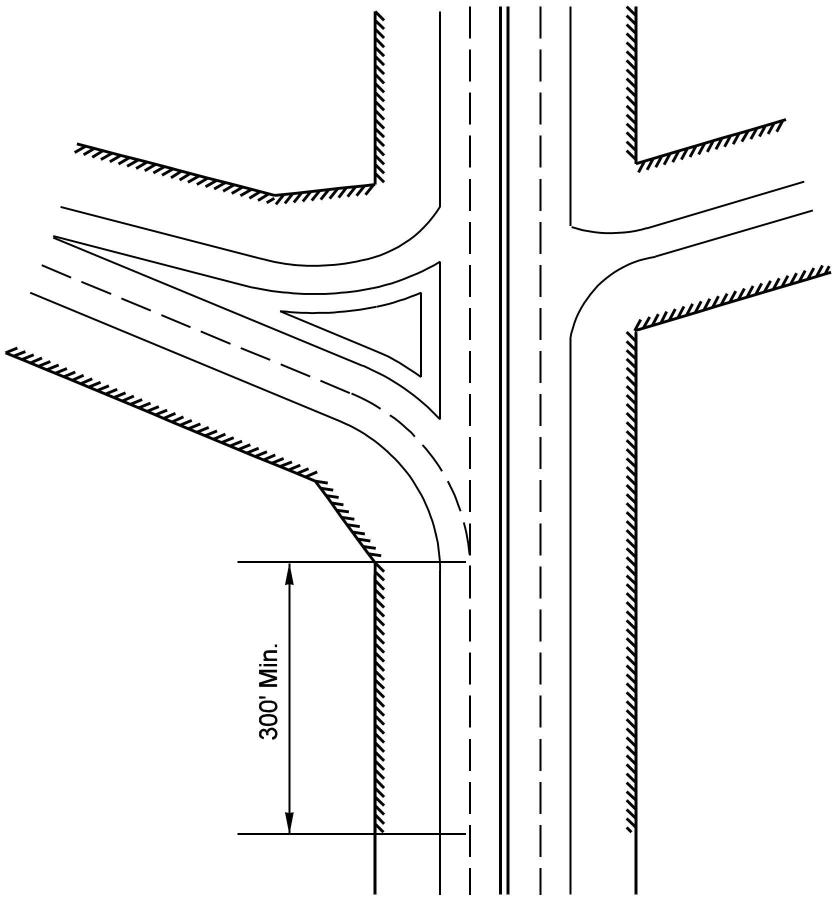


Full Access Control Limits - Interchange
Figure 1430-1c

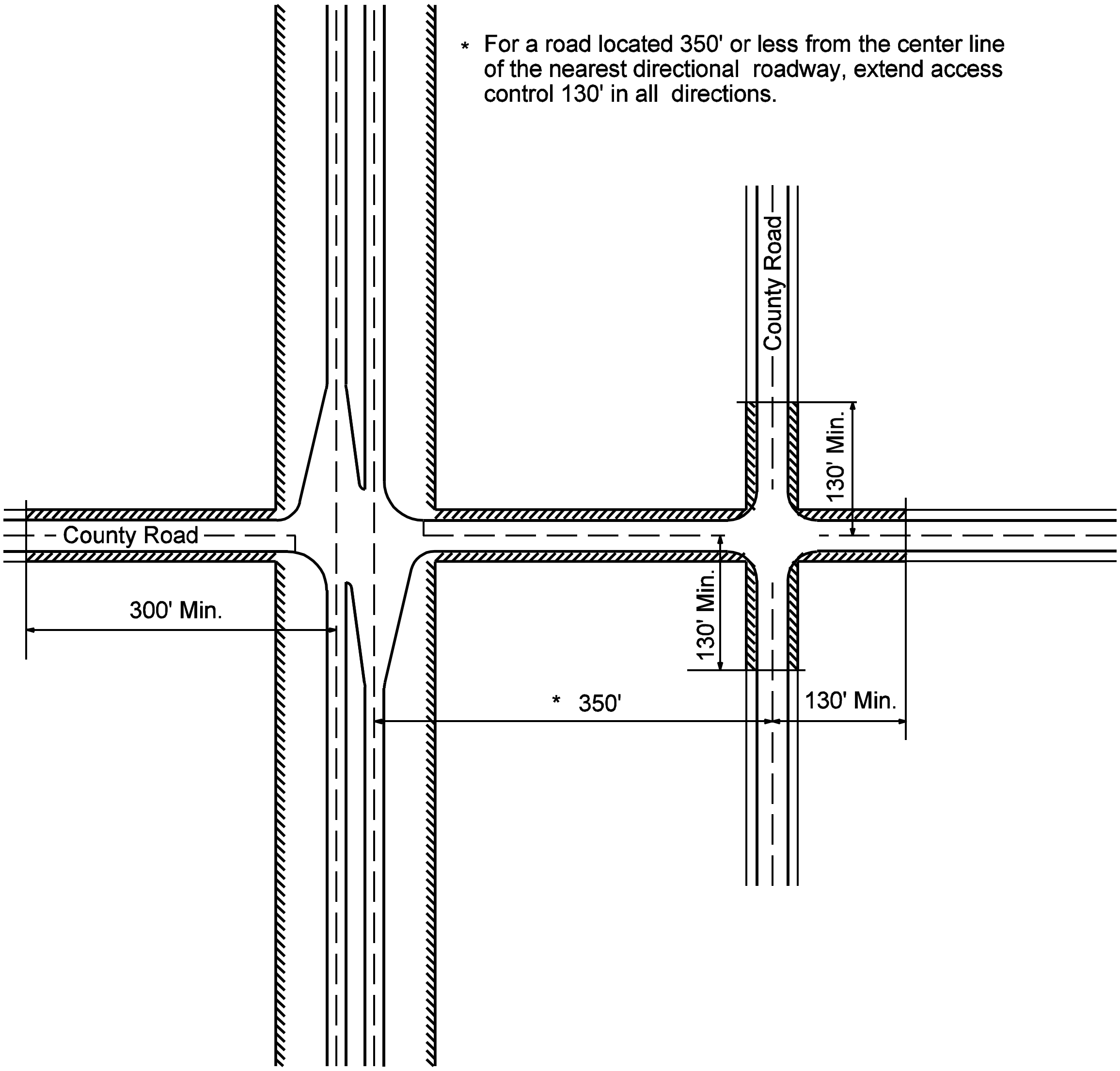


Full Access Control Limits - Ramp Terminal With Transition Taper

Figure 1430-2

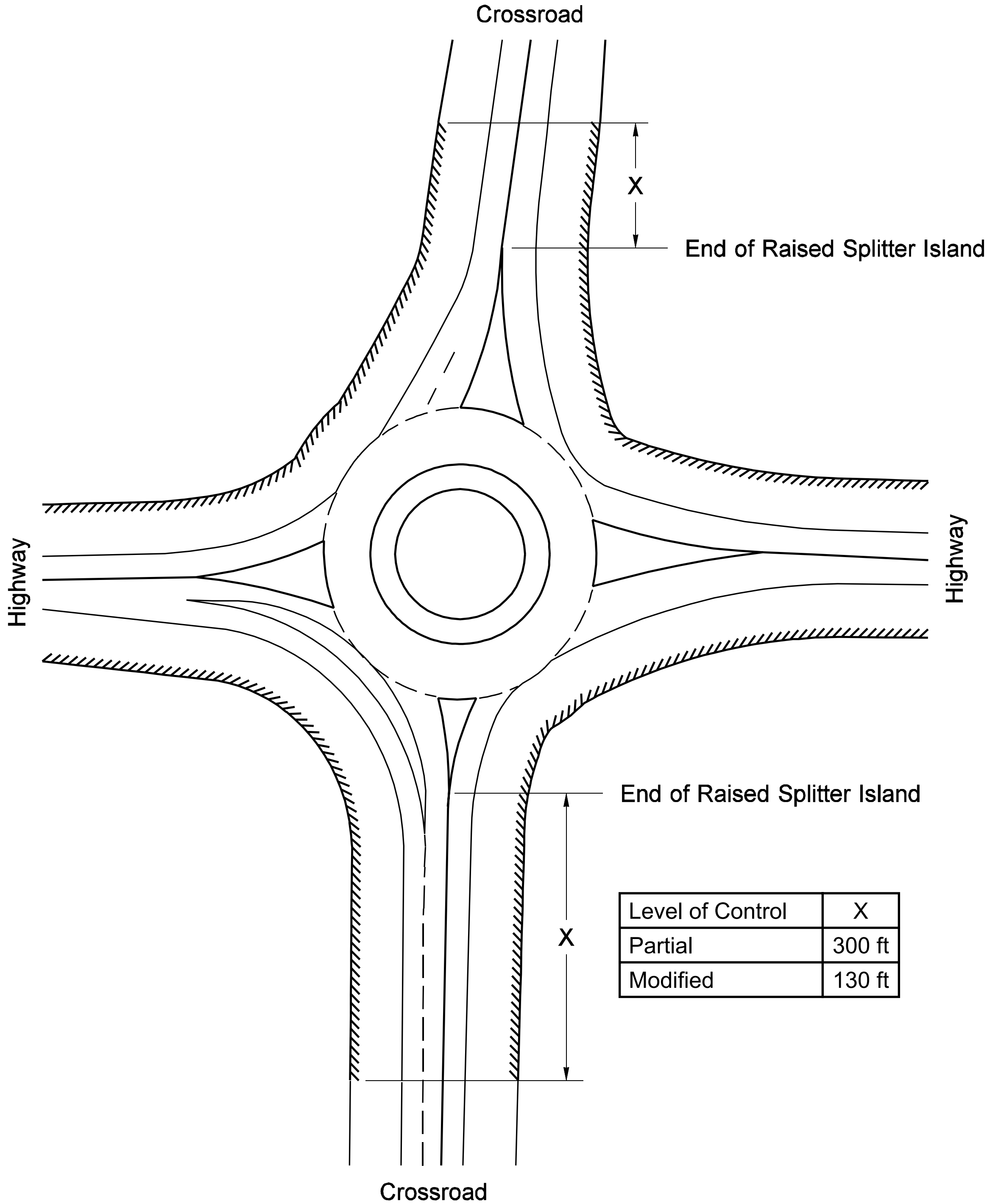


Full Access Control Limits - Single Point Urban Interchange
Figure 1430-3



Partial Access Control Limits - At-Grade Intersections

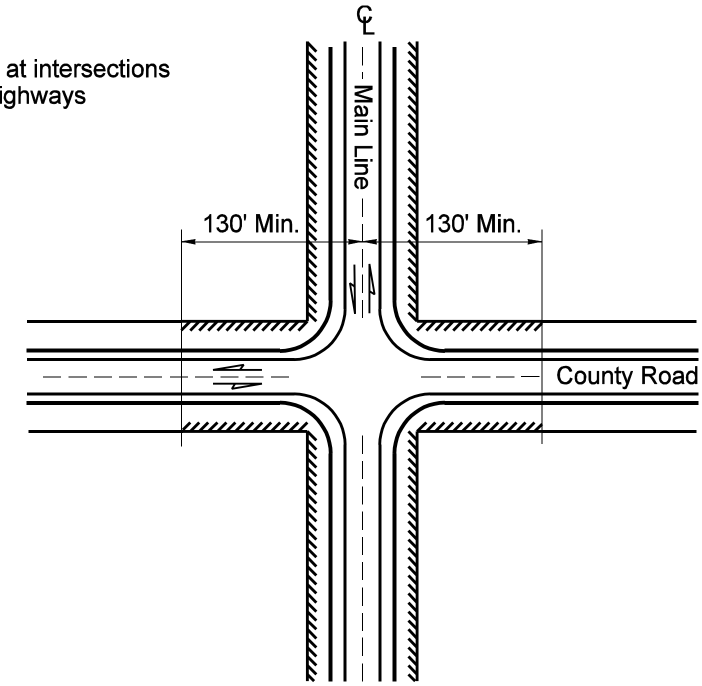
Figure 1430-4



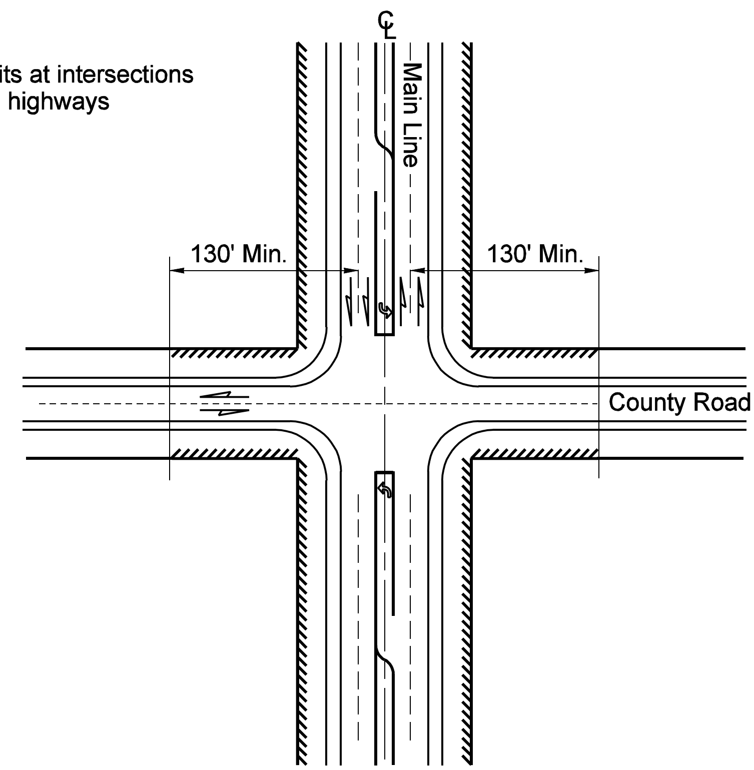
Level of Control	X
Partial	300 ft
Modified	130 ft

Partial and Modified Access Control Limits - Roundabout Intersections
Figure 1430-5

Access control limits at intersections
modified control highways
two-lane



Access control limits at intersections
modified control highways
multilane



Modified Access Control Limits - Intersections
Figure 1430-6

1435.01 General

This chapter describes the permitting process for granting permission to connect to managed access highways within unincorporated areas. Chapter 1420, "Access Control," has an overview of access control, and the references list and the definitions of terminology for this chapter.

In Washington, managed access highways include all state highways that are not limited access highways. The managed access highways do not include limited access highways where the access rights have been acquired in compliance with Revised Code of Washington (RCW) Chapter 47.52. State highways that are planned for or established as limited access, as listed in the Access Control Tracking System (at http://www.wsdot.wa.gov/eesc/design/access/, under the RELATED SITES heading), are treated as managed access highways until such time when the limited access rights are acquired.

Access to managed access highways is regulated by the governmental entity having jurisdiction over the highway's roadsides. Access connection permits are issued on managed access highways. The Washington State Department of Transportation (WSDOT) has access connection permitting authority over all state highways outside incorporated towns and cities. Incorporated towns and cities have access connection permitting authority for the managed access state highways within their boundaries.

Managed access highways are classified from Class 1, the most restrictive, to Class 5, the least restrictive. Access connections to managed access highways are further designated by category, from Category I to Category IV, by vehicular usage.

After a new law, RCW 47.50, went into effect (in 1991) by establishing access management, the first set of new rules, Washington Administrative Code (WAC) 468-51, titled Highway Access Management Access Permits--Administrative Process, was prepared and then adopted by the department in July 1992. This first WAC established a permit fee schedule and application process for only those state highways under the access connection permitting authority of WSDOT.

The second set of new rules, WAC 468-52, titled Highway Access Management -- Access Control Classification System and Standards, was prepared and then adopted by the department in February 1993. This second WAC created a classification system and established design criteria for all managed access highways, including those managed access state highways within the incorporated limits of a town or city.

As with any set of rules, time determines what works and what needs to be changed. Beginning in 1998, the department began reviewing the two existing Highway Access Management WACs (468-51 and 468-52) for possible modifications and improvements. After numerous meetings with representatives from the private sector, government, lawmakers, and the public, the department adopted a newly revised pair of WACs in March 1999.

1435.02 Managed Access Classes

Managed access state highways consist of a classification system of five classes. The classes are arranged from the most restrictive Class 1 to the least restrictive Class 5. In general, most state highways outside the incorporated limits of a city or town have been designated as a Class 1 or 2 highway, with only the most urban, lower speed state highways within an incorporated town or city having the Class 5 designation. Figure 1435-3 lists the five classes of highways with a brief description of each class.

WSDOT keeps a record of the assigned managed access classifications, by mile post, in the database: Access Control Tracking System at http://www.wsdot.wa.gov/eesc/design/access/ under the RELATED SITES heading.

The principal objective of the managed access classification system is to establish access management criteria to be adhered to in the planning for and (regional) approval of access connections to the state highway system.

On Class 1 highways, mobility is the primary function, while on Class 5 highways, access needs may have priority over through mobility needs. Class 2 highways also favor mobility while Class 3 and Class 4 highways generally try to strike a balance between mobility and access. However, remember that restricting or keeping access connections to a minimum is a goal of WSDOT to help preserve the safety, operations, and functional integrity of the state highway.

The most notable distinction between the five classes is the minimum spacing requirements of access connections. Minimum access point spacings, on the same side of the highway, are shown in Figure 1435-3.

On all highway classes one through five, access connections are to be located and designed to minimize interference with transit facilities and high occupancy vehicle (HOV) facilities on state highways where such facilities exist or where such facilities are proposed in a state, regional, metropolitan, or local transportation plan. In such cases, if reasonable access is available from the public road/street system, access is to be provided from the public road/street system rather than from the state highway.

The functional characteristics and the legal requirements for each class are as follows:

(1) Class 1

(a) **Functional Characteristics:**

Class 1 highways provide for high speed and/or high volume traffic movements for interstate, interregional, and intercity travel needs, and some intracity travel needs. Service to abutting land is subordinate to providing service to major traffic movements.

Highways in Class 1 are typically distinguished by a highly controlled, limited number of (public and private) access points, restrictive medians with limited median openings on multilane facilities, and infrequent traffic signals.

(b) **Legal Requirements:**

1. It is the intent that Class 1 highways be designed to have a posted speed limit of 50 to 65 mph. Spacing of intersecting streets, roads, and highways are planned with a minimum spacing of one mile (1 mi). One-half mile (1/2 mi) spacing may be allowed, but only when no reasonable alternative access exists.
2. Private access connections to the state highway are not allowed except when the property has no other reasonable access to the public road/street system. When a private access connection must be provided, the following conditions apply:
   - The access connection continues until such time when other reasonable access to a highway with a less restrictive access control class or access to the public road/street system becomes available and is allowed.
   - The minimum distance to another access point is one thousand three hundred twenty feet (1320') along the same side of the highway. Nonconforming access connection permits may be issued to provide access connections to parcels whose highway frontage, topography, or location otherwise precludes issuance of a conforming access connection permit, however, variance permits are not allowed.
   - No more than one access connection may be provided to an individual parcel or to contiguous parcels under the same ownership.
   - All private access connections are for right turns only on multilane facilities, unless special conditions justify the exception and are documented by a traffic analysis, in the access connection permit application, that is signed and

sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

- Additional access connections to the state highway are not allowed for newly created parcels resulting from property divisions. All access for these parcels must be provided by an internal road/street network. Access to the state highway will be at existing permitted locations or at revised locations.

3. Restrictive medians are provided on multilane facilities to separate opposing traffic movements and to prevent unauthorized turning movements.

(2) Class 2

(a) **Functional Characteristics**

Class 2 highways provide for medium to high speeds and medium to high volume traffic movements over medium and long distances for interregional, intercity, and intracity travel needs. Direct access service to abutting land is subordinate to providing service to traffic movement.

Highways in Class 2 are typically distinguished by existing or planned restrictive medians on multilane facilities, and by large minimum distances between (public and private) access points.

(b) **Legal Requirements**

1. It is the intent that Class 2 highways be designed to have a posted speed limit of 35 to 50 mph in urbanized areas and 45 to 55 mph in rural areas. Spacing of intersecting streets, roads, and highways is planned with a minimum spacing of one-half mile (1/2 mi). Less than one-half mile (1/2 mi) intersection spacing may be allowed, but only when no reasonable alternative access exists.

   In urban areas and developing areas where higher volumes are present or growth that will require signalization is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate signal progression. Addition of all new access points, public or private, that might require signalization will require an engineering analysis that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

2. Private access connections to the state highway system are allowed only when the property has no other reasonable access to the public road/street system or if access to the public road/street system will cause unacceptable traffic operational conditions or safety concerns on that system. When a private access connection must be provided, the following conditions apply:

   - The access connection continues until such time when other reasonable access to a highway with a less restrictive access control class or acceptable access to the public road/street system becomes available and is allowed.
   - The minimum distance to another (public or private) access point is six hundred sixty feet (660’) on the same side of the highway. Nonconforming access connection permits may be issued to provide access to parcels whose highway frontage, topography, or location precludes issuance of a conforming access connection permit.
   - Only one access connection is allowed for an individual parcel or to contiguous parcels under the same ownership unless the highway frontage exceeds one thousand three hundred twenty feet (1320’) and it can be shown that the additional access connection will not adversely affect the desired function of the state highway in accordance with the assigned managed access Class 2, and will not adversely affect the safety or operation of the state highway.
   - Variance permits may be allowed if there are special conditions and the exception can be justified to the satisfaction of the department by a traffic analysis in the access connection permit application

that is signed and sealed by a qualified professional engineer who is registered in accordance with Chapter 18.43 RCW.

- All private access connections are for right turns only on multilane facilities unless there are special conditions and the exception can be justified to the satisfaction of the department by a traffic analysis in the access connection permit application that is signed and sealed by a qualified professional engineer who is registered in accordance with Chapter 18.43 RCW, and only if left turn channelization is provided.
- Additional access connections to the state highway are not allowed for newly created parcels resulting from property divisions. All access for these parcels must be provided by an internal road/street network. Access to the state highway will be at existing permitted locations or at revised locations.

3. On multilane facilities, restrictive medians are provided to separate opposing traffic movements and to prevent unauthorized turning movements; however, a nonrestrictive median or a two way left turn lane may be used when special conditions exist and main line volumes are below 20,000 ADT.

(3) Class 3

(a) **Functional Characteristics**

Class 3 highways provide for moderate travel speeds and moderate traffic volumes for medium and short travel distances for intercity, intracity and intercommunity travel needs. There is a reasonable balance between access and mobility needs for highways in this class. This class is to be used primarily where the existing level of development of the adjoining land is less intensive than maximum build out and where the probability of significant land use change and increased traffic demand is high.

Highways in Class 3 are typically distinguished by planned restrictive medians on multilane facilities, and medium minimum distances between (public and private) access points. Two-way left-turn lanes may be used where special conditions justify them and main line traffic volumes are below 25,000 ADT. Development of properties with internal road/street networks and joint access connections are encouraged.

(b) **Legal Requirements**

1. It is the intent that Class 3 highways be designed to have a posted speed limit of 30 to 40 mph in urbanized areas and 45 to 55 mph in rural areas. In rural areas, spacing of intersecting streets, roads, and highways is planned with a minimum spacing of one-half mile (1/2 mi). Less than one-half mile (1/2 mi) intersection spacing may be allowed, but only when no reasonable alternative access exists.

   In urban areas and developing areas where higher volumes are present or growth that will require signalization is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate signal progression. Where feasible, major intersecting roadways that might ultimately require signalization are planned with a minimum of one-half mile (1/2 mi) spacing. Addition of all new access points, public or private, that may require signalization will require an engineering analysis that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

2. Private Access Connections:

   - No more than one access connection may be provided to an individual parcel or to contiguous parcels under the same ownership unless it can be shown that additional access connections will not adversely affect the desired function of the state highway in accordance with the assigned managed access Class 3, and will not adversely affect the safety or operation of the state highway.

- The minimum distance to another (public or private) access point is three hundred thirty feet (330’) on the same side of the highway. Nonconforming access connection permits may be issued to provide access to parcels whose highway frontage, topography, or location precludes issuance of a conforming access connection permit.
- Variance permits may be allowed if there are special conditions and the exception can be justified to the satisfaction of the department by a traffic analysis in the access connection permit application that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

(4) Class 4

(a) **Functional Characteristics**

Class 4 highways provide for moderate travel speeds and moderate traffic volumes for medium and short travel distances for intercity, intracity and intercommunity travel needs. There is a reasonable balance between direct access and mobility needs for highways in this class. This class is to be used primarily where the existing level of development of the adjoining land is more intensive and where the probability of major land use changes is less probable than on Class 3 highways segments.

Highways in Class 4 are typically distinguished by existing or planned nonrestrictive medians. Restrictive medians may be used to mitigate unfavorable operational conditions such as turning, weaving, and crossing conflicts. Minimum access connection spacing requirements apply if adjoining properties are redeveloped.

(b) **Legal Requirements**

1. It is the intent that Class 4 highways be designed to have a posted speed limit of 30 to 35 mph in urbanized areas and 35 to 45 mph in rural areas. In rural areas, spacing of intersecting streets, roads, and highways is planned with a minimum spacing of one-half mile (1/2 mi). Less than one-half mile (1/2 mi) intersection spacing may be allowed, but only when no reasonable alternative access exists.

   In urban areas and developing areas where higher volumes are present or growth that will require signalization is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate signal progression. Where feasible, major intersecting roadways that might ultimately require signalization are planned with a minimum of one-half mile (1/2 mi) spacing. Addition of all new access points, public or private, that may require signalization will require an engineering analysis that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

2. Private Access Connections:

   - No more than one access connection may be provided to an individual parcel or to contiguous parcels under the same ownership unless it can be shown that additional access connections will not adversely affect the desired function of the state highway in accordance with the assigned managed access Class 4, and will not adversely affect the safety or operation of the state highway.
   - The minimum distance to another (public or private) access point is two hundred fifty feet (250’) on the same side of the highway. Nonconforming access connection permits may be issued to provide access connections to parcels whose highway frontage, topography, or location precludes issuance of a conforming access connection permit.
   - Variance permits may be allowed if there are special conditions and the exception can be justified to the satisfaction of the department by a traffic analysis in the connection permit application that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

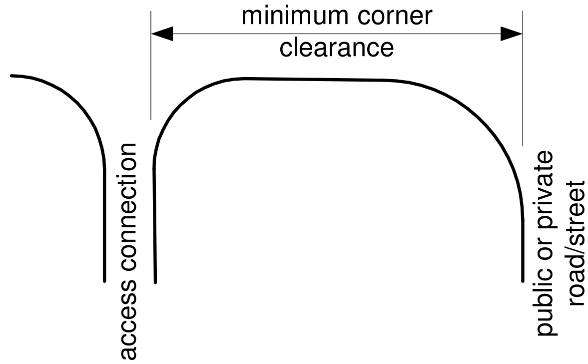
(5) Class 5

(a) **Functional Characteristics**

Class 5 highways provide for moderate travel speeds and moderate traffic volumes for primarily short travel distances for intracity and intracommunity trips and for access to state highways of a higher class. Access needs may generally be higher than the need for through traffic mobility without compromising the public health, welfare, or safety. These highways will generally have nonrestrictive medians.

(b) **Legal Requirements**

1. It is the intent that Class 5 highways be designed to have a posted speed limit of 25 to 35 mph. In rural areas, spacing of intersecting streets, roads, and highways is planned with a minimum spacing of one-quarter mile (1/4 mi). Less than one-quarter mile (1/4 mi) spacing may be allowed where no reasonable alternative exists. In urban areas and developing areas where higher volumes are present or growth that will require signalization is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate signal progression. Where feasible, major intersecting roadways that might ultimately require signalization are planned with a minimum of one-quarter mile (1/4 mi) spacing. Addition of all new access points, public or private, that might require signalization will require an engineering analysis that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.
2. Private Access Connection:
    - No more than one access connection may be provided to an individual parcel or to contiguous parcels under the same ownership unless it can be shown that additional access connections will not adversely affect the desired function of the state highway in accordance with the assigned managed access Class 5, and will not adversely affect the safety or operation of the state highway.
    - The minimum distance to another (public or private) access point is one hundred twenty five feet (125') on the same side of the highway. Nonconforming access connection permits may be issued to provide access to parcels whose highway frontage, topography, or location precludes issuance of a conforming access connection permit.
    - Variance permits may be allowed if there are special conditions and the exception can be justified to the satisfaction of the department by a traffic analysis in the access connection permit application that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.



Minimum Corner Clearance
Figure 1435-1

1435.03 Corner Clearance Criteria

In addition to the five access control classes, there are also corner clearance criteria that may be used for access connections near intersections. See Figure 1435-1.

Corner clearance spacing must meet or exceed the minimum access point spacing requirements of the applicable managed access highway class. A single access connection may be placed closer to the intersection, in compliance with the permit application process specified in WAC 468-51, and in accordance with the following criteria:

With Restrictive Median		
Position	**Access Allowed**	**Minimum (feet)**
Approaching Intersection	Right In/Right Out	115
Approaching Intersection	Right In Only	75
Departing Intersection	Right In/Right Out	230*
Departing Intersection	Right Out Only	100
Without Restrictive Median		
Position	**Access Allowed**	**Minimum (feet)**
Approaching Intersection	Full Access	230*
Approaching Intersection	Right In Only	100
Departing Intersection	Full Access	230*
Departing Intersection	Right Out Only	100

* For speeds less than 35 mph, and for access Class 5, 125 feet may be used.

Minimum Corner Clearance: Distance From Access Connection to Intersections
Figure 1435-2

(a) The minimum corner clearance criteria in Figure 1435-2 may be used where access point spacing cannot be obtained due to property size and a joint use access connection cannot be secured, or where it is determined by WSDOT to be not feasible because of conflicting land use or conflicting traffic volumes or operational characteristics.

(b) Some local agencies have adopted corner clearance as a design element in their adopted design standards. Coordinate with the local agency regarding corner clearance of an access connection near an intersecting local road or street.

(c) In cases where access connections are allowed under the above criteria, the conforming permit issued in compliance with WAC 468-51 must contain the following additional conditions:

1. Variance and nonconforming permits are not allowed.
2. There must be no more than one access connection per property frontage on the state highway.
3. When a joint-use access connection or an alternate road/street system access (meeting or exceeding the minimum corner clearance requirement) becomes available, the permit holder must close the permitted access connection, unless the permit holder shows to the WSDOT's satisfaction that such closure is not feasible.

1435.04 Access Connection Categories

Whenever an access connection permit is issued on a managed access state highway, the permit must also specify an access connection category. There are four categories, defined as Category I to Category IV. The first three categories, I through III, are based on the maximum vehicular usage of the access connection. Category IV specifies a temporary use, usually for less than a year. Access connection permits must specify the category and the maximum vehicular usage of the access connection in the permit

All access connections are determined by the WSDOT to be in one of the following categories (WAC 468-51-040):

(1) Category I

"Category I - minimum connection" provides connection to the state highway system for up to ten single family residences, a duplex, or a small multifamily complex of up to ten dwelling units that use a common access connection. The category also applies to permanent access connections to agricultural and forest lands, including field entrances; access connections for the operation, maintenance, and repair of utilities; and access connections serving other low volume traffic generators expected to have an average weekday vehicle trip ends (AWDVTE) of one hundred (100) or less.

(2) Category II

"Category II - minor connection" provides connection to the state highway system for medium volume traffic generators expected to have an AWDVTE of one thousand five hundred (1500) or less, but not included in Category I.

(3) Category III

"Category III - major connection" provides connection to the state highway system for high volume traffic generators expected to have an AWDVTE exceeding one thousand five hundred (1500).

(4) Category IV

"Category IV - temporary connection" provides a temporary, time limited, connection to the state highway system for a specific property for a specific use with a specific traffic volume. Such uses include, but are not limited to, logging, forest land clearing, temporary agricultural uses, temporary construction, and temporary emergency access. The department reserves the right to remove any temporary access connection at its sole discretion and at the expense of the property owner after the expiration of the permit. Further, a temporary access connection permit does not bind the department, in any way, to the future issuance of a permanent access connection permit at the temporary access connection location.

1435.05 Access Connection Permit

RCW 47.50 requires all access connections to be permitted. This can be accomplished by the permitting process or by the connection being "grand-fathered." Grand-fathered means it was in place prior to July 1, 1990. The grand-fathered status remains in effect until WSDOT requires removal (1435.07) or there is a change from the 1990 AWDVTE or established use of the property.

All new access connections and alterations and improvements to existing access connections to state highways require an access connection permit. Every owner of property that abuts a state highway has the right to reasonable access. This right may be restricted with respect to the highway if reasonable access can be provided by way of another public road/street.

When a new road or street is to be constructed, WSDOT approval is required for intersection design, spacing, and construction work on the right of way. This is usually in the form of a Developer Agreement. If, however, an access connection permit is issued, it will be rendered null and void if and when the road or street is duly established as a public road or public street by the local governmental entity.

Access connection permits authorize construction improvements, relating to the access connection only, to be built by the permit holder on department right of way. It is the responsibility of the applicant or permit holder to obtain all other local permits or other agency approvals that are required, including satisfaction of all environmental regulations. Except where the access connection replaces an existing access connection as a result of department relocation activity, it is the responsibility of the applicant to acquire any property rights necessary to provide continuity from the applicant's property to the state highway right of way if the applicant's property does not abut the state's right of way.

The alteration or closure of any existing access connection caused by changes to the character, intensity of development, or use of the property served by the access connection or the construction of any new access connection must not begin before an access connection permit is obtained.

If a property owner or permit holder who has a valid access connection permit wishes to change the character, use, or intensity of the property or development served by the access connection, the permitting authority must be contacted to determine whether an upgraded access connection permit will be required.

Regardless of where the permitting authority lies, it is the responsibility of the applicant to gain approval of plans (showing the construction details) from the Department of Transportation if there is to be any effect on state highway geometrics, channelization, or drainage. The design must conform to guidance that is elsewhere in this manual; Chapters 910, 920, and 940, for example; and other WSDOT manuals as applicable. Scheduling the work is discussed in 1435.08(3). The preconstruction conference is discussed in 1435.09.

1435.06 Permit Process

An access connection permit is obtained from the department by submitting the appropriate application form, including the fee, plans, traffic data, and access connection information to the department for review. All access connection and roadway design documents for Category II and III permits must bear the seal and signature of a professional engineer registered in Washington State.

The permitting process begins with the application. Upon submittal of the application with all the attached requirements it is reviewed and either denied or accepted. If denied, the department must notify the applicant in writing stating the reasons and the applicant will have thirty (30) days to submit a revised application. Once the application is approved and the permit is issued, the applicant may begin construction. No construction is allowed on the department's right of way until all necessary department and local government permits are issued.

The Access Manager in each region keeps a record of all access points distinguishing between those that are permitted and those that are grand-fathered. A permit for a grand-fathered access point is not required but may be issued for record-keeping reasons.

(1) Conforming Access Connection Permit

Conforming access connection permits may be issued for access connections that conform to the functional characteristics and all legal requirements for the designated class of the highway.

Conforming access connection permits may not be issued for access connections to Class I or II highways because of the legal restriction of private access connections. See Figure 1435-3.

(2) Nonconforming Access Connection Permit

Nonconforming access connection permits may be issued for short-term access connections pending availability of a future joint-use access connection or public road/street system access:

- For location and spacing not meeting requirements.
- For Category I through IV permits.
- After an analysis and determination by the department that a conforming access connection cannot be made at the time of permit application submittal.
- After a finding that the denial of an access connection will leave the property without a reasonable means of access to the public road/street system.

In such instances, the permit is to be noted as being a nonconforming access connection permit and contains specific restrictions and provisions, including:

- Limits on the maximum vehicular use of the access connection.
- The future availability of alternate means of reasonable access for which a conforming access connection permit can be obtained.
- The removal of the nonconforming access connection at the time the conforming access is available.
- The properties to be served by the access connection.
- Other conditions as necessary to carry out the provisions of RCW 47.50.

(3) Variance Access Connection Permit

Variance access connection is a special nonconforming or additional access connection permit issued for long-term use where future public road/street system access is not foreseeable:

- For location and spacing not meeting requirements or for an access connection that exceeds the number allowed for the class.
- For Category II and III permits only.
- After an engineering study demonstrates, to the satisfaction of the department, that the access connection will not adversely affect the safety, maintenance, or operation of the highway in accordance with its assigned managed access class.

In such instances, the permit is to be noted as being a variance access connection permit and specifies conditions or limits including, but not limited to:

- Limits on the maximum vehicular use of the access connection.
- The properties to be served by the access connection.
- Other conditions as necessary to carry out the provisions of RCW 47.50.

This permit will remain valid until modified or revoked by the permitting authority unless an upgraded permit is required due to changes in property site use. (See 1435.08(1).)

A variance access connection permit must not be issued for an access connection that does not conform to minimum corner clearance requirements. (See 1435.03.)

(4) Median Opening

Median opening includes openings requested for both new access connections and for existing access connections. See Chapter 910 for median crossover spacing and other design guidance.

- New median openings proposed as part of a new access connection are reviewed as part of the permit application review process.
- Requests for the construction of new median openings to serve existing permitted access connections require a reevaluation of the location, quantity, design of existing access connections, and traffic at the existing access connections.
- The property owner must file a new access connection permit application, for the proper access connection category, showing the new proposed median opening location and design and its relationship to the existing or modified access connections.
- Nothing contained herein is to be construed to prohibit the department from closing an existing median opening where operational or safety reasons require the action.
- The department must notify affected property owners, permit holders and tenants, in writing, thirty (30) days in advance of the closure of a median opening unless immediate closure is needed for safety or operational reasons.

1435.07 Design Considerations

See Chapter 920, "Road Approaches," for design considerations (design templates) and Chapter 700 regarding mailbox locations.

1435.08 Other Considerations

(1) Changes in Property Site Use With Permitted Access Connection

The access connection permit is issued to the permit holder for a particular type of land use generating specific projected traffic volumes at the final stage of proposed development. Any changes made in the use, intensity of development, type of traffic, or traffic flow require the permit holder, an assignee, or the property owner to contact the department to determine if further analysis is needed because the change is significant and will require a new permit and modifications to the access connection. (WAC 468-51-110)

A significant change is one that will cause a change in the category of the access connection permit or one that causes an operational, safety, or maintenance problem on the state highway system based on objective engineering criteria or available accident data. Such data will be provided to the property owner and/or permit holder and tenant upon written request. (WAC 468-51-110)

(2) Existing Access Connections

(a) **Closure of Grand-Fathered Access Connections** Any access connections that were in existence and in active use on July 1, 1990 may be grand-fathered.

The grand-fathered access connection may continue unless:

- There are changes from the 1990 AWDVTE.
- There are changes from the 1990 established use.
- The department determines that the access connection does not provide minimum acceptable levels of highway safety and mobility based on accident and/or traffic data or accepted traffic engineering criteria. (A copy of which must be provided to the property owner, permit holder, and/or tenant upon written request.) (WAC 468-51-130)

(b) **Department Construction Projects**

1. Notification

   The department must notify affected property owners, permit holders, business owners, and emergency services in writing, where appropriate, whenever the department's work program requires the modification, relocation, or replacement of their access connections. In addition to written notification, the department will facilitate, where appropriate, a public process that may include, but is not limited to, public notices, meetings or hearings, and individual meetings.

2. Modifications -- Considerations

   When the number, location, or design of existing access connections to the state highway is being modified by a department construction project, the resulting modified access connections must provide the same general *functionality* for the existing property use as they did before the modification, taking into consideration the existing site design, normal vehicle types, and traffic circulation requirements. These are evaluated on an individual basis. It is important to remember that the intent is not to *damage* the property owner by removing nonconforming access connections, but to eliminate access connections that are both nonconforming and not needed.

   The permitting authority evaluates each property individually to make a determination of which category of access connection and which design template (Chapter 920) will be reasonable. If it is a commercial parcel, determine if the business can function with one access connection. Each parcel, or contiguous parcels under the same ownership being used for the same purpose, is only allowed one access connection. If the business cannot function properly with only one access connection, a variance permit may be issued for additional access connections. If the property is residential, only one access connection is allowed, however, certain circumstances might require an additional access connection.

3. Costs

   - **Replacement of existing access connections** - When access connections are made as part of a department construction project replacing existing access connection points without material differences, no additional permit is required. Costs are borne by the department.
   - **Modifications** - If the modification of the access connection point is based on the owner's request and is more extensive than the routine replacement of an existing access connection, the owner must also participate in the differential cost.

(3) Work by Permit Holder's Contractor

The department requires that work done by the owner's contractor be accomplished at the completion of the department's contract or be scheduled so as not to interfere with the department's contractor. The department may require a surety bond prior to construction of the access connection in accordance with WAC 468-51-070.

1435.09 Preconstruction Conference

All new access connections including alterations and improvements to existing access connections to the highway require an access connection permit. The department may require a preconstruction conference prior to any work being performed on the department's right of way. The preconstruction conference must be attended by those necessary to assure compliance with the terms and provisions of the permit. Details for the individual access connections will be included in the construction permit. This may include access connection widths, drainage requirements, surfacing requirements, mailbox locations, and other information. (WAC 468-51-090)

1435.10 Adjudicative Proceedings

Any person who has standing to challenge any of the following department actions may request an adjudicative proceeding (an appeal to an Administrative Law Judge) within thirty (30) days of the department's written decision: (WAC 468-51-150)

- Denial of an access connection permit application pursuant to WAC 468-51-080
- Permit conditions pursuant to WAC 468-51-150
- Permit modifications pursuant to WAC 468-51-120
- Permit revocation pursuant to WAC 468-51-120
- Closure of permitted access connection pursuant to WAC 468-51-120
- Closure of grand-fathered access connection pursuant to WAC 468-51-130

An appeal of a decision by the department can only be requested if the administrative fee has been paid. If the fee has not been paid, the permit application is considered incomplete and an adjudicative proceeding cannot be requested.

Below is a brief summary of the adjudicative proceeding process. For the purpose of this summary, the responsibilities of the department are separated into those actions required of the region and those actions required of Headquarters. The following summary is also written as if the appealable condition was a denial of an access connection request.

1. The region receives an access connection permit application, with fee.
2. The region processes the application and makes a determination that the access connection request will be denied.
3. The region sends to the applicant a written letter denying the access connection. Included in this letter is notification that the applicant has thirty (30) days to request an adjudicative proceeding if the applicant disagrees with the region's denial decision. The region must notify affected property owners, permit holders, business owners, tenants, lessees, and emergency services, as appropriate.
4. The applicant, within thirty (30) days, requests an adjudicative proceeding.
5. The region reviews its initial denial decision and determines if there is any additional information presented that justifies reversing the original decision.
6. If the region determines that the original denial decision will stand, the region then forwards copies of all applicable permit documentation to the Access and Hearings Manager (AHM) at Headquarters for review and processing.
7. The AHM reviews the permit application and, if need be, consults the Attorney General's (AG) office for advice and direction.

8. If the initial findings of the AHM agree with the region's denial decision, Headquarters sends to the applicant a written letter, with the signature of the State Design Engineer, informing the applicant that a hearing will be set up for the applicant to attend and appeal in person the department's decision to deny access.
9. The region reserves a location and obtains a court reporter, while Headquarters obtains an Administrative Law Judge (ALJ) to conduct the proceeding. Headquarters, by written letter with the State Design Engineer's signature, notifies the applicant of the time and place for the hearing. The department has ninety (90) days from receipt of the applicant's appeal to approve or deny the appeal application, schedule a hearing, or decide not to conduct a hearing. The actual hearing date can be set beyond this ninety (90) day review period.
10. The region's AG leads the department's presentation and works with both the region and the AHM regarding who will testify and what displays and other information will be presented to the ALJ (note: the AHM will typically not attend these proceedings).
11. After hearing all the facts, the ALJ issues a decision, usually within a couple of weeks after the proceedings. However, the ALJ has ninety (90) days in which to serve a written Initial Order, stating the decision.
12. The ALJ's decision is final unless the applicant, or the department through the AHM, decides to appeal the ALJ's decision to the State Design Engineer. This second appeal must occur within twenty (20) days of the ALJ's written decision.
13. If appealed to the State Design Engineer, the State Design Engineer has ninety (90) days to review the Initial Order, and all the facts and supporting documentation, and issue a Final Order. The review by the State Design Engineer does not require the applicable parties to be present and may involve only a review of the material submitted at the adjudicative proceeding.
14. The State Design Engineer's decision is final unless appealed within thirty (30) days to the Washington State Superior Court.

The above represents a general timeline if all appeals are pursued. Based on the above timelines it can take nearly a year before a Final Order is issued. If appealed to Superior Court, up to an additional 18 months can be added to the process. In any case, contact the region's Development Services Engineer for further guidance and direction if an appeal might be coming.

1435.11 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 website: http://www.wsdot.wa.gov/eesc/design/projectdev/

Class	Noncon-forming	Variance	Conforming	Access Point Spacing **	Limitations
Class 1 Mobility is the primary function	Yes*	No	No	1320’	1 access connection only to contiguous parcels under same ownership Private access connection is not allowed unless no other reasonable access exists. (Must use public road/street system if possible.)
Class 2 Mobility favored over access	Yes*	Yes*	No	660’	1 access connection only to contiguous parcels under same ownership unless frontage >1320’ Private access connection is not allowed unless no other reasonable access exists. (Must use public road/street system if possible.)
Class 3 Balance between mobility and access in areas with less than maximum build out	Yes	Yes	Yes	330’	1 access connection only to contiguous parcels under same ownership. Joint access connection for subdivisions preferred, but private access connection allowed with acceptable justification.
Class 4 Balance between mobility and access in areas with less than maximum build out	Yes	Yes	Yes	250’	1 access connection only to contiguous parcels under same ownership except with acceptable justification.
Class 5 Access needs may have priority over through mobility needs	Yes	Yes	Yes	125’	More than 1 access connection per ownership allowed with acceptable justification.

* The access connection continues only until such time when other reasonable access to a highway with a less restrictive class or acceptable access to the public road/street system becomes available and is allowed.
** Minimum, on the same side of the highway.

Managed Access Highway Class Description
Figure 1435-3

1440.01 General

The Washington State Department of Transportation (WSDOT) is permitted, by an agreement with the Board of Registration for Professional Engineers and Land Surveyors, to "practice land surveying" under the "direct supervision of either a licensed professional land surveyor or a licensed professional engineer." See Figure 1440-1, Interagency Agreement.

1440.02 References

RCW 58.09, "Surveys -- Recording"

RCW 58.20.120, "System designation -- Permitted uses"

RCW 58.24.040(8), ". . . temporary removal of boundary marks or monuments"

WAC 332-120, "Survey Monuments -- Removal or Destruction"

WAC 332-130, "Minimum Standards for Land Boundary Surveys and Geodetic Control Surveys and Guidelines for the Preparation of Land Descriptions"

Interagency Agreement Between the Washington State Department of Transportation and the Board of Registration for Professional Engineers and Land Surveyors

Construction Manual, M 41-01, WSDOT

Highway Surveying Manual, M 22-97, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

WSDOT Monument Database at http://www.wsdot.wa.gov/monument/

1440.03 Procedures

For WSDOT projects, it is recommended that surveying activities include (if appropriate) but not be limited to the following items.

(1) During the Project Definition Phase

(a) Include any pertinent surveying information in the Project Summary.

(b) Research for recorded survey monuments existing within the project area.

(c) Determine and prioritize project survey needs and tasks to be completed.

- Cadastral issues
- Right of way issues
- Geodetic control issues
- Photogrammetry issues
- Other issues as needed

(2) During Design and Development of the Plans, Specifications, and Estimate

(a) Hold a presurvey conference.

(b) Schedule tasks with surveyors.

(c) Perform field reconnaissance, mark existing recorded survey monuments, and determine location of possible new survey monuments. Also mark found unrecorded monuments for preservation if practical.

(d) Determine impact to geodetic monuments and notify OSC Geographic Services.

(e) See the *Highway Surveying Manual* to:

- Convert Washington state plane coordinates to project datum.
- Document the procedure and combined factor used for converting between datums.

- Determine survey collection methods.
- Collect primary, secondary, and tertiary survey data.
- Process and import secondary, tertiary, or other survey data into design software for use by designers.

(f) Apply to the Department of Natural Resources (DNR) for permits for monuments that will be disturbed or removed (Chapter 1450).

(g) Archive new primary and secondary survey control data in the WSDOT Monument Database and GIS, as appropriate, for future retrieval.

(h) Ensure that all survey monuments within the right of way of the project are shown on the contract plans in order to avoid accidental damage.

(i) Develop a Record of Survey (RCW 58.09) or a Monumentation Map as required (Chapter 1450).

(3) After Construction is Completed

(a) Complete "Post Construction" survey as described in the *Highway Surveying Manual* and the *Construction Manual*.

(b) Have DNR Completion Report signed and stamped by the appropriate professional in direct responsible charge of the surveying work, then file with DNR as described in Chapter 1450.

1440.04 Datums

A datum is a geometrical quantity or set of quantities that serves as a reference, forming the basis for computation of horizontal and vertical control surveys in which the curvature of the earth is considered. Adjusted positions of the datum, described in terms of latitude and longitude, may be transformed into plane coordinates on a state system.

(1) Horizontal

WAC 332-130-060 states that "The datum for the horizontal control network in Washington shall be NAD83 (1991) as officially adjusted and published by the National Geodetic Survey of the United States Department of Commerce and as established in accordance with chapter 58.20 RCW. The datum adjustment shall be identified on all documents prepared; i.e., NAD83 (1991)." For further information, see the *Highway Surveying Manual*.

(2) Vertical

The Federal Geodetic Control Subcommittee (FGCS) has affirmed the North American Vertical Datum of 1988 (NAVD88) as the official civilian datum for surveying and mapping activities in the United States. WSDOT has adopted this datum. For further information, see the *Highway Surveying Manual.*

1440.05 Global Positioning System

A Global Positioning System (GPS) uses a constellation of satellites and earth stationed receivers to determine geodetic positions (latitude and longitude) on the surface of the earth. This survey technology is used by WSDOT personnel. See the *Highway Surveying Manual* for more detailed discussions.

GPS technology is changing rapidly. The key point is for the designer and surveyor to select the best tool (GPS application) for doing the survey. Often times a combination of GPS and traditional (Total Station) surveying is appropriate.

1440.06 WSDOT Monument Database

The WSDOT Monument Database provides storage and retrieval capabilities for data associated with survey control monuments set by WSDOT. This database supports and tracks the Report of Survey Mark and aids in fulfilling WSDOT's obligation to contribute to the body of public record, thereby minimizing the duplication of survey work.

The Internet address http://www.wsdot.wa.gov/monument/ is used to access the WSDOT Monument Database.

1440.07 Geographic Information System

The Geographic Information System (GIS) is a collection of information from many sources. Its purpose is to assemble data into a central database for the common good. The data is stored on many levels so that the desired information can be selected and combined to achieve the desired product. Surveying and photogrammetric data are vital elements of this system.

1440.08 Photogrammetric Surveys

Photogrammetric surveys are performed to furnish topographic or planimetric maps and cross sections for use in the reconnaissance, location, and preliminary design phases of highway work. To use photogrammetric surveys for final design and construction requires that the ground be nearly bare to obtain the necessary accuracy. By using well-planned aerial photography in stereoscopic plotters, contours and other physical features are delineated on map sheets to a scale consistent with the accuracies or detail required.

The usefulness of aerial photography is not limited to mapping. Taking the form of enlargements, mosaics, and digital images, it can be used as a visual communication tool (displays and exhibits) for planning, design, property acquisition, engineering, construction, litigation, and public relations.

To obtain information on preparation, procedure, and programming of aerial photography and photogrammetric mapping and applications, contact the Geographic Services Branch. When requesting a photogrammetric survey, specify the desired units and check the units of the product. Allow for the time required to communicate the complex and detailed work request, develop the service, and accomplish the product.

1440.09 Documentation

See Chapter 1450 for documentation related to monuments.

Primary and secondary survey control data are archived in the WSDOT Monument Database and GIS when available.

As a minimum, permanent hard copies of the following are to be preserved in a manner that can easily be retrieved in the future:

- ☐ Report of Survey Marks
- ☐ Project datum conversion documentation
- ☐ Legal research (descriptions, lists of references, etc.)

P65:DP/DMM

INTERAGENCY AGREEMENT BETWEEN
THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
AND THE BOARD OF REGISTRATION FOR PROFESSIONAL
ENGINEERS AND LAND SURVEYORS

THE FOLLOWING Interagency Agreement is hereby entered into between the Washington State Department of Transportation (hereafter referred to as “WSDOT”) and the Washington State Board of Registration for Professional Engineers and Land Surveyors (hereafter referred to as “BOARD”).

I

DECLARATIONS OF THE PARTIES

A. WHEREAS the BOARD has the exclusive authority to regulate the practice of engineering and land surveying in Washington; and

B. WHEREAS WSDOT employees are required to practice land surveying as defined by RCW 18.43.020 in carrying out the program of said agency; and

C. WHEREAS WSDOT is exempted from necessarily using a licensed land surveyor to perform said surveys in accordance with the provisions of the Survey Recording Act, RCW 58.09.090; and

D. WHEREAS both the BOARD’S and WSDOT’S goals include the performance of land surveys in conformance with recognized standards of practice and relevant laws and administrative codes in order to safeguard life, health, and property; and

E. WHEREAS the parties to the Agreement agree to the following Principles of Agreement.

II

PRINCIPLES OF AGREEMENT

A. The practice of land surveying performed by WSDOT employees shall be under the direct supervision of a licensed professional land surveyor OR licensed professional engineer. Said licensee shall hold a valid Washington license issued in conformance with RCW 18.43.

B. All surveys performed by WSDOT employees shall be performed in accordance with the Survey Standards promulgated under Chapter 332-130 WAC.

C. When a survey has been performed by WSDOT employees a survey map shall be prepared and filed with the county engineer in compliance with RCW 58.09.090(1)(a). Said map’s contents shall be in conformance with the requirements of RCW 58.09.060 and WAC 332-130. Furthermore, said map shall contain the stamp and signature of the licensee who was in direct responsible charge of the work.

Interagency Agreement
Figure 1440-1a

D. A record of corner information shall be filed in accordance with RCW 58.09.040(2) and 58.09.090(2) where WSDOT employees replace or restore an existing or obliterated general land office corner. Said record of corner information shall be signed and stamped by the professional land surveyor or professional engineer responsible for said work.

E. The temporary removal or destruction of any section corner or any other land boundary mark or monument shall be permitted if performed in compliance with RCW 58.24.040(8).

F. Whether performed by a licensed professional engineer or a licensed professional land surveyor, any surveys performed by WSDOT shall be in accordance with the standards generally expected of those practicing professional land surveying.

IN WITNESS WHEREOF: The Washington State Department of Transportation and the Board of Registration have signed this Agreement.

/s/ Ed W. Ferguson

________________________	____January 5, 1990 ____
Ed W. Ferguson, PE DEPUTY SECRETARY Department of Transportation	Date

This Agreement approved by motion of the Board dated January 19, 1990.

/s/ Wesley E. Taft

___________________________	____January 19, 1990____
Wesley E. Taft, PE CHAIRMAN, Board of Registration	Date

Interagency Agreement
Figure 1440-1b

1450.01 General

Proper monumentation is important in referencing a highway's alignment that is used to define its right of way and the department can contribute to the body of public records and minimize duplication of survey work by establishing and recording monuments that are tied to a state plane and to a standard vertical datum. In addition, the department is required by law to perpetuate existing recorded monuments. (See RCW 58.09.) Consequently, the department shall provide monuments for realignments and new highway alignments and shall perpetuate existing monuments impacted by a project.

Both the Department of Natural Resources (DNR) and the Geographic Services Branch maintain records of surveys performed and survey monuments established. New monuments are to be reported to both operations.

Existing monuments are not to be disturbed without first obtaining the DNR permits required by state law. DNR allows the temporary covering of a string of monuments under a single permit. State law requires replacement of land boundary monuments after temporary removal according to permit procedures. WSDOT control and alignment monuments may be removed without replacement if approved by the Geographic Services Branch. (Notify DNR.)

Other requirements pertaining to specific monuments are discussed below.

Figure 1450-1 summarizes the documentation requirements for new and existing monuments.

The region is responsible for obtaining all required permits before any existing monument is disturbed and for the research to locate existing monuments as required by WAC 332-120-030 as follows:

> *(2) Any person, corporation, association, department, or subdivision of the state, county or municipality responsible for an activity that may cause a survey monument to be removed or destroyed shall be responsible for ensuring that the original survey point is perpetuated. It shall be the responsibility of the governmental agency or others performing construction work or other activity (including road or street resurfacing projects) to adequately search the records and the physical area of the proposed construction work or other activity for the purpose of locating and referencing any known or existing survey monuments.*

1450.02 References

"Engineers and Land Surveyors," RCW 18.43

"Surveys — Recording," RCW 58.09

"State Agency for Surveys and Maps — Fees," RCW 58.24

"Survey Monuments--Removal or Destruction," WAC 332-120

"Minimum Standards for Land Boundary Surveys and Geodetic Control Surveys and Guidelines for the Preparation of Land Descriptions," WAC 332-130

"*Manual of Instructions for the Survey of the Public Lands of the United States* 1973 BLM, U.S. Department of Interior"

1450.03 Definitions

monument, as defined for this chapter, is any physical object or structure which marks or references a survey point. This includes a point of curvature (P.C.), a point of tangency (P.T.), a property corner, a section corner, a General Land Office (GLO) survey point, a Bureau of Land

Management (BLM) survey point, and any other permanent reference set by a governmental agency or private surveyor.

removal or destruction the physical disturbance or covering of a monument such that the survey point is no longer visible or readily accessible.

1450.04 Control Monuments

Horizontal and vertical control monuments are permanent references required for the establishment of project coordinates tied to a state plane and elevations tied to a standard vertical datum. By establishing and recording permanent control monuments, the department eliminates duplication of survey work and contributes to the body of public records.

Horizontal and vertical control monuments are required for highway projects requiring the location of existing or proposed alignment or right of way limits. Monuments set by other agencies may be used if within two kilometers (1.24 miles) of the project and the required datum and accuracy were used. To omit monumentation when it is impractical, a variance must be sought from the State Survey Support Engineer.

When control monuments are required for a given project, either show the existing and proposed control monuments on the contract plans or include an approved variance in the design report.

For horizontal control:

- Use North American Datum 1983, revised 1991 (NAD83/91).
- Use a minimum of second order, Class II procedures as defined in the *Highway Surveying Manual* (M 22-97).
- Provide two monuments near the beginning of the project.
- Provide two monuments near the end of the project.
- Provide a pair of monuments at about five kilometer (or 3-mile) intervals throughout the length of the project.

For vertical control:

- Use North American Vertical Datum 1988 (NAVD88). See the *Highway Surveying Manual* for orders of accuracy required.
- Use at least third order procedures within project limits as defined in the *Highway Surveying Manual*.
- Provide vertical control throughout the length of the project. Desirable spacing is at or near each milepost or every other kilometer. Maximum spacing is five kilometers (3.11 miles) apart.

All control monuments that are established, reestablished, or reset must be filed with the county engineer and DNR. Submit a <u>Monumentation Map</u> that has been signed by the supervising, licensed, professional engineer, or land surveyor (or, if the monument is not used to reference right of way or land corners, submit a Record of Survey Mark).

1450.05 Alignment Monuments

Alignment monuments are permanent references required for the establishment or reestablishment of the highway and its right of way. Generally, highway and ramp center line P.C.s and P.T.s are monumented. Establishment, reestablishment, or resetting of alignment monuments is required on the following highway projects:

- New highway alignment projects.
- Highway realignment projects involving new right of way. (Monuments are only required for the realigned highway section.)
- Highway projects where alignment monuments already exist.

Before an existing alignment monument is reestablished or reset, a DNR permit is required.

All alignment monuments that are established, reestablished or reset must be filed with the appropriate county engineer and DNR. A copy of a Monumentation Map is filed with the county engineer of the county in which the monument is located and the original is sent to the Olympia Service Center Right of Way Plans Branch. The Olympia Service Center will forward a copy to DNR for their records.

1450.06 Property Corners

A new property corner monument will be provided where an existing recorded monument has been invalidated as a direct result of a right of way purchase by the department. The new property corner monument shall be set by or under the direct supervision of a licensed professional land surveyor. The licensed professional land surveyor must record the survey with the county auditor and send copies to DNR and the Headquarters (HQ) Right of Way Plans Branch.

1450.07 Other Monuments

A DNR permit is required before any monument may be removed or destroyed.

Existing section corners and BLM or GLO monuments impacted by a project shall be reset to perpetuate their existence. After completing the work, a Land Corner Record is required.

Other permanent monuments established by any other governmental agency must not be disturbed until the agency has been contacted to determine specific requirements for the monument. If assistance is needed to identify a monument, contact the Headquarters (HQ) Geographic Services Office.

Resetting monuments must be done by or under the direct supervision of a licensed professional engineer or a licensed professional land surveyor. A copy of a Monumentation Map is filed with the county engineer of the county in which the monument is located and the original is sent to the HQ Right of Way Plans Branch. The HQ Right of Way Plans Branch will forward a copy to DNR for their records.

1450.08 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 website: http://www.wsdot.wa.gov/eesc/design/projectdev/

1450.09 Filing Requirements

(1) DNR Permit

When a DNR permit is required, use the application form shown in Figure 1450-2a. The completed application must be signed by a licensed professional engineer or a licensed professional land surveyor and submitted to DNR.

Monumentation work cannot be done until DNR has approved the permit. Verbal permission may be granted by DNR pending the issuance of a written permit.

After resetting the monument, the survey method used must be filed with DNR using the completion report form shown in Figure 1450-2b. The form must be signed by a licensed professional engineer or a licensed professional land surveyor.

(2) Monumentation Map

When a Monumentation Map is required, a plan sheet is prepared. Generally, the plan sheet is based on a right of way plan obtained from the HQ Right of Way Plans Branch. A Monumentation Map contains a description of all new and existing monuments indicating their kind, size, and location. In addition, it must contain the seal and signature of a licensed professional engineer or a licensed professional land surveyor. See the *Plans Preparation Manual*.

A copy of a Monumentation Map is filed with the county engineer of the county in which the monument is located and the original is sent to the HQ Right of Way Plans Branch. Headquarters will forward a copy to DNR for their records.

(3) Land Corner Record

When a Land Corner Record is required, use the forms shown in Figures 1450-3a and 3b. The completed forms must be signed and stamped by a licensed professional engineer or a licensed professional land surveyor and submitted to the county auditor for the county in which the monument is located. Copies are sent to DNR and the HQ Right of Way Plans Branch.

SET NEW

WSDOT Control Monument

Before: No permit required.

After: File a copy of a Monumentation Map with the county engineer. Send the original to the HQ R/W Plans Branch.

Alignment Monument

Before: No permits required.

After: File a copy of a Monumentation Map with the county engineer. Send the original to the HQ R/W Plans Branch.

Property Corner Monument*

Before: Engage a licensed professional land surveyor.

After: Licensed professional land surveyor files Record of Survey with county auditor and DNR and send a copy to the HQ R/W Plans Branch.

DISTURB EXISTING*

Control Monument

Before: Obtain DNR permit.

After: File a copy of a Monumentation Map with the county engineer. Send the original to the HQ R/W Plans Branch.

Alignment Monument

Before: Obtain DNR permit.

After: File a copy of a Monumentation Map with the county engineer. Send the original to the OSC R/W Plans Branch.

Section Corner, BLM, or GLO Monument

Before: Obtain DNR permit.

After: File Land Corner Record with the county auditor and DNR and send a copy to the HQ R/W Plans Branch.

All Other Monuments

Before:

- Obtain DNR permit.
- Contact governmental agency.

After: File a copy of a Monumentation Map with the county engineer. Send the original to the HQ R/W Plans Branch.

*Property corner monuments must be filed within 90 days of establishment, reestablishment, or restoration.

Monument Documentation Summary
Figure 1450-1

APPLICATION FOR PERMIT TO REMOVE OR DESTROY A SURVEY MONUMENT

PERMIT NO.

You are hereby authorized to remove or destroy the described survey monument(s):

AUTHORIZING SIGNATURE/DATE
(DNR or Other Authorizing Agency)

APPLICANT INFORMATION:

NAME: TELEPHONE NO: DATE:

COMPANY OR AGENCY NAME AND ADDRESS:

I estimate that this work will be finished by (date)____________________.

_________I request a variance from the requirement to reference to the Washington Coordinate System. (Please provide your justification in the space below.)

The variance request is ___ approved; ___ not approved. (FOR DNR USE ONLY) Reason for not approving:

MULTIPLE MONUMENTS:

______Check here if this form is being used for more than one monument. You must attach separate sheets showing the information required below for each monument affected. You must seal, sign and date each sheet.

INDEXING INFORMATION FOR AN INDIVIDUAL MONUMENT:

1) THE MONUMENT IS LOCATED IN: SEC_________TWP_________RGE_________1/4-1/4________

2) ADDITIONAL IDENTIFIER: (e.g., BLM designation for the corner, street intersection, plat name, block, lot, etc.)

MONUMENT INFORMATION: Describe: 3) the monument/accessories found marking the position,
4) the temporary references set to remonument the position (include coordinates when applicable), and
5) the permanent monument(s) to be placed on completion (if a permanent witness monument(s) is set include the references to the original position).

SEAL/SIGNATURE/DATE SIGNED

(Form prescribed 2/94 by the Public Land Survey Office, Dept. of Natural Resources, pursuant to RCW 58.24.040 (8).)

DNR Permit Application
Figure 1450-2a

COMPLETION REPORT FOR MONUMENT REMOVAL OR DESTRUCTION

(TO BE COMPLETED AND SENT TO THE DNR AFTER THE WORK IS DONE.)

_____ I have perpetuated the position(s) as per the detail shown on the application form.

____
SEAL/SIGNATURE/DATE SIGNED

OR

_____ I was unable to fulfill the plan as shown on the application form. Below is the detail of what I did do to perpetuate the original position(s). (If the application covered multiple monuments attach sheets providing the required information. Seal, sign and date each sheet.)

____
SEAL/SIGNATURE/DATE SIGNED

DNR Completion Report Form
Figure 1450-2b

LAND CORNER RECORD

(THIS FORM PRESCRIBED BY THE PUBLIC LAND SURVEY OFFICE, DEPARTMENT OF NATURAL RESOURCES, PURSUANT TO RCW 58.09.. ALPHA-NUMERIC INDEX DIAGRAM ON THE BACK.)

CORNER INDEXING INFORMATION:

TWP_______________ RGE_______________ CORNER CODE_____________________

(Willamette Meridian) (See instructions on back of LCR)

ADDITIONAL IDENTIFIER: (e.g., BLM designation for the corner, street intersection, plat name, block, lot, etc.)

COUNTY: AUDITOR'S USE

LAND SURVEYOR INFORMATION: (or Public Officer as per RCW 58.09.090)

This corner record correctly represents work performed by me or under my direction in conformance with the Survey Recording Act.

COMPANY OR AGENCY:

ADDRESS:

SEAL/SIGNATURE/DATE

WASHINGTON PLANE COORDINATES: N: E:

ORDER: ZONE: DATUM (Date of adjustment):

CORNER INFORMATION: Use the space below to provide the following information regarding the corner: <u>(1) Pertinent Corner History</u>, <u>(2) Evidence Found at the Corner</u>, and <u>(3) Corner Perpetuation Information</u>. Please title and number the parts of your discussion accordingly. If additional space is needed use the back. (For (3), diagram the references. Also, provide the cross-reference to a map of record, if applicable, the surveyor's field book no./page no., and the date of work.) (See the back of this form for the requirements of the Survey Recording Act.)

DATE OF FORM: 2/92

Land Corner Record

Figure 1450-3a

MARK THE CORNER LOCATION ON THE DIAGRAM BELOW AND FILL IN THE CORNER CODE BLANK ON THE OTHER SIDE:

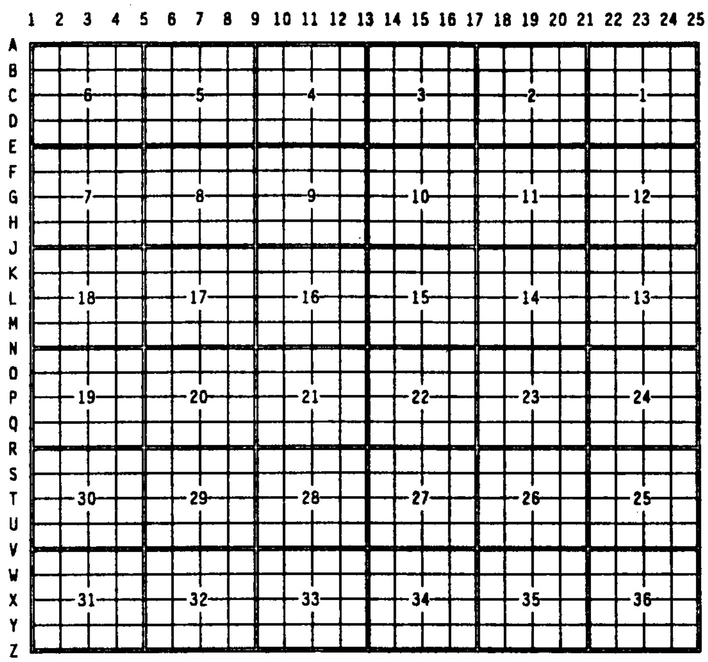
(1) For corners located at the intersection of two lines (Section corners, quarter corners and sixteenth corners):

(a) The corner code is the alpha-numeric coordinate from the diagram below that corresponds to the appropriate intersection of lines.

(2) For corners that are not located at the intersection of two lines (Meander corners, DLC's, HES's, reservation boundaries, mining claims, etc.):

(a) For corners that are on one line only the corner code is the line designation and the related line segment; i.e., a corner on line 5 between "B" and "C" is designated BC-5.

(b) For corners that are between lines the corner code is both line segments; i.e., a corner in the SE1/4 of the SE1/4 of section 18 is designated MN-4-5.



RCW 58.09.060 (2) requires the following information on this form: an accurate description and location, in reference to the corner position, of all monuments and accessories (a) found at the corner and (b) placed or replaced at the corner; (c) basis of bearings used to describe or locate such monuments or accessories; and (d) corollary information that may be helpful to relocate or identify the corner position.

SPACE FOR ADDITIONAL COMMENT:

Land Corner Record

Figure 1450-3b

1460.01 General

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

The reason for discouraging encroachment onto the right of way is to limit the presence of people and animals that might disrupt the efficient flow of traffic on the facility. Although not the primary intent, fencing does provide some form of separation between people, animals, the traffic flow, or other special feature and, therefore, a small measure of protection for each.

1460.02 References

Plans Preparation Manual, M 22-31, WSDOT

Roadside Manual, M 25-30, WSDOT

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

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

1460.03 Design Criteria

(1) General

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

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

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

(2) Limited Access Highways

On highways with limited access control, fencing is mandatory unless it has been established that such fencing may be deferred. Fencing is required between frontage roads and adjacent parking or pedestrian areas (such as at rest areas and flyer stops) and highway lanes or ramps unless other barriers are used to discourage access violations.

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

Unless there is a possibility of access control violation, fencing installation may be deferred until needed at the following locations. (When in doubt, consult the Headquarters (HQ) Access and Hearings Engineer.)

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

(3) Managed Access Highways

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

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

(4) Special Sites

Fencing is often needed at special sites such as pit sites, stockpiles, borrow areas, and storm water detention facilities.

Fence storm water detention facilities and wetland mitigation sites when they are located outside highway right of way fencing.

Fencing is not normally installed around storm water detention ponds or wetland mitigation sites within the right of way fencing unless any one of the following conditions are met:

- The slopes into the storm water detention facility or wetland mitigation site are steeper than 3H:1V.
- The storm water detention facility or wetland mitigation site is located near a school, park, trail, or other facility frequented by children or the elderly.

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

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

- 1020 Bicycle Facilities
- 1025 Pedestrian Design Considerations
- 1120 Bridges

The type and configuration of the fence is determined by the requirements of each situation.

1460.04 Fencing Types

(1) Chain Link

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

- Along an existing business district adjacent to a freeway.
- Between a freeway and an adjacent parallel city street.
- At locations where existing streets have been cut off by freeway construction.
- At industrial areas.
- At large residential developments.
- At military reservations.
- At schools and colleges.
- At recreational and athletic areas.
- At developed areas at the intersection of two limited access highways.
- At any other location where a barrier is needed to protect against pedestrian, bicyclist, or livestock encroachment in limited access areas.
- See Chapter 640 for roadway sections in rock cuts.

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

(a) **Type 1.** A high fence for areas of intensified use, such as industrial areas, or school playgrounds. It is not to be used within the Design Clear Zone because the top rail of the fence is considered a hazard. (See Chapter 700.)

(b) **Type 3.** A high fence for use in suburban areas with limited existing development. It may be used within the Design Clear Zone.

(c) **Type 4.** A lower fence for special use, such as between the traveled highway lanes and a rest area or flyer stop, or as a rest area boundary fence if required by the development of the surrounding area. This fence may be used along a bike path or hiking trail to separate it from an adjacent roadway.

(d) **Type 6.** A lower fence used instead of Type 1 where it is deemed important not to obstruct the view toward or from areas adjacent to the highway. This fence is not to be used within the Design Clear Zone because the top rail of the fence is considered a hazard. (See Chapter 700.)

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

(2) Wire Fencing

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

(a) **Type 1.** This fence is used in urban and suburban areas where improvements along the right of way are infrequent and future development is not anticipated. It may also be used adjacent to livestock grazing areas. The lower portion of this fence is wire mesh and provides a barrier to children and small animals.

(b) **Type 2.** This fence is used in farming areas to limit highway crossings by farm vehicles to designated approaches: in irrigation districts to prevent ditch riders, maintenance personnel, and farmers from making unauthorized highway crossings; and where new alignment crosses parcels previously enclosed by barbed wire.

(3) Other Considerations

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

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

Do not straddle or obstruct surveying monuments.

1460.05 Gates

Keep the number of fence gates along limited access highways to a minimum. On limited access highways, all new gates must be approved as described in Chapter 1425, "Access Point Decision Report."

Usually such gates are necessary only to allow highway maintenance personnel and operating equipment to reach the freeway border areas without using the through-traffic roadway. Gates may be needed to provide access to utility supports, manholes, and the like, located within the right of way.

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

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

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

1460.06 Procedure

Fencing is included in the access report, in accordance with Chapter 1430, and the PS&E, in accordance with the *Plans Preparation Manual*.

1460.07 Documentation

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

A

C

D

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